The 6th International Weed Science Congress

Proceeding

Hangzhou, China
17-22 June,2012

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Global agrochemicals industry - “The rules of the game are changing”

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Key global trends: Every twelve years one billion people join the world’s population, most of them in emerging economies. By contrast, in most developed countries (Europe, the US, Japan), a population decline is being witnessed. The population growth in emerging economies has been accompanied by massive urban migration, so that in 1950 less than one billion people populated the world's cities, nowadays these cities are inhabited by around three and a half billion people (half of the entire world population). This trend is only the tip of the iceberg - in 2050, more than five and a half billion people will be city dwellers.When people move to the city, they join the workforce. As a result, in the past twenty-five years the global labor force has been augmented by around 800 million more workers. The wage gaps between developed and developing countries, coupled with the growth in the number of workers, have in the past twenty years led to a massive relocation of production to emerging markets and to the "import" of unemployment to developed economies.

In the past twenty-five years the fall of the walls in Eastern and Central Europe in the late nineteen-eighties, the development and urban immigration in China and India, with the subsequent addition of people to the workforce, have resulted in an addition of two and a half billion new consumers to global trade.The combination of these trends is at the core of the shift of the world's center of economic gravity to the developing economies. These economies have led the world growth for at least the past two decades and are expected to continue to do so in the next decades as well.The global megatrends mentioned above along with the technological revolution, combined with the information revolution, have made the world a smaller place. People have become more connected with each other. It is changing the way in which people communicate and stimulating the pace of change even more.

The structural change that the world has been undergoing has placed pressure on the bottlenecks – natural resources are dwindling, especially water, energy, agricultural arable land, food, forests.Migration of production to developed countries has wide economic consequences – a decrease in global inflation over the past threedecadesand an increase in global cash surpluses, has led to a drop in interest rates and sowed the seeds of the global debt crisis. This crisis continues to threaten global stability, adding to the pressure on governments due to the need to protect social security and mitigate inequality.All of the above are underpinning the social unrest now spreading globally - in developing and developed economies alike.

All of these trends are influencing competitive environments in all industries, everywhere. Competition is growing fiercer, becoming increasingly concentrated, increasingly global, and differences between "winners" and "losers" are shrinking.All you need to do is overlook one significant change in the competitive landscape to find yourself falling behind – or even out of the game – faster than ever before.The rules of the game are changing, industry after industry. **Companies that were leaders in their field, a great distance ahead of the competition, are finding themselves being left behind and sometimes even involved in a fight for their very survival. New rivals from unexpected places are claiming – and gaining – leadership.And all of this is happening with steadily increasing speed.**

The global food challenge: "If we don't take the necessary measures, famine will be the scandal of this century." (French Minister of Agriculture Bruno Le Maire at the UN food agency crisis talks in July 2011).Growing demand for food (as a result of population growth and rising standard of living, expressed in consumption of more calories per day) has encountered significant bottlenecks in food production (water, availability of agricultural land, increased use of energy crops for energy production). Together with extreme weather conditions that have accompanied the global climate change, they have placed our world at a crucial juncture where current technologies are unable to provide a satisfactory response to food demand, with the immediate result being a continuous increase in prices of agricultural crops and sharply rising food prices in the past three decades. The food crisis is not limited to developing regions. It is a challenge that faces us all.

Agriculture – the next big thing: The imbalance between supply and demand dictates the need for a new vision for world agriculture, a vision that will allow for a quantum leap in agricultural productivity in both developing economies (through rapid realization of existing advanced technologies) and developed economies (through innovation, creativity and investments in research that will lead to development and implementation of new technologies), and increased availability and utilization of agricultural land (including creative solutions for water usage), without damaging the ecological system.The combination of all of the above places world agriculture,one of mankind's most basic occupations, in an unprecedented role.

Changes in the global agrochemical industry: The agrochemical industry is active in the development, production, marketing and distribution of crop protection products and solutions, serving farmers and agriculture professionals worldwide and enabling them to protect crops against disease, pests, fungus and weeds.Thus, this important industry merges with the set of necessary solutions to the global food issue and possesses significant potential arising from global trends in general and trends in the world of agriculture and food in particular.At the same time, in the past two decades several forces have been in play, which possess great influence on the industry’s competitive environment:

- A significant increase in the share of generic products on account of patented products;
- The shift of the center of gravity to emerging economies;
- The rapid development in the agrochemical industry in China;
- The rapid development of the seeds and traits category;
- A significant rise in the costs and duration of developing new chemical molecules;
- The growing stringency and force of regulation and registration requirements;
- Increasing consolidation among customers and distributors

The convergence of these forces has also changed the rules of the game in the global agrochemical industry, and all the phenomena described in the first part of this paper are relevant to this industry as well.Therefore, to fully tap the growth potential inherent in the business, we must look reality in the eye and adapt our business model to a changing industry and to where the industry will be five and ten years down the road.

Makhteshim Agan – creating simplicity in agriculture: Makhteshim Agan is the world's largest company in generic crop protection products (agro-chemistry).The company sells its products in one hundred and twenty countries through some fifty subsidiaries possessing registration capabilities, which are spread throughout major countries worldwide. It has seven product development centers (in Israel, Germany, Switzerland, the US, Brazil, India and Columbia), five synthesis sites and fourteen formulation sites, and one of the most extensive product portfolios in the industry.

The company, which was founded with the goal of solving domestic problems related to the paucity of agricultural resources in the young and developing State of Israel, today exports its know-how, expertise and products all over the world."Creating simplicity in agriculture" in a world that is becoming increasing complex is the mission the company has defined and its driving force, shaping its strategy and underlying its operational activity. The meaning of this promise is to create and deliver to farmers everywhere in the world – from villages growing their own food through to the largest growers – solutions that are accessible, easy to use and practical, enabling them to increase crop yield while improving and protecting it.Solutions of this kind are crucial in order to provide a nutritional response to the growing number of the world's inhabitants. But as is often the case, a simple response is not always a simple thing. Behind user simplicity Makhteshim Agan has placed a broad global array of knowledge and experience, high-level scientific, technological and engineering capabilities, expertise in product registration, adherence to strict environmental protection standards, uncompromising quality control, and global marketing and distribution channels. The company places special emphasis on creating an organizational climate that encourages innovation as an essential tool to cope with global challenges.

“From the future backwards”– the business combination between Makhteshim Agan and ChemChina: In October 2011 ChemChina (among the leading chemical corporations in China), IDB and Makhteshim Agan announced the merger and integration of Makhteshim Agan and ChemChina's agrochemical operations. Realization of the full potential inherent in the integration of these businesses will accelerate the introduction of a new business model that is optimally aligned with the changes in the industry, designed to realize the great opportunities while minimizing risks arising from these changes.

Conserving genetic diversity of natural flora: its relevance to modern farming

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Owing to the rapid increase in global human population, which is combined with the gradual decrease in arable land and shortage of agricultural sources such as water and mineral, the world has faced serious challenges of **food security**. As described in the Declaration in the summary report from the World Summit on Food Security held at the FAO headquarters in Rome, Italy in 2009: "the number of people suffering from hunger and poverty now exceeds 1 billion, and that to feed a world population expected to surpass 9 billion in 2050, agricultural output will have to increase by 70%." (http://www.iisd.ca/ymb/food/wsfs2009/html/ymbvol150num7e.html). This Declaration clearly reflects the great challenge of the world food shortage and future food demand. It is therefore essential to increase the efficiency of agricultural production on the limited arable land by increasing the per-unit area crop yield. To achieve this goal, we need to effectively utilize genetic diversity of crop species and their wild relative species, in addition to the exploitation of new technologies that can be used in agriculture to significant enhance crop production.

Genetic diversity represents one level of **biodiversity** (the variability among living organisms from all sources, CBD) that also includes other elements of **species diversity** and **ecosystem diversity**. Genetic diversity refers to the total number of genetic characteristics in the genetic makeup of a species (Wikipedia). This definition emphasizes that genetic diversity is harbored by individuals and populations of a species. The losses of individuals and populations of a species will lead to the losses of genetic diversity. As important resources, genetic diversity provides essential materials for human livelihoods and for the genetic improvement of crop species. This is because genetic diversity serves as a way for organisms to adapt to changing environments, and many useful genes can be utilized in crop breeding. Plant species that occur in natural flora, particularly those that are related to the cultivated species, are comprised of different level of gene pools. According to the accessibility of genetic diversity harbored by plant species, Haland and De Wet (1971) categorized genetic diversity of germplasm into different gene pools: the **primary gene pool** (GP-I), the **secondary gene pool** (GP-II), and the **tertiary gene pool** (GP-III). Germplasm included in GP-I mainly represents diversity within cultivated species, whereas that included in GP-II and GP-III represents diversity in wild species of natural flora. The long-term availability and effective utilization of genetic diversity in different gene pools will be essential to guarantee the sustainable crop production.

The threat to genetic diversity

Genetic erosion or the losses of genetic diversity in cultivated plant species in agro-ecosystems and their wild relatives in natural ecosystems have posed a serious problem for the sustainable agriculture and crop production (Bellon et al. 1998). The happening of **genetic erosion** is largely due to the factors such as the extensive adoption of high-yielding crop varieties, expansion of farming areas, change of agricultural styles, deforestation, urbanization, industrialization, and disturbances to natural habitats by human activities. In many regions of Asia where development of industry and economy is rapid, many populations of crop wild relative species become extinct or are under threats because their natural habitats are seriously damaged by the extension of farming areas, expansion of communication systems such as road construction, and pressures from urbanization (Lu, 2001). The changes of global climate, air pollution, and the unexpected drought or flood in many areas have also considerably deteriorated the habitats of wild flora. As a consequence, the deterioration and changes of natural habitats have caused the losses or gradual size-decrease in populations of wild species, which has significantly reduced the genetic diversity in different gene pools.

Such a threat to genetic diversity of wild flora can be reflected by the case of common wild rice (*Oryza rufipogon*) that is the ancestor of cultivated rice in China. According to the unpublished data from the Chinese Academy of Sciences (CAS), the Chinese Wild Rice Expedition Team collected *O. rufipogon* germplasm in southern China during 1970s and the Team found many populations. When a team of CSA revisited the same sites where *Oryza rufipogon* populations were collected in 1990s, the team found that nearly 80% of the sites did not have *O. rufipogon* populations, and some of the survived *O. rufipogon* populations were significantly reduced in size (D. Y. Hong personal comm.). Our own field surveys also indicated that many populations of wild wheat and wild soybean species recorded in Chinese Flora and local Floras were no longer existed when our collecting teams revisited these sites (Lu 2001). A similar situation was reported for many other relative species in China, as well as in other countries. This situation indicates that effective conservation of genetic diversity of the wild relative species in natural flora is urgently required.

Strategies for conversing genetic diversity

Given that genetic diversity of natural flora is harbored by populations of plant species, strategic conservation of these populations is essential for maintaining its continued availability and diversity. Commonly, there are two basic approaches for genetic diversity conservation: *ex situ* and *in situ* conservation.

***Ex situ* conservation** requires the actual removal of target genetic resources from their original habitat (Lu, 2001). This conservation strategy has played an essential role in maintaining genetic diversity and effective its utilization in many countries. However, genetic resources conserved under *ex situ* strategy become isolated from their natural habitats. The expected evolution of the genetic resources is discontinued, and therefore, *ex situ* conservation is considered being static in terms of evolution (Bellon et al. 1998), particularly for the genetic resources stored in germplasm bank. Obviously, *ex situ* conservation is not the only strategy for genetic diversity conservation. An alternative strategy, ***in situ* conservation** that emphasizes conserving the genetic integrity by conserving the resources in their original habitats (Lu 2001), becomes an effective complementary approach for genetic diversity conservation. Under the *in situ* condition the evolutionary processes of the conserved species or populations will be continued, and the new inheritable adaptation to the changing environment will be selected during the conservation process. Therefore, *in situ* conservation provides a valuable, long-term, and dynamic strategy for conserving genetic diversity.

However, due to the lack of effective methodology and limited understanding of genetic variation under the *in situ* conservation, this strategy has received less attention. For effective *in situ* conservation of natural genetic diversity, it is necessary and urgent to generate knowledge related to *in situ* conservation activities, including biosystematics, genetic diversity pattern, eco-geographic distribution, population dynamics of targeted species, and interaction between human, plants and the environment in a given eco-system.

Challenge of modern farming for genetic diversity conservation

With the development of modern farming, agricultural production becomes much more effective than the conventional farming. This development not only largely affected genetic diversity in agro-ecosystems by the rapid replacement of traditional crop varieties containing abundant genetic diversity with a few extensively cultivated modern varieties, but also genetic diversity of natural flora through the interaction of human activities and changes of agriculture and natural habitats. One of the neglected influences on genetic diversity of natural flora is the continued introgression of crop genes into wild relative species and its potential causes for the loss or change of diversity.

Following the definition in its broad sense, **introgression** indicates ‘‘the transfer of genes between genetically distinguishable populations” (Rieseberg and Carney 1998). Introgression can take place between populations of wild species that are related (wild-wild). It can also happen between a cultivated species and its close wild relatives (crop-wild). With the expansion of modern farming and commercial cultivation of crops at an extensive scale, introgression of crop genes to different wild relative species is commonly reported (Ellstrand, 1999; Song et al., 2006). Introgression is considered to have a significant influence on genetic diversity (Ellstrand and Schierenbeck, 2000; Stewart et al., 2000), and differentiation of plant populations or species (Ellstrand et al., 1999; Jiang et al., 2012). It is reported that natural introgression of a cultivated species with its populations of wild relatives has played an important role in changing their evolutionary process (Ellstrand et al., 1999). The gradual accumulation of crop-specific alleles through recurrent gene flow and introgression into local populations of a wild relative species may considerably alter the intrinsic genetic composition of these populations and diversity patterns of the wild gene pool (Bartsch et al., 1999; Song et al., 2003, 2006). Such crop-wild introgression may enhance adaptability of a wild population, leading to its rapid expansion (Ellstrand and Schierenbeck, 2000), but also contribute to the extinction of a local wild population because of the swamp effect (Kiang et al., 1979). Either of the circumstances will have strong influences on the conservation of genetic diversity in natural flora.

Therefore, studies should be undertaken to determine the genetic effect of crop-gene introgression into wild relative species, particularly in the regions with extensive modern farming. If there is a strong adverse effect from such introgression, it is necessary to take an effective measure to avoid extensive introgression from cultivated plants. All these together demonstrate the challenge of conserving genetic diversity of wild rice species in under the circumstance of crop-wild introgression.

Transgene introgression and genetic diversity conservation

The rapid development of transgenic biotechnology in modern agriculture has greatly promoted the commercial cultivation of **genetically modified (GM) crops** with novel trails such as those resistant to biotic and abiotic stresses worldwide (James, 2001). The great success in the application of transgenic biotechnology in agriculture has made a tremendous contribution to the world crop production and food security. However, the cultivation of GM crops has accelerated the changes of farming styles, affecting genetic diversity in agro-ecosystems of many countries that have adopted the biotechnology. For example, the application of herbicide resistant GM crops has completely changed the traditional weeding practices and biodiversity of weed species. In addition, the extensive environmental release of GM crops has aroused concerns over **transgene introgression** into wild relative species, which may cause unwanted consequences to genetic diversity in natural flora (Ellstrand, 2003; Lu and Yang, 2009).

Questions have been raised for transgenes introgression from a GM crop into their wild relatives occurring in agro- and natural ecosystems, which may have the undesired impacts on conserving genetic diversity. In the context of *in situ* conservation, if a considerable amount of crop genes including transgenes introgress into wild populations, genetic integrity of the conserved populations will be significantly affected. If transgenes with strong natural selective advantages introgress into wild populations, it will significantly change the genetic composition, evolutionary potential, and invasiveness of wild populations (Ellstrand and Schierenbeck 2000; Lu and Snow, 2005; Lu and Yang, 2009). This will make the conservation of genetic diversity of wild species and populations more difficult. Therefore, understanding the genetic and evolutionary impacts of introgressed crop genes, including transgenes, on genetic diversity of wild relatives is very important, which will facilitate the development of effective strategy for conserving genetic diversity of natural flora in the biotechnology ear of modern farming.

Acknowledgements: This work was supported by the National Basic Research Program of China (Grant No. 2011CB100401).

Strategies for advancing bioherbicides

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Biopesticide technology is emerging as a viable and environmentally-friendly pest management tool in agriculture. The public's demand for safer foods and concern for the environment have encouraged initiatives to develop alternatives to conventional herbicides. These issues are driving the need for a paradigm shift in the manner in which our food supply is managed. Biopesticide use alleviates the heavy dependency on chemical pesticides while meeting the needs of organic and pesticide-free crop production. Management of weed populations that have developed resistance to chemicals can be achieved through the application of bioherbicides that exhibit novel modes of action, thereby mitigating or delaying the development of weeds showing single or multiple resistance to specific chemical herbicides.

Bioherbicides are defined as plant pathogens to weeds, which when applied in an inundative fashion, similar to synthetic herbicides, reduce the competitive ability of the target weed below economic or ecological threshold levels. They are composed primarily of naturally-occurring microorganisms such as fungi and bacteria as the active ingredient which are generally mass-produced through fermentation technology, formulated and applied at high inoculum rates to the weed. They are generally regarded as safe due to their lower human and mammalian toxicity and not expected to survive and persist in the environment. Historically, bioherbicides were often selected as host-specific pest control agents to a particular weed species, but it is currently recognized that broad-spectrum activity against a wide range of weed species is preferred to increase the economic and market potential of the bioherbicide product. Many of our modern bioherbicides are being commercialized for broad-spectrum use.

The early success of bioherbicides such as Collego® and DeVine®, along with a few additional bioherbicide products, created a great deal of interest in their future as a weed management tool. The prototype model for bioherbicides often followed the chemical herbicide industry model, however, their future has come into question because many more potential pathogens have not been commercialized. Critics have pondered whether the prospects for bioherbicides have been exaggerated or whether they can live up to their expectations. A variety of factors that have been attributed to their less than spectacular performance are biological, environmental, technological, and commercial in nature. However, important advances in fermentation and formulation technology and methods for improving efficacy during the past couple of decades have been made. Additional research efforts to understand these factors have provided some answers into addressing how bioherbicides can be used as part of a weed management strategy.

Strategic Framework for Biopesticide Development

The cost and consistency of the microbial organisms with varying environmental conditions, efficient mass production (i.e. fermentation), formulation and delivery systems, and prolonged shelf-life have always been a challenge to the development and commercialization of bioherbicide products. Past experiences have shown extensive complexities within weed/pathogen systems, which affected product development. Research must tackle these complexities with more innovative approaches by addressing biological, environmental, and technological issues to achieve success.

Contrary to popular belief by many government and university researchers that once a microbial organism has been discovered in the laboratory, the final biopesticide product is imminent, a biopesticide product is one where all the platform technologies involved in product development are considered (Figure 1). The taxonomy, biological characterization, mode of action, and efficacy are among the factors that are core to the selection of the biopesticide organism, but the platform technologies including fermentation, formulation, and application/delivery systems are integral to the actual “product” itself. In fact, discovery of a promising organism as the active ingredient is often the easiest part of the battle, but it is the selection and development of the appropriate fermentation system (e.g. liquid/submerged vs. solid-state) for economic scale-up in combination with the most suitable formulation (e.g. liquid/spray application vs. granule/seed treatment/soil application) and the type of application method (e.g. foliar- vs. soil- applied) that determine the biopesticide product and its performance. Indeed, “orphaned” biopesticide technologies have been the result of difficulties in selecting the right fermentation and/or formulation process during the product development phase as these processes will determine whether the product is a go or no-go for industry. These three platform technologies are often inter-related and any minor changes to each of these processes will have impact on each other, thus potentially leading to significant improvements in biopesticide performance in the field.

The Process of BiopesticideDevelopment

Biopesticide discovery and development follows a process of incremental steps that are unique for each target pest-biopesticide system. The Biopesticide Innovation Chain (Figure 2) was a concept developed that depicts several critical stages for developing a biopesticide product using a series of “Go vs No-Go” criteria in order to make decisions on the feasibility of the organism and target weed. This concept is applicable to any type of biopesticide (i.e. bacteria, fungi, viruses, natural product) and is appropriate to any type of crop pest (i.e. weed, invertebrate/insect pest, plant pathogen).

The early stages link discovery to proof-of-concept and platform technology development, as described earlier. Basic assessments of biology, environment, biochemistry, and small-scale fermentation and formulation are conducted under laboratory, greenhouse and field conditions, with emphasis placed on characterization, safety, and practicality of the biopesticide organism. The importance of regulatory and market considerations cannot be underestimated since they will dictate the success or failure for commercialization. These two areas are equally important because they define the field of use and the market will pre-determine the experimentation and scientific data required to register the product.

The later stages in the innovation chain (i.e. application development and technology transfer) test the robustness of the earlier decisions by actively working with various stakeholders involved in biopesticide development. These include the industry partner, other collaborators, and regulators to develop the data required for the registration package. Moving into commercial scale-up can still affect the final stages of product development, often requiring significant investment back into technology development to move from the bench to pilot scale to commercial manufacture. Commercial scale-up, registration, and technology adoption is usually directed by an industry partner, but the champion of the project is usually the lead scientist or inventor who should work collaboratively on the project with industry until technology adoption has occurred. Past experience shows that it can ease the transition phases and add potential new product value.

Summary

Despite the resources that have been dedicated to traditional weed control, particularly chemical herbicides, weeds continue to thrive and adapt in modern agriculture. If we are to build the next generation of bioherbicides, a shift in philosophy of weed management and the role of bioherbicides as part of an Integrated Weed Management (IWM) package is required. Less focus should be on development of stand-alone products but there is a need to focus on weed population management and bring together research teams with diverse expertise that lead to successful integration of biological herbicides as a component of IWM.

This presentation will focus on the strategies necessary for successful development of commercially viable bioherbicide products and will present examples of bioherbicides that are in the pre-commercialization and registration phases.

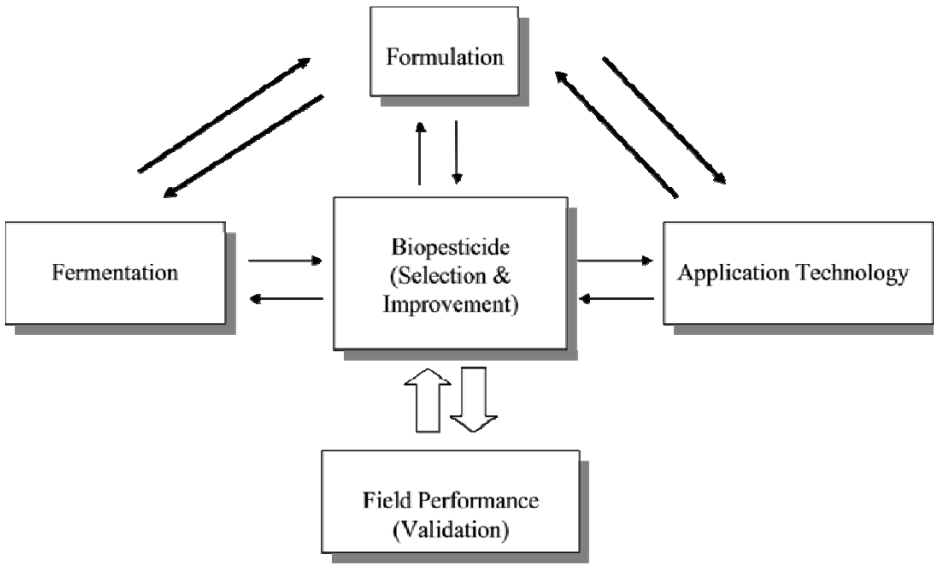

Figure 1. Strategic Framework for Evaluation and Development of Biopesticides

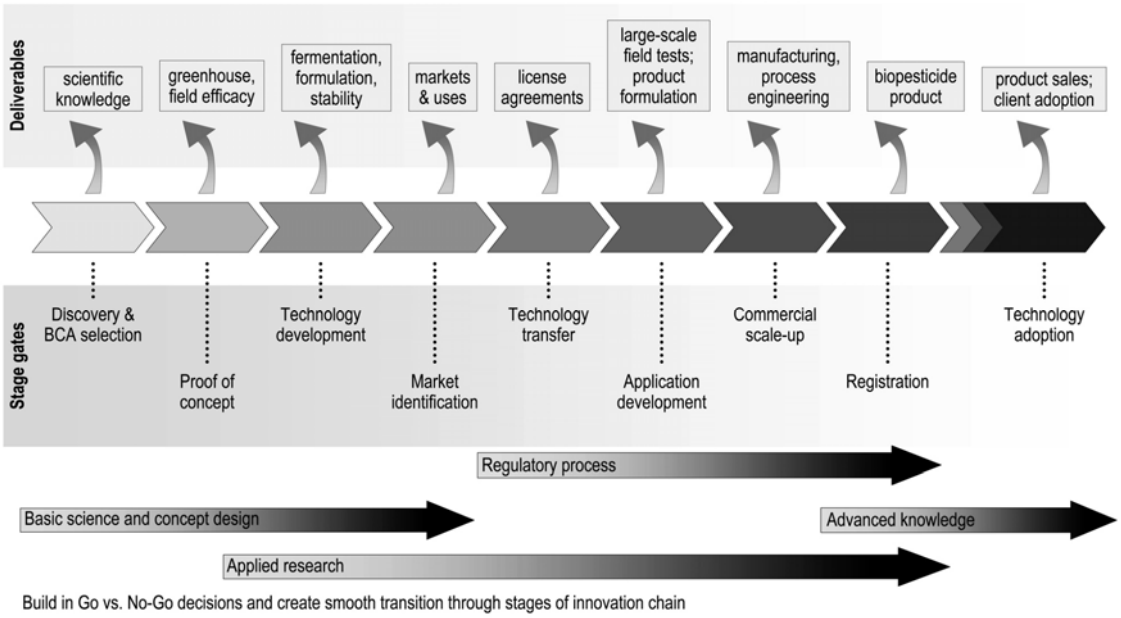

Figure 2.Biopesticide Innovation Chain (from Boyetchko and Svircev, 2009, 2011)

Weeds, seeds, and biotechnology

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Over the next 50 years, agriculture needs to produce more food than has been produced in the past 10,000 years, and needs to produce it in environmentally sustainable ways. To achieve that goal, weed scientists will need to evaluate all weed management technologies with the potential to improve food production including the use of biotechnology to make herbicide-resistant crops. The first genetically modified herbicide-resistant crops, particularly glyphosate-resistant soybeans, corn, cotton, and canola, dramatically improved agricultural productivity and changed how many growers managed weeds. These genetically modified crops were the impetus for a major restructuring of both the seed and pesticide industries.

For the last 16 years, the most effective choice to manage weeds for many growers with has been to use glyphosate in glyphosate-resistant crops. Glyphosate-resistant crops first became available in 1996, at a time when growers greatly needed the technology. Weeds were becoming widely resistant to commonly used selective herbicides and farm size was increasing while the number of farm workers was decreasing. Weed management was becoming too complicated, time consuming, and costly for the new large scale and highly efficient agricultural production systems. The ability to use glyphosate in the crop made weed management easy, efficient, economical, and more environmentally compatible than the systems that they replaced. Growers rapidly adopted glyphosate-resistant crops wherever they became available and made glyphosate-resistant crops the most rapidly adopted technology in the history of agriculture.

The widespread use of glyphosate in glyphosate-resistant crops reduced the investment by industry to discover new herbicides and led to a decline in the use of other herbicides. In just seven years, the number of herbicide actives used on at least 10 percent of the soybean area in the USA declined from 11 to just one, glyphosate. Still, using glyphosate alone in glyphosate-resistant crops worked very well for more than a decade, but weeds eventually did evolve widespread resistance. Today, the rapid rate that weed populations are evolving resistance to glyphosate and other herbicides in conjunction with the lack of any new herbicides with new modes-of-action is threatening the sustainability of current crop production practices. Growers are now being forced to diversify their weed management systems and only use glyphosate in combination with other cultural, mechanical, and herbicide options.

The new paradigm for managing weeds in high production crop systems is creating opportunities for weed scientists to develop new diverse and integrated weed management systems. Any new formulation or application technology that can help growers manage the complexity of diversification will likely be successful. New herbicide-resistant crops will also help by expanding the utility of currently available herbicides and making it easier for growers to apply mixtures, but herbicide-resistant crops will not replace the long-term need to discover new herbicide modes of action. Growers in areas that have not adopted glyphosate-resistant crops yet can learn from the experiences of growers who have and use diverse weed management practices when herbicide-resistant crops are introduced. If used correctly, herbicide-resistant crops with resistance to glyphosate, glufosinate, and other herbicides can reduce selection pressure on any single weed management practice and be an important component of future weed management systems that help sustain currently available weed management technologies until new ones can be developed.

Keywords: biotechnology, crop, weed, herbicide, glyphosate, resistance, tolerance, best management practices

Biology, dynamics and ecology of weeds

Oral presentations

Comparisons of functional traits between introduced weeds and co-occurring natives across China

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Many plant species have been intentionally or accidentally introduced outside their native habitats by humans. A small proportion of them become invasive species, changing species composition, structure, and functioning of invaded ecosystems and causing great economic and biodiversity losses worldwide. The mechanisms underlying biological invasions are still not well elucidated. Higher growth rate has been found for many invasive plants compared with co-occurring natives. Relative growth rate is correlated with net assimilation rate and leaf area ratio. Net assimilation rate is associated with photosynthesis; leaf area ratio depends on specific leaf area and biomass allocation to leaves. Thus, many researchers tested the hypothesis that invasive species have higher photosynthesis and specific leaf area than natives. However, no consistent conclusion is achieved, for which there are many reasons. For example, higher photosynthesis may need higher resource investments in leaves, leading to higher energy expenditure on biomass production (construction cost) and higher respiration loss, and therefore impairing growth. Increased photosynthesis may not result in increased growth if it is achieved by extremely increased energy expenditure. Plants should benefit from high photosynthesis per unit energy investment, i.e. high photosynthetic energy-use efficiency. Thus, we hypothesized that compared with natives invasive plants have higher photosynthetic energy-use efficiency and shorter payback time, the time required for a leaf to amortize construction cost through photosynthesis. However, little effort has been made to test this hypothesis. To explore the traits contributing to invasion success of introduced weeds, we measured leaf nutrient concentration, thickness, density, specific leaf area, photosynthesis, photosynthetic energy-, nitrogen-, phosphorus-, water-use efficiencies, payback time, and leaf decomposition rates in more than 150 invasive and native herbaceous plants in six provinces across China. During the conference, I will present the results on behalf of my collaborators, Ting-Fa Dong, Shu-Mei Jiang, Guo-Hua Ding, Zhi-Dong Xu, Bo Qu, Zhan-Gen Lu, Dong-Ping Dong, Jing-Gang Zheng, Wen-Guo Wang.
Keywords: invasiveness;leaf nutrient concentrations;photosynthesis;resource-use efficiency;specific leaf area;

Mapping of European Weeds: Objectives, achievements and future activities of the EWRS – Working Group

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The mission of the EWRS Weed Mapping WG is: i) to provide an overview on the occurrence and spreading of weeds in Europe and other continents and ii) to exchange data, tools and methods for the assessment, spatial documentation of species and biotypes on arable and non-crop land. The major tasks of the WG are: i) to compare and combine data from weed surveys in physical maps, ii) to document population dynamics and regional weed changes, iii) to derive predictions for weed problems in selected areas and on selected sites, iv) to communicate developments in defined segments and compare them with developments outside the EU and v) to find common and most efficient rules and tools for the assessment and documentation of data. A communication network has been established with regional coordinators from the following groups of countries; [Scandinavia and Baltic States], [Spain, Portugal, France and Italy], [Poland, Belarus and Ukraine], [Czech Republic, Slovenia, Slovakia and Austria],[Israel, Turkey, Jordan, Egypt and Greece], [Germany, Benelux, Great Britain, Switzerland],[Hungary, Romania] and [Serbia, Croatia, Bosnia, Montenegro, Bulgaria] According to our WG protocols the weeds are prioritized according to their frequency and maintaining of biodiversity in major crops grown in each country. In particular, the three most frequent grass species and dicot species will be mapped while, the invasive weeds (3 major grass and dicot species) will be also included in a separate list. Furthermore, the six most endangered weed species will also be mapped. The first achievements are outlined as follows: i) draft maps of most common weeds in cereals, corn and oilseed rape were derived from national surveys, ii) a server was established at the University of Hohenheim and a new software for mapping weeds (WeedMap) is being developed, iii) the nomination of regional coordinators, iv) the preliminary agreement on software and methodology. Two official workshops have been held, the 1st in Prague (May 13-15th, 2009) and the second in Jokioinen (September 21-23th, 2011). For 2012 or 2013, it is intended to organize the third workshop in Greece. Future topics are the improvement of existing maps and the preparation of global maps, the involvement of new software, and the correlation of weed occurrence and agro-ecological zoning.
Keywords: weed mapping; current status;EWRS -WG;

QTL and haplotype analysis of wild and crop-mimic traits in US weedy rice

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Weeds retained wild traits and also developed crop-mimic traits to adapt to human-disturbed environments. This research aimed to identify quantitative trait loci (QTL) associated with the adaptive traits and to determine genomic organization patterns for QTL regions in US weedy rice. A population of 450 F2 plants from the EM93-1 (cultivated line)/US1 (weedy line) cross was evaluated for 6 wild and 8 crop-mimic traits with 35 parameters. A total of 43 QTL was mapped on 17 regions of 9 chromosomes; US1 and EM93-1 contribute effect-increasing alleles to 32 and 11 of the 43 loci, respectively. Of the 17 QTL regions, 14 cluster with 2 to 6 QTL, and 11 contain QTL for both wild and crop-mimic traits. A core collection of 27 US weedy lines and 16 lines of wild rice were determined for haplotype patterns for 14 QTL clusters. The number of haplotypes was significantly (P=0.0004) lower in the weedy (5.8) than in the wild (8.0) lines. The US weedy rice lines were classified into 3 groups based on frequencies of the EM93-1- and US1-like haplotypes. Group I (3 clusters) or II (3 clusters) contains only the US1-like (22-30%) or the EM93-1-like (33-63%) haplotype, and Group III consists of 8 clusters with both EM93-1-like (19-74%) and US1-like (7-41%) haplotypes. This research

demonstrated that genes responsible for weed adaptation tended to inherit as haplotypes from existed weeds, cultivars, or wild relatives, and US weedy rice has a relatively narrowed genetic diversity for the adaptive traits.
Keywords: Quantitative trait locus;haplotype;adaptive traits;crop mimicry;weedy rice;

Biological causes of cornflower regression

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Agroecosystems are currently experiencing high biodiversity loss. This decline results from intensive cropping systems. However, not all the anciently present weeds respond similarly. There should be specific biological traits that render some species more prone to disappear from arable fields than others. Investigating the biological causes of regression could inform about management strategies in changing agricultural farming systems. In this report we focus on cornflower (Centaurea cyanus) that is an emblem of the flora associated with traditional cereals in Europe. It is currently disappearing from Western regions. Several traits were investigated as seed longevity in the soil, establishment capacity and mating system. Special emphasis is given to self-incompatibility and requirement of cross-pollination by insects, which, in conjunction to the decline of the pollinator insects, results in a concurrence of un-adapted biological characteristics. However, some self-compatible individuals could occur and be selected in case of small population size and shortage of pollinators. This “recue” process is at fitness cost due to inbreeding depression, which again could contribute to cornflower regression. The consequences in terms of ecosystemic services provided by such a segetal species are discussed.
Keywords: Life history traits;Mating system;Biodiversity;

Factors affecting seed dormancy in cow cockle (*Saponaria vaccaria.* L)

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Cow cockle (Saponaria vaccaria. L), is an introduced summer annual weed of Northern Great Plains. It is being considered for domestication because of its high quality starch, cyclo-peptides and saponins. The seed exhibits a non-deep physiological seed dormancy and is considered as one of the prime obstacles for cow cockle domestication. The objective of present investigation is to determine the effect of temperature and photoperiod on cow cockle seed dormancy. Fifteen genotypes were germinated under five temperatures (5, 7.5, 10, 15 & 20 oC) with two temperature regimes (Constant & Alternating). This test was conducted both in light and dark. Significant effect of temperature and light on seed dormancy was observed ($P<0.0001$). The variability for seed dormancy among the genotypes ranged from 4 % to 62 %. Mongolia was identified as low or no dormancy genotype. Genotypes, Saskatoon Wild and White Beauty were considered as highly dormant genotypes. Among the mean temperatures, 10 oC was proved to be optimal germination temperature with least dormancy (19 %). Under similar mean temperature, individually, light germination (41%) and fluctuating regime (42 %) were more effective in breaking seed dormancy. However, at 10 and 15 oC light interacts with constant regime and at remaining temperatures dark interacts with alternating regime to reduce the seed dormancy in cow cockle. Temperature regime and photoperiod has little or no effect of seed dormancy under optimal germination temperatures.
Keywords: Summer Annual;Domestication;Seed Dormancy;Temperature Regime;Photoperiod;

Evolutionary divergence of seed dormancy in US weedy red rice

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Weedy red rice is the most difficult-to-control weed in rice production. Many ecotypes have deep seed dormancy; thus, primarily contributing to its persistence. Understanding the genetic controls of dormancy could help find means to circumvent this weedy trait for better red rice management. This study aimed to determine the population variation in red rice seed dormancy at different incubation temperatures and after-ripening time, and to evaluate the genetic diversity of dormancy-linked loci of selected Arkansas red rice populations. The germination behavior of red rice was evaluated at incubation temperatures of 1, 15, and 35°C and after-ripening periods of 0, 30, 60, and 90 d in two independent experiments. Incubation at 1°C followed by 30°C most effectively released dormancy. After-ripening for 30 d reduced dormancy drastically. Blackhull red rice populations were more dormant and showed higher inter- and intrapopulation variation in dormancy than strawhull populations. To evaluate the genetic diversity of dormancy loci, 13 simple sequence repeat markers distributed across 4 chromosomes were used. Dormant blackhull, dormant strawhull, non-dormant blackhull, and non-dormant strawhull populations were included. Overall Nei’s genetic diversity (GD) of these dormancy-linked loci was high (GD=0.66), indicating high genetic variation among the accessions in these dormancy-related alleles. High GD was found among and within populations, indicating significant diversification of this weedy trait. Overall, blackhull had higher GD (0.56) than strawhull populations (0.50). Red rice populations differ greatly in their potential to persist. A mixture of different dormancy ecotypes in one field portends an extended germination period of weedy rice especially in tropical regions.
Keywords: genetic diversity;germination;oryza sativa;Simple sequence repeat SSR;blackhull;

Effects of excessive soil moisture on seed viablity, seed dormancy, and seedling emergence in upland weeds

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The soil moisture content of Japanese soybean fields is often excessive because many soybean fields are used in rice paddy–upland rotation systems and they are submerged during the rice growing rotations. Thus, Japanese upland weed seeds are subjected to both excessive soil moisture and submerged conditions. Soil moisture is one of the main environmental factors affecting seed viability, seed dormancy, and seedling emergence. However, the effects of excessive soil moisture conditions on upland weeds are not well documented. In this study, we evaluated the effects of excessive soil moisture and submerged conditions on 12 upland weed species. Seed viability and dormancy were determined using buried and non-buried seeds retrieved from moist soils (groundwater level 10 cm below the soil surface), submerged soils (covered with 7.5 cm of water), and control (upland) soils in April, May, June, and July. Seedling emergence was evaluated in moist soils from April to November. These experiments were conducted in 2010 and 2011. The moist and/or submerged conditions reduced the viability of non-buried seeds in 6 weed species, including Echinochloa crus-galli and Solanum nigrescens. However, neither the moist nor the submerged conditions reduced the viability of any of the buried weed seeds.
Keywords: dormancy;seedling emergence;germination;soil moisture;upland weed;

Soil-buried seed dormancy and longevity in weeds: from examples to generalization

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The main part of the life-cycle of weeds, especially in cultivated fields, is spent as seeds buried in the soil. Longevity and dormancy are two major traits driving weed survival and infestation in the framework of crop rotation and management. Modelling allows inference of these key processes from morpho-anatomical description of the seeds, thus avoiding long-term germination studies of buried seeds over the years. Two new sets of experimental data on two different weeds offer the opportunity to compare actual results to predicted values. This study deals with cornflower (Centaurea cyanus), a winter weed of cereals and oilseed rape in regression in Western Europe, and wild radish (Raphanus raphanistrum), a spring-emerging weed in oilseed rape and cereals abundant in acidic soil. Cornflower has naked seeds while wild radish seeds are protected from water and oxygen access and fungal and bacterial attacks within pod segments. In addition, we used small and large-seeded populations of wild radish in order to increase morphological variation. Seeds were buried in the soil 30 cm below surface, and a fraction was excavated every month for three years, and then tested for survival and dormancy. Survival of cornflower seeds declined quickly after two years while no mortality was observed for wild radish. The prediction of longevity in terms of seed coat thickness fitted the expected range of values. Both species displayed seasonal dormancy, the peak of germination being delayed by two months for wild radish versus cornflower. Consequences on life-cycle and infestation potential are discussed as well as the efficiency of interpolating traits values from other species.
Keywords: Seed;Longevity;Dormancy;Modelling;

The soil seed bank of Mikania micrantha in contrasting environments in Viti Levu, Fiji

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Mikania micrantha Kunth. is one of the top ten worst invasive plant species in the world. It is a highly reproductive weed species, but little is known about its soil seed bank. A study on the size of M. micrantha soil seed bank was undertaken in the high and moderate rainfall regions of Viti Levu Fiji in 2009 and in 2010. The results demonstrate M. micrantha soil seed banks to be small representing <1% of the entire soil seed bank in both regions. Laboratory studies indicated that M. micrantha seed had a field longevity potential of between 1 to 3 years. There was a low species richness in the seed banks of the two study regions and a dominance of other weeds such as Ludwigia spp. However, there was a greater species richness in sites without M. micrantha as compared to those sites with high densities of M. micrantha. All plant species identified in the two study sites were introduced. This study suggests that M. micrantha may not need a large soil seed bank for sustaining populations in these regions of Fiji and that it depends more on its vegetative reproductive potential to sustain its populations. In addition, the monoculture stand and the allelopathic effect of M. micrantha may have contributed to the low species richness and diversity at the sites with a heavy density of the weed.
Keywords: Mikania micrantha;soil seed bank;rainfall;Viti Levu Fiji;species richness;

The resource pool diversity hypothesis: genesis, insights, and future directions

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The Resource Pool Diversity Hypothesis (RPDH) was proposed to explain how crop plant diversity may mediate competition for soil resources between weeds and crops. The primary tenets of the RPDH are that (1) in plant communities, the intensity of inter-specific competition can depend upon the degree to which niche differentiation and resource partitioning occur among species; (2) agricultural management practices, such as crop rotation, cover cropping, manure application, and weed management, result biological inputs to the soil; and (3) these biological inputs to the soil directly or indirectly become resource pools from which crops and weeds may partition nutrients. The RPDH leads to the prediction that along a gradient of increasing cropping system diversity, yield loss due to weed-crop competition for soil resources should decrease. Recent research conducted in a variety of ecosystems

supports the main tenets of the RPDH; however, direct tests of the hypothesis are lacking. Research aimed at quantifying soil resource pool diversity under different agricultural management systems and determining the extent to which crops and weeds differentially uptake organic and inorganic pools of key soil nutrients will be necessary to validate the RPDH. Validation of the RPDH would have important implications across a broad range of cropping systems for the development of management strategies that aim to reduce crop yield loss to weeds or competition between coexisting crop species grown as intercrops.
Keywords: Competition;Diversity;Ecology;Niche;Soil communities;

Competitive interactions between weedy rice and cultivated rice for N, P, and K fertilizers

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Weedy rice has become a serious threat to quality and quantity of rice production in Sri Lanka. A pot experiment was conducted to investigate the impact of weedy rice competition on cultivated rice for N, P, and K fertilizers in a screenhouse at the Rice Research and Development Institute (RRDI), Batalagoda. A two-factor factorial experiment, with sixteen treatments in three replicates, was established in a completely randomized design. Two cultivated rice varieties (Bg 352 and Bg 358) and two weedy rice biotypes (Kurunegala and Matara) were evaluated for growth, yield component, yield, and relative recovery efficiencies of N, P, and K fertilizers. The results showed that irrespective of fertilizer application, competition with weedy rice resulted in significant reductions in tiller number, leaf chlorophyll content, flag leaf area, and total biomass of cultivated rice. The number of panicles per plant, filled grain percentage, and 1,000-grain weight of cultivated rice were significantly decreased due to competition with weedy rice under fertilized and nonfertilized situations. In the cultivated rice, the relative recovery efficiencies were decreased by 23% to 15% and 12% for N, 50% to 37% and 25% for P, and 64% to 25% and 25% for K due to competition with Kurunegala and Matara weedy rice biotypes, respectively. Competition with weedy rice for fertilizers reduced yield by 45% in Bg 352 and by 60% in Bg 358.
Keywords: Weedy rice;fertilizer;efficiency;

Maize-Weed competition for soil resources

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Weeds compete with crops for light, soil water and nutrients. Nitrogen (N) is the primary limiting soil nutrient. Forecasting the effects of N and soil water on growth, development, and interplant competition requires accurate prediction of N and water uptake and distribution within plants. Several years of research has been conducted at the University of Nebraska to determine the effects of variable N and water addition on maize and velvetleaf growth, N and water uptake, N distribution within these species, and on maize-velvetleaf interference relationships. Maize and velvetleaf N uptake was accurately predicted using the N concentration – biomass relationship to forecast N demand. Velvetleaf was found to modify its partitioning of new growth to roots versus shoots more than maize when N was limiting. Since velvetleaf shoot growth responds more to N addition than maize, yield loss due to velvetleaf interference may increase with increasing N supply when relative time of emergence is similar. Water use efficiency of maize was up to 30% greater for maize than velvetleaf, and maize closed its stomates at lower soil water content than velvetleaf. Velvetleaf had greater impact on maize yield under conditions of limited water supply, indicating that crop tolerance to velvetleaf interference is greatest when there is sufficient soil water available to supply the full water demand of the maize crop. Our long-term goal is to use quantitative information on resource uptake and utilization in ecophysiological models of interplant competition to predict the outcome of crop-weed interactions as influenced by resources in a changing climate.
Keywords: interplant competition;modeling;interference;

Harvest loss in Canola and the problem of volunteer weeds in Western Canada

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Seed shatter in canola leads to a considerable yield loss and the dispersal of canola seeds into the soil seedbank. The volunteer plants can then create weed problem in the subsequent crops and result in crop yield loss. In 2010 and 2011 a total of 66 canola fields were sampled in western Canada using Vacuum cleaner. Both swathed and straight cut fields were sampled within 3 weeks of harvest to measure canola seedbank addition in producers' fields. Germinated seeds were counted and included in the total seed loss. After separating the seeds from crop residue and soil, the weight of pure seed was measured to calculate the amount of seed loss per unit area. Data concerning agronomic and harvest specific information were collected for each field using short survey questionnaires. The average seed loss was found to be 190 kg ha-1 which is equivalent to 7.6 % of the total yield and resulted in seedbank addition of approximately 5980 viable seeds per m2. This loss is higher than the previously reported loss of 107 kg ha-1 or 5.9 % of the total yield and seedbank addition of 3000 viable seeds per m2. Seed loss among producers ranged from 4.3 to 9 % of the total yield and resulted in seedbank addition which is many times more than the normal seeding rate of canola. These seeds can persist in the soil seedbank resulting in volunteer weeds many years after the last canola crop. There was no significant difference in seed loss between swathed and straight cut fields. Seed loss was found to correlate with total yield and variety. The increase in seed loss this time is attributed to the increase in yield of the current canola genotypes.
Keywords: Volunteer canola;Seed loss;Seedbank addition;Swathed;Straight cut;

Contrasting the above and belowground responses of the invertebrate community to the presence of Impatiens glandulifera.

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Vegetation structure and above and belowground invertebrate communities are intrinsically linked, though few studies have assessed the impact of non-native plants on all levels. The dynamics of the vegetation structure and invertebrate community composition were evaluated in relation to the abundance of Impatiens glandulifera (Balsaminaceae), an invasive weed in the UK. The above and belowground invertebrate community composition was assessed at nine invaded and nine uninvaded sites using aerial and ground suction sampling, combined with soil cores every four weeks during the summer of 2007 and 2008. The percentage cover of all plant species was assessed each year. Over 130,000 invertebrates were identified and subdivided into 22 Orders and Suborders. The plant community was significantly different in invaded sites and this coincided with shifts in the invertebrate community structure. The abundance of aboveground detritivores, herbivores, and predators was significantly lower in the invaded sites compared to the uninvaded sites. By contrast, the belowground community showed significant within and between year fluctuations where detritivore abundance was higher in the peak summer months in the invaded sites compared to the uninvaded sites. However, the overall abundance of all belowground invertebrate groups showed no significant difference. The results suggest that the presence of I. glandulifera results in shifts in the overall invertebrate community structure, which differs between the above and belowground habitats. These shifts can potentially lead to fragmented, destabilised ecosystems, which could have serious consequences for ecosystem processes and functioning, which may lead to complications for habitat restoration unless remedial actions are implemented.
Keywords: Impatiens glandulifera;impact ;invertebrate community;above ground;below ground;

Allometry and growth patterns of Scirpus grossus L. on paddy and peat soils

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Scirpus grossus is a principal rhizomatous weed in Malaysian rice fields. This study describes the modular dynamics, spatio-temporal growth patterns of aerial plant and sub-terranean rhizome populations of this scourge on fertilized and unfertilized peat and paddy soils. The NPK fertilizer application at 100:30:30 ha-1 resulted in more robust aerial plant growth generating 253.5 ramets m-2 compared with 235.6 ramets m-2 in unfertilized peat soils, 24 weeks after planting of the mother plant. The parallel figures for plants growing on paddy soils of the Jawa series were 97.08 ramets m-1 in fertilized paddy soils and 83.7 ramets m-1 in unfertilized paddy soils. Mean ramets mortality was significantly higher in unfertilized than fertilized peat soils resulting in respective net populations of 218.8 ramets m -2 and 114.3 ramets m -2 in fertilized and unfertilized soils. In paddy soils the respective resultant net populations were 91.4m-2 and 75.1 ramets m-2 .Flowering set in earlier among ramets in fertilized peat and paddy soils with 103.2 and 49.6 flowering ramets m-2, respectively vis-a-vis 77.5 and 47.8 flowering ramets m-2, 24 weeks after transplanting of the mother plant in unfertilized soils. Fertilizer applications to either peat or paddy soils did not register any significant difference in mean plant height, chlorophyll contents, and chlorophyll fluorescence measurements vis-a-vis those plants devoid of fertilizer application. The time- and space-mediated clonal growth of S. grossus did not register any significant preferential directionality and dispersion of aerial plants and their sub-terranean rhizomes irrespective of fertilizer application or soil types, but rather displaying opportunistic resource capture by aerial and sub-terranean modules.
Keywords: Scirpus grossus;clonal growth ;allometry;soils;

Detecing predation by slugs on dandelion (Taraxacum officinale) seedlings ?methods and spatiotemporal trends

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Dandelion is a common Asteraceae species populating disturbed sites and patches within swards where it becomes an important competitor of grass. Natural control against dandelion includes seedling predation where most important factors are the slugs Arion lusitanicus. Since estimating mortality in naturally established seedlings is difficult we exposed laboratory grown seedlings as baits for slug predation. This method demonstrated how local and temporal variation in seedling survival, expressed as estimated-times-to-death and proportion of survived seedlings, is well correlated with slug feeding activity. Its advantage is that seedlings in baits may be placed at any place and time required by experiment. However, estimated time to seedling death was shorter in bait exposed than naturally established seedlings. Supported by GACR 526/09/1436.
Keywords: Asteraceae;Arion lusitanicus;estimated time to death;bait;consumption;

Merremia boisiana (Gagnep.) Oostr. in South China: an overview

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Merremia boisiana (Gagnep.) Oostr., a perennial evergreen woody vine to tropical and subtropical Asia, has become an invasive species in Hainan and Guangdong provinces of China during the recent two decades. It has caused significant negative impacts to many secondary forests, open woodlands, and shrub lands. In severely infested forests, the weed can cover the whole habitat, reaching an area of 300 hectares and smothering native trees underneath. Because of its rigorous, fast and rampant growth habit, and also the expansion of its geographical range, it has been called 'forest killer' and has received much attention by scientists and the public in the recent years. The photosynthetic rate of the vine is higher than co-ocurring plants. It grows all over the year, with the fastest growth between May to September, during which it has the potential to grow 10 cm long a day. Also, many new twigs emerge that can reach a length of 8 – 10 m and a diameter of 1 cm in that year. After several years later, the vine can form a blanket that covers the whole habitat from a single individual. Growth and photosynthesis of the vine is positively correlated with temperature. The vine also has high allelopathic effects on other plants. Herbicides of glyphosate, velpar, sulfometuron methyl, and benzoate aqueous solution were proposed to control the vine. But despite their short-term efficiency, the vine can re-emerge and cover the whole habitats several years later after application of the herbicides. Mechanical removal was also proposed to control the vine, but it is difficult to do such manual removal in dense *M. boisiana* habitats. Future research should address what caused its rapid explosion, and design integrated control methods to protect forests and environment.
Keywords: expand, global change, impacts, invasive, vine

Perennial weeds: Phenology and Biomass development

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Achieving an effective control of perennial weed species in the Netherlands is becoming increasingly problematic, especially with the decreasing number of chemical control options. The development of alternative, non-chemical control options is therefore increasingly important. The development of these control options do however require a different insight in and knowledge on the biology of these species. Insight in the species life cycle under common Dutch conditions is currently unavailable and required. A three year lasting experiment was started in 2009 on two fields in which the following perennial species were planted: Sonchus arvensis Cirsium arvense, Rorippa sylvestris, Mentha arvensis, Convolvulus sepium, Rumex obtusifolius, Equisetum arvense, Elymus repens, Stachys palustris, Tussilago farfara and Persicaria amphibia. The extended BBCH scale was used to observe weed development on a weekly basis. For each of the plant species sixteen destructive measurements were taken every month during the growing season in 2009 and 2010: dry weight measurements of stems, roots, leaves and flowers and/or seeds. Total root length and number of sprouts per root were determined from April to July.Stem emergence was calculated as a fraction of the total number of stems that emerged per species. Stem emergence, and the moment the onset of a phenological stage was reached (e.g. eight leaf stage, flowering, vegetative reproduction, senescence) was plotted vs. heat sums. Dry matter growth of above-ground, below-ground, stem, leaf and inflorescence dry weight were log-transformed to overcome unequal variances and were plotted versus the heat sum. Both the onset of important phenological stages and the development of biomass could be related to heat sums and each other.
Keywords: phenology;dry matter;perennials;root;field experiment;

Poster presentations

Weed flora and seedbanks in arable fields in the moist savanna zone of Nigeria

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A weed survey was undertaken of arable fields in the moist savanna zone of Nigeria to assess the weed composition and seedbank and to identify weeds of agricultural importance in the zone. The survey covered three locations in the derived savanna (DS) [Agwu 6o 04′ N, 7o 28′ E; Ankpa 7o 25′ N, 7o 38 E; Oji River 6o 17′ N, 7o 07′ E], two locations in the southern Guinea savanna (SGS) [Lafia 8o 35′ N, 8o 37′ E; Makurdi 7o 35′ N, 8o 32′ E], and another two locations in the northern Guinea savanna (NGS) [Bauchi 10o 01′ N, 9o 45′ E, Zaria 9o 04′ N, 7o 40′ E]. A total of twenty cropped fields were sampled in each location. Weed density varied significantly with location and agro-ecological zone. Agwu had the highest weed density while the lowest weed density was recorded in Makurdi. Overall, total weed density was significantly higher in the DS than in the SGS and NGS, the reverse was true of the weed seedbank. Bauchi had the highest weed seedbank. Ageratum conyzoides, Aspilia africana, Chromolaena odorata, Tridax procumbens, and Lindernia spp. dominated the soil seedbank in the DS. Grasses were more abundant in the soil seedbank of SGS and NGS. Weed species composition and diversity differed with agro-ecological zone. The Poaceae, Asteraceae, Cyperaceae and Rubiaceae families were wide spread in the three agro-ecological zones. The following species were more important in the DS: Imperata cylindrica, Chromolaena odorata, Crotalaria retusa, Cyclocarpa stellaris, Pennisetum polystachion, Plastostoma africanum, Solenosstemon monostachyus and Vicoa spp. The SGS was dominated by Hyperrhenia spp., Erigrostis glomeratum, Panicum pansum, Sebastriana chamaela, Tephrosia pedicellata and Tephrosia spp., while Acalypha spp., Alysicarpus glumaceus, Andropogon pseudaprius, Ethulia conyzoides, Microchloa indica, Nelsonia canesiens, Pennisetum pedicellata and Zornia glochidiata were closely associated with NGS.
Keywords: Weed density ;Seedbank;Savanna;

Relationships of rice yield components by rice- *E. crus-galli* and rice-*E. kuroguwai* competition under transplanted rice cultivation

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Field experiments were conducted to investigate relationships of rice yield components by rice - *Echinochloa crus-galli* and rice - Eleocharis kuroguwai competition under transplanted rice cultivation in 4 major rice production areas, Suwon, Daejeon, Iksan and Naju in Korea. Correlation and linear regression analyses were also conducted to investigate the effects of weed interference on rice yield components measured in all the sites. All the components such as number of spikes, number of grains, maturity and 1,000-grain weight were all negatively affected by E. crus-galli and E. kuroguwai. Among the components, number of spikes was most negatively affected by both weed species, followed by % maturity, 1,000-grain weight and number of grains. The reason why the number of spikes was most negatively affected may be because that it had been affected from the early stage of rice-weed competition, while the other components was affected at a later stage of rice-weed competition after heading stages. Linear regression analyses to relate weed density and rice yield components showed that rice yield components were more negatively affected by E. crus-galli than E. kuroguwai. When compared reduction rate of yield components with increasing weed density, 1,000-grain weight was about 3.2 times more rapidly reduced by E. crus-galli interference than E. kuroguwai. Number of grains, number of spikes and maturity were also more rapidly reduced by *E. crus-galli* than E. kuroguwai with differences of 1.8, 1.7 and 1.5 times, respectively, between them. Therefore, in spite of regional variation, it can be conclude that E. crus-galli is more competitive than E. kuroguwai under transplanted rice cultivation. Our study showed that early competition of both weed species with rice significan
Keywords: competition;*Echinochloa crus-galli*;Eleocharis kuroguwai;rice;yield components;

Effect of burial depth, soil texture and moisture content on common lambsquarters (*Chenopodium album*) and redroot pigweed (*Amaranthus retroflexus*) emergence

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In order to study the effect of soil texture, soil moisture and depth of seed burial on emergence percentage and rate of commom lambsquarters and redroot pigweed, two separate factorial experiments were conducted based on RCBD with three replications at Birjand University. Experimental treatments were burial depth with 5 levels including 0, 0.5, 1, 2 and 3 cm, soil moisture with 3 levels including 20% FC, 60% FC and 100% FC, and soil texture with two levels including a loamy and a sandy soil. Common lambsquarters seedlings under moisture content of 20% FC only emerged from 0.5 and 1 cm burial depths. In contrast, seeds buried at all depths emerged when provided with 60% and 100% FC, and in all of them the greatest emergence percentage was observed in the loamy texture. The greatest emergence rate was observed in loamy soil and 100% FC. In redroot pigweed, no emergence was observed for all combinations of soil texture and burial depth treatments at 20% FC. The greatest emergence percentage and rate of redroot pigweed occurred in loamy soil at 100% FC. Increasing the burial depth from 1 to 2 and 3 cm decreased the emergence percentage from 74 to 60 and 56%, respectively. At all burial depths and moisture levels, the greatest emergence percentage and rate occurred at loamy soil and there was often a significant difference.
Keywords: soil texture;weed emergence;emergence rate;fatal germination;cultivation;

The cultivation indoor of Copperleaf (*Acalypha australis* L.) as a new bioassay target weed of compounds herbicidal activity and effects

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Copperleaf (Acalypha australis L.), a common weed in Northern China, is difficult to control and makes a great loss of agricultural production in recent years. Moreover, the Copperleaf has showed a trend of more and more crazy. To control the Copperleaf effetely and minimize the loss made by the copperleaf, the biological characteristics of Copperleaf seeds and the patterns of its growth and development were under research. The results indicated that the suitable temperature for the copperleaf seeds germination is 25-30℃ and the suitable soil water condition is about 80% of the maximum water capacity of the soil. The copperleaf can live from spring to autumn in warm and humid climate. The weak alkaline is the best soil condition for the copperleaf living. The appropriate thickness of covering soil in planting is 1-1.5 cm and the ratio of seedling emergence is decreased significantly when the thickness is more than 2 cm. Under the suitable growth condition, the copperleaf can seedling emergence from the seeds at about 7-14 days after planting. Summarily, the copperleaf can be cultivated and breeding indoor in large-scale and continuously, which can be benefit to the study in future. Meanwhile, the study on chemical control of copperleaf indoor was also carried out, which showed that the novel herbicidal compound SYP-18601 developed by Shenyang Research Institute of Chemical Industry, could control the copperleaf before the living stage of forth leaves, with a dose of 24 g a.i./ha.
Keywords: Copperleaf; biological characteristics; cultivated and breeding indoor; chemical control;

Methods for determination of the impact of weeds in annual crops

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The crop yield are severely affected by the weeds. A research program was established by four Universities (UFRGS- UTFPR-UFSM- IPBeja) to determine the intensity of weed impact on several crops. The objective of this work was to evaluate two methods of determining the impact of weed species on crop productivity. The weed species and the location of the experiments were: Urochloa plantaginea (Link) R. D. Webster, in Eldorado do Sul, Brazil (BR); Digitaria horizontalis Willd., in Frederico Westfalen, BR; and Euphorbia heterophylla L., in Pato Branco, BR, Solanum americanum Mill., in Beja, Portugal. The first three weed species were evaluated in competition with the common bean (Phaseolus vulgaris L.) crop, and the last species was evaluated in the tomato (Solanum lycopersicum L.) crop. The classical additive experiment was used, i.e., from the emergence of the crop plants, different densities of each weed were established. Crop management decisions followed the procedures adopted by the farmers of each region, targeting very high yield productivity. By the end of the season, the crop yield was harvested and its reduction due to weeds was determined. Two methods to determine the impact of weeds were compared: the classical rectangular hyperbole curve and the linear curve. In the first case, all data was used to attain the "i" parameter; whereas in the second case only the first linear portion was used to attain the "b" parameter from the weed density-yield data. In several experiments the "i" parameter was numerically superior to the "b" parameter, suggesting a super-estimation of the impact of each weed on the crop. Nevertheless, each weed had a huge impact on the crop yield, ranging from 1% to 19% of productivity reduction.
Keywords: retangular hyperbola;linear equation;common bean;tomato;

An artificial neural network approach for modelling weed emergence dynamics: the case of *Avena fatua* L.

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Weed emergence predictive models are essential tools for the implementation of more efficient and sustainable control tactics in agricultural systems. Avena fatua is worldwide distributed noxious weed which produces severe yield losses in cereal crops. In the semiarid temperate region of Argentina, A. fatua emergence patterns show great variability between years mainly due to a highly unpredictable precipitation regime and a fluctuating thermal environment. Artificial neural networks (ANN) models are known for their capacity to describe highly non-linear relationships among variables thus showing a high potential applicability in ecological systems. The objectives of the present work were to: (i) develop different ANN model architectures based on ecophysiological indexes; (ii) compare ANN predictive accuracy with traditional non-linear regression models. A multilayer perceptron structure with three layers (input, hidden and output layer) and a Bayesian Regularization Backpropagation algorithm were used. Input variables for model development were: hydrothermal-time (θHT) and the combination of thermal-time (θT) and hydro-time (θH) as independent variables. The accumulated proportion of seedling emergence was the output variable. A total of 528 input/output data pairs corresponding to 11 years of data collection were divided into training (82%) and test (18%) subsets. Traditional non-linear regression (NLR) sigmoid shape models were evaluated (Weibull, logistic, general logistic). ANN and NLR models based on θHT showed similar goodness of fit (RMSEtrain = 0.214; r = 0.84) and predictive capability (RMSEtest = 0.177; r = 0.92), irrespective of the number of model parameters. Conversely, an ANN model with θT and θH as input variables and 30 effective parameters gave the best prediction of emergence data (RMSEtest = 0.078; r = 0.98) showing a satisfactory generalization capacity. These results indicate an advantage of ANN models over NLR methods further suggesting its potential applicability in weed management decision support systems.
Keywords: artificial neural networks;multilayer perceptron;weed emergence;predictive model;Avena fatua;

Dynamic study of the *Flaveria bidentis* soil seed bank

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The study of soil seed bank in wasteland and riverbank which was invaded by Flaveria bidentis for several years shows that: 20 species of plant were fond in the soil seed bank, after the invasion of Flaveria bidentis, the quantity of Flaveria bidentis seed is up to 13947/㎡ and 12527/㎡ in two sample plots, the proportion of the total seed bank is 96.32% and 88.05%, turn into the dominant community; for the vertical distribution, the number of seeds in two plots took on a decreasing trend with soil depth increasing, 70% and 60% seeds in two plots are mainly concentrated in the 0-2cm soil layer; the change of the seed bank in the seasonal dynamics is that, the number of Flaveria bidentis seed bank is reducing in both of the samples.
Keywords: Flaveria bidentis;soil seed bank;dynamic change;

A phylogeny of the Korean Echinochloa taxa derived from nuclear DNA internal transcribed spacer region sequence data

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Echinochloa, a difficult genus, is one of the most problematic weeds in paddy field of Korea. There are seven taxa identified and one taxon might be added in Korea. A phylogenetic relationship among 17 Korean accessions belonging to eight taxa of the genus was inferred from nuclear ribosomal DNA internal transcribed spacer region sequence variation. Setaria viridis was used as outgroup. Phylogeny estimated using parsimony methods revealed that the Echinochloa is monophyletic. Echinochloa is composed of four main clades which are E. glabrescens, E. colona, E. crus-galli comples, i.e., var. crus-galli, var. praticola, and var. echinata, E. esculenta and E. oryzoides, and E. spp clades. The largest clade is consisted of morphologically different species. However, this is also supported by Yamaguchi et al. Pairwise sequence divergence values ranged from 0.00 among E. crus-galli complex, E. esculenta, and E. oryzicola to 0.761% between E. glabrescens and E. colona across all accessions. Ecotypes of each taxon were homogeneous. Phylogenies based on neighbor-joining method gave similar topology to that based on maximum parsimony. These results should be further studied vigorously with more markers to confirm relationships among the Echinochloa.
Keywords: Echinochloa;phylogeny;ITS;Korea;taxa;

Effect of soybean crop on the processes that ensure the success of *Digitaria sanguinalis* to maintain its population on a field

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Digitaria sanguinalis (L.) Scop. (large crabgrass) is a summer annual weed that has increased its constancy since the adoption of no tillage system in the summer crops of the Argentinean Rolling Pampas. This success over time and space may possibly be related to control avoidance by establishing seedlings at different moments during the crop cycle. Weed establishment depends on seed dormancy, germination and seedling emergency. All these processes are modulated by pre dispersal factors occurring during seed growth and development and post dispersal factors affecting seed bank environment. The objectives of this work were to study i) the modifications of the environment produced by different soybean crop arrangements and its effect on weed plant biomass, seed production and dormancy and ii) the effect of soybean crop competition and different soil covers on weed establishment. For the first objective a manipulative factorial field experiment (factors: soybean crop-weed competition, interrow distance, soybean maturity group and inter-row distance) and a mensurative field experiment (treatments: plants growing with crop, with crop but in a gap on the crop and without crop) were performed in 2009-10. For the second objective a factorial manipulative experiment (factors: soybean crop – weed competition and soil cover) was performed in 2010-11. The presence of the crop reduced the radiation intercepted by the weed and the R-FR ratio. The crop – weed competition for radiation affected weed biomass and partitioning to reproductive structures. As biomass decreased, the seeds per plant decreased linearly. On the other hand, the modification of the environment where the mother plant grows caused a reduction on the dormancy level of seeds. Homogeneous soybean crops together with maize or soybean stubble on soil surface reduced the germination-emergence of D. sanguinalis by reducing fluctuations of soil temperature. Soybean crop modified the performance of D. sanguinalis through changes of the pre-dispersal and post-dispersal environment.
Keywords: Digitaria sanguinalis;Soybean;Weed establishment;Pre-dispersal environment;Post-dispersal environment;

Diversity of weeds and arthropods in fencerows is enhanced when crop types at both adjoining fields are different

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Plant communities within fields and their surroundings have been considered as drivers of biodiversity in agricultural areas. Linear habitats, such as fencerows and field margins, usually sustain higher plant diversity than within fields due to the greater environmental stability, which may enhance the biodiversity of adjoining fields. This study is aimed at testing if crop heterogeneity at adjoining fields affects fencerow weed and arthropods assemblages and discuss its importance to functional biodiversity in landscapes with highly intensified agriculture. We selected homogeneous and heterogeneous pairs of fields separated by fencerows. Weed and arthropod species were recorded at different distance to fencerow (0, 4, 20 and, 100 m). Mean species richness and similarity index (Jaccard) were calculated. Results report that both weed and arthropod fencerow assemblages are significantly affected by the level of heterogeneity of the adjoining fields. The richness of weed species in fencerows intersecting heterogeneous neighbourhoods and the abundance of non-herbivore arthropods are greater than those of fencerows dividing homogeneous neighbourhoods. Differences in fencerow assemblages were not caused by an additive effect of species associated to different crops. Species assemblages of fencerows intersecting heterogeneous cropping neighbourhoods are composed by species that are not found in the adjoining fields. This suggests that field interface offers a habitat suitable for more diverse assemblages when crops sharing it are different. Heterogeneous neighbourhoods effects on assemblage´s diversity occurs despite of the fact that the fields in this study share the same agricultural history over the last thirty years, and the difference in neighbourhood cropping heterogeneity changes on a yearly base. Differences in fencerow weed assemblages are also found within the adjoining fields at increasing distance to fencerow. Cropland heterogeneity provided by crop diversification affect fencerow habitats promoting diverse weed and arthropods communities, which are important for sustaining farmland biodiversity and ecosystem services.
Keywords: biodiveristy;agricultural intensification;cropland heterogeneity ;richness;linear habitats;

Do land-use intensification and landscape complexity affect weed diversity in dryland cereal fields in South Spain?

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Agricultural intensification has decreased weed diversity and weed composition in cereal crops.Weeds are an important constraint of crop yield, but they also provide important ecological services supporting higher trophic levels. Therefore, the analysis of the response of arable species to intensification is necessary in order to formulate effective conservation strategies. The aim of this study was to analyse effects of both land-use intensification characterized by nitrogen input and landscape complexity on weed diversity in Mediterranean dryland cereal fields. The study was conducted in 23 conventional cereal fields in South Spain. Plant richness, diversity, evenness and soil nitrogen content were estimated in three field locations: boundary, edge and centre. Landscape complexity was characterized within a circular sector of 1 km radius around each field and estimated by a proportion of arable land. Our results showed no effect of land-use and landscape complexity on weed diversity. However, weed diversity was determined by field location: Species richness was significantly smaller in the field centre than in its boundary and edge of field. Evenness was highest in the edge. Our results suggest field edge as area of special interest for arable weed conservation in dryland cereal fields. Landscape complexity and land-use intensification do not seem to play a significant role on weed diversity.
Keywords: Biodiversity;evenness;Agricultural intensification;soil nitrogen;field edge;

Effect of weedy rice with different density on photosynthetic characteristics and grain filling course of cultivated rice. **Gui Li**

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Field experiment were conducted to explore the effect of weedy rice (Oryza sativa f. spontanea) （WR）at different density (0, 2, 4, 6, 8 plants/m2) on photosynthetic characteristic and grain filling course of cultivated rice (nanjing 44) (CR). The results showed that: 1)At the tillering stage of CR, tillering number (TN) and stomatal conductance (TC) were lower significantly than the control (without WR) at higher WR density. But the net photosynthetic rate (NPR) of the CR reduced at ≥4 plants/m2 WR. Fv'/Fm' and ΦPS Ⅱ showed the significant deviation with the control. 2) NPR and net assimilation (NA) of the CR declined as the WR density increase during the grain filling stage. But the average increment weight rate of spike increased at prophase of grain filling process, and then decreased. 3) The CR yield decreased by 24.94%, 31.40%, 33.69% and 60.14% at 0, 2, 4, 6, 8 plants/m2 of WR density accordingly. According to the yield component analysis, the effect of WR on effective panicle number (EPN) and seed setting rate (SSR) were more obvious than on thousand grain weight (TGW) and grain number per spike (GN). Therefore, the WR had remarkable effect on the NPR at the tillering stage. Meanwhile, the NPR and NA at the grain filling stage presented the positive correlation with the yield of CR (R2=0.9994 and R2=0.9953 respectively). In addition, the ratios of source to sink in increment (RSS) of CR during the filling stage were 0.58, 0.45 and 0.42 at the WR density of 0, 4 and 8 plants/m2 accordingly. It was evident that NPR and the RSS could decrease strikingly at tillering/filling stage as the WR density increase, which made photoassimilate could not meet the requirement of grain filling. Thereafter the EPN and SSR declined. Thus the yield of CR decreased ultimately.
Keywords: weedy rice;cultivated rice;density;photosynthetic characteristics;yield;

GA_3 and KNO_3: helpful substances for dormancy breaking of African rocket (*Malcolmia africana* L.(R.BR.)) seeds

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African rocket is a noxious winter annual weed species belonging to Brassicaceae family, which occurs in natural and agro-ecosystems of South Khorasan, Iran. As dormancy of African rocket seeds makes its control very difficult and there is no information about the cause and form of dormancy in this weed species, its dormancy and germination requirements were investigated using a CRD experiment with three replications at the Research Laboratory of Faculty of Agriculture, Birjand University during 2011. African rocket seeds were subjected to different treatments including various levels of GA_3, KNO_3, HNO_3, H_2SO_4, HCl, moist and dry stratification, mechanical scarification and soaking in water. The combination effects of treatments including HCl + GA_3, HCl + KNO_3 on seed germination were also employed. Untreated African rocket seeds (control) could just germinate to 8%. Amongst scarification treatments, mechanical scarification using sand paper for 30 seconds and chemical scarification with HCl for 1 minute resulted in 60 and 55% germination, respectively, while chemical scarification with H_2SO_4 and HNO_3 could not enhance germinability of this species. Exposing seeds to 40 g/l KNO_3 for 12h and 750 mg/l GA_3 for 24h increased germinability to 83 and 88%, respectively. Moist stratification at 3°C for 15 days was also successfully released seed dormancy and resulted in 90% germination. The greatest germination percentage (99%) was found when seeds were exposed to the combination of HCl for 1 minute and 750 mg/l GA_3 for 24h. Results of this study indicated that this weed dormancy is mainly a physiological type, but there is still a physical barrier component in the seed coat.
Keywords: Seed dormancy; Germination; GA_3; KNO_3;

Evaluating the germination response of African rocket (*Malcolmia africana* L.(R.BR.)) seeds to salinity and drought stress

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African rocket is a noxious winter annual weed species belonging to Brassicaceae family, which occurs in natural and agro-ecosystems of South Khorasan, Iran. Laboratory experiments were conducted to determine the effect of salinity and drought stress on seed germination of African rocket. Although seed germination was >88% in NaCl concentrations up to 80 mM, further increased salinity levels remarkably decreased germinability. So that only 5% of seeds could germinate at 160mM NaCl and no germination was observed at 320 and 640 mM NaCl. The three-parameter logistic model provided a satisfactory fit for the response of seed germination to NaCl concentration and solution osmotic potential. The parameter x50 of the fitted logistic model representing the NaCl concentration required for 50% inhibition of the maximum germination was 110.35 mM. Seed germination was >98% up to the osmotic potential of -0.4 MPa, but declined to 38% at the osmotic potential of -0.6 MPa and germination ceased at -1 MPa osmotic potential. The parameter x50 of the fitted logistic model representing the osmotic potential required for 50% inhibition of the maximum germination was -0.57 MPa. Results from our study show that African rocket is fairly tolerant to water stress during germination and can tolerate dry soils, while cannot tolerate high saline soils at germination stage.
Keywords: Germination; Osmotic potential; Salt and drought stress;

Operational planning model for optimal herbicide-based weed management in winter crops

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Weeds produce important crop yield losses. Among the methods for weed control, herbicide use is the most common. Nowadays, optimization of herbicide application is pursued to mitigate environmental impact, reduce the appearance of herbicide-resistant weed populations, and minimize the cost/benefit ratio. This work proposes a conceptual operational planning model aimed to calculate the optimal application times of herbicides along an agronomical season in order to rationalize the frequency of applications with respect to experience-based approaches and to maximize the economical benefit of the activity. The system wheat-wild oat (Triticum aestivum–Avena fatua), typical of the semiarid region of Argentina, is used as a case study. The proposed model uses Cousens' hyperbolic equation to describe crop yield loss due to weed competition and makes use of the concept of "time-density equivalent". To simplify the analysis and represent extreme cases, constant weed emergence patterns (2, 8 and 15 plants/m2/day) were assumed. In all scenarios an herbicide was applied in crop pre-emergence to eliminate the first emerging seedlings that would have a large impact on the final crop yield. In the last two cases the model also recommended a second application immediately after the end of crop susceptibility period. The GAMS platform and the solver BARON were used to program and solve the resulting mixed integer non-linear model. It should be mentioned that an optimal scheme of herbicide application that maximizes crop yield may not be compatible with a conservationist strategy towards minimizing the environmental impact and delaying the appearance of herbicide-resistant biotypes.Therefore, a multi-objective approach should be adopted to consider the tradeoff between these objectives.
Keywords: crop-weed system;operational planning;chemical control;mathematical molde;weed management;

Influence of common cocklebur competition on phonological characters of maize

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Maize is greatly influenced by competition of common cocklebur having an adverse impact on its phonology and growth. Hence, to evaluate the effect of cocklebur on phenological characters of maize, field experiments were conducted at Agricultural Research Farm, Agricultural University Peshawar, Pakistan during summer 2006 and 2007 using a randomized complete block design with split plot arrangement replicated three times. Four maize densities and seven varying densities of common cocklebur were tested. Data were recorded on emergence m-2, days to tasseling, silking, maturity, and plant height of maize crop. All the maize phonological characters were significantly affected by the alternate crop and weed densities. The emergence m-2 was significantly reduced with increase in the densities of the crop and weed. The tasseling stage of maize was delayed significantly at the highest maize density of 12.5 plants m-2 and at cocklebur densities ranging from 8 to 12 plants m-2. The effect on silking stage of maize was though non significant statistically however it took 4-7 days for the maize plants in all the treatments to switch over from tasseling to silking stage. Weed density of 0 to 4 plants m-2 had no effect on days to maturity however the maturity stage was significantly delayed by increasing weed density from 6 to 12 plants m-2. Plant height of maize was also convincingly influenced by the varying densities of either species, and plant heights were greater at 7.5 and 10 maize plants m-2. Moreover, increasing the cocklebur density from 0 to 6 plants m-2, maize plant height progressively increased but in contrary the plant heights declined at 8 to 12 cocklebur plants m-2. The data eventually suggested that both the crop as well as weed density do influence the phonological
Keywords: Cocklebur;crop-weed competition;density;maize;Xanthium strumarium;

Weed species and community structures of linseed fields in Gansu Province

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Weed species and community structures of linseed fields in Gansu Province HU Guan-fang，LIU Min-yan，NIU Shu-jun，LI Yu-qi，YU Hai-tao（Institute of Plant Protection，Gansu Academy of Agricultural Sciences，Lanzhou730070，China）Abstract：The thesis surveyed weed species and community structures of linseed fields in the main producing cities of Wuwei, Baiying, Lanzhou, Dingxi, Pingliang and Qingyang in Gansu Province The results showed that there were over 200 species of weeds in the linseed fields in Gansu Province，the dominant populations in the weed communities were *Polygonum convolvulus, P．sibiricum, P．aviculare, Chenopodium album, C．serotinum, C．glaucm, C．aristatum, C．foetidum, Kochia scoparia, Salsola collina, Suaeda glauca, Amaranthus retroflexus, A．lividus, Stellaria media, Lepyrodiclis holosteoides, Hypecoum leptocarpum, Capsella bursa-pastoris, Chorispora tenella, Descurainia sophia, Lepidium apetalum, Malcolmia africana, Vicia bungei, Medicago sativa, Erodium stephanianum, Hibiscus trionum, Calystegia hederacea, C．sepium, Lappula echinata, Lycopsis orientalis, Elsholtzia ciliate, Solanum nigrum, Plantago asiatica, Galium aparine var．tenerum, Cephalanoplos segetum, C．setosum, Ixeris chinensis, Lactuca tatarica, Sonchus brachyotus, S．oleraceus, Taraxacum mongolicum, Xanthium sibiricum, Avena fatua, Setaria viridis, Echinochloa crusgalli var．mitis, Leymus secalinus, Phragmites communis, Poa annua, Chloris virgata* and *Digitaria sanguinalis*, etc.The weeds was divided into39 community groups，there were 8 main community groups.
Keywords: Linseed;Weed species;Community structure;

Study on biology of germination and emergence in black nightshade (*Solanum nigrum* L.)

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Black nightshade (*Solanum nigrum* L.) is one of the problematic weeds in sugar beet, cotton, corn, soybeans, potatoes, pulses, garlic, onion, tobacco, vegetable farms and orchards. In order to study the germination and emergence biology of black nightshade experiments were conducted at Research Laboratory of Birjand University during 2010 and 2011. In growth cabinet, experiments were carried out to identify the effective treatments in dormancy breaking and determine the effects of temperature, light, salinity, drought stress, pH and burial depth on germination and emergence of this species. The effect of temperature and light was conducted in a factorial experiment based on CRD, while other factors were studied based on CRD with three replications. Results showed that amongst all treatments just stratification in +3oC for two weeks, chemical scarification with sulfuric acid (98%) for 15 seconds and potassium nitrate (5000 and 10000 ppm) could release seed dormancy. Black nightshade seeds germinated under light/dark regime greater than under continuous dark regime, indicating this weed species is photoblastic. Black nightshade seeds germinated 46.44% in a range of alternating light/dark temperatures (5/15, 10/20, 15/25, 20/30, 25/35 and 30/40oC) and the maximum germination (66.66%) was observed at 20/30oC. Increased salinity and drought levels significantly decreased the germination percentage of black nightshade (no germination was recorded at osmotic potential of -0.8 MPa). Investigation of different acidity conditions showed that black nightshade had maximum germination percentage under alkaline conditions. The black nightshade seedlings could emerge from a range of burial depths (0 to 3cm) and the maximum emergence (68.66%) was observed from 0.5cm. The information of this study would be useful for the improvement of this weed species management programs.
Keywords: Biology;Black nightshade;Environmental factors;Germination;Weed;

Effect of cotton (*Gossypium hirsutum* L.) competition on growth properties and seed production of black nightshade (*Solanum nigrum* L.)

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Black nightshade (*Solanum nigrum* L.) is one of most important weeds in cotton. In order to study the effect of cotton (Gossypium hirsutum L.) competition on this weed growth properties and seed production, experiments were conducted at Research Laboratory and Field of Agricultural Faculty of Birjand University during 2010 and 2011. In growth cabinet, an experiment was carried out to identify the impact of cotton competition on maternal plants of black nightshade on its seed traits, which studied based on CRD with three replications. The field trial was a factorial experiment based on RCBD with three replications. Experimental treatments in the field were competition from cotton (Varamin variety) at variable densities including 3, 6, 9 and 12 p/m2 and black nightshade density with 3 p/m2. One pure stand of black nightshade (3 p/m2) was added to each block as well. Results showed that the germination percentage of black nightshade seeds decreased due to increased cotton competition with maternal plants of black nightshade. Field experiment showed that increasing cotton density caused significant reductions in canopy and stem diameter, plant height, number of flowers, and fruits, leaf area, , dry weights of leaf, stem, flowers and fruits, number of fruits per plant, number of seeds per fruit and number of seeds per plant of black nightshade.
Keywords: Competition;Growth characterestics;Maternal plant;Seed production;

Occurrence and prevention of weeds in Loquat orchards in Taihu Lake region

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Abstract: Weeds are harmful to the growth and production of loquat fruit. Our survey on the occurrence of weeds in loquat orchards in the Taihu Lake region has found weeds of over 100 species in 29 families. The most commonly found weeds are of the grass family, followed by weeds in the families of Asteraceae, Polygonaceae, Amaranthaceae and Cyperaceae. In addition, there are relatively widespread weeds of the families of Chenopodiaceae, Convolvulaceae, Portulacaceae, Commelinaceae, Rubiaceae and

Caryophyllaceae. The soil-treatment herbicides such as Trifluralin, Kingduer, Prowl, Acetochlor were tested by enclosed soil treatment before weed seedlings were to emerge. And the leaf-treatment herbicides such as Haloxyfop-R-methyl, Clethodim, Sethoxydim, Quizalofop-p-ethyl, Fluazifopbutyl, Fenoxaprop-ethyl, Quizalofop-P-Tefuryl were tested on leaves and stems of the grass-family weed seedlings. The tests showed that herbicides are effective and highly safe. With the subsequent control on adult weeds, the weed-controlling management in loquat orchards involves three measures of "enclosing, killing and pulling."
Keywords: loquat orchard;weeds;prevention and control;

Phylogenetic study of the Korean Setaria taxa derived from nuclear DNA internal transcribed spacer and chloroplast trnL intron and trnL-F intergenic spacer sequences

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The genus Setaria is identified by nine taxa in Korea and one invasive species is getting problematic. A phylogenetic relationship among 31 Korean accessions belonging to eight taxa of the genus was inferred from combined data of nuclear ribosomal DNA internal transcribed spacer and chloroplast DNA TrnL intron and TrnL-F intergenic spacer sequence variation. Echinochloa crus-galli was used as outgroup. Sequences of 31 Setaria and outgroup species were aligned to 1557 bp and the number of parsimony-informative characters were 78. Phylogeny estimated using parsimony methods revealed that the Korean Setaria is monophyletic. Setaria was composed of three clades indicated with I, II and III. The clade I was consisted of S. glauca, S. glauca var. dura and S. pallidefusca. The clade II, the largest clade, was consisted of S. faberi, S. viridis var. viridis, S. viridis var. pachystachys, S. x pycnocoma and weedy types of S. itailica. The relationship among the species of the clade II was not resolved. The clade III was consisted of S. hondrachne alone. Phylogenies based on neighbor-joining method gave similar topology to that based on maximum parsimony. These results should be further studied vigorously with morphological characters to confirm relationships among the Setaria.
Keywords: Setaria;molecular phylogeny;ITS;trnL-F;pairwise sequence divergence;

Genetic diversity of Italian weedy rice populations

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Weedy rice (Oryza sativa L.) is one of the major issues of rice cultivation worldwide. In Italy it infests about 70% of the total rice area. Variable morphological and physiological traits permit to distinguish different weedy rice populations, however little is known about genetic differentiation and origin of Italian weedy rice populations. The objective of the study was to genetically characterize different Italian weedy rice populations selected on the basis of variable morphological traits. The main Italian rice territory was divided into 10 geographical areas in which 40 weedy rice populations were collected and grouped according to the awn traits. The populations were 25% awnless, 20% mucronate and 55% awned (30% black-awned and 25% straw-awned). After the seed collection, all the populations were sown in a same field and characterized morphologically on the basis of plant and seed traits. Genetic characterization using 20 SSR markers was performed on all the weedy rice populations and 20 rice cultivars, including some very old (late 19th century) nowadays no longer cultivated. ANOVA analysis showed that morphological plant and seed traits were significantly affected by the area of collection and awnedness group. The genetic analysis showed relatively low diversity among the tested populations, despite the overall Fst (0.1789), that indicated substantial differentiation among them. Upon STRUCTURE analysis performed on genetic distance, the populations clustered in three groups, with a separation between weedy rice and the cultivars. An UPGMA dendrogram, calculated out of the distance data obtained by the SSR analysis, showed similar grouping of the samples. Old cultivars showed similarity with weedy rice and clustered with it in both STRUCTURE and UPGMA analysis, suggesting a common origin.
Keywords: Red rice;SSR;weeds;plant morphology;

Research advance on weeds control in rapeseed field in southeast China

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Weeds are one of the most harmful threats to oilseed rape fields throughout the world, which cause huge loss in China every year as well. In order to reduce the damage of weeds, the characteristics of weed comunities and weed growth have been investigated as well as the various technologies of weeds control, mainly including chemical control techniques, farming control, transgenic technologies and selection of herbicide resistant mutants. However, as some control technologies are often misused or applied excessively by farmers or even agronomists, a number of problems, such as herbicide resistance and herbicide injury, occur in farmlands. Thus it is really urgent to do more research and application on new methods or strategies to control weeds comprehensively and effectively.
Keywords: oilseed rape;weeds damage;weeds control; herbicide resistance;

Ambrosia artemisiifolia growth as affected by winter wheat and barley density and harvesting period

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Common ragweed (*Ambrosia artemisiifolia* L.) is a plant native to America that has become a troublesome weed in European field crops such as maize, soybean, wheat. Field experiments were conducted from 2009 to 2011 in a field highly infested by *A.*

artemisiifolia (more than 200 seedlings/m2 in 2009) to assess the effect on the weed of wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*), seeded at a density of 280 or 230 kg ha-1 and 260 or 180 kg ha-1 respectively, and harvested at 35% and 14% grain moisture maturity (for silage forage or grain production, respectively). Crops were seeded in autumn on 2 x 25m plots, with 3 replicates. Treatments were maintained in the same plots over 3 growing seasons. Weed control was carried out in post-emergence against monocot species only. A. artemisiifolia emerged already during cultivation of the winter cereals, during the first decade of April in 2009 and 2010, and in the last decade of March in 2011. All combination of treatments (crop species, crop densities and harvesting period) demonstrated to reduce A. artemisiifolia biomass by up to 60% (wheat grown for silage forage) in comparison with the untreated (no crop presence). Harvesting period resulted in the highest effect on the weed growth over the 3 growing seasons. In the last year A. artemisiifolia density and soil coverage recorded in winter wheat were 30% higher than in barley, with differences between crop densities lower than 5% in both crops. In all considered years, higher A. artemisiifolia biomass (30% and 50% for wheat and barley, respectively) was recorded at the end of the season (September) in the plots where crops were harvested earlier.
Keywords: common ragweed; winter wheat; barley; competition;

Effect of maternal light environment of Lithospermum arvense on offspring germinability

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Lithospermum arvense is a weedy annual species of winter cereal crops of the south-west area of Buenos Aires, Argentina. Maternal environmental factors, such as light, may affect seed development having consequences on the variance of fitness components like seed dormancy. The aim of this work was to investigate the effect of light intensities of the maternal environment on seed germinability of the progeny. Plants of L. arvense were grown under full sun and 37% neutral shade. Freshly matured seeds (F1) were stored dry in darkness at 25 °C until 589 °C.day of after-ripening. Germination trials were carried out in a growth chamber under a constant thermal regime (15ºC) either under complete darkness or under a 14-h photoperiod. Seeds were incubated in 9-cm-diameter plastic Petri dishes either with 5 ml of distiller water or with a NO3K solution (2% w/w). A factorial design with three factors was established: maternal environment (100 and 63% light availability), incubation photoperiod and incubation medium (distilled water or NO3K solution). Dishes were wrapped in aluminum foil so as to exclude light. Germination was assessed after 12 and 16 days of incubation. A positive interaction between maternal environment and incubation photoperiod was observed ($p < 0.05$) with slightly increasing trend to more germination under complete darkness conditions. Neither a medium environmental effect nor a maternal light effect was observed ($p>0.05$). Further studies should be conducted in order to evaluate possible fitness effect of light maternal environment on future generations (F2, F3, F4).
Keywords: LITHOSPERMUM; maternal effect; light; germinability;

Competitiveness of a transgenic rice (CPPO06) resistant to protoporphyrinogen oxidase inhibiting herbicides

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A new trait of transgenic plants may alter competitive ability and consequently increase the possibility of weediness of the plants. This study was conducted to determine competitiveness of herbicide resistant transgenic rice (CPPO06) over-expressing protoporphyrinogen oxidase (Protox) gene of Myxococcus xanthus. Competition between CPPO06 and its non-transgenic parental variety, Dongjin rice, was evaluated using a set of replacement series experiment with five ratios and four plant densities. The plant biomass per pot of the CPPO06 and Dongjin rice was similar and corresponded to the theoretical response of two plants having equal competitiveness. ANOVA for individual plant height, tiller number, and shoot dry weight showed no ratio effect in the mixtures indicating no competition between CPPO06 and Dongjin rice. These results suggest that the trait producing Protox of M. xanthus is not associated with competitive ability in rice. So, the chance of weediness or invasiveness of CPPO06 is unlikely to be greater than those of Dongjin rice.
Keywords: competition;environmental risk;GMO;

The evolution of mating system during invasioni in *Plantago virginica*

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Invasive species have largely impacted ecosystem and social economy, but the general pattern of invasive success is still not well known so far. Although previous studies ever focused on the divergence of plants' life history traits during invasion, few of them put attentions to mating system, which is the direct trait affecting plant's adaptative divergence. In present study, we take *Plantago virginica* as model species, US (native place) and China (invasive species) as studied sites, by using methods of field investigations, molecular marker and common garden experiments to make comparison study with respect to mating system, so that we could verify our theoretical predictions: 1) higher selfing rates; 2) lower genetic diversity; 3) less inbreeding depression in invasive populations. The novel insight in our research is to make comparison study between native and introduced sites by integrating both evolution of mating system and plant invasion, i.e. studying the mating system using invasive species and detecting the invasive pattern by studying evolution of mating system. Thus, we can directly inspect the previous theory, and it's helpful for us to know the invasive pattern from a new insight. So far, we have found some evidences supporting our above predictions.
Keywords: biological invasions;mating system;genetic bottle;plantago virginica;genetic diversity;

The molecular mechanisms of Glyphosate-resistant in weeds

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The herbicide glyphosate is becoming widely used in the world due to high economic returns. However, increased use of glyphosate over years imposes selective genetic pressure on weed populations. It has resulted in the evolution of resistance in weeds in many parts of the world. The resistance mechanisms thus far elucidated are reduced glyphosate translocation and target-site mutations in the EPSPS gene. In this paper, We will mainly discuss the molecular glyphosate-resistant mechanisms, such as the level and activity of the target enzyme of the herbicide-5-enolpyruvylshikimate-3-phosphate synthase(EPSPS), the corresponding gene amplification and mRNA level. It provides certain reference value for glyphosate-resistant research and the weed control strategy.
Keywords: glyphosate;mechanism;weeds;resistant;EPSPS;

Effect of weed removal time on corn yield as affected by nitrogen source and rate

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Two of the greatest factors, following genetics, impacting production & yield in agronomic crops are fertility & weed management. The uptake efficiency of N is dependent upon many factors including tillage system, soil type, crop, weeds, & the amount and type of N fertilizer applied. The relationship & interaction between crops & weeds is important, & determining how North Carolina corn production may be impacted by different fertilizers could improve N use efficiency & overall corn yields. Field studies were conducted in 2011 at the Upper Coastal Plains Research Station near Rocky Mount, NC & the Central Crops Research Station in Clayton, NC. Treatment factors included N source, N rate & weed removal time with a factorial treatment arrangement. The N sources included urea ammonium nitrate, chicken litter, & sulfur coated urea with rates of 0, 27.22, 54.43, & 81.65 kg N/A. Weed removal times were at 0, 7.62, & 15.24 cm heights. Significant location, N source, & weed removal height effects were observed for corn yield. When weeds were allowed to remain in the field with corn, the weeds were able to compete with corn for N over a greater time period therefore reducing corn yield potential which showed the importance of the critical period of weed removal. The interaction between location and source of N is due to the difference in soil types at the two research stations with Clayton having a lighter, sandier soil which is better known for leaching & Rocky Mount having a heavier soil with greater clay content. The increased corn yield corresponding with an increase in applied N is expected, as N is an essential nutrient in corn production & is partially due to the increase in N Uptake Efficiency with greater N rates applied.
Keywords: Zea mays;Digitaria sanguinalis;Amaranthus palmeri;Nitrogen;

Survey of rare and endangered plants on arable land in the Czech Republic

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Diversity of weed communities has been changing during the history of agriculture due to introduction of non-native species and different adaptation ability of individual species on new developments in farming practices. The aim of study was to explore current situation in occurrence of rare and endangered weedy plants associated historically with crops under influence of soil management systems, and environmental site conditions. Our survey was conducted in 2006-2008 on conventional and organic farms in winter cereals, spring cereals and root crops. At each site, one phytocoenological relevé (100 m2) was recorded in the field centre in the period of full vegetation growth. The coverage of species was estimated using Braun-Blanquet cover-abundance scale. Totally, 290 relevés have been recorded. From totally 172 plant species found, 19 are listed on Black and Red List of Vascular Plants of the Czech Republic. Five species are there classified as strongly threatened, 7 as threatened, and 7 as less endangered requiring further monitoring. Regarding the origin, only 3 of them were native (apophytes), and other 16 were non-native (naturalized archaeophytes). Based on constancies, occurrence of endangered species was 4.5 times higher in organic than in conventional agriculture, and approximately 2 to 3 times higher in cereals than in root crops. The highest number of endangered and rare species is associated with Caucalidion lappulae alliance in cereals on slightly alkaline soils. Although the weed diversity decreased in last decades, rare species still occurred in approximately one third of fields visited in our study. Majority of species classified as endangered were mainly non-native archaeophytes which are not capable of adaptation to current agricultural practices.
Keywords: rare and endangered species;arable land;environmental site conditions;types of farming;Czech Republic;

Gene flow between Clearfield® wheat and jointed goatgrass (*Aegilops cylindrica*)

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Clearfield® wheat (*Triticum aestivum*) varieties carry the Imi1 gene, which is responsible for conferring resistance to the imidazolinone (IMI) herbicide imazamox. This trait allows the selective control of jointed goatgrass (*Aegilops cylindrica*) (JGG), a difficult to control annual grass weed in winter wheat. Wheat (2n = 6x = 42; AABBDD) and JGG (2n = 4x = 28; CCDD) are genetically related and have a common ancestor, Aegilops tauschii, the donor of the D genome. Thus, Imi1 gene flow between the resistant wheat and JGG may occur via hybridization and backcross events. Hybrids (F1) of IMI-resistant wheat and JGG were identified in 2008 in a commercial wheat field in Oregon, USA. In 2009 and 2010, surveys were conducted across the wheat production regions of Oregon in order to understand the extent of the imazamox-resistant hybrids. Tissue and spikes from hybrids were collected and assays were performed in order to detect the presence of the Imi1 gene. A total of 128 sites were surveyed in the

two years. Of 1,162 hybrids tested, 904 were positive for the Imi1 gene. The average F1 seed set of the 2-year survey was 1.88%. Our results demonstrate that the Imi1 gene is moving from IMI-resistant wheat to hybrid plants and potentially to backcross generations. This movement is taking place in commercial wheat fields and in non-crop sites close to these fields.
Keywords: Triticum aestivum;hybridization;imidazolinone;Imi1;non-crop areas;

The community composition and biodiversity of weeds in conservation tillage system in Qinghai province

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Weed survey was conducted by sampling method of inverted W-pattern to determine the composition of species and structure of weed communities in conservation tillage system. The results showed that there were 67 weed species belonging to 25 families in conservation tillage in Qinghai.The predominant species were Elsholtzia densa Benth, Galium aparine(L)Var tenerum Rcbb, Avena fatua L., Chenopodium album L., Sonchus arvensis Linn and Cephalanoplos setosum (willd.)kitam. There were 5 species of regional predominant weeds,17 common weeds and 39 general weeds.Weed communities in Huangzhong dominated by Galium aparine(L)Var tenerum Rcbb + Elsholtzia densa Benth + Chenopodium album L. + Avena fatua L. + Cephalanoplos setosum(willd)Kitam + Phragmites + Polygonum nepalense Meisn, weed communities in Minhe dominated by Setaria viridis+Chenopodium album L.+ Polygonum aviculaye L. +Avena fatua L. + Convolvulus arvensis L. +Polygonum oonvolvulus L + Cephalanoplos setosum(willd)Kitam. Communities structure in Pingan were Avena fatua L. + Galium aparine(L)Var tenerum Rcbb + Sonchus brachyotus D C+ Cephalanoplos setosum(willd)Kitam+ Leymus Hochst+ Polygonum oonvolvulus L+Elsholtzia densa Benth+ Polygonum aviculaye L.+Euphorbia helioscopia.In Hualong,weeds communities consisted of Lepyrodiclis holosteoides+Galium aparine(L)Var tenerum Rcbb+Avena fatua L.+Polygonum oonvolvulus L+Sonchus brachyotus D C+Elsholtzia densa Benth, weeds communities in Datong consisted of Avena fatua L.+ Galium aparine(L)Var tenerum Rcbb+ Chenopodium album L.+ Cephalanoplos setosum(willd)Kitam+ Equisetum arvense l.+ Elsholtzia densa Benth,and weeds communities in Gangcha consisted of Elsholtzia densa Benth+Lepyrodiclis holosteoides+ Chenopodium album L.+ Bromus tectorum+ Sonchus brachyotus D C+ Daucus carota. The species richness, diversity and evenness degree of weed communities in conservation tillage of Huangzhong and Datong were higher than other regions, but the dominance index was lower. About weed community structure, Huangzhong is similar to Datong.The difference of weed community composition in conservation tillage system may be caused by different geographical environment, climatic conditions and control methods.
Keywords: conservation tillage ;weed communities;;species diversity;;dominance;

Effect of soil disturbance on seedling emergence of mouse barley (*Hordeum murinum* L.) and hoary cress (*Cardaria draba* L.)

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To determine how magnitude and distribution of emergence of these species differs with timing of superficial disturbance of the soil around the time of emergence, three replications of 1000 seeds of each species were buried in mesh cages (25 x 25 cm and 4 cm deep) in June 2011 and soil disturbance treatments were applied when farmers began to till their wheat fields in autumn. So five soil disturbance treatments were applied with 1-week intervals and an undisturbed soil treatment was also included as a control treatment. Number of emerged seedlings was recorded weekly until spring 2012. Results showed that mouse barley seedlings emerged very earlier than hoary cress ones, so that first mouse barley seedlings were observed 4 weeks after first soil disturbance comparing with the earliest hoary cress seedlings which emerged 18 weeks after first soil disturbance (WAFS). This indicates that hoary cress requires higher temperatures for its emergence in comparison with mouse barley. The greatest emergence percentage of mouse barley (80%) was observed in undisturbed soil. This treatment provided greater than 70% of mouse barley seedling emergence at 4 WAFS, while those plots that received disturbance at 5 WAFS could emerge only to 8%, indicating that mouse barley emerges in greater amounts and also earlier in the fields that receive soil disturbance sooner in the season. The greatest hoary cress seedling emergence was only 3% which was observed in those plots that received disturbance at 6 WAFS. It is notable that this species started its emergence at late winter and did not have any emergence during winter months. As hoary cress does not show any type of dormancy, it seems that this species might deplete the greatest part of its seedbank at early spring.
Keywords: tillage;emergence percentage;soil disturbance;seedling;

Seed germination characteristics of ornamental grass *Eragrostis spectabilis*

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Abstract: *Eragrostis spectabilis* is used as an ornamental grass in China. But some research reported that it had high potential risk of becoming invasive. Usually successful exotic weeds had strong reproduction ability. And for now, germination characteristics of *Eragrostis spectabilis* seeds have not been reported. Effects of temperature, light, water stress and soil depth on *Eragrostis spectabilis* seeds germination were studied by petri dish and pot experiments in germination box and glasshouse. The results showed that the positive germination temperatures were between 17.7℃ and 43.2℃, with the best temperature of 39.2℃. Light was preferred for seed germination, the germination percentage was relatively higher under continuous light condition than continuous dark condition. PEG6000-simulated water stress significantly inhibited the germination. When water potential decreased to -8.0 bar, seeds could not germinate. The soil depth of 0.5 cm was ideal for germination and the germination percentages from 0-1 cm were more than 60%. The germination percentage decreased significantly with the increase of soil depth during 1-4 cm. This research indicated that environment condition has significant influence on seed germination of *Eragrostis spectabilis*. The spreading and infestation of this grass might be managed by regulating its seed germination.
Keywords: *Eragrostis spectabilis*;Germination;Weed;Temperature;Soil depth;

The dynamics of shikimate accumulation and chlorophyll relative content in *Digitaria sanguinalis* (L.) Scop. following glyphosate application

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To understand glyphosate effects in *Digitaria sanguinalis* grown at different stages, shikimate accumulation and chlorophyll relative content in plants grown in different stages was determined by spectrophotometric assay and the SPAD-502 readings, respectively. Shikimate accumulation levels increased with all dosages tested. The SPAD values declined from 1 to 7 days after treatment. 5328.0 μg/g shikimate accumulation was achieved in elder plants , and 5331.0 μg/g of that was revealed in the younger plants 7 DAT. The shikimate accumulate in the younger plants were higher than in elder plants most days after treatment. The lowest SPAD values in the leaves of younger plants were 3.4 at the treated dosage of 3280 g a.i/ha, it was 0.05 times of the untreated plants. The lowest values in the leaves of elder plants was 3.7, it was 0.09 times of the untreated plants. Those indicated that the data could provide basis for developing methods to detect the sensitivity of *D. sanguinalis* to glyphosate.
Keywords: Glyphosate; Shikimate; Chlorophyll; *Digitaria sanguinalis* (L.) Scop;

Barnyardgrass (*Echinochloai*) seed bank construction and utilization

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Barnyardgrass (*Echinochloa*) Seed Bank Construction and Utilization Lu Yongliang Zhou Yongjun Yu Liuqing State Key Laboratory of Rice Biology, China National Rice Research Institute, 359 Tiyuchang Road, Hangzhou 310006, China There are 10 species and 5 variations of genus Echinochloa in crop field in China, where they are very successful competitors thanks to their broad ecological tolerance and ability to mimic the crop. Echinochloa species are first one among the major weeds in China rice fields, which was infested more than 42%.Yield losses was more than 50% when the Echinochloa species densities arrived 13 plants m-2 at seeding stage. Due to the morphological variability, the classification of the different species is often difficult and uncertain, also because several integrading polymorphic complexes can be found. Despite the great importance of these weeds and their wide morphological variability, only a little information is available on classification, distribution, and herbicide sensitivity etc. in China rice filed. It is significance to construct the seed bank of China rice field barnyardgrass for research. During 2011, 1200 samples of different kind barnyardgrass were collected from 13 important rice production provinces in China. The following research work will be focus on: evaluation of the different and strongest dormancy behaviour; classification by morphological and molecular biology; genetic diversity; rice field distribution by kinds, herbicide resistance and sensitivity evaluation etc..
Keywords: Barnyardgrass; Biology;

The biological form and characteristics of Jiangsu weedy rice

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Abstract Along with the transfer of rural labor and the prevalence of simplified cultivation rice technologies in the 2000s, weedy rice has caused serious damage to rice production and commercial quality in many regions of Heilongjiang, Liaoning Ningxia, Jiangsu, Shanghai, Guangdong and other Provinces in China, and over 600,000 ha rice were infested every year. Because of no-tillage farming technique including interplanting rice with wheat stubble and dry direct seeding of rice has been extensively used, the total infesting area by weedy rice reached to ~200,000 ha in Taizhou and Yangzhou of central Jiangsu Province in 2008, which accounted for about 25% of total acreage of direct sowing rice. To clearly classify Jiangsu weedy rice, 23 distinct weedy rice samples collected from Jiangsu were grown. Morphological and biological characteristics including coleoptile color, leaf sheath color, tillering number, plant height, ratio (length/width) of the reversed 2nd leaf and flag leaf, heading date, panicle exsertion, panicle type, spike length, effective panicles, glume color, hull color, awn length, ratio (length/width) of grain, seed-setting percentage, 1000-grain weight and pericarp color of the all samples were investigated during the entire growing period. The results showed that the plant height and leaf size of weedy rice was closer to that of cultivated rice Ningjing 1 at the seedling stage. However, it was significantly different from the cultivated rice after the tillering stage. Weedy rice has an obvious and comprehensive advantage of fast growth and high weed competition at late stage. Its average values of plant height and tiller number were 0.8-28cm and 6.1 higher than that of cultivated rice, respectively. However, seed setting percentage, 1000-grain weight and ratio (length/width) of grain were 15%, 7g and 1.3 lower than that of cultivated rice, respectively. Most of weedy rice plants were tall with upright panicles and its maturity was about 15 days earlier comparing to the rice varieties. The majority of weedy rice samples showed red pericarp and straw to dark brown colored hull. Consequently, our study suggested that Jiangsu weedy rice might be divided into 8 biotypes. The characteristics of biotype A (52.2%) showed upright plant type, straw color hull, red pericarp and awnless, was taller plant height than that of cultivated rice. The characteristics of biotype B (13%) , biotype C (8.7%), biotype D (8.7%) and biotype G (4.3%) were identical to that of biotype A, except for white pericarp (biotype B), awned seed (biotype C), lower plant height than cultivated rice (biotype D) and loose plant type (biotype G) . Biotype E (4.3%) was different from biotype D with black brown hull. Biotype F (4.3%) was closer to that biotype E except for lower plant height than cultivated rice. Biotype H (4.3%) was different from biotype G with white pericarp and awned seed.
Keywords: weedy rice;morphology;biology;biotype;Jiangsu province;

Study on the bioassay of imazethapyr residual quantity in the soil of cold region

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Study on the bioassay of imazethapyr residual quantity in the soil of cold region Huang Yuanju，Piao Dewan，Wang Yu ，Huang Chunyan (Institute of Plant Protection of Heilongjiang Academy of Agricultural Sciences, Harbin 150086 ,China) Imazethapyr is a wide-spectrum herbicide. Now it is mostly applied in Heilongjiang soybean production. But it brought severe problems in crops production in next season due to its high residue. The experiment was carried out in the field of the Institute of Plant Protection of Heilongjiang Academy of Agricultural Sciences in 2010. We selected a field where imazethapyr is not applied and the soil is black with a middle texture, the content of organic matter is 2.81%, pH 6.75. We use corn as indicator plant for bioassay. Fresh weight of corn roots assayed Imazethapyr residual kinetics quantity in the soil. The Herbicide is 5% pursuit SL (Imazethapyr). “Hydrojet” nozzles were used for the herbicide spraying, with consumption rate 300L/hm2，with 75ga.i./hm2，150ga.i./hm2 and control. The standard curve setting used the method of plant cultivation in soil. The results shown, this method has g/kg.μhigh sensitive, and the lowest limit of Imazethapyr detection reaches 5 The Imazethapyr decomposed quickly in the initial stages and after then decomposition is slow. The initial Imazethapyr concentration has not significant influence on the decomposition speed. So the Imazethapyr residual quantity increases with the application rate inceasing. This result had a direct relation with the climate conditions of Heilongjiang province. The samples of Imazethapir residual quantity detection is a part of bioactivity in the soil. Therefore, the method of bioassay is more practical value in agricultural production than assaying used sensitive equipments for test Imazethapyr residual quantity in soil.
Keywords: imazethapyr;residual quantity ;bioassay ;soil;cold region ;

Effect of degluming and biotype on *Sorghum halepense* seed dormancy response to stimulatory treatments

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Control of Johnsongrass is difficult because it produces large quantities of seed and rhizomes. The majority of freshly harvested seeds are highly dormant with primary dormancy Seed dormancy mechanisms in this weed species are poorly understood. In order to determine the relationship between the biotypes and the seed germination and effect of various dormancy breaking treatments on johnsongrass seed dormancy, a laboratory experiment was conducted in Research Center of Flakkebjerg, Aarhus university, Denmark in 2011. Seeds of johsongrass from Iran and Serbia were used in this study. Both biotypes, Iranian and Serbian, were divided into two groups, deglumed and intact seeds and then exposed to Immersion in NaOCl, H2SO4, H2O2, boiling water, for 10 h, 30 min, 72 h, 10 min; respectively, Pre-chilling with water and scarifying seeds with sand paper. Seeds then transferred to petri-dishes and incubated for 28 d in water, KNO3 and GA3 and in darkness and 16-day light. Incubation temperatures were 28 and 20/35 (16 h low, 8 h high for all treatments). Results showed that seed of both biotypes responded to treatments differently. In general soaking seeds of both biotypes in H2O2 led to highest germination rate. Presence of glum had inhibitory effect on seed germination and degluming increased seed germination more than 80%. These results demonstrated the effect of climate condition on seed dormancy properties and its response to seed dormancy breaking factors.
Keywords: seed germination ;Serbian biotype;Iranian biotype;Pre-chilling ;Incubation temperature;

Weed community dynamics of rice fields in different management systems

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The aim of the study was to describe the weed community dynamics of rice fields in different management systems. The study was carried out from 2004 to 2009 at Vercelli (N-W Italy) considering eight plots managed in different ways: autumn ploughing with straw incorporation and rice seeding in flooded field as a reference treatment (SAF), spring ploughing with straw incorporation and rice seeding in flooded field (SPF), autumn ploughing with straw incorporation and rice seeding in dry field (SAD), straw burning in autumn and rice seeding in flooded field (SBF), autumn ploughing with straw and liquid manure incorporation and rice seeding in flooded field (SMAF), rice rotation with two years of rice and one of maize (SPFR1, SPFR2, SPFR3). Weed assessments were performed in 3 untreated areas for each plot several times during the growing season. Weed seed bank was determined in 2006 and 2009, taking soil cores at 0-10 cm and 10-20 cm depth. The major weeds found in water-seeded plots were: Heterantera reniformis, Schoenoplectus mucronatus, Ammania coccinea and Lindernia dubia, while Echinochloa crus-galli was mainly present in SAD plot. Lower relative weed densities were found in SBF, SAD and SPFR3 with values ranging from 2.6% (SAD-2004) and 82% (SPFR-2009) compared to the reference treatment SAF. The other rotational plots showed a more variable density through the years and a higher number of weed species. Weed seed bank was comprised between 1500 seeds m-2 (SAD and SBF-2009 at 0-10 cm) and 10700 seeds m-2 (SPFR3-2006 at 10-20 cm). Seed bank values were similar among the plots, with a strong effect of crop rotation.
Keywords: ploughing;dry seeding;rotation;

Spatial and temporal competition between corn and Galinsoga ciliata on plant growth

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G. ciliata is a very important invasive weed. It is a dominant weed and caused serious yield reduction in farmland in southwest China. To examine how G. ciliata disturb corn growth, pot experiments were carried out to explore the competition between G. ciliata and corn. In order to find influence of G. ciliata density on plant growth of corn, biomass of seedling in pot with one corn and different numbers of G. ciliata under three nitrogen applications was investigated. The result was showed biomass of corn was decreased with increment of seedling numbers of G. ciliata. Shoot biomass was highest in 200 mg kg-1 urea application compared to other two applications; while root biomass was highest in 400 mg kg-1 urea application. Biomass reduction of corn was promoted as numbers of G. ciliata was increased. Biomass of G. ciliata per pot was higher in 200 mg kg-1 urea application and 6 plants. It is indicated the influence of completion between corn and G. ciliata in low nitrogen fertilizer was more intensive. In order to find the relationship between plant competition intensity and planting period, plant biomass of one corn and two G. ciliata with different planting intervals was analyzed. 49 d intervals between corn and G. ciliata caused significantly biomass of corn. Biomass of G. ciliata was reduced at least 1/3 every 7 d intervals from 0 to 42 days. After 42 days, new seedlings of G. ciliata could not grow anymore. It is indicated G. ciliata existence in early stage of corn caused serious influence on corn growth. In conclusion, the above results suggested low plant density and existence of G. ciliata in early stage could cause intensive competition to corn.
Keywords: Galinsoga ciliata;corn;invasive plant ;temporal competition ;spatial competition;

WeedMap – an internet geodatabase for recording, archiving and displaying weed vegetation data

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An EWRS weed mapping initiative started in 2009 with the aim of learning about the past and current activities on regional and country scales, concentrating on methodologies and available data. In the meantime, many weed scientists from all continents have expressed an interest to join this initiative. One of the recent tasks is the preparation of European and global weed maps. To attract collaborators for weed surveys and to allow a broader community an access to existing data, the internet approach is a very suitable solution. The software WeedMap allows the collection and the management of data from weed surveys (either vegetation relevés or single species data) based on the Document Management System (DMS). WeedMap is freely accessible through the internet on www.weedmap.eu. An multilevel access authorisation ensures the availability of defined modules for the administrator, for competent regional scientists and also for the public. It allows imports of data from a keyboard or in standardized formats. Header data as the crop, management systems, herbicides etc. can be recorded for each documented site (relevé). This software enables the displaying of species occurring in selected regions. It is also possible to define the importance or ranks of weed species in individual crops under various management systems. The system is able to create maps of relevés and also maps of the species distribution. Temporal and spatial changes can also be analysed from historical data. An effective searching tool allows many types of analytical outputs. Data exchange with other applications is ensured via import/export capabilities (XML and CSV formats). The software is being tested with regional data and the authors are presently looking for collaborators worldwide.
Keywords: weed distribution;weed mapping;weed survey;

Dynamics of weedy rice seed bank associated with occurrence and harmfulness in Jiangsu Province, China

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Weedy rice competes aggressively with the cultivated rice, reducing cultivated rice yields and quality. Serious infestation resulted from the unexpectedly occurred weedy rice sometimes caused rice harvestless in Jiangsu Province, China. In this paper we studied three years' dynamic change of weedy rice seed bank and analyzed the relationship between the seed bank density and population density in order to reveal the dynamics of the seed bank and elucidate the source of weedy rice population in six direct-seeding rice fields of six county-level cities along the Yangtze River in Jiangsu Province, China. The results showed that about 34-55% of weedy rice seeds reproduced shattered onto the ground resulting in a dramatic increase in weedy rice seed bank density in autumn and then the seed bank density decreased over 70% in the later six months until the following year's seedling emergence season. More than 70% weedy rice seeds in seed bank were found 0-10cm below ground level. A significant linear correlation was found between weedy rice emergence and the seed bank density of 0-10cm soil layer. The exponential correlation between cultivated rice yield loss and adult weed rice density was detected. According to the dynamic data obtained during the whole weedy rice life cycle, a semi-empirical mathematic model was developed with well fit of the experimental data for the prediction of the seed bank scale. Integrated the semi-empirical model and the exponential curve together, weedy rice density and rice yield loss can be predicted based on seed bank density or the previous year's mature plant density. In a word, the present results may be useful to predict weedy rice occurrence and infestation level so that a practical control measure can be adopted in advance.
Keywords: weedy rice;infestation;seed bank;mathematic model;prediction;

Locally produced Bioactive Compost spreads weed seed in Fiji

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Humans play a pivotal role in the spread of weed seeds. A study to determine the presence and identity of weed seeds in a bioactive compost produced and sold locally in Fiji was undertaken in Suva Fiji in 2011. Bioactive compost bags were purchased from local hardware shops and contents were sampled and spread thinly over a base of pure sand in a seedling tray. The emerged seedlings were identified to species level. There were twelve weed species belonging to eight different families present in the bioactive compost. The five most frequently occurring weed species in the bioactive compost were Eleusine indica (L.) Gaertner (crowsfoot), Ludwigia octovalvis (primrose), followed by Physalis angulata L., Oxalis corniculata L. and Echinochloa colona (L.) Link. There were c. 2,000 viable weed seeds per 20 kg bag of bioactive compost. This study demonstrated that bioactive compost spreads weed seed around Fiji and is the first record of a study to determine the sources of weed seed spread in Fiji.
Keywords: Bioactive compost;weed seed spread;Fiji;Eleusine indica ;Ludwigia octovalvis ;

Integrated weed management in arable crops

Oral presentations

Decision support system for field specific herbicide spraying solutions

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Concerns regarding environmental protection and increasing weed resistance problems generate a need to optimise and reduce herbicide use. Field specific solutions possess a large potential for dose reductions compared to more general recommendations on a regional or crop level. Crop Protection Online (CPO) is a commercialised weed decision support system, which has been developed through the last 25 years to optimise both herbicide choice and dosages on a field level. The central part of CPO is herbicide dose-response curves linked to target efficacies of the different weed species. The target efficacies of the weed species are specific for crop type, crop yield potential, weed density, season and resistant biotypes. Temperature, weed developmental stage and drought stress induce parallel shift of the dose-response curves. The core program contains calculation procedures and algorithms, while the parameters are stored in databases. This enables adjustments to CPO for conditions in other countries. Several components of CPO have been implemented in Norway on a commercial basis and CPO is currently adapted through projects in Spain, Germany, Poland, Italy and Slovenia. Field validation trials in Denmark and Norway have resulted in average weed cover at harvest of 5 - 10% and 2 -3 %, respectively, and no difference for yield compared to reference treatments. The potential for herbicide reductions in Denmark and Norway has been estimated to 40 - 50% following advices from CPO on a field level. Results from barley field trials in Catalonia indicate that CPO also has a potential for herbicide reductions under more arid conditions. Site specific solutions, at least on a field level, are required to achieve substantial herbicide reductions and CPO offers a robust advice.
Keywords: decision support system;dose-response curves;weed control;reduced herbicide dose;

Review on critical period for weed control in Turkey

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The critical period for weed control (CPWC) is a component of integrated weed management strategies and general weed control programs. The aim of this paper is to review current CPWC studies in Turkey. The first study was published in potato in the West of Turkey in 1976. Later, studies in potatoes were conducted Central and East of Turkey too. The CPWC in potatoes is identical in all regions, which are 15 to 49, 14 to 49 and 10 to 40 days from emergence, which are parallel with results from other countries. CPWC studies on corn and cotton are the well-known ones including some specific weed species and main and double cropping practices. In the second crop corn CPWC starts at the same time as the main crop (for example, it starts with corn emergence for 5% or less acceptable yield loss) but it lasts longer although data are obtained from different corn producing regions of Turkey. CPWC in cotton starts at the 1st to 3rd week after emergence depending on years almost in all regions but it ends in different times from 6th week to 12th week not in regard to acceptable yield loss. CPWC for chickpea, soybean, groundnut, wheat, sugar beet, leek, bean, onion, direct seeded pepper and lettuce for some regions of Turkey has been studied, which CPWC were expressed as phenological stages of crop, calendar days or growing degree days. Although the growing degree days give more universal result, calendar days are more useful for farmers because of their educational level. Unfortunately, there is a problem extending results to practice. Further researches on CPWC in other crops are needed, in the other regions of Turkey, for different cropping systems as well as verifying current research results that would increase conveying findings to the farmers.
Keywords: CPWC;IWM;IPM;

Efforts towards the management of the invasive weed, parihenium (*Parthenium hysterophorus* L.) in eastern and southern Africa

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Parthenium (*Parthenium hysterophorus* L.), is an invasive annual plant native to sub-tropical areas of South and North America that adversely affects food security, biodiversity, and habitat conservation as well as livestock health in many parts of Africa, Asia and Australia. Its prolific production of readily-dispersed seeds, adaptability to a wide range of habitats, drought tolerance, ability to produce allelochemicals that affect surrounding plants and high growth rate, allow it rapidly and extensively colonize new areas. It caused sorghum yield loss of 40% in Ethiopia and it competes with preferred pasture species, reducing pasture carrying capacity by up to 90%. An international collaborative study conducted in Africa begun in 2005 determined that the distribution of parthenium in Ethiopia, Kenya, South Africa, Swaziland, Tanzania and Uganda was more extensive than previously known. CLIMAX modeling indicated that most of sub-Saharan Africa is climatically suitable for the favorable growth of parthenium. Efforts to control parthenium biologically, using introduced natural enemies were initiated in Ethiopia in 2007. Release of the leaf-feeding beetle, Zygogramma bicolorata *(Coleoptera: Chrysomelidae*) in South Africa and Ethiopia is pending, while release of the stem-boring weevil, *Listronotus setosipennis* (*Coleoptera: Curculionidae*), is pending in South Africa and still under evaluation in Ethiopia. Biological agents in combination with cultural control measures are necessary to reduce the adverse impact of parthenium on food crops and livestock in eastern and southern Africa.
Keywords: Parthenium;Biological Control;Food Security;Weed;Africa;

Implementation of Integrated Pest Management – Denmark as an example

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By 2014 farmers in the European Union must grow their crops according to the IPM principles as formulated in the Directive on Sustainable Use of Pesticides (2009/128/EC). In Denmark implementation of IPM, including integrated weed management, in arable crops was initiated in 2010 and will continue until the end of 2015. The Danish Agricultural Advisory Service (DAAS), which is owned by the Danish farmers, is responsible for transferring the overall IPM principles into concrete tools and best management practices. The Danish government provides funding for a demonstration project with five demo farms and a project with 'IPM advisory packages' for about 1400 farmers.
The objective of the Knowledge Centre for Agriculture in DAAS is to synthesize knowledge about IPM, including weed control, and formulate tools and best practices which can easily be implemented by the farmer. For the main crops we have formulated IPM tool boxes telling what to do, how to do it, and why. This also serves as a list of content for the advisers involved in advising the farmers three times a year during a period of two years. Crop rotation, mechanical weed control, anti-herbicide resistance strategies, monitoring and mapping of weeds, avoiding spread of noxious weeds, are among the main subjects.
An IPM point system has been developed for the evaluation of the efficiency of demonstrations and advice as instruments to enhance the use of IPM. The point system contains questions about IPM awareness and practice on the farm and will be used at the beginning of the two-year period and again at the end.
It can already be concluded that in order to ensure ownership and engagement in implementing IPM, it is important that tools and best practices are adaptable to the daily routines on the farm, and that the economic impact is positive or at least neutral.
Keywords: IPM;Implementation;Farmers behavior;Advisory service;Tools;

Long term tillage and integrated weed management on weed shift, weed control efficiency and productivity of maize – sunflower cropping system in vertisols

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Tillage or soil surface manipulation to obtain desired seedbed is a major input in agricultural production and helps in controlling weeds. Field experiments were conducted from 2005 to 2010 at Tamil Nadu Agricultural University research farm to develop information on weed population dynamics in maize – sunflower cropping system. Main plot consisted of four tillage methods viz., Zero tillage (ZT) followed by ZT, ZT – Conventional tillage (CT), CT-ZT and CT - CT for maize - sunflower cropping system. Weed management methods were adopted for both the crops were HW on 25 & 45 DAS, PE herbicides (Atrazine 0.5 a.i. kg/ha for maize and Pendimethalin @ 1.0 a.i. kg/ha for sunflower) with HW on 45 DAS and Un Weeded Control. Cynodon dactylon, Panicum repens, Digera arvensis and Chloris barbata in grasses, Cyperus rotundus in sedges and Trianthema portulacastrum, Parthenium hysterophorous, Digera arvensis and Datura metal in BLWs were dominant weeds. Continuous ZT encouraged more of grass weeds

and increased the compaction of soil which results in lower yield and economics compared with high yield economics in CT. Lower bulk density and higher total porosity, infiltration rate and available soil N, P and K were recorded in CT combined with HW twice and PE herbicide application. The CT recorded more number of bacteria, fungi and actinomycets in the cropping system. In weed seed bank study increased density of grasses was observed in ZT and lower density was recorded in CT. The relative density of grasses and BLWs were constant in CT-CT tillage system.
Keywords: Tillage;Weed shift;Maize; Sunflower;Weed management;

Weed management of small grains in California

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Weed control is a major issue in small grain production in California. Oftentimes both broadleaf and grassy weeds are problematic in wheat production requiring the use of two different herbicides with different application timing. To cut costs, growers are interested in combining applications. However, crop safety and efficacy with herbicide combinations is a concern and the appropriate application timing was not been well tested. Several research studies were conducted to evaluate weed control and crop safety with selected new and standard herbicides applied alone and in combination and at different growth stages. In addition evaluations included the addition of liquid fertilizer in some trials. Herbicides evaluated included 2,4-D, dicamba, MCPA, carfentrazone, tribenuron, pinoxaden, fenoxaprop, pyroxsulam and others. Axial and Puma gave the best control of wild oats. Pyroxsulam gave good control of wild oats, fiddleneck, shepardspurse, chickweed, stinging nettle, but is weak on mustards. Triburon gave excellent control of most broadleaves but control was slow. Wheat injury at four locations was evaluated and found that in general, herbicide treatments had little to no crop injury at any site. The wheat injury caused by most of the tank mixtures with carfentazone, dicamba, and others disappeared after four to five weeks. Preliminary results indicated that there was no significant difference in bushel weight, protein, or yield between any of herbicide treatment combinations in the absence of weeds.
Keywords: Weed Management;Small Grains;California;

Height-to-space ratio of soybean—a simple and practical index for determining critical periods for control of red morning glory (*Ipomoea coccinea*)

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In Japan, some alien annual morning glory species (*Ipomoea* spp.) have invaded soybean fields and have caused serious weed problems. The rapidly growing vines climb and wrap soybean plants and considerably reduce the yield. A field study was conducted over 2 yr (2010–2011) to determine the period taken from the emergence to the beginning of vine elongation and the critical periods for control of red morning glory (*Ipomoea coccinea*) in soybean fields at 3 seeding timings (mid June, early July, and early August) and 2 row spacings (60 cm and 36 cm). Ten scarified seeds of red morning glory were seeded in the middle area between rows at 1-cm depth and 5-cm intervals at 0, 5, and 7 weeks after seeding soybean in 2010 and at 0, 1, 2, 3, 4, 5, 6, and 7 weeks after seeding in 2011. The periods from emergence to beginning of vine elongation varied from 2 to 4 weeks. In all cases, the red morning glory seeds planted after the light intensity at the soil surface in the interrow position reduced to less than 50% of the relative photosynthetic photon flux density (PPFD) died or grew weakly, even if they survived. The canopy height-to-row space ratio (defined as the height-to-space ratio) at 50% of the relative PPFD was almost 1 for all seeding timings and row spacings in both years. On the basis of this ratio, all the red morning glory plants could be completely controlled by cultural and chemical control practices until the height-to-space ratio reached 1, that is, 60 cm canopy height in a soybean field with 60 cm row spacing. Thus, the height-to-space ratio may be useful as a simple and practical index for determining the critical period for the control of red morning glory in soybean fields.
Keywords: alien weeds;Ipomoea;canopy height;row spacing;soybean;

Management of great bromes (*Bromus diandrus* Roth) within Western Australian wheat belt

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Brome grass is highly competitive in wheat crops resulting in wheat yield reduction by 30% in Western Australia (WA). A two-year rotation trial (2009 to 2010) at Northam (31.653 S, 116.699 E), WA examined the effect of stubble mulching, tillage methods and herbicides on crop establishment, seed bank biology and control of brome grass, and wheat yield. Brome grass plant and head density, crop phytotoxicity and crop grain yield were measured. Brome grass seed bank was monitored by sampling soils from the exclusion zones and subjecting the collected soils to weed seedling emergence.
In disc sowing system where stubble was present at sowing, all soil-applied herbicides caused injury to the crop in 2009 only but pyroxasulfone and trifluralin appeared much safer on wheat crop than prosulfocarb + s-metolachlor. In knife point sowing system, phytotoxicity from herbicides was nil or very low. Pyroxasulfone was more effective in controlling brome grass than trifluralin and prosulfocarb + s-metolachlor. Brome grass seed head production was the lowest in pyroxasulfone and lower in prosulfocarb + s-metolachlor plots compared to trifluralin. Herbicides increased wheat grain yield by 10 to 16% in 2009 and 23 to 31% in 2010, compared to the untreated control. In absence of fresh recruitment, herbicides significantly reduced residual seed bank. However, pyroxasulfone and prosulfocarb + s-metolachlor appeared to have lower residual seed bank than trifluralin. Disc and knife sowing systems had lower residual seed bank of brome grass seed than full-cut sowing systems. The results suggest that pyroxasulfone applied with knife point or disc sowing systems was the safest on wheat crop, provided the most effective control of brome grass and greatest reduction in residual seed bank, and increased wheat grain yield.

Keywords: Brome grass;stubble;tillage;soil applied herbicides;seed bank dynamics;

The renewed role of residual herbicides in weed management in cotton

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Lack of rotation of crop and/or herbicides in major arable crops around the world has led to the evolution of numerous herbicide-resistant weeds that are not controlled with the available modes of action. The intensive adoption of minimum tillage and glyphosate resistant (RR) crops dramatically increased the severity of the wide ranging infestation of 'hard to kill' weeds. Of particular importance is the recent evolution and rapid distribution of weeds resistant to glyphosate – one of the most widely used herbicides applied in high frequency in RR crops. The over reliance on glyphosate as the single solution for weed control in a continuous RR crop rotation and the abandonment of the residual herbicides significantly facilitated the evolution and spread of glyphosate resistant weeds. The threats imposed by herbicide resistance on the sustainability of the agro-ecosystem and food supply resulted in an increased awareness of the public, farmers and chemical producers alike, to the dangers associated with this phenomenon. Inclusion of residual herbicides with different modes of action improves the efficacy and broadens the range of controlled weeds and limits the further spread of troublesome and resistant weeds. A practical example of an ongoing program combining residual herbicides such as diuron, prometryn and fluometuron could be demonstrated in RR cotton in the US. Under such conditions where Palmer amaranth (Amaranthus palmeri) evolved resistance to glyphosate, farmers are being rewarded for using these residuals along with glyphosate as part of their weed management practice, hence contributing to the sustainability and profitability of cotton production. This approach should be applicable to other arable crops, e.g. soybean and corn, not only in the US, but worldwide.
Keywords: diuron;prometryn;fluometuron;glyphosate;

Bio- efficacy of clethodim against grassy weeds in blackgram (*Vigna mungo* (L.) Hepper) and its residual effect on succeeding maize crop

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A field experiment was conducted during rainy season of 2009-10 and 2010-11 at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh, India to evaluate the bio-efficacy of clethodim against grassy weeds in blackgram and its residual effect on succeeding crop of maize during rabi. The post-emergence treatments applied at 20 days after sowing (DAS) include clethodim at 36, 48, 60 g/ha with 0.25% Non ionic surfactant (NIS) plus 0.04% Ammonium sulphate (AMS), clethodim 48 g/ha with 0.25 % NIS, clethodim 48 g/ha with 0.04 % AMS, clethodim at 48 g/ha and 96 g/ha (for phyto-toxicity) in comparison with standard herbicides quizalofop ethyl 50 g/ha, fenoxa prop ethryl 67.5 g/ha, hand weeding at 15 and 30 DAS and weedy check. All the treatments were replicated thrice in a randomized block design. Results revealed that among the different doses of clethodim, post emergence application of clethodim 60 g/h, reduced grassy weed growth and recorded higher crop dry weight, yield components and seed yield (421 kg/ha) over its lower dose (36 g/ha) but was on par with its next lower dose of 48 g/ha with NIS or AMS. None of the doses of clethodim including the highest dose (96 g/ha) did not cause any injury to blackgram. In field experiment residual carry over effect of clethodim at different doses of 36 to 96 g/ha were studied using maize as succeeding indicator crop. Difference were non significant on plant population, yield and yield components of maize indicating that there was no residual effect of clethodim in soil after harvest of blackgram crop. It can be concluded that the post emergence application of clethodim 60 g/ha with 0.25 % NIS and 0.04% AMS was found to be effective in controlling grassy weeds without any crop injury and residual effect on succeeding crop
Keywords: Clethodim;Grassy weeds;blackgram;

Effect of Tembotrione on mixed weed complex in maize

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Maize (Zea mays L.) is an important cereal crop in many developed and developing countries of the world and, provides more food than any other cereal. Weeds constitute a major component among the bottlenecks for successful crop production. The degree of crop- weed competition is determined by the weed species and density, duration of infestation, associated crops in the field, growth habit of crop plants and environmental conditions. The early control of weeds in maize is vital for maximizing yield. Early maize plants are not competitive and their growth can be severely restricted if weeds are not controlled. In recent years, various types of improved herbicide have been developed, but the efficiency of herbicides has to be evaluated in different places with different molecules. Hence, to evaluate the efficiency of new herbicide Tembotrione 42% SC as early post emergence application against mixed weed flora in irrigated maize, a field experiment was conducted during January 2010 and March 2010 at Tamil Nadu Agricultural University, Coimbatore, India. The experiment involved twelve treatments viz., application of Tembotrione 42% SC @ 100 g/ha-1, 110 g/ha-1, 120 g/ha-1, 240 g/ha-1 with surfactant and application of Atrazine 50%WP @ 1000 g/ha-1, 2,4D Na salt 80%WP @ 800 g/ha-1 and Diuron 80%WP @ 1000 g/ha-1 with unweeded control and hand weeding rice at 20 and 40 DAS. Maize hybrid COH(M)5 was sown with a spacing of 60 cm x 25 cm. Weed characters were studied at 15, 30, 45 and 60 DAS. The results revealed that the Tembotrione 120 g/ha + Surfactant 1000 ml/ha has showed a good weed control against the weed flora. The maximum grain yield of 5861 kg/ha was achieved with the application of Tembotrione @ of 120 g/ha + Surfactant 1000 ml/ha and was the best treatment compared to all the other herbicidal treatments. However, higher yield and effective control of weeds in maize was achieved by application of Tembotrione 120 g/ha + Surfactant 1000 ml/ha without any phytotoxicity.
Keywords: tembotrione;maize;weed complex;

Efficacy of propaquizafop 10 EC, quizalofop ethyl 5 EC and fenaxy-p-ethyl 9 EC on control of annual grassy weeds in *Vigna mungo* (L.) Hepper during rainy season under rainfed situation

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Vigna mungo (L.) Hepper (Black gram) is an important food legume in India. The crop is generally grown as sole crop during rainy season (June to October) in Southern India under rainfed situation and in rice fallows in summer (January to April). Weeds pose serious problems and weeds alone cause 50 to 60 % yield losses in black gram. Pre-emergence herbicides have certain limitations in their applications. With the changing scenario in weed management, there is need for effective post-emergence herbicides for control of annual grassy weeds. Therefore, field trial was carried out on medium Vertisols during rainy seasons (June-October) (2004 to 2005 and 2009) under rainfed situations at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka State, India) to evaluate the efficacy of three post-emergence {Propaquizafop 10 EC (SOCEITY 10 EC), Quizalofop ethyl 5 EC (TARGA SUPER 5 EC) and Fenoxaprop-p-ethyl 9 EC (WHIP SUPER)} on control of annual grassy weeds in black gram. Rainfall during the cropping seasons of 2004, 2005 and 2009 was 194.9 mm (16 RD), 598.7 mm (46 RD) and 674.2 mm (43 RD), respectively. These results indicated that post-emergence application of either Propaquizafop 10 EC (50 to 200 g/ha) or Quizalofop ethyl 5 EC (50 g/ha) or Fenoxaprop-p-ethyl 9 EC (100 g/ha) produced 28.13 to 64.38 per cent higher seed yield of blackgram over weedy check treatment (1269 kg/ha). Annual grassy weeds (*Digitaria* Spp. *Eleusine indica* L, *Dinebra retroflex* Panz, *Echinochloa colonum* L., *Pannicum* Spp and *Setaria* Spp.) were effectively knocked down by all the post-emergence herbicides. All herbicides did not control broadleaves. The weed control efficiency tended to decreases with increase in moisture stress.
Keywords: Quizalofop ethyl 5 EC ; Propaquizafop 10 EC; Fenaxaprop-p-ethyl 9 EC ; annual grassy weeds;

Alternatives to glyphosate for summer grass control

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The sub-tropical grain region of Australia stretches from northern New South Wales to central Queensland, where both summer and winter crops are grown. A 6-10 month fallow (non-crop period) is needed between crops to conserve soil moisture for the following crop. Summer grass weed species Echinochloa colona, Chloris virgata and C. truncata are problematic during summer fallow and use stored water. Zero-tilled, chemical fallows are common where glyphosate is relied upon for weed management. As a result, populations of E. colona and C. truncata have developed glyphosate resistance. Furthermore, glyphosate does not provide reliable control of C. virgata. The objective of this study was to identify effective alternatives to glyphosate for fallow control of these summer grass species.The most effective chemical tactic identified was the double knock with >98% field control. Double knock is the sequential application of two different weed control tactics so that the second tactic controls survivors of the first. A pot experiment evaluated the impact of different double knock treatments; glyphosate followed by paraquat (traditional), and haloxyfop followed by paraquat (new), and assessed the affect of timing between knocks on efficacy. A field experiment assessed the inclusion of a residual herbicide as part of the double knock. Residual herbicides significantly reduced subsequent emergences with best treatments metolachlor and metolachlor + atrazine giving 96 and 92% reduction respectively.The affect of different forms of tillage on emergence was assessed in two field experiments. All forms of tillage reduced emergence of all three weed species (40 - 100%) and caused different levels of seed burial.Effective chemical and non-chemical alternatives to glyphosate have been identified. Application of these alternatives in an integrated approach will improve long-term control of key summer grass weed species, limiting seed bank replenishment and reducing risk for glyphosate resistance.
Keywords: Echinochloa colona;Chloris truncata;Chloris virgata;glyphosate;double knock;

Uses of saflufenacil: synergism with herbicides of different mechanisms of action, response of adjuvants and residual effect in combination with imazapic and graminicides

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The research project was developed with three main objectives: (a) evaluate the synergistic effect of the combination of saflufenacil with imazapic and glyphosate, (b) compare the efficacy of adjuvant based on mineral and vegetable oil, associated with saflufenacil and (c) assessing the viability of using the herbicide saflufenacil in pre-emergence and associated with imazapic and graminicides. All tests were conducted in greenhouse conditions at ESALQ-USP, using the weeds Euphorbia heterophylla and Ipomoea grandifolia, experimental design of randomized blocks, four replications. Evaluations were performed at 15, 30, 45 and 60 days after treatments (DAT), by visual ratings, and data were subjected to analysis of variance, being significant by F test, mean were compared using the Tukey test at 5% probability. The results showed that the herbicide saflufenacil, associated with glyphosate or imazapic, promotes a synergistic effect with these herbicides, thus ensuring effective control of these herbicides in the studied weeds. The addition of mineral or vegetable oil in the spray mixture with the herbicide saflufenacil is needed in post-emergence application; however, both mineral and vegetable oil had the same efficacy in this study. The association of saflufenacil with imazapic in pre-emergence conditions showed synergist increases in the residual effect of imazapic. These results allow stating that in general the herbicide saflufenacil is a very important tool in weed management in agriculture, and the synergistic effects of the herbicide combinations with different mechanisms of actions should be better exploited in agriculture.
Keywords: saflufenacil;adjuvantes;synergism;imazapic;glyphosate;

Poster presentations

The culture method of Copperleaf (*Acalypha australis* L.) as a new target for herbicide activity screening in greenhouse

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Copperleaf (*Acalypha australis* L.), a common weed in Northern China, is difficult to control and makes a great loss of agricultural production in recent years. Moreover, the Copperleaf has showed a trend of more and more crazy. To control the Copperleaf effetely and minimize the loss made by the copperleaf, the biological characteristics of Copperleaf seeds and the patterns of its growth and development were under research. The results indicated that the optimal temperature for the copperleaf seeds germination is 25-30^{o}C and the optimal soil water condition is about 80% of the maximum water capacity of the soil. The copperleaf can live from spring to autumn in warm and humid climate. The weak alkaline is the best soil condition for the copperleaf living. The appropriate thickness of covering soil in planting is 1-1.5 cm and the ratio of seedling emergence is decreased significantly when the thickness is more than 2 cm. Under the suitable growth condition, the copperleaf can seedling emergence from the seeds at about 7-14 days after planting. Summarily, the copperleaf can be cultivated and breeding in greenhouse in large-scale and continuously, which can be benefit to the study in future. Meanwhile, the study on chemical control of copperleaf in greenhouse was also carried out, which showed that the novel herbicidal compound BAS 800H developed by BASF could control the copperleaf before the living stage of forth leaves, with a dose of 36 g a.i./ha.

Control effect on *Cirsium setosum* of several herbicides in field

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Cirsium setosum is an important weed grown in wheat, maize or soybean fields and dry loose soil in China. They can not only compete for water, nutrients, sunlight and growth space with crops, but also are the host of sunflower sclerotinia rot and cotton aphid which is the plant viral disease transmission mediator. Field efficacy trails were conducted to define the control effects on *Cirsium setosum* of 18 different mechanism herbicides which were dicamba, tribenuron-methyl, 2,4-D butylate.picloram, carfentrazone, bromoxynil octanoate, fluoroglycofen-ethyl, 2,4-D butylate, mesotrione, fomesafen, paraquat, pyroxsulam, nicosulfuron, atrazine, glyphosate, MCPA, bentazon and lactofen. The results showed that, yellow, dry leaves and malformed pants were observed on Cirsium setosum after 10d for treatment in most treated areas. The amount and weight control effects of 2,4-D butylate.picloram 26% EC and dicamba 48% AS were 71.19%, 70.69% and 91.63%, 88.67% respectively and better than other herbicides on the thirty day after treatment. The control effect of fluoroglycofen-ethyl 10% EC and glyphosate 41% AS were followed, with the amount control effects were 64.88% and 63.15% respectively, and the weight control effects were both 84.69%. The control effect of other herbicides was lower than 60%. Resuscitation rates of Cirsium setosum in paraquat, bromoxynil octanoate and lactofen treatment areas were higher than others, and control effect was reduced 30 d after treatment. In conclusion, 2,4-D butylate.picloram, dicamba, fluoroglycofen-ethyl, glyphosate can be used to control Cirsium setosum. Long-term management of weeds is best achieved through farming adjustment, interchangeable of different herbicides or using mixed herbicides.
Keywords: *Cirsium setosum*; control effect; herbicides;

Status of weed infestation in Soybeen RR crop in Brazi

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Soybean is the main crop in Brazil, with 23.2 million ha grown last season (2010/11), the mainly producers regions are South/Southeast (44.2%) and Center West/Northeast (53.4%). Since the release of the planting of RR soybeans in Brazil, in 2005, Embrapa Soybean has been doing an annual monitoring of the situation of this GMO crop. The first region to use this technology was the South since the adoption has grown toward the North due to the development of adapted cultivars. In the last season the soybean RR was cultivated in 80% of the total area of the soybean crop, with 85% in the South/Southeast and 65% in the Center West/Northeast. The average number of glyphosate applications has remained stable, being 2.4 per property in the last season. However, the doses of glyphosate per unit area has increased from 768 g ae/ha in 2005/06 to 1584 g ae/ha in 2010/11. There was also a large increase in the addition of other herbicides to glyphosate, which in 2005/06 was 4.9% against 64.2% achieved last season, including herbicides applied in burndown. Currently, the main weeds tolerant to glyphosate are Commelina sp., Ipomea sp., Richardia brasiliensis, Tridax procumbes, Chamaesyce hirta, Spermacoce latifolia and Eleusine indica. Five cases of glyphosate resistant weeds have been registered in Brazil: *Conyza bonariensis*, *Conyza canadensis*, *Conyza sumatrensis*, *Digitaria insularis*, and *Lolium multiflorum*. The volunteer soybean RR control is also a problem, because these plants infest winter crops and reproduce diseases as soybean rust (*Phakopsora pachyrhizi*). In conclusion, the RR soybean is probably going to be cultivated in almost the total area of this crop in Brazil; the glyphosate dependence is increasing, and the problems with tolerant and resistant weeds are also increasing.

Combination of nicosulfuron and wheat straw mulching on yellowtop (*Flaveria bidentis*) control in summer corn

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Yellowtop (*Flaveria bidentis*),native to North America, was first observed in China in 2003 and spread to four provinces within 8 years. It could germinate in roadsides, ditch edges, construction waste grounds, wastelands, urban green spaces and farm lands causing environment problems and yield loss through competition and allelopathic interactions. The population of yellowtop infested summer corn reduced corn yield by 10% to 30% accordingly due to lack of appropriate management. Winter wheat- summer corn double cropping is widely practiced in China and generally wheat straw was spread to cover the field before corn seeded. Nicosulfuron was registered in corn to control broad leaf weeds and grass weeds as post application. But little information is available on the combination of nicosulfuron and wheat straw mulching for selective yellowtop control in summer corn. Therefore, the objective of this research was to evaluate the effects of nicosulfuron and the combination of the herbicide with wheat straw on yellowtop control and corn yield. Field experiment was conducted in 2009 to 2010,in Hebei,China, with a factorial design. The main plots were mulched with wheat straw of the following rates 0, 1500, 3000, 4500 kg/ha before corn seeded and sub-plots were treatments with nicosulfuron 0, 30,45,60g ai/ha each. The results revealed that mulching with wheat residues markedly reduced the density of yellowtop by 39.1%-77.8% and combining straw mulching 4500 kg/ha with nicosulfuron 30g ai/ha site specific applied at 3 to 5 leaf stages of yellowtop controled the weed by 99.8% without yield reduction of corn, which was 28.6% greater than the same rate of nicosulfuron without mulching. That concluded that straw mulching could promote weed control efficacy combining with herbicide in yellowtop management.
Keywords: Yellowtop;Straw Mulching ;Nicosulfuron;Control;

Efficacy of post-emergence herbicides on control of annual grassy weeds in *Arachis hypogaea* L. during rainy season under rainfed farming situations

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Arachis hypogaea L. (Groundnut) is an important oilseed crop of India. It is mainly grown during rainy season in Karnataka state. The weeds pose serious problem and weeds alone account for one-third of the total loss due to pests weed infestation is considered as one of the critical factors for rainy season groundnut. In addition, if the groundnut field is left un-weeded during rainy season, planting of succeeding crop during post rainy season under rainfed situation would be very difficult or some times not possible at all, particularly in the regions where double cropping is practiced. Pre-emergence herbicides have certain limitations in their applications. With the changing scenario in weed management, farmers in a need of effective post-emergence herbicide for control of annual grassy weeds. Therefore, field trial on medium Vertisols during 2006 to 2008 was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka State, India) to study the effect of pre-emergence and post-emergence herbicide alone or in combination on control of annual grassy weeds in groundnut during rainy season (June-October). Results indicated that post emergence application of Quizalofop Ethyl 5 EC @ 50 g/ha at 23 to 33 days after groundnut sowing was most effective against annual grassy weeds (Digitaria Spp. *Eleusine indica* L, *Dinebra retroflexa Panz*, *Echinochloa colonum* L., *Pannicum* Spp., and *Setaria* Spp.) compared to post-emergence application of Imazethapyr (10 WSC) @ 50 to 75 g/ha. Grassy weeds were completely killed by Quizalofop Ethyl 5 EC. On the other hand, grassy weeds were regenerated in Imazethapyr applied plots. Pre-emergence application of Pendimethalin (30 % EC) @ 1000 g/ha was more effective in controlling monocot and dicot weeds.
Keywords: Quizalofop ethyl 5 EC;Pendimethalin (30 % EC);Dicot weeds;Monocot weeds;

Nitrogen uptake by weeds is reduced with use of polymer-coated urea compared with urea

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Previous studies have documented that weeds, as well as crops, respond positively to nitrogen fertilizer. Multi-year field experiments were conducted at three sites in Alberta, Canada to determine whether nitrogen uptake by weeds would be affected by nitrogen fertilizer formulation. Urea (46-0-0) was compared with polymer-coated urea [Environmentally Smart Nitrogen (ESN), Agrium Inc.] in a no-till canola (*Brassica napus*) production system. Both urea fertilizer forms were side-banded 3 cm away and 4 cm below the canola seed row during the planting operation. Weed shoot nitrogen concentration was determined 4 and 8 weeks after emergence (WAE) by randomly collecting 5 to 10 plants of each species per plot and analyzing for nitrogen using an automated combustion analyzer coupled with a mass spectrometer. Results indicated that nitrogen concentration of wild oat (*Avena fatua*) was lower with ESN compared with urea in 4 of 9 and 9 of 9 site-years at 4 and 8 WAE, respectively. Wild buckwheat (*Polygonum convolvulus*) nitrogen concentration was lower with ESN than urea in 3 of 7 and 6 of 7 site-years at 4 and 8 WAE, respectively. Nitrogen concentration of catchweed bedstraw (*Galium aparine*) was lower with ESN compared with urea in 1 of 2 and 2 of 2 site-years at 4 and 8 WAE, respectively. This reduced nitrogen uptake by weeds with ESN compared with urea fertilizer resulted in higher canola yields in 35% of the cases. Seed oil concentration of canola (mean value of 436 g kg^{-1}) was similar with ESN and urea in all site-years, indicating that canola quality was maintained with ESN fertilizer use. Fertilization with the slower nitrogen release form of urea (ESN) compared with urea exhibited potential to reduce weed competitiveness and increase canola productivity.
Keywords: nitrogen fertilizer;slow release nitrogen;weed competition;nitrogen uptake;canola;

Effects of winter cereal cover crop mulches on weeds, yield and sugar content of sugar beet (*Beta Vulgaris* L.)

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Weeds have always been known as a limiting factor in sugar beet production. As the sugar beet plant is a poor competitor against weeds (especially in early growth stage) and the cost of conventional method of weed control (Hand weeding) is very high, so nonchemical management before planting can help weed control in sugar beet. For the spring planting of sugar beet, seed bed must be prepared in autumn and planting narrow leaf cover crops among the rows of sugar beet leads to germination reduction and spring weed growth. In previous research the use of winter cover crop reduced total annual spring weed biomass by 70%.In order to determine the effects of winter narrow-leaf cereal as cover crops on weed management, root and sugar yield and sugar content of sugar beet and to determine the benefits of seed bed preparation in autumn instead of spring, a field study was conducted in 2008-2009 at Iranian Research Institute of Plant Protection, Tehran, Iran. Cover crop systems included Wheat (*Triticum aestivum* L.), Barley (*Hordeum vulgare* L.) Triticale (X tri*ticosecale*) and Rye (*Secale cereale* L.) and integrated treatments (cover crops +herbicide) compared with weed free, weedy and conventional herbicide (Betanal progress AM) controls. Results showed that weed suppression by all cover crops was the same as conventional herbicide (Betanal AM).Total weed biomass reduction in barley and rye treatment was the same as conventional herbicide. The lowest total weed biomass at the end of growth cycle was observed in barley+betanal herbicide treatment. Barley cover crop+betanal herbicide suppress weeds more efficiently than other treatments and gave the highest root and sugar yield (29.83 and 4.47t/ha respectively).If seed bed preparation done in autumn, planting of barley, rye, wheat and triticale cover crops between the rows of sugar beet is recommended and will lead in prevalent weed suppression, consequently quantitative and qualitative sugar beet yield increase.
Keywords: cover crops;herbicide;mulches;sugar beet;weeds

Efficacy of different formulation of Imazethapyr on control of weeds in *Arachis hypogaea* L. and its residual effect on succeeding wheat in groundnut-wheat sequence cropping system

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Weeds pose serious problem in groundnut cultivation and weeds alone account for one-third of the total yield losses due to pests. Pre-emergence herbicides have certain limitations in their applications. Post-emergence herbicide like Imazethapyr has certain advantages in weed management in crops. However, the knowledge on the efficacy and effect of post-emergence application of different formulations of Imazethapyr on control of weeds in groundnut and its residual toxicity on succeeding rainfed wheat crop are meager. Therefore, field trials were conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka State, India) during 2008 to 2010 to study the effect and efficacy of different formulations of Imazethapyr on control of weeds in groundnut and its residual effects on succeeding wheat crop. Results of the trials showed that post-emergence application of either Imazethapyr XL 10 SL formulation (500 to 1500 ml/ha) or Imazethapyr 10 % SL formulation (1000 ml to 1500 ml/ha) sprayed 23 to 33 days after groundnut sowing suppressed the growth of both dicot (broad leaved) and monocot weeds (annual grassy weeds). Both the formulations of Imazethapyr failed to knock down the weeds completely. On the contrary, annual grassy weeds showed regeneration/re-growth in the plots which received post-emergence application of both the formulation of Imazethapyr. Post-emergence application of both the formulation of Imazethapyr applied @ 1000 ml to 1500 ml/ha although suppressed the weeds in groundnut had resulted in reduced plant height, reduced number of pods/plant, reduced pod weight/plant and reduced pod yield of groundnut over weed free check treatment. Further, post-emergence application of Imazethapyr (both formulations) which were used for control of weeds in preceding groundnut resulted in 100 per cent residual phyto-toxicity on succeeding rainfed wheat crop sown 90 days after Imazethapyr application in preceding groundnut crop (wheat seeds did not germinate in Imazethapyr treated plots).
Key words: Imazethapyr XL 10 SL, Imazethapyr 10 % SL, Phyto-toxicity, Dicot weeds, Monocot weeds

Efficacy of Odyssey 70 % WG on control of weeds in *Arachis hypogaea* L. during rainy season and its residual toxicity on succeeding cereal crops during post-rainy season

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Weeds pose serious problem in groundnut production. Pre-emergence herbicides have certain limitations in their applications. With the changing scenario in weed management, there is need to evaluate effective post-emergence herbicide/s for control of weeds. Therefore, a field trial was conducted at MARS, UAS, Dharwad (Karnataka State, India) on medium Vertisols during 2010 to evaluate the efficacy of Odyssey 70 % WG on control of weeds in groundnut and its residual effects on succeeding cereal crops. Results of the trial showed that post-emergence application of Odyssey 70 % WG (35 % Imazethapyr 10 % SL + 35 % Imazamox 12 % SL) applied at different rates (52.50, 61.25, 70.00 and 140.00 g/ha) with or without MSO adjuvant was very effective in suppressing growth and bio-mass of annual grassy and broad leaved weeds. Post-emergence application of Odyssey 70 % WG applied at different rates also resulted in higher weed control efficiency and higher pod yield over weedy check treatment. Post-emergence application of Odyssey 70 % WG @ 140 g/ha alone or with MSO adjuvant reduced pod yield of groundnut. Post-emergence application of Odyssey 70 % WG at different rates with or without adjuvant used for control of weeds in groundnut during rainy season did not cause any residual phytotoxicity on succeeding post rainy season cereal crops such as wheat, sorghum and maize. Thus, it can be concluded that post-emergence application of Odyssey 70 % WG @ 52.50, 61.25 and 70.00 g/ha with or without MSO adjuvant found most effective in reducing growth and bio-mass of weeds in groundnut. Post-emergence application of

Odyssey 70 % WG used for control weeds in preceding groundnut crop did not cause any residual phytotoxicity on succeeding cereal crops sown 179 days after herbicide application.
Key words: Odyssey 70 % WG, Imazethapyr 10 % SL, Imazamox 12 % SL, Quizalofop ethyl 5 EC, Propaquizafop 10 EC

Tolerance of dry beans to halosulfuron-methy

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Four field trials were conducted over a two-year period (2009 and 2010) at Exeter and Ridgetown, Ontario to evaluate the tolerance of adzuki ('Erimo'), black ('Black Velvet'), cranberry ('Etna'), kidney ('Red Hawk'), otebo ('Hime'), pinto ('Wind Breaker'), Small Red Mexican ('Merlot') and white ('T9905') beans to halosulfuron applied postemergence (POST) at 35 and 70 g ai ha-1. All treatments including the non-treated control were maintained weed free during the growing season. Halosulfuron applied POST caused as much as 73, 7, 13, 12, 12, 11, 11 and 9% injury in adzuki, black, cranberry, kidney, otebo, pinto, Small Red Mexican (SRM) and white beans, respectively. Halosulfuron applied POST reduced adzuki bean height as much as 52 and 70% at Exeter and Ridgetown, respectively. Plant height was not affected in the other market classes of dry bean evaluated. Halosulfuron POST reduced shoot dry weight of adzuki bean 68% at both rates evaluated. Otebo and SRM bean shoot dry weight were not affected when halosulfuron was applied POST at 35 g ai ha-1 but otebo bean shoot dry weight was reduced 12% and SRM bean shoot dry weight was reduced 14% at 70 g ai ha-1. Shoot dry weight of black, cranberry, kidney, pinto and white bean was not affected with either rate of halosulfuron. Halosulfuron applied POST resulted in a delay in maturity of adzuki, cranberry and kidney bean but the maturity of the other market classes was not affected. Seed yield of adzuki bean was decreased 58% at 35 g ai ha-1 and 68% at 70 g ai ha-1 with halosulfuron. White bean yield was not affected with halosulfuron applied POST at 35 g ai ha-1 but was reduced 9% at 70 g ai ha-1. Seed yield of black, cranberry, kidney, otebo, pinto and SRM bean was not reduced with either rate of halosulfuron.
Keywords: Sensitivity;white bean;black bean;adzuki bean;pinto bean;

Weed control and sensitivity of oats with various doses of saflufenacil

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Saflufenacil is a new herbicide being developed by BASF for broadleaved weed control in maize, soybean and other crops prior to crop emergence. Six field studies were conducted in Ontario, Canada over a three year period (2008 to 2010) to evaluate the potential of saflufenacil applied pre-emergence (PRE) at various doses for broadleaved weed control in oats. Saflufenacil applied PRE caused minimal visible injury at 1, 2 and 4 weeks after emergence (WAE) in oats. At 4 WAE, the dose of saflufenacil required to provide 95% control of *Ambrosia artemisiifolia* (common ragweed), *Chenopodium album* (common lambsquarters), *Polygonum convolvulus* (wild buckwheat), *Polygonum scabrum* (green smartweed) and *Sinapsis arvensis* (wild mustard) was 72 to >100, >100, 74, 58 and >100 g ai ha-1, respectively. Generally, similar saflufenacil dose response trends were seen at 8 WAE. The doses of saflufenacil required to provide 95% reduction in density and dry weight ranged from 95 to >100 and 42 to >100 g ai ha-1 respectively for *A. artemisiifolia*, *C. album*, *P. convolvulus*, *P. scabrum* and *S. arvensis*. Oat yield showed no sensitivity to saflufenacil at the doses evaluated. Based on this study, saflufenacil applied PRE can be safely used in spring planted oats for the control of some troublesome annual broadleaved weeds.
Keywords: broadleaved weeds;saflufenacil;weed dry weight;yield;oats;

Responses of spring planted barley, durum wheat, oats, and wheat to pyroxasulfone

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Pyroxasulfone is a new herbicide being developed for weed control in corn, soybean and other crops prior to crop emergence. There is little information on the tolerance of spring planted cereals to pyroxasulfone under Ontario environmental conditions. Four field studies were conducted in Ontario over a three year period (2009 to 2011) to evaluate the tolerance of spring planted barley, durum wheat, oats, and wheat to pyroxasulfone applied preemergence (PRE) at 62.5, 125, 250, and 500 g ai/ha. Regression equations were used to calculate the predicted pyroxasulfone doses (g ai/ha) that resulted in 5, 10 or 20% injury, or a 5, 10 or 20% reduction in height and yield. The dose of pyroxasulfone that caused 5% injury in spring planted barley, durum wheat, oats, and wheat was as low as 23, 14, 7, and 164 g ai/ha at 1 WAE; 40, 13, 7, and 127 g ai/ha at 2 WAE; 33, 132, 110, and 472 g ai/ha at 4 WAE; and 38, 74, 32, and >500 g ai/ha at 8 WAE, respectively. The dose of pyroxasulfone that caused 5, 10, and 20% reduction in height was 80, 160, and 321 g ai/ha in barely; 30, 58, and 128 g ai/ha in durum wheat; 16, 30, and 59 g ai/ha in oats; and 149, 299, and >500 g ai/ha in wheat, respectively. The dose of pyroxasulfone that caused 5, 10, and 20% reduction in yield was as low as 31, 63, and 126 g ai/ha in barely; 25, 49, and 98 g ai/ha in durum wheat; 8, 16, and 34 g ai/ha in oats; and 122, 244, and 489 g ai/ha in wheat, respectively. Based on this study, in general among spring planted cereals evaluated, wheat is more tolerant than barley followed by durum wheat followed by oats.
Keywords: pyroxasulfone;barley;durum wheat;oats;wheat;

Influence of late emerging weeds in glyphosate-resistant corn yield

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Fifteen field trials were established during 2009 to 2011 at various locations in Ontario, Canada and Michigan, USA to determine the effect of late emerging weeds on the yield of glyphosate-resistant corn. Data were separated into two environments based on the impact of treatment on corn yield. Environments were kept constant throughout the analysis for ease of interpretation. There were no differences among corn height for any treatments or between environments. Environment 1 (4/15 sites) had yield loss if weeds were allowed to emerge after glyphosate application at the 2 leaf stage of corn, but not if weeds were allowed to emerge after glyphosate application at the 4, 6, 8, or 10 stage of the corn. Environment 2 (11/15 sites) had no yield loss if weeds emerged after a glyphosate application at the 2 leaf corn. The most prominent weeds were ABUTH, AMARE, AMBEL, CHEAL and SETVI. While weeds were allowed to emerge after various corn leaf stages they did not necessarily impact yield, it is probable that weed seeds were added to the soil seed bank for weeds emerging at corn 2 leaf and 4 leaf corn stage (also supported by visual ratings). Weeds emerging after 6, 8, and 10 leaf corn were small (low biomass/seedlings) and most likely did not reach reproductive maturity. Based on this study, corn must be maintained weed free up to the 4-leaf stage. Any weeds emerging after that do not influence corn yield.
Keywords: glyphosate-resistant corn ;velvetleaf;lambsquarters;redroot pigweed;common ragweed;

Weed suppression ability of spring barley varieties at different stand density

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A major component of integrated weed management is the use of competitive species and varieties. It is well known that some crops are more competitive against weeds than others; however, more consideration should be given to the choice of competitive varieties within a crop species. An effective practice to optimize weed-crop competition is manipulating plant density. A decrease in the leaf area index (LAI) variation may contribute to enhanced weed suppression and increased yield.
During the period of 2008 – 2010, three two - factorial split - plot trials with four replicates were conducted in spring barley crop at Institute of Agriculture, Lithuanian research Centre for Agriculture and Forestry (55023`50``N and 23051`40``E). The trials were integrated in a five-field crop rotation consisting of winter wheat, sugar beet, spring wheat, spring barley, field pea. Spring wheat preceded spring barley. Experimental plots were arranged with varieties (Aura DS, Barke, Gustav) as the main plot factor. The selected varieties were sown to achieve target densities of 200, 400 and 600 plants m^{-2}. No weed control measures were undertaken. At the onset of foliar diseases, fungicides were applied according to the local recommendations. Leaf area index (LAI) was measured using a mobile device "SunScan". The value of LAI was higher in barley with a higher seed rate. Averaged over all experimental years, weed biomass was significantly lower in spring cereals with a higher seed rate. The regression analysis indicated that with increasing crop stand density weed biomass decreased for all spring barley varieties. The relationship between crop density and weed biomass was shown to be significant at $P<0.01$. Spring barley varieties significantly differed in weed suppressive ability, especially in the plots with low stand densities. The tall spring barley variety Aura was a better competitor against weeds compared to the short variety Gustav. Sowing density was a more important factor than variety for weed biomass reduction.
Keywords: spring barley;variety;seed rate;weeds;LAI;

Changing agricultural practices modifies the species and trait composition of the weed flora. A simulation study using a model of cropping system effects on weed dynamics

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Cropping systems change to adapt to socio-economical and environmental constraints (e.g. simplified tillage) and to profit from technological innovations (e.g. genetically-modified crops). These changes can result in unexpected side-effects which are difficult to determine in fields. The objective of the present study was to use a model, FLORSYS, to evaluate such impacts ex ante on weeds. FLORSYS quantifies the effects of crop succession, management techniques and climate on multi-specific weed dynamics over the years; it was parameterized with functional relationships predicting model parameters (e.g. seed mortality) from species traits (e.g. seed coat thickness). Cropping systems typical of three French regions and various management modifications were simulated, using a weed flora consisting of seven mostly autumnal species and local weather sets. The Aquitaine scenario (maize monoculture with annual mouldboard ploughing) presented a total maximum weed infestation of approximately 0.01 plants/m² averaged over the simulation, consisting mostly of CAPBP, with a few VERHE and AVEFA. Weed flora in Burgundy (winter oilseed rape / winter wheat / winter barley, with ploughing before wheat) was more diverse (ALOMY, GERDI, STEME, a few CAPBP). Poitou-Charentes (rape / wheat / sunflower / wheat, with ploughing three years out of four) presented a 100-times higher infestation, consisting mostly of AVEFA and a few STEME. Modifying management practices changed both weed density and composition. For instance, simplifying or abandoning tillage greatly increased weed infestation, and no-till favoured grass weeds to the detriment of broad-leaved species. Infestations were related to species traits, and the selected traits depended on cropping systems. For instance, species with heavy seeds were selected in scenarios with frequent ploughing, probably because they can germinate and emerge even when deeply buried. The present methodology is now being adapted to evaluate the impact on biodiversity of crop management practices accompanying GM varieties in the EU project AMIGA.
Keywords: Cropping systems;Species traits;Model;Simulation;

Weed control under different tillage methods and their effect on the maize yield under conditions of the Forest-Steppe zone of Ukraine

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[Background]Maize is one of the leading crops and its grain is used for food, feed, ethanol production etc. In recent years areas under this crop in Ukraine have grown up to 3.6 m. ha, and grain production exceeded 18 m. t. [Objectives]The problems of maize productivity increase and search of the ways of reduction of energy costs for its production, mainly introduction of no-till technology and efficacy weed control practices, are still very urgent for the farmers. [Materials and Methods]Field trials were carried out in 2010-2011. Three methods of soil tillage were researched in the trial:1. Plowing at the depth of 20-22 cm; 2. Disking at the depth of 10-12 cm; 3. No-till.
Two concepts were used for weed control:
1. Weed control without herbicides; 2. Topramezon 62.5 a.i. g ha-1+dicamba 160 a.i. g ha-1 + metolat 1.25 L ha-1.
The pre-sowing application of glyphosate 1440 a.i. g ha-1 took place at the no-till plots. The post-emergence application took place at 3-leaf phase of maize and grass weeds were at the 1-3 leaf stage and broad-leaved weeds were at the first true leaf stage. [Results] Analysis of research results has shown that the plots had a mixed type of weed infestation before herbicide application. Weed number on untreated plots was 138 m-2, among them such weeds as *Setaria glauca* L. – 45-76 m-2 and *Echinochloa cruss-galli* (L.) Roem. – 26-45 m-2 dominated. As for perennial species there were *Elytrigia repens* L. – 2-4 m-2 and *Convolvulus arvensis* L. – 1-3 m-2. Application of topramezon 62.5 a.i. g ha-1 + dicamba 160 a.i.g ha-1 + metolat 1.25 L ha-1 ha-1 provided 90-91 % weed control. Yield increase 2.49 t ha-1 was obtained against a background of plowing where herbicide was applied. [Conclusions] Efficacy of weed control concept has not been sufficiently different against methods soil tillage. Grain maize yield in no-till variant was reliably lower than in plowing.
Keywords: maize;weed control;tillage;no-till;herbicides;

Different fertilization affects tausch's goatgrass (*Aegilops tauschii* Coss.) competition in wheat (*Triticum aestivum* L.)

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Tausch's goatgrass is a worst weed, originated in Eastern Europe, West Asia. In the past ten years, Tausch's goatgrass become one of the most serious weeds in wheat fields in China, the outbreak area is expanding rapidly. The number of infested area estimated at 0.33 million ha. To bring serious harm to China wheat production, causing huge economic losses. A 2-year field study was conducted at Xinxiang Field Station of Institute of Plant Protection, CAAS in Henan Province to evaluate the effect of fertilizer placement on competition between winter wheat and Tausch's goatgrass. 750 kg/ha of compound fertilizer (N:P:K=14:16:15) was placed either by soil surface broadcast, or 5 cm deep-band applicaton and 2.5 cm aside the wheat row, or 10 cm deep spot application and 5 cm aside the wheat row. The study indicated that the placement of fertilizer had a significant effect on the growth and development of both Tausch's goatgrass and winter wheat. Neither fertilizer placement nor Tausch's goatgrass presence affected winter wheat emergence. It appears that with broadcast application, Tausch's goatgrass seedlings had easy access to fertilizer, compared to wheat seedlings. Placing fertilizer deep in the soil and closer to the wheat seedlings reduced the access of Tausch's goatgrass to nutrients and favored wheat seedlings. The presence of 50 Tausch's goatgrass plants/m^2 increased wheat height slightly, while the competition resulted in 2.4% spikes/m^2 decrease, 7.0% seeds/spike and 4.4% 1000-seed weight reduction, and 5.6%, 8.1%, 18.6% and 24.7% wheat yield loss in four kinds of treatments compared to the treatment of deep band fertilizer placement with Tausch's goatgrass absence.
Keywords: cultural control;weed management;deep band;deep spot;broadcast;

The opportunity and challenge of weed management in transgenic biotechnology era

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Weedy species have unexceptionally strong ability to quickly evolve and adapt to the changing agro-ecosystems under intensive human management. Consequently, weeds can successfully survive in crop fields under different environmental conditions and human's weed control. Battles between weed survival and human management of weeds are everlasting. The development of biotechnology has provided many opportunities for effective weed control under different conditions. For example, the development of genetically engineered (GE) crops with transgenes tolerant to herbicides provide an excellent case for selectively killing weeds that do not have such tolerances, particularly for those closely related to crops referred to as feral species such as weedy rice and weedy *Brassica*. It is usually very difficult to control this type of weeds by selective herbicides because of their conspecific nature to the crops. The GE herbicide tolerant crops seem to provide a solution for the effective control of feral weeds by selective herbicides. However, recent studies have shown that the introgression of transgenes (including herbicide tolerant genes) from a GE crop to its co-existing feral weeds through gene flow will bring novel traits to the feral weeds and make the weed control more complicated. This presentation will specifically address transgene flow from a GE crop to feral populations and their fitness change brought by the introduction of transgenes, using weedy rice as an example. Transgene flow to weedy species and its resultant environmental impacts well illustrate the challenge of weed management in transgenic crop fields where transgene introgression to feral populations commonly occurs.
Keywords: opportunity;challenge;biotechnology;weed management ;

Control effect of different herbicides on *Eriochloa villosa* (Thunb.) Kunth in soybean field

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In Heilongjiang province, *Eriochloa villosa* (Thunb.) Kunth has become a dominant weed species in soybean field in recent years. And peasants recognized that it was more difficult to control than other grass weed species, such as barnyard and foxtail. It was possible to relate to its morphology, herbicide selected and its application rate and time. For that reason, the influence of different foliar-applied herbicides and their application rate and time on control effect against *Eriochloa villosa* (Thunb.) Kunth was investigated through pot-culture method. The test weed seeds were collected in Harbin. The test herbicides were sethoxydim (Nippon Soda Co., Ltd.), clethodim (CAC Group Co., Ltd.), haloxyfop-P-methyl (Dow AgroSciences LLC.), fluazifop-P-butyl (Ishihara Sangyo Kaisha, Ltd.), quizalofop-P-ethyl (Nissan Chemical Industries. Ltd.) and quizalofop-P-tefuryl (Chemtura Inc.).The results were as follows. To control the 1-1.5 leaf age *Eriochloa villosa* (Thunb.) Kunth, sethoxydim, clethodim, haloxyfop-P-methyl, fluazifop-P-butyl, quizalofop-P-ethyl and quizalofop-P-tefuryl was applied in dosage of 131.25 g/ha, 90.00 g/ha, 64.80 g/ha, 135.00 g/ha, 71.25 g/ha, 36.00 g/ha respectively. To control 3-3.5 leaf age *Eriochloa villosa* (Thunb.) Kunth, sethoxydim and haloxyfop-P-methyl could be applied, the application rate was 168.75 g/ha and 97.20 g/ha respectively. Sethoxydim could effectively control 4 and upwards leaf age *Eriochloa villosa* (Thunb.) Kunth only, and its application rate was at least 187.50 g/ha.*Eriochloa villosa* (Thunb.) Kunth should be controlled before 3 leaf age. The later herbicides were applied, the worse the control effect was, and the larger the application rate was. In their dosages recommended on the labels, Sethoxydim could well control 1-6 leaf age *Eriochloa villosa* (Thunb.) Kunth, Clethodim, haloxyfop-P-methyl, fluazifop-P-butyl, quizalofop-P-tefuryl could well control *Eriochloa villosa* (Thunb.) Kunth, and quizalofop-P-ethyl couldn't well control 1-6 leaf age *Eriochloa villosa* (Thunb.) Kunth.
Keywords: *Eriochloa villosa* (Thunb.) Kunth;foliar-applied herbicide;control effect;soybean field;

Occurrence of *Rumex* spp and its control in rapeseed production system

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Rumex species from *Polygonaceae* family become one of the most noxious weeds. Infested area by these weeds expands in China year by year, especially in no-tillage rapeseed systems. Occurrence of *Rumex* spp. in rapeseed systems is investigated in this study. The integrated weed management system (IWM) has been developed for control of this weed based on the rational crop rotation, control in the preceding crops, pre-emergence herbicide application, and biological control. The IWM system reduces the weed occurrence and spread and provides a useful tool for weed control in zero and direct sowing soil tillage systems. Species of genus *Rumex* are perennial plants which propagate through seeds and root buds. *Rumex dentatus* L. and *Rumex crispus* L. are the main species in Shaanxi plain. Their seeds germinate in September, and blossom and ripen from May to July. *Rumex* plants can be 90-120 cm tall, have a strong reprodutive capacity, wide adaptability and develop synchronously with oil-seed rape. Prevention and control measures are: 1) proper rotation of crops and control in previous crops. Rotation between oil-seed rape and wheat is recommended. Dicamba and Tribenuron-methyl should be used for control of *Rumex* spp. plants in wheat as a forecrop in order to reduce reproductive abilityand population dynamics. 2) Treatment by glyphosate IPA (1.125 – 1.538 kg ha^{-1}) should be used in 2-3 days before the sowing in no-tillage and direct sowing systems. Acetochlor (0.375 – 0.9 kg ha^{-1}) is used pre-emergence. 3) The survivals of *Rumex* spp. could be controlled using *Gastrophysa atrocyanea* Motschulsky which is also an effective method for control of the growth and reproduction of *Rumex* spp. IWM system is able to reduce the *Rumex* spp. occurence about 98%.
Keywords: broad leaved dock;oil-seed rape;weed control;integrated weed management;IWM

Synthesis and biological activities of novel n-dichloroacetyl oxazolidines

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Herbicide safeners selectively protect crops from herbicide damage without reducing activity in target weed species. These compounds allow greater flexibility in the choice of crops grown in rotation. It is reported that N-dichloroacetyl oxazolidines can protect crops from the toxicity of thiocarbamate, chloroacetanilide and sulfonylurea herbicides. In order to search for new N-dichloroacetyl oxazolidines compounds with higher biological activity and study the interrelationship of their protective effect with GSH, we synthesized several compounds by introducing substituted alkyl, cycloalkanes and aryls into the structure of oxazolidine, and their preliminary biological activities were tested. We prepared these compounds through condensation of nitroparaffin with aldehyde to produce nitro alcohols; then a reduction reaction with iron and hydrochloric acid to obtain amino alcohols; thirdly, a condensation reaction with ketones to form 1,3-oxazolidine; and finally acylation by dichloroacetyl chloride with triethylamine as the acid attaching agent. The structures of these new compounds were characterized by infrared, 1H NMR, 13C NMR and elemental analysis. The test of biological activity in greenhouse showed that both the plant height and GSH content were elevated with the title compounds to some extent. When the concentration of acetochlor was 10 mg/kg in soil, 10 mg/kg of compound Ⅲ（N-Dichloroacetyl-3-methyl -1-oxa-4-aza-spiro-4.5-decane）increased the height of maize seedling by 56.97% after 7days growth, while 50 mg/kg , increased by 75.52%. The results indicated that introduction of small alkyl group in the 2-position of oxazolidine ring conferred a rather satisfactory results.
Keywords: herbicide safener;oxazolidines;biological activity;

Control of *Ambrosia artemisiifolia* in clearfield® sunflower cultivation

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Ambrosia artemisiifolia L.(common ragweed) is an annual species native to North America. This plant, introduced in Europe in the early 1940s, is nowadays considered one of the major causes of summer pollinosis in several European countries. Since the mid-1990s, the species has been increasingly reported as a weed of annual summer crops such as maize and sunflower. This trend suggests the need to investigate in control strategies in crop species belonging to the same family of the weed. The objective of this research was to assess the effect of chemical and mechanical *A. artemisiifolia* control methods in Clearfield® sunflower (tolerant to imazamox). Two field experiments were conducted in 2010 and 2011, with a natural infestation almost completely dominated by the presence of *A. artemisiifolia* (more than 300 seedlings/m^2), to evaluate the control of this weed by means of herbicides applied in pre-emergence (S-metolaclor in combination with aclonifen, pendimethalin or oxadiazon), post-emergence (imazamox in combination with propaquizafop), and mechanical control (inter-row hoeing combined with ridging). Pre-emergence treatments were evaluated alone or followed by inter-row hoeing. The best control of *A. artemisiifolia* was obtained with the post emergence application of imazamox in combination with propaquizafop, with 80% of density and biomass reduction in comparison with the untreated control. Among the pre-emergence treatments the mixture of S-metolaclor with oxadiazon resulted in the highest efficacy (about 70%). As expected, higher weed control was assessed when pre-emergence applications were coupled with the mechanical control. Weed control results obtained with mechanical interventions applied alone (inter-row hoeing, combined ridging) were higher than those obtained with the chemical weed control in pre-emergence. With the exception of the untreated, no differences were recorded in terms of yield among treatments.
Keywords: common ragweed;pre-emergence herbicide;post-emergence herbicide;mechanical control;

Integrated weed management in rice

Oral presentations

Alternative rice establishment methods and recruitment prediction to manage multiple herbicide resistance

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Widespread herbicide resistance in the major weeds of rice, such as Echinochloa. phyllopogon threatens the sustainability of rice production in California. We demonstrated that alternative stand establishment techniques changed the weed recruitment environment and reduced weed seedbanks. Water seeded systems favored aquatic weeds while drill seeding favored dryland weeds, thus offsetting the impact of herbicide-resistant (HR) weeds. HR *E. phyllopogon* pressure on the crop was further reduced using a stale seedbed (StSb) approach with a non-selective herbicide (glyphosate), for which resistance has not evolved, followed by no soil disturbance. The StSb technique can be optimized by maximizing pre-glyphosate recruitment. Thus we applied population-based threshold models to determine temperature, moisture and oxygen conditions for highest germination and emergence rates in non-dormant seed. Given the absence of negative effects of hypoxia on germination and the sensitivity to hypoxia and to moisture stress during emergence, optimization of *E. phyllopogon* recruitment in field soils could involve flooding fields for an initial duration of 35 thermal units (oC d-1) to promote >90% germination, followed by field draining to enable weed emergence under near field capacity conditions, at which point glyphosate would eliminate most of that season's possible *E. phyllopogon* emergence. Fields should be kept flooded during wither for approximately one month to release seed from dormancy and enhance pre-glyphosate recruitment. This integrative approach is being adopted by California growers and is the basis of sustained rice cropping in spite of widespread herbicide resistance in the major weeds.
Keywords: herbicide resistance; population based threshold model; stale seedbed; recruitment; *Echinochloa*;

The effects of *Monochoria vaginalis* on rice yield properties and the estimation of economic thresholds for the weed control.

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Sheathed monochoria [(*Monochoria vaginalis* (Burm.F.)] is a troublesome weed in rice (*Oryza sativa* L.) field in the world. A field experiment was carried out to study the damage of Sheathed monochoria to rice yield and its economic thresholds. The results showed that Sheathed monochoria accumulated heavy amount of biomass and nutrient (NPK) as well as water, and as the consequences of competition between the rice and weeds, the weeds deteriorated the light condition and inhibited the rice growth. The optimum regression model for the rice yield loss (y) and the density of Sheathed monochoria (x) was established as a square root model (y=8.4371+5.0249sqrt(x), F=177.4195, $P < 0.0003$) . When 6000－9000 kg/hm^2 of rice yield were expected, the related economic threshold for Sheathed monochoria weed by manual weeding were 4-14.8 plant/m^2; while for the chemical herbicides of 10% Bensulfuron-methyl WP, 10% Pyrazosulfuron WP, 48% Bentazon, and 56% 2m-4kh sodium salt, were 1-1.6 plant/m^2.
Keywords: Sheathed monochoria; rice; competition; economic infestation level; economic threshold;

Variation in the morphology of offspring derived from single panicle of weedy rice

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Weedy rice is one of the most problematic weeds of direct seeded rice worldwide. It is closely resembles to cultivated rice. This weed infests fields in all major rice growing areas in Sri Lanka and causes severe yield losses and increases production costs. Managing weedy rice is a challenging problem for farmers and this is complicated by difficulty in distinguishing it from the sown crop. Rice is mainly self-pollinated but, to certain extent it can cross-pollinate; rice varieties show a degree of segregation and various off types even in seed production programs to maintain purity. Information on out-crossing rate of rice varieties is important in guiding the management of seed production programs as this will influence the percentage of the Other Distinguishable Varieties (ODV) in the seed sample. Opening of florets in weedy rice and cultivated rice is between 08: 00 and 09: 00 am and the duration is longer in weedy rice providing greater possibility for cross-pollination. The objective of this study was to determine the morphological variation of offspring derived from panicles of different bio-types of weedy rice collected from an infested area – "Hathamuna Yaya" in Matara District, Sri Lanka. Panicles of seven morphologically different bio-types of the weedy rice were collected and twelve seeds of each panicle were selected at random, germinated and separately grown in pots. The identification of each bio-type was made using characterization catalogue as developed at Rice Research and Development Institute, Batalagoda, Sri Lanka. General linear models and cluster analysis were performed on the datasets using SPSS PC, Ver. 16.0. Seven dendrograms were resulted with varying number of clusters (3-6 at 75% phenon level) representing each panicle. Comparison of dendrograms showed there is a significant morphological variation resulting from wide segregation in the offspring derived from the selected seeds of the same panicle. The results further demonstrate the higher possibility of cross-pollination in weedy rice which explains the high level of ODV found in weedy rice infested rice fields.
Keywords: : Morphological variations ; panicles;Weedy rice ;Sri Lanka;

Imazapyr and imazapic carryover effects on subsequent crops in rice soils of eastern Uruguay

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Imazapyr and imazapic are sprayed to control mainly medium- and heavy-infested fields of red rice (*Oryza* spp.). Their average field life are over 100 days; therefore, they would have carryover effect on subsequent crops. Field experiments were conducted to study carryover effects of imazapyr and imazapic when applied over Clearfield® rice on imidazolinone non-resistant rice (*Oryza sativa* L. cv. El Paso, cv. INIA Olimar, cv. INOV ST), Italian ryegrass (*Lolium multiflorum* Lam. cv. LE 284) and summer forage crop (Sorghum bicolor x S. sudanensis cv. San Pedro, cv. ACA 726). Rates of imazapyr and imazapic studied were 0 + 0, 90 + 35 and 180 + 70 g ae ha-1. Every field experiment had the following crop sequence. Clearfield® rice was followed by Italian ryegrass broadcasted over rice straw one week after rice was harvested and finally, imidazolinone non-resistant rice was seeded under no-tillage conditions after sward was burnt with glyphosate at the Experimental Unit Paso de la Laguna (UEPL) and at Río Branco (RB) while a summer forage crop was seeded only at RB. Soils characteristics for UEPL and for RB were 5,4; 1,3; 27; 46; 27 and 5,5; 0,96; 48; 33; 18 for pH (H20), organic carbon, sand, silt and clay contents; respectively. There were no significant differences for any of measured variables neither on imidazolinone non-resistant rice at both locations nor on summer forage crop at RB. Italian ryegrass stand, tiller per plant-1 and dry weight per plant-1 at 90 days after seeding (DAS) were not affected by herbicide treatments in none of five experiments. Dry matter production at 180 DAS was reduced (p=0.0042 and p=0.0007) by 22 and 23 percent at UEPL and at RB; respectively. Plant height at harvest was decreased (p=0.0125) by 11 percent only at RB.
Keywords: imazapyr and imazapic; carryover effect; *Oryza sativa* L.; *Lolium multiflorum* Lam.; Sorghum bicolor x S. sudanensis;

Weedy rice control with integrated management in direct seeded rice in the Philippines

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The effectiveness of the integrated weedy rice management (IWRM) strategies were evaluated on farmers' fields and compared with the farmers' practices for weedy rice control in wet-direct seeded wet sown rice. The study was conducted in ten farmers' field at Dingle, Iloilo, Philippines during 2010 wet season and 2011 dry season. Results show that integrating weedy rice management components and combining the use of certified seeds, good land preparation, single herbicide application of a pre- or early post-emergence herbicide, provided significant reduction of weedy rice compared with farmers practice. Higher percentage control of weedy rice on IWRM practice plots resulted in lower density of weedy rice at harvest and provided higher grain yield than plots with farmers management practices. Minimizing weedy rice-crop competition by properly managing weedy rice will give positive benefits to the rice crop. Greater yields and net income can be achieved with integrated management practices, and better control has additional benefits of reducing the buildup of weedy rice in farmers' fields.
Keywords: direct seeded wet sown rice; integrated weedy rice management;

Integrated long term herbicidal weed and nitrogen management in transplanted rice-rice cropping system of Tamil Nadu, India

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Nitrogen use is likely to change the crop-weed ecology as well as herbicide activity and residue in the soil. Hence, with the objective to evaluate long-term herbicide application integrated with nitrogen management on weed shift, weed control efficiency, soil micro flora, herbicide residue and productivity of transplanted rice-rice cropping system, field experiments were conducted from 2001 to 2011. Field trial was carried out with hand weeding twice, PE butachlor 0.75 or pretilachlor 0.75 kg/ha or in rotation + POE 2-4, D, 0.4 kg/ha along with inorganic and organic N at 75 and 25 percent in RBD with four replication. Analysis of summed dominance ratio of weeds showed that the grass weed density decreased from 53.0 to 33.5% from first to XXIII rice cycle. *Echinochloa colona, Leptochloa chinensis* and *Marsilea quadrifolia* which were present in first crop was absent in XXII and in XXIII rice. Among the sedges, *Cyperus iria* was recorded in first crop, was absent during XXII and XXIII crops. Shift in weed species from *E. colona* to *Panicum distachyon* and absence of *Eclipta alba* was observed. Improvement in soil microflora was observed with herbicides application. Residues of butachlor, pretilachlor and 2, 4-D were below deductible level in soil and crop. Broad leaved weed density was lower in XXII and XXIII rice crops compared to first rice and the effect was more under rotational herbicides [butachlor + 2,4-D (kharif season) and pretilachlor + 2,4-D (rabi season)] and integration of N. Integration of weed control by butachlor + 2,4-D with 100% inorganic nitrogen recorded higher grain yield during rabi, 2010-11 and kharif, 2011 and it was on par with butachlor + 2,4-D followed by pretilachlor 0.75 + 2,4-D 0.4 kg ha-1 during both the seasons.
Keywords: Transplanted rice;weed shift;weed control efficiency;soil micro flora;rice productivity ;

Metazosulfuron: a new sulfonylurea herbicide for rice

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Metazosulfuron, (1-{3-chloro-1methyl-4-[(5RS)-5,6-dihydro-5-methyl-1,4,2-dioxazin-3-yl] pyrazol-5-ylsulfonyl}-3-(4,6-dimethoxypyrimidin-2-yl)urea) is a new sulfonylurea (SU) herbicide discovered and developed by Nissan Chemical Ind. Ltd.

Metazosulfuron shows excellent herbicidal activity against a wide range of annual and perennial weeds against paddy weeds including SU-Resistant biotypes. Many greenhouse tests and field trials have been conducted in China, Korea and Japan. The results demonstrate metazosulfuron excellently controls *Echinochloa* spp., sedges and other paddy weeds at 60-100g ai/ha with good crop safety. Factors influencing the herbicidal activity of metazosulfuron were also investigated; the absorption speed and germination depth of weed tubers, which are both important elements altering efficacy of herbicides in paddy field. Tubers of *Eleocharis kuroguwai* and *Scirpus maritimus* were treated with metazosulfuron and some other ALS inhibitors and were rinsed off 24hr after treatment. Then, the tubers were transplanted to untreated pots. Among the compounds tested, metazosulfuron showed the strongest efficacy against them. This quick "absorption speed" of metazosulfuron shows its stable performance under various field conditions. Tubers of Cyperus serotinus were planted 3cm, 1cm and 0cm in depth, and the efficacy of metazosulfuron to C. serotinus germinated from these three different depths was tested. No difference of the efficacy was observed among the three groups. This result indicates that metazosulfuron would constantly control C. serotinus and other weeds in the field regardless of the germination depth. Due to its strong herbicidal activity and preferable biological features, metazosulfuron will be a potent weed control agent in paddy field.
Keywords: new herbicide; metazosulfuron; SU-Resistant weeds; paddy field;

Ricer™ 60OD: A novel penoxsulam + cyhalofop-butyl formulation for use in direct-seeded rice In China

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™ 60OD is a pre-mix rice herbicide product containing 10 g ai penoxsulam + 50 g ai cyhalofop-butyl/liter. Penoxsulam, a triazolopyrimidine sulfonamide herbicide, is sold in many countries for broad-spectrum control of broadleaf weeds and some grasses in rice. Cyhalofop-butyl, an aryloxyphenoxy propionate herbicide, is used globally for controlling grass weeds in rice. In China, Ricer™ 60OD efficacy and crop tolerance field trials were conducted in direct-seeded rice from 2005 to 2011 and results demonstrated good to excellent control of many important rice weeds. Ricer™ 60OD at 2.25 to 2.5 L pr/ha (22.5 to 25 + 169 to 188 g ai/ha, penoxsulam + cyhalofop-butyl, respectively) as a post-emergence foliar application at 10 to 15 days after rice seeding provided excellent control of barnyardgrass (*Echinochloa crus-galli*), Chinese sprangletop (*Leptochloa chinensis*), knot grass (*Paspalum distichum*), annual sedge (*Cyperus difformis*/*C. iria*), bulrush (*Scirpus juncoides*), monochoria (*Monochoria vaginalis*/*M. korsakowii*), annual arrowhead (*Sagittaria* spp), water plantain (*Alisma plantago-aquatica*) and Indian rotala (*Rotala indica*). Ricer™ 60OD provided 2 to 4 weeks residual weed control and demonstrated no visual phytotoxicity in direct-seeded rice. This product is being registered in China for use in transplanted and nursery rice in 2012. ™ Trademark of Dow AgroSciences LLC.
Keywords: Ricer; Penoxsulam; Cyhalofop; Direct-seeded rice; Dow AgroSciences;

Poster presentations

Two biotypes of weedy rice and effect on yield factors of cultivated rice in Jiangsu Province of China

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The rice area infested by weedy rice in the provinces of Heilongjiang, Liaoning, Jiangsu and Guangdong of China accounts for 610,000 ha. Most of the populations of weedy rice collected from Jiangsu Province belong to indica type, while those collected from Liaoning Province belong to japonica type. Weedy rice infestation in rice became more serious in Jiangsu Province after the development of the reduced tillage for dryseeding. A dwarf weedy rice biotype(JDWR-A) and a tall biotype (JDWR-B) were collected from this area and tested to measure their effects on yield of cultivated rice. The results of the study on competition between the two weedy rice biotypes and cultivated rice showed that the dwarf type affected yield components of cultivated rice more significantly. JDWR-A at a density of two, four, and six plants per m2 decreased the number of panicles by 45.2%, 51.7% and 63.4%, and the number of spikelets per panicle by 18.4%, 28.4% and 28.6%, as well as the yield of cultivated rice by 24.58%, 42.09% and 54.55% respectively. At the same densities, JDWR-B decreased the number of panicles by 38.3%, 45.1% and 48.2%, the number of spikelets per panicle by 3.1%, 10.1% and 3.9%, as well as the yield decreased 7.17%, 26.48% and 37.12% respectively. However, The competion of the two biotypes resulted in no diference in 1000 grain weight
Keywords: weedy rice; biotype;competition;

Species composition and characterization of weed community in rice fields in Hubei Province

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Weed survey was conducted by inverted W-pattern to determine the species composition and structure of weed communities in rice fields in Hubei Province in China. The results showed that 138 weed species (including varieties) belonging to 46 families and 95 genera were found. Among them, 6 species were considered as dominant weeds, including *Echinochloa crus-galli, Leptochloa chinensis, Cyperus difformis, Monochoria vaginalis, Eclipta prostrata and Alternanthera philoxeroides*; 14 species were regional dominant weeds; 27 common weed species and 91 normal weed species. The overall abundance of *E. crus-galli, M. vaginalis, L. chinensis, E. prostrata, A. philoxeroides* and *C. diff*ormis were relatively higher and were the main components of weed communities in all rice regions in Hubei province. Weed community mainly consisted of *E. crus-galli+C. diff*ormis+*M. vaginalis* in transplanted rice fields, and *L. chinensis+E. crus-galli+E. prostrata+A. philoxeroides* in direct-seeded rice fields. The species richness and diversity of weed community in paddy rice fields in Jianghan Plain region were higher than in other regions, but the Simpson's index

and evenness index were relatively lower. Based on the Sorensen's similarity index, the structure of weed community in Ebei region was similar to that of direct-seeded rice fields. The difference of weed occurrence and community structure might result from the crop type, farming system and edaphic condition.
Keywords: paddy rice; weed community; species composition; relative abundance; similarity;

Effects of weed populations on rice yield under different rice cultivation modes

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A field experiment was conducted in southern China to study the effects of different weed populations (naturally occurring populations of weed, gramineous weeds, broad-leaved and cyperaceae weeds, and weed-free treatment) on rice yield under four rice cultivation modes (hand-transplanted rice; throwing-transplanted rice; mechanical-transplanting rice; direct seeding rice). The results showed that the rice yield loss was the highest in naturally occurring populations of weed plot under four different cultivation modes (37.7%, 32.3%, 52.1% and 76.6%, respectively). The lowest yield loss occurred in broad-leaved and cyperaceae weeds plot. The effects of different weed populations on yield loss were also investigated in four cultivation modes. The highest yield loss was caused by weeds under direct seeding rice mode. They declined by 76.6%, 56.0% and 15.6% in naturally occurring population and gramineous and broad-leaved and cyperaceae weeds plot, respectively. In mechanical-transplanting rice, the yield loss was 52.1%, 29.1% and 9.0% in turn. In hand-transplanted rice, the yield losses of rice were 37.7%, 20.5%, and 14.0%. The yield loss was the lowest in throwing-transplanted rice and approximately was 20%. In weed controlling plot (weed-free treatment), The highest rice yield was 7003.5kg/hm2 in direct seeding rice, which was higher by 35.8% , 40.3%, and 47.5% than hand-transplanted rice, throwing-transplanted rice and mechanical transplanting rice, respectively. These results indicated that direct seeding rice might be the most attractive cultivation mode for it could offer more potential benefits including savings in time, labor, energy and water than other three modes.
Keywords: the yield loss of rice; cultivation modes; weed populations

Study on the phytotoxicity of several herbicides to rice

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A greenhouse experiment was conducted to determine the dose at which butachlor, quinclorac and bensulfuron-methyl can cause phytotoxic effects to the rice. Rice seeds pregerminated at 10-14 C in a growth chamber were sown in 11-cm-diameter plastic pots filled with a 2:1 (wt/wt) mixture of sand and soil which were watered fully. Part of germinated rice seeds were sowed 2 days after the pots with soil were sprayed with butachlor with different doses. The other sowed rice were treated until seedlings at two- to three-leaf with bensulfuron-methyl, and quinclorac. Every one week after treatment, the phytotoxicity dose and symptom were recorded, and the pictures of the symptoms were also taken. Results showed that the rice that were exposed to 3750g a.i./ha of butachor presented significantly slow development, the tips of budlet were dried-up and ultimately resulted in stunted growth and death of rice. Dose of quinlorac exceeded 400 g a.i./ha caused rice seedlings grow badly and become distorted in contrast with the control. The higher quinclorac dose, the more obvious symptoms. Seedlings at two- to three-leaf were exposed to 45 g a.i./ha of bensulfuron-methyl, the rice were affected slightly, but they returned to normal about 10 days after treatment. However, when dose of bensulfuron-methyl exceeded 90 g a.i./ha, the rice tender leaves became deeper green and could not unfold completely. In conclusion, the right dose of butachlor, quinclorac, and bensulfuron-methyl should be 1250-2500, 225-400 and 45-90 g a.i./ha, respectively.
Keywords: butachlor; bensulfuron-methyl; quinclorac; phytotoxicity symptoms

Experimental study of biological characteristics of malignant weed-*Eleocharis plantagineiformis* and its control strategies in rice field

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The study results showed that *Eleocharis plantagineiformis* prefers to grow in continuous cropping paddy-fields characterized by long-term moist and neutral soils with loose texture and high organic matter content. Its corm distributes deeply and has dormancy stage; the optimum temperature for its germination is 25-30 °C., Corm starts to grow at 15 d and its ramet peak period is around 50 d; it emerges at 7~10 d after transplanting and the peak of weed growth is at 15~25 d; the emergence occures at 5~7 d after seedling transplanting. Underground corms begin to form from late August to early September, continuing till mid-late October. Bulbs are not tolerant to drought, cold and sun; however under the soil, they can remain vital over 5 years. Persistence of E. plantagineiformis in field infestations is due to vegetative growth, while spread over long distance relies mainly on seeds. The most effective management of this weed is based on application of herbicides in partially drained fields (3-5cm water), with subsequent restoration of normal flooding conditions.
Keywords: *Eleocharis plantagineiformis*; Biological Characteristics; Control Strategies.

Natural sensitivity to imazamox in Italian weedy rice populations

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The objective of this study was to evaluate the sensitivity to imazamox herbicide of 142 Italian weedy rice populations selected in a territory representing of about 90% of total Italian rice fields, on the basis of their phenotypic features (awnedness) and sampling location (north-west, south-west and east areas). Two experiments were conducted to assess the number of dead plants and shoot biomass reduction at different days after treatment (8, 15, 22, 29, 36, and 73 DAT) at the rate of 70 g ha^{-1}. The experiments were carried out in greenhouse by seeding weedy rice in alveolar trays (3 seeds/alveolus) with 6 replications. Hierarchical clustering on the number of dead plants at different DAT resulted in five clusters of imazamox sensitivity. Cluster 4 contained 28 weedy rice populations, mainly awned (64%) which required longer time (48 days) to reach 80% control than the others. Cluster 3 was composed by 22 populations (68% awned) requiring shorter time (13 days) to obtain the same level of weed control. Clusters 1, 2 and 5 showed an intermediate behavior with 23, 32, and 30 days, respectively, in order to reach 80% control. Biomass reduction of the weedy rice treated with imazamox ranged between 66-93% compared to non-treated plants. Both the most (89% biomass reduction) and least sensitive (69% biomass reduction) groups of weedy rice populations were mainly awned. The results obtained from this study pointed out that Italian weedy rice populations gave a dissimilar reaction to imazamox herbicide.
Keywords: Red rice; weeds; herbicide tolerance;

Cultural approaches to manage weedy rice in Asia

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Rice is a principal source of food for more than half of the world population. It is predicted that weedy rice is likely to emerge as a major threat for rice production in Asia in future especially with the likely change in rice establishment methods from puddled transplanting to direct-seeding. Failure to recognize and account for these threats will jeopardize the stability of rice production in many areas, or limit the options for crop management particularly for those seeking direct-seeded rice as an alternative. Weedy rice is very similar to the cultivated rice, making it difficult to identify and differentiate from cultivated rice at early stage. Moreover, it has high levels of seed dormancy and longevity in the soil, shatters seeds easily, and possesses colored pericarp. All these traits make weedy rice highly competitive and difficult-to-control in rice leading to reduction in yield and quality. Improved and environmentally sound management strategies should be exploited for cultural practices, including water management and use of competitive crops, together with manual, chemical, and mechanical interventions. Weedy rice infestations could be better managed by exploiting strategies, such as avoiding weedy rice seeds being introduced by contaminated tillage and harvesting machines; using weed-free seed and weed‑competitive varieties; stale-seedbed practices and good land preparation, crop rotation, rotation of crop establishment methods (transplanting, dry seeding including zero till, and wet seeding); agronomic practices (line sowing, narrow row spacing, and increased seed rate); and water seeding.
Keywords: weedy rice;direct-seeding;transplanting;water seeding;

Competitive interactions between weedy rice and cultivated rice in Sri Lanka

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Weedy rice is closely related to cultivated rice and infests fields in all major rice-growing areas of Sri Lanka. It threatens the sustainability of cultivated rice production causing increased production costs and serious yield losses due to competition. The competitive outcomes between rice (*Oryza sativa* L.) variety Bg 379-2 and a black-hulled weedy rice biotype collected from Matara District were tested to evaluate the competitive interactions between weedy rice and cultivated rice. The experiment was conducted in cement pots filled with top soil collected from one field. In each pot four, two-day-incubated sprouted seeds of Bg 379-2 were established with 15 cm spacing. These were grown with 0, 1, 2, 3, 4 and 5 weedy rice plants per pot depending on the treatment. Plant height, tiller count and leaf count were measured at weekly intervals, dry weight of aerial and underground parts and length of roots and shoots at 8 weeks after sowing (8WAS) and number of plants/unit area, panicles/unit area, grains/unit area and weight of thousand grains after harvesting were taken for Bg 379-2. Weedy rice density had significant ($p<0.05$) effect on Bg 379-2 height from 4WAS, leaf count from 2WAS up to harvesting stage, number of tillers in 5WAS and 6WAS, biomass production of shoot, root, grains/panicle, panicles/m2, and Bg 379-2 yield (g/m2). With high weedy rice densities (55 plants/m2) there was 78% grain yield loss of Bg 379-2 compared to control. Under 44, 33 22 and 11 plants/ m2 weedy rice densities, yield loss was 71%, 66%, 53% and 42% respectively. Results of the study clearly illustrate that black-hulled weedy rice biotype had a severe adverse effect on the growth and grain yield of cultivated Bg 379-2 rice variety. These results could be provided baseline information for farmer-awareness programs and to strengthen farmer capabilities of weed management in rice fields. In particular, these results may provide guidance and justification for the costs of weedy rice prevention and control measures
Keywords: Competitive interactions; Cultivated rice; Weedy rice; Sri Lanka;

Control of weedy rice in direct seeded rice using the clearfield production system in Malaysia

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Weedy rice (red rice) was first discovered in 1988 in Malaysia and since then had rapidly become an important weed in all granary areas (approx. 400.000 ha). It is estimated that USD60 million (RM180 mil) in rice yield is lost to weedy rice competition per year in Malaysia alone. There is no selective rice herbicides for the control of weedy rice. lmidazolinone-tolerant rice cultivars hold the answer for effective management of weedy rice (Oryza sativa complex) in wet-seeding rice culture. The combination of imidazolinone tolerant varieties (MR 220CL1 and MR 220CL2) with imidazolinone herbicides is known as the Clearfield Production System. Clearfield Rice Production System is able to effectively control weedy rice, where no other herbicides or system can control in wet-seeding culture. The use of the Clearfield Production System will directly benefit the rice industry in Malaysia by providing an effective and innovative chemical control to the management of weedy rice. The Clearfield Production System is the first non GMO herbicide tolerant rice to be introduced in the Asia Pacific Region.Reduces the total cost of weed management. Increases yield back to >5.5 t/ha from <3 t/ha due to weedy rice infestation.This technology is cost efficient with returns equivalent to more than 2 times (>USD 650/ha) from investment of USD 270/ha (RM800/ha).Early and effective control of weedy rice. Simultaneously controls other noxious paddy weeds. Improves quality and quantity of harvest and reduce weedy rice dockages. Reduces amount of herbicides (generally 500-1000 g ai/ha) released into the environment;100- 150 g ai/ha imidazolinone (217 g OnDuty™WG/ha). Efficient water usage through delayed flooding and indirectly reduces Golden Apple Snail damage on rice fields.
Keywords: Weedy rice;Clearfield;Imidazoline tolerant;

Controlling *Echinochloa* spp. with herbicides in an integrated management system: results and new challenges

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Rice systems in Uruguay include an important area of rotation with pastures for cattle grazing. Alternating rice crops with pastures as well as summer tillage and levees construction the year before planting could improve various aspects of rice management, including IWM. Less weeds presence would be expected in those systems. Aiming to evaluate chemical options under these conditions we conducted experiments in two ecological different sites in the center and north of Uruguay during three years. Natural infestation of both *E. crus-galli* and *E. colona* prevailed in Site 1 whereas *E. colona* was the main weed in Site 2. Nevertheless, much less weed infestations were found in both sites than those situations around where summer tillage was not done. Many tested options succeeded in both sites, reaching excellent rice productivity as well as weed-free plots at harvest, important issue to prevent posterior infestations. In Site 1, penoxsulam (0.042 kg.ha-1) was the best treatment, with or without clomazone (0.384 kg.ha-1 pre-emergence), whereas in Site 2, tank mix of bispyribac (0.04 kg.ha-1) plus quinclorac (0.375 kg.ha-1) had best results. The use of clomazone pre-emergence was almost inevitable for good results in Site 1, where *E. crus-galli* infestation was important. Excellent results were also found with graminicidas as profoxidim, although it showed phytotoxicity over the tested cultivar. Attending to reach higher water use efficiency, new irrigation and systematization methods had exposed new challenges on weed control. In that sense, new experiments were established to gather information about successful *Echinochloa* spp. control under the alternate production systems (intermittent irrigation and multiple levees). Partial results show a different response of chemical treatments under the alternative conditions, suggesting a lower efficiency in weed control related to intermittent irrigation; response to multiple levees systematization is not clear yet. We continue looking forward to options for a successful integrated weed management under new irrigation and systematization.
Keywords: Echinochloas;crop rotation;irrigation;herbicides;rice and pastures;

Growth variability of Italian weedy rice populations grown with or without cultivated rice

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The aims of these studies were to evaluate the growth variability (growth experiment) and the response to cultivated rice competition (competition experiment) of 10 weedy rice populations selected in Italian rice fields on the basis of their phenotypic features. The experiments were carried out under field conditions in 15-L pots with 6 replications by seeding 1 weedy rice plant/pot in growth experiment, and 1 weedy rice plant surrounded by 10 cultivated rice plants/pot in competition experiment. Plant height, tiller and leaf numbers were recorded 6 times through the growing season for both studies. In the competition study, leaf area, tiller and leaf weight were also assessed.In the growth experiment a variable behaviour was shown by the different weedy rice populations for all the growth parameters. The culm numbers was the most homogeneous parameter among the populations, while leaf weight was the most variable. In the competition experiment, curve fitting between each growth parameter and time after seeding showed different behaviour with and without rice competition. Weedy rice in competition always showed lower growth indices than when grown alone. Plant height was the parameter less affected by competition, showing an average of 16% reduction compared to non-competition. Leaf and culm weight were heavily affected by competition with an average of 68% and 65% reduction, respectively. Two awnless populations showed an opposite growth behaviour, being the most and the least affected by rice competition with a 30% difference in growth reduction averaging among all parameters. Italian weedy rice populations, with phenotypic variability, responded diversely in terms of plant height, leaf and culm production, in either presence or absence of rice.
Keywords: red rice; competition; weeds;

Integrated weed management in horticultural crops

Oral presentations

Moving vegetable weed management from IWM to IPM

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During the past 50 years weed management in many crops came to rely heavily on herbicides. Losses in herbicide registrations and increased resistance of weeds to herbicides, now make it imperative that management of weeds, especially in vegetables, return to IPM principles. For weeds, the principles of IPM, often referred to as IWM, involve the use of cultural tactics, biological control, and mechanical control, including use of hand labor, in addition to the judicious use of herbicides. IWM programs should operate on a philosophy of managing the seed bank, rather than managing this year's weed problem. Anything less means that farmers are doomed to fight the same weed control 'fire' on an annual basis. There is increasing evidence that a weed management philosophy that aims at eliminating seed rain will eventually result in decreased seedbank size, leading to weed management programs that are more sustainable. Ecologically weeds are producers and therefore have the potential to interact with pest organisms in all other categories. Management of weeds are critical components of management of nematodes, pathogens (especially viruses), vertebrates and many arthropod pests in vegetable crops. The role of weeds, from an IPM viewpoint, is complicated by the fact that weeds can also serve as a resource for beneficial insects. This means that weed management must also be a component of the broader concept of IPM; hence the title for this paper. Most current IPM programs, including IWM, are level I IPM, with no allowance for impacts of management of one pest species on unrelated pest organisms. Farmers do not have the luxury of managing a single pest organism without considering impacts on the other organisms in the ecosystem. To the end of attaining level II IPM, which considers all pest categories in a comprehensive manner, weed management must move from IWM to IPM.
Keywords: thresholds;integration;seedbank;hand labor;

Evaluation of an in-row rotating cultivator in vegetable crops

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The objective of this project was to test a robotic intra-row cultivator in California vegetable crops to determine if the cultivator can be used to thin lettuce as well as remove in-row weeds from within lettuce and tomato seed lines. The Tillett and Hague rotating cultivator, sold commercially in the United Kingdom, is capable of removing weeds from within the crop row. Field studies were conducted on lettuce and tomatoes during 2009 and 2010 at Salinas, CA USA to evaluate the intra-row cultivator. The rotating cultivator was compared to a standard cultivator to remove inter-row weeds. The trials were arranged in a split-plot design with cultivator as the main plot and herbicide as the split plot. Treatments were replicated four times. Herbicide standards in lettuce were pronamide PRE at 1.35 kg ai ha-1 and in tomato rimsulfuron applied pre-transplant at 35 g ha-1 followed by trifluralin at layby at 0.84 kg ha-1. Weed density, hand thinning/weeding time, crop stand, crop injury and crop yield evaluations were measured. Analysis of variance and mean separation by either LSD (P=0.05) or Duncan's (P=0.05) was performed on all data. A commercial direct-seeded lettuce planting near Gonzales, CA was thinned and weeded with the rotating cultivator. After machine thinning with the rotating cultivator and inter-row cultivation with the standard cultivator, the trial was hand thinned. In 2009 and 2010 the rotating cultivator reduced lettuce hand thinning and weeding times by 64% and 51% respectively. At Salinas, CA in 2009 and 2009 the rotating cultivator reduced lettuce hand thinning and weeding times by 31% and 32% respectively. The rotating cultivator tested was found to reduce handweeding inputs in lettuce and tomato.
Keywords: in-row cultivation;robotic weeding;tomato;physical control;lettuce;

2,4-D and dicamba tolerant crop systems threaten fruit and vegetable production, and agroecosystem services

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Soybeans and cotton are planted on approximately 25 and 5.6 million hectares mostly in the central and southern US where fruits, vegetables and organic production is increasing. Cultivars with tolerance to 2,4-D or dicamba, designed to address glyphosate resistant weeds, will be introduced starting 2015. Fruit and vegetable crops are often grown nearby fields of agronomic crops. Here we provide a preliminary assessment of likely impacts on specialty crops, agro-ecosystem services, and rural communities. Risk assessments were conducted using standard herbicide evaluation procedures, and low-dose/high volume POST applications of each herbicide to simulate drift. 2,4-D and dicamba doses common to all experiments were 1X, 1/30X, 1/100X and 1/300X based upon 1X rates of 0.56 and 0.84 kg ai ha^{-1} of dicamba and 2,4-D, respectively. In most experiments combinations with glyphosate were included as the new tolerance traits will be stacked with glyphosate tolerance. Specialty crop tolerance to both herbicides varied significantly with sensitivity of grape > tomato > cucurbits > peppers ≥ cabbage. Tank-mixes with glyphosate were almost always more phytotoxic than either herbicide applied alone and 2,4-D and dicamba were consistently more toxic than glyphosate at equivalent doses. Applications at the flowering stage resulted in greater crop injury and yield suppression than applications at earlier vegetative states of growth. A review of the literature indicates that widespread increased use of 2,4-D and dicamba is likely to have

direct and indirect toxic effects on pollinator and beneficial insect communities. Because offsite movement is inevitable acrimony between neighbors and lawsuits are anticipated.
Keywords: 2;4-D tolerant; dicamba tolerant; fruit and vegetable crops; crop tolerance; pollinators

Máodò: weed management issues in North American edamame

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Despite the fact that the United States is a global leader in commodity soybean production, most of the vegetable soybean (i.e. edamame or máodò) consumed in North America is imported from Asia. Interest in edamame produced in the U.S. is on the rise among consumers; however, the U.S. vegetable processing industry cites weed interference as the single most important threat to production of the crop. This paper reports a brief history of edamame production in the U.S., current interest in the crop, the registration status of key herbicides, and recent weed management research by state and federal scientists in Illinois. Field trials were conducted to evaluate the effectiveness of various weed management systems that included the few herbicides that are either currently registered for use or could be registered in the near future. Results are promising for systems that also integrate seedbed preparation, scouting, timely intervention, different herbicide modes of action, and mechanical weed control. In order to quantify weed management-related traits, including risk of crop injury from certain herbicides, a wide range of edamame and soybean germplasm was evaluated. In 2011, 122 edamame entries were tested, as well as 33 commodity soybean entries with known sensitive or tolerant herbicide responses. Several soybean growth characteristics important to compete against weeds, such as emergence rate and rapid leaf development, varied widely among edamame cultivars. Responses to bentazon and imazamox applied postemergence indicated relatively high levels of tolerance among edamame entries. Several chemical and non-chemical weed management tactics look promising; however, expansion of herbicide options will require additional product registrations.
Keywords: soybean;minor use;vegetable;herbicide injury;competitiveness

Cyperus rotundus biomass production and tuber viability response to rates of halosulfuron

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The world's worst weed, *Cyperus rotundus* (purple nutsedge), is a troublesome species of many crops in the southern United States. Tubers are the major reproductive *C. rotundus* mechanism. Vegetables are grown on low density polyethylene mulch, a system that tends to enhance *C. rotundus* growth. Herbicides are used for control, but it is not clear what effect herbicides have on tuber viability. Research evaluated *C. rotundus* dose response to halosulfuron in terms of shoot injury, tuber production, and tuber viability. Six halosufluron treatments were applied at 7 to 210 g ai/ha, along with a nontreated control (NTC). Shoot response to treatment was measured colormetrically using digital images over time. Sixteen weeks after planting (8 weeks after treatment), entire plots were excavated; shoot, root, and tuber biomass determined and tuber viability evaluated. Spectral data from plant images indicated shoot responses to halosulfuron had an LD_{50} of 11 g ai/ha at six weeks after treatment. At excavation, 8 weeks after treatment, tuber number and biomass, and shoot biomass were reduced as rates of halosulfuron increased. Reduction of tuber number to <80% of the NTC required halosulfuron at ≥105 g ai/ha. In contrast, reductions in tuber and shoot biomass to <80% of the NTC required only 52 g ai/ha. Viability of tubers in the NTC were 100%, while tuber viability was 63, 44, 32, 11, 7, and 2% for 7, 13, 26, 52, 105, and 210 g ai/ha, respectively. These data indicate that halosulfuron reduced *C. rotundus* tuber production and viability at rates below those typically needed to control above ground biomass. This suggests that tuber populations may be targeted by herbicide applications that may appear to be ineffective in controlling *C. rotundus* shoots.
Keywords: *Cyperus rotundus*;purple nutsedge;halosulfuron;LD50;

Recent developments in weed management for Florida citrus

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The USA is the second largest producer of citrus in the world. Florida citrus growers produce more than 65% of the total citrus produced in the USA. Weed control is a major component in citrus production. Herbicides are an important component of integrated weed management in citrus. Recently, several new herbicides have been registered for Florida citrus, this includes indaziflam, flazasulfuron, and saflufenacil for weed control in Florida citrus. Glufosinate, a non-selective, post-emergence herbicide is in the process of registration. If registered, glufosinate will be an additional tool to supplement glyphosate and paraquat which are commonly used post-emergence herbicide in citrus. Saflufenacil is a uracil based herbicide which is a potent inhibitor of protoporphyrinogen oxidase (PPO). It is a post-emergence broadleaf herbicide with some residual effect; therefore, usually applied as tank mix with broad spectrum or grass herbicides. Indaziflam, a cellulose biosynthetic inhibitor, is an alkylazine herbicide for pre-emergence, broad spectrum weed control in several perennial crops. It provides excellent long term residual weed control in citrus at low rates (73 g ai ha^{-1}) compared to other residual herbicides. Flazasulfuron is a sulfonylurea herbicide (acetolactate synthase inhibitor) and has pre-emergence and some post-emergence activity. It is expected that these new herbicides introduced in Florida citrus will provide additional tool to growers for improved weed control.
Keywords: Herbicides; Weed control; Citrus

To burn or not to burn, that's the question

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Primocanes are managed in red raspberry to increase berry production. Herbicides have been usedfor more than forty years in the Pacific Northwest to manage primocanes. Given the changes in cultivars, herbicides, and machine harvesters during the past forty years, a study was initiated in 2010 to determine whether caneburning of current Pacific Northwest raspberry cultivars still is a useful practice. Two trials were conducted on both commercial and research fields, using red raspberry cultivars 'Meeker', 'Coho' and 'Cascade Bounty'. Caneburning with oxyfluorfen and carfentrazone was evaluated in both trials. Data gathered were floricane length, number of fruting sites, fruit yeilds and training time. All caneburning treatments successfully eliminated the first flush of primocanes and suppressed primocane regrowth of all cultivars in the early season. Most caneburned raspberry growth rates were similar to non-caneburned raspberry by about 80 days after treatment in both trials, except 'Cascade Bounty' growth rate was suppressed by caneburning until about 119 days after treatment on the second trial. On the research field site, 'Meeker' floricanes were 21% longer than 'Cascade Bounty' in both years at the end of growing season, but floricane length did not differ by herbicide treatment for either cultivar. Non-treated raspberries produced 24 to 26% fewer fruiting sites than did caneburned raspberries. Two-year average yield of 'Meeker' was increased 27 to 31% by caneburning in the commercial trial and 33 to 40% in the second year of the research trial. 'Coho' and 'Cascade Bounty' yield were not increased by caneburning. Caneburning only reduced time spent on dormant-season training of 'Meeker' by about 45 hr/ha/person in the first year. Terbacil with or without caneburning herbicides provided over 89% weed control in late Aug regardless of weed pressure and cultivar.
Keywords: raspberry;caneburning;carfentrazone;oxyfluorfen;terbacil;

Poster presenations

Nutritional value and storage ability of pepper (*Capsicum annum* L.) depends on method of weeds control

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Vegetables are a major source of biologically active substances and their nutritional value has a high importance to consumers. The studies conducted in 2010-2011 in Skierniewice were undertaken to evaluate the storage ability and nutritional value of pepper (*Capsicum annum* L.), produced under different weed management systems. Pepper was grown in the field and different weed control methods were used in the experiments: a) herbicide control; b) mechanical control; c) herbicide + mechanical control; d) mulches (polypropylene and plastic film) control; e) hand weeding. During the field experiments the leaf chlorophyll content, relative variable chlorophyll fluorescence and pepper yield were measured. Pepper fruits were stored through 14 days, at the temperature of 8 °C. After the storage the chilling injuries, shrivelled, spoiled and rotten fruits and colour defects were estimated. Chemical analysis of the fruits including dry matter, ascorbic acid, total sugars and soluble phenols content were performed before and after the storage. The results revealed that the storage ability of pepper fruits did not depended on weed control methods but these methods modified the nutritional quality of pepper before and after the storage. Ascorbic acid content in fresh and stored fruits was the lowest in pepper grown in the film mulch. In fresh pepper grown in polypropylene mulch the sugar content was the highest in the experiments. After the storage the content of total sugars increased in pepper grown in plastic mulch, hand weeded and in the control treatment. Mulches and herbicide decreased the soluble phenols contents. Weed control methods did not affect the colour of fresh and stored pepper.
Keywords: pepper; weed control; nutritional value; storage ability;

Performance of sulfentrazone and flumioxazin herbicides in strawberry

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Strawberry is grown as a perennial crop in the Pacific Northwest of the USA and weed control is major cost for establishment and maintenance of strawberry beds. Sulfentrazone and flumioxazin herbicides were evaluated for crop safety and efficacy in newly-planted and established strawberry over three years near Mount Vernon, WA. In established strawberry from 2009 to 2011, sulfentrazone (0.17, 0.23, 0.28, 0.34 kg a.i. ha^{-1}) and flumioxazin (0.06, 0.08, 0.11, 0.13 kg a.i. ha^{-1}) was causing less than 10% strawberry foliar injury by approximately two months after treatment (MAT). In 2010, 30% strawberry defoliation was observed with 0.28 kg a.i. ha^{-1} sulfentrazone by 1 MAT and 33% defoliation was observed from flumioxazin at all rates except 0.06 kg a.i. ha^{-1}, compared to 23% defoliation in non-treated strawberry in 2010. No visible foliar injury occurred in 2009, but foliage was injured at all rates with both herbicides at 1 MAT in 2011. Weed control at 2 MAT in 2009 and 2010 averaged 60 and 78%, respectively. In 2011, all treatments provided greater than 88% weed control. Berry yield and fruit size were not affected by neither herbicide in all years. In newly-planted strawberry from 2009 to 2011, herbicide combinations with sulfentrazone and flumioxazin combined excellent (94%) weed control through July with good crop safety. Mid-season crop injury was measurable only in 2010, when sulfentrazone + oxyfluorfen resulted in 14% injury and flumioxazin with sequential pendimethalin and sulfentrazone caused 13% injury. All flumioxazin combinations decreased leaf area (LA) by 42% in 2010 and sulfentrazone decreased LA by 39% only when pendimethalin or oxyfluorfen were added.
Keywords: sulfentrazone; flumioxazin; strawberry; western Washington

Integrated weed management in plantation crops

Oral presentations

Overview on weed management in sugarcane in Brazil

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Global leaders are searching for clean, renewable options to provide energy and reduce petroleum use. Sugarcane has emerged as an important alternative for meeting those needs. This powerful plant is grown in more than 100 countries and holds the potential to reduce greenhouse gas emissions, diversify energy supplies and create jobs. In the past 30 years, Brazil has become energy independent and a leader in renewable energy, with more than 9 million ha of sugarcane cultivated for the production of sugar, ethanol, bioelectricity, bioplastic and biohydrocarbons. The cropping system adopted is based on a weed management system that relies mostly on the use of long term residual herbicides. Therefore, the main objective of this presentation is to discuss and present some aspects of Brazilian experience in sugarcane cropping system on chemical weed management. A case of weed shift in the *Digitaria* genus is discussed, especially on *Digitaria nuda* selection under high herbicide selection pressure of substituted ureas, triazolinone and ALS inhibitors. The growers experience and scientific results is presented showing the influence of sugarcane green harvest residue (straw) on weed dynamics and herbicide efficacy, comparing to the conventional system. Ratoon cane chemical weed control is frequently done under soil drought conditions and that may require certain chemical and physical properties of the herbicides, therefore herbicide soil interactions with tropical soils will be also presented with results. Crop rotation and its influence on the weed management in the crop is a practice that influences directly the weed management in plant cane, and that is one of the topic discussed with field data.
Keywords: Crop residue; *Digitaria*; drought conditions; crop rotation; residual herbicide;

The effect of herbicides on *Miscanthus giganteus* rhizomes and seeds

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Miscanthus giganteus has production potential for biofuel at many locations in the world. However there is little information about the herbicide effects on establishment and control of this species as an invasive plant. Greenhouse, laboratory and field studies were conducted at the University of Georgia, USA with the objective of screening potential PPI, PRE and POST emergence herbicides and herbicide combinations for *M. giganteus* when establishing from vegetative rhizomes and seeds. For the post treatments, *M. giganteus* was established to approximately 40 cm in height then treated with POST applications of 27 herbicides to evaluate efficacy. Nicosulfuron, trifloxysulfuron, sulfometuron, clodinafop, fluazifop, pyrithiobac caused significant injury, reducing height as well as dry weight as compared to the non-treated control. Sethoxdim, dichlofop, imazamox, flumioxazin, imazapic and imazethapyr caused either significant lower height or injury; these treatments also produced dry weights to less than 80% of the non-treated control. Results of the PPI and PRE emergence study in greenhouse using *M. giganteus* rhizomes indicated that most of the 21 treatments did not significantly injure or cause growth stunting, except for EPTC at a 2x rate, which reduced height and biomass as compared to the non-treated control. Oxadiazon and herbicide combinations containing imazethapyr exhibited some injury, reduced heights and less biomass. These data indicate that PPI, PRE, and POST emergence herbicides can be utilized for establishment of *M. giganteus* from vegetative rhizomes and some POST emergence herbicides have the potential to be used in *M. giganteus* control. Herbicide screening for *M. giganteus* seeds is also under evaluation using a bioassay technique in laboratory studies.
Keywords: *Miscanthus giganteus*; biofuel crop; post emergence herbicides; crop injury; residual herbicides

Can weeds be used as an indicator of cassava mealy bug (*Phenacoccus manihoti*) infestation?

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Weeds are an alternative host of many insects and plant diseases. In 2009, severe infestation of cassava mealy bug (*Phenacoccus manihoti*) was firstly found in cassava plantations of Thailand. However, favorite weeds as alternate host of cassava mealy bug have not been identified. During 2010-2011, survey of weed species as a host of cassava mealy bug was conducted in six provinces of northeast Thailand and two provinces of central Thailand. In each field, weed density and number of cassava mealy bugs (both adults and nymphs) on weed plants were randomly counted in twenty 0.25 m^2 quadrate. In total 42 infested cassava fields, forty three weed species were found. However, only six weed species (i.e. *Praxelis clematidae* (Griseb.) R.M. King & H. Robinson, *Abutilon indicum* Sweet, *Richardia braziliensis* Gomez, *Achyranthes aspera* Linn., *Scoparia dulcis* Linn., *Alysicarpus vaginalis* (L.) DC.) were recognized as alternate host. Frequency of cassava mealy bugs found on those weeds was 36, 5, 14, 5, 2 and 5, respectively. In addition, no correlations between density of weed species and the number of cassava mealy bugs on weed plant were found in those six weed species. It was interesting to note that the spread of exotic weed *Praxelis clematidae* may coincide with the invasion of cassava mealy bug in Thailand
Keywords: alternate host; cassava mealy bug; exotic weeds; Cassava plantations

Integrated weed management in cotton in India

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Cotton is the major cash crop of India that witnessed highest adoption rate of any GM crops in the world. Since its approval in 2002 increase in Bt cotton area was only 5-6% in the first 3-4 years, but then it picked up fast and in states like Haryana (4th largest producer in India), Bt cotton now constitute > 95% area under cotton. Thanks to increase in Bt cotton area, its production increased significantly to make India the second largest producer of cotton in the world with productivity of 554 kg/ha by 2007-08. Currently a downward trend is witnessed in yield due to increased demand of nutrients, moisture and poor weed control. Though it is more competitive than non-Bt cotton, weeds are still one of the major yield constraints. Labor shortage in agriculture not only affected manual weeding, but cotton picking was also hampered. There is limited choice of cotton herbicides in India. Hot weather and lower soil moisture at planting time is a limiting factor for the efficiency of PRE herbicides. Lack of selective POE herbicide, diverse weed flora, weed stage at spraying and emergence of several weed flushes in the early growth period makes it challenging to achieve season long weed control. Glyphosate is one of the options in roundup ready flax, but apprehension of resistance evolution is causing hesitation to government agencies for its approval on large scale at farmers' fields. The present paper will discuss the available weed control options in India using pre and post-emergence herbicides, their sequential and tank mixtures and integration with agronomic practices in keeping weeds at a low profile for sustainability of Bt cotton and improving financial health of Indian cotton farmers. Change in plant architecture is also needed for greater mechanization.
Keywords: Bt cotton; Herbicides; manual/mechanical weeding; Soil moisture; herbicide efficiency

Poster presentations

Weed suppression and seed yield in Trinidad with three North American cowpea lines selected for use as cover crops

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Cowpea (*Vigna unguiculata* (L.) Walp) is an annual legume that is widely used in the tropics and subtropics for food and animal feed. However, it is underutilized as a cover crop and green manure for reducing off-farm inputs and improving farm sustainability. During fallow periods, cowpea can be used to provide rapid soil cover that prevents soil erosion, suppresses weeds, and supplies nitrogen to a subsequent crop. Three cowpea germplasm lines developed from South Carolina land-races were released by the US Department of Agriculture for use as weed-suppressive cover crops in 2010. They are intended to replace varieties that tend to be weedy because of dormant seed production. The lines (US-1136, US-1137, and US-1138) were evaluated for weed suppression and seed yield in Trinidad at the University of West Indies field station in comparison with a local cultivar bred for food use (VRB7). Cowpeas were hand planted in rows or broadcast at 25 seeds per m^2 in November, 2010 and November 2011 and a weedy fallow treatment was included as a control. Seeds germinated in three days and broadcasting was as effective as planting in rows for establishment of the cowpeas. The ability to broadcast a cowpea cover crop will limit the labor cost for planting. VRB7, US-1136, and US-1138 had an erect growth habit and were earlier maturing than the semi-erect US-1137. The predominant weeds were grasses in both years. No effect of cowpea cover crop on weed density was apparent at 2, 4, and 7 weeks after planting (WAP). However, by 9 WAP total weed density was 178 weeds m^{-2} in the weedy control, which was significantly greater than with the cowpea treatments. At 126 weeds m^{-2}, VRB7 had a higher weed density than the US accessions, which averaged 78 weeds per m^{-2}. Weed biomass with cowpea cover crops was lower than in the weedy control by 4 WAP. Seed yields with US-1136 and US-1138 were greater than with US-1137. These results indicate the potential for utilizing cowpea for the ecological management of weeds and further studies are recommended to refine cover crop use for Caribbean cropping systems.
Keywords: *Vigna unguiculata*; cover crop; weed suppression; green manure;

Performance of the herbicide CMT-505 in sugarcane for *Digitaria* spp. under different moisture regimes in Brazil

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The weeds of the genus *Digitaria* spp are among the most important weeds in Brazil, for the cultivation of sugar cane. This crop occupies about 8.5 m ha and requires the use of herbicides for the control of weeds including *Digitaria* spp throughout the year under variable soil moisture conditions. Herbicide CMT-505 was evaluated against crabgrass (*Digitaria ciliaris*) at three different times, aiming different situations of soil moisture after application. The tests were conducted in locations close to each other, in Piracicaba, SP (application July 2011) and Santa Barbara D'Oeste, SP (applications in August and September 2011). The experimental site had sandy soils and the rains started in September, thus being evaluated in trials, periods of drought on the efficiency of CMT-505. The herbicide treatments were in liters or kilograms of commercial product per hectare: CMT-505 0.3, 0.4 and 0.5, CMT-505 + Butiron (tebuthiuron) 0.3 +1.5, 0.4 + 1,5, 0.5 + 1.5, CMT-505 + MIL FH 0415/08 (isoxaflutole) 0.3 + 0.12, 0.4 + 0.12, 0.5 + 0.12, Plateau (imazapic) 0.19, Dinamic (amicarbazone) + Provence (isoxaflutole) 1.0 + 0.12. The herbicide treatments were applied using CO_2-pressurized backpack sprayer in pre-emergence of the crop and crabgrass. The results showed that CMT-505 was able to control crabgrass for 150 days, even at lower dose, isolated and applied in July 2011, with an interval of 60 days for the first rain. CMT mixtures with tebuthiuron and isoxaflutole were equally viable, regardless of dose. CMT-505 was also selective to cane sugar varieties RB 855453 and SP 832847.
Keywords: grasses; water availability; application time; herbicide mixtures;

Performance of the herbicide CMT-505 applied in different soil textures in cane sugar in Brazil

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Sugar cane requires the use of herbicides for weed control throughout the year. Thus, the herbicide CMT-505 was evaluated for weed control in sugar cane crop in two soils of contrasting textures. The tests were conducted in locations close to each other, in Piracicaba, SP (sandy soil) and Iracemapolis, SP (clay soil). The fields were sprayed in July 2011, a period that is normally dry for the region studied. The herbicides were in liters or kilograms of commercial product per hectare: CMT-505 0.3, 0.4 and 0.5, CMT-505 + Butiron (tebuthiuron) 0.3 + 1.5, 0.4 + 1,5, 0.5 + 1.5, CMT-505 + MIL FH 0415/08 (isoxaflutole) 0.3 + 0.12, 0,4 + 0.12 and 0.5 + 0.12, Plateau (imazapic) 0,19 or 0,21, Dinamic (amicarbazone) + Provence (isoxaflutole) 1.0 + 0.12 or 1,2 + 0.12, the latter two being used at higher rates in the clay soil, as well as treatments with and without weeding. The PRE application of herbicides was made by a CO_2-pressurized backpack sprayer. The results showed that CMT-505 was able to control infestations of crabgrass (*Digitaria ciliaris*) and purple nut sedge (*Cyperus rotundus*) up to 150 days, even at lower dose and isolated, with the first rains 60 days after application in sandy soil. CMT-505 was effective only at higher dose of 500 ml ha^{-1} in the clay soil against crabgrass and bindweed (*Merremia aegyptia*). Tank mix applications of CMT 505 with tebuthiuron and isoxaflutole were equally effective, other than CMT-505 for each soil type. CMT-505 was also selective to sugar cane varieties RB 855453 in sandy soil and RB 867515 in clay soil.
Keywords: *Cyperus*; *Digitaria*; *Merremia*; herbicide mixtures; varietal selectivity

Periods of *Raphanus raphanistrum* L. interference with sunflower in Rio Grande do Sul – Brazil

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Sunflower (*Helianthus annuus* L.) is increasing in importance as oilseed for biodiesel production in Brazil, but there are some obstacles in its production, emphasizing the weed interference. The study aimed to determine the periods of *Raphanus raphanistrum* L. interference in sunflower crop and its effects on crop parameters. A field experiment was conducted at the Universidade Federal de Pelotas (UFPel) in randomized complete block design with four replications. The sunflower cultivars was BRS 321, early maturing variety, planted at a spacing of 80 cm, population of 60.000 plants ha^{-1} and fertilized with 300 kg ha^{-1} of NPK and 45 kg ha^{-1} of nitrogen. The treatments included periods of coexistence and control of *R. raphanistrum* with the crop. The evaluation periods were 0, 7, 14, 24, 28, 35 and 102 days after emergence (DAE). The average population of *R. raphanistrum* was 189 plants m^{-2}, the removal was performed in each period by rouging. The variables evaluated at the end of the growing season were: plant height, capitulum diameter, thousand kernels weight and final yield. The critical period of interference was estimated by subtracting 5% of the value estimated by the model plots maintained free of weed coexistence throughout the crop cycle; this value was considered the cost for control adoption. Sunflower must remain free from the presence of *R. raphanistrum* for a period between 17 and 53 DAE. The presence of *R. raphanistrum* reduced plant height, capitulum diameter, thousand kernels weight and yield of sunflower.
Keywords: *Helianthus annuus*; weed competition; critical period; yield loss

Weed management in non-crop areas

Oral presentations

The undesired vegetation in archaeological sites. Integrated management in respect to historic landscape

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Weeds and shrubs constitute a problem in historic sites while use of herbicides is prohibitive in order to avoid deterioration of the monuments. We developed a 3 years integrated weed management program in the archaeological site of Eleusis to control the weed flora with friendly approach towards the historic environment. Five methods (a-e) were selected according to the vegetation type in selected parts of the site.Soil solarization(a) was applied with black PVC for 3 months to control herbaceous species. The results showed a decreased of winter weed populations by 80% and by 55% for spring weed populations, compared to the control. An integrated method (b) consisted by mechanical and chemical means was used in order to eliminate shrubs and small trees grown on the monument. The shrubs were pruned down and a dense suspension of glyphosate (Round Up 42 SG - 100 g in 300 ml of water), was spread on the sections or injected inside the cambium. Both methods were 100% effective during the records for the 2 following years. NAA 400 mg l (Apponon) (c) was sprayed, to induce fruit drop in olive trees in order to prevent the spread olive seedlings on the monuments. The method resulted in complete fruit abortion and the effective restriction of olive seedlings for the 2 following years. To protect a mosaic floor at a Roman villa from weeds, successive layers of quartz sand, geotextile, LECA (light expanded clay aggregate) and gravel were applied (d). That inactive materials restricted the weeds establishment at a low populations covering only the upper gravel layer. Furthermore, plantation of aromatic plants (e), harmonized to the historic feature of the site, was established around the villa, a prohibitive method for weed entrance inside the place.
Keywords: vegetation management; archaeological sites

Abundance and control of urban weeds

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Data on a 3 years monitoring study in a typical German city (Braunschweig) will be presented. Weed species and weed coverage have been assessed at more than 100 fixed plots in order to describe the typical urban weed infestation. During the complete period we found 78 weed species e.g. groups of weeds. Beside bryophytes most frequent were Sagina procumbens, Poa annua, Taraxacum officinale and Polygonum aviculare. 26 species, including many arable annual weed species occurred very sporadically (frequency < 1%). The mean weed coverage was 6.3% but was much higher in some cases in industrial zones. Weed control trials including physical and chemical control measures have been conducted at 10 sites located in Braunschweig from 2005 to 2007. Five different control measures were evaluated in terms of efficacy and long-term effects. Additional investigations focused on the optimization of rotowiper system which has been specifically developed for weed control on pavements by using glyphosate. This system was compared with a broadcast application of natural herbicides like pelargonic and acetic acid.
Keywords: weed species; glyphosate; non-chemical control; pavements

Innovations in sustainable weed control on pavements

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Each country in EU has to have a National Action Plan (NAP) for sustainable use of pesticides by the end of 2012. This also applies to non-crop area. Currently, ca. 75 % of all non-agricultural pesticides are herbicides in the Netherlands. Over 50% of these pesticides are herbicides used on pavements. Herbicide weed control on pavements has the lowest direct costs compared to non-chemical methods in the Netherlands today. However, adverse side effects of herbicide weed control can be large when the use is without emission reducing measures. During the past 10 years, we collected data on efficacy, costs and environmental effects of different weed control methods (brushing, flaming, hot air, water and/or steam treatment, and herbicide weed control) applied on pavements in the Netherlands. The data are collated in a decision support system (DSS) called SWEEP (Sustainable weed control on pavements). Costs and environmental effects of the methods are considered and recommendations are made in a way that environmental targets are met against the lowest possible costs. An Environmental Life Cycle Assessment (LCA) is a key part of the SWEEP DSS. It weighs e.g. aquatic effects of herbicide weed control versus energy use of thermal weed control. The LCA showed that the environmental effect of a herbicide control system depends to a large extent on the amount of herbicide run-off. That is why rate and rain prediction are important criteria for herbicide weed control in the SWEEP system. The criteria are mandatory for herbicide use on pavement in the Netherlands, in combination with selective application technology and certification. Advances innew preventive and curative weed control methods being part of SWEEP on pavements will be shown.
Keywords: weed management;hardsurfaces;LCA;control methods;DSS; pavements

The status of herbicide registration and application in non-crop areas in China

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The status and policies of herbicide registration and application in no-crop area in China was summarized in this paper. The chemical herbicides could play an very important role to control the weeds and shrubs in no-crop area. Some concerning problems in herbicide registration and application in this field were pointed out and approaches of effective solutions for these problems were also

discussed. There are ideas about new herbicide development, new application techniques, herbicidal resistance, environmental contamination, etc. It needs to overcome these problems for sustainable development of agriculture in China.
Keywords: Herbicide, Registration, Application, Non-crop area

Competition effects of native weeds on Eupatorium adenophorum seedlings

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Eupatorium adenophorum is one of major invasive weeds in China and has caused great ecological disaster and economic losses, such as the decrease in biodiversity and the change in structure and function of ecosystem. A variety of methods about controlling crofton weed have been conducted, including the prevailing method of replacement control. Based on previous seed germination experiment, two non-invasive plants, Lolium perenne and Dactlis gloerata, were chosed as the replacement for crofton weed to clarify the competition effects. There were two time treatments, that is, A referred to the replacement weeds planted one month ahead of crofton weed and B referred to replacement and target weeds planted meanwhile. The dynamics of height, as well as the leaf number, biomass and the number of crofton weed seedlings were measured as well as the biomass and the height of the replacement plants every month. Four months later, no crofton weed seedlings were found in treatment A. In contrast, a decending trend during the investigation period appeared about the number of crofton weed seedlings in treatment B, the indices of leaf number, height and biomass of crofton weed seedlings were significantly lower than those in control. It was notable that both the biomass and height of L. perenne decresed at every investigation period. The results suggested that D. gloerata possessed a potential replacement capability on crofton weed.
Keywords: crofton weed; competiton effect;Dactlis gloerata;replacement;

Integrated management of eastern redcedar in nebraska's pastuer

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Eastern redcedar (*Juniper virginiana* L.) is an invasive species that is invading pastures and rangelands of Midwestern states, including Nebraska. Therefore, a series of studies evaluated Eastern redcedar control using an integrated management approach based on herbicides and mechanical removal in 2001 and 2002 at three locations in Nebraska. Herbicides were applied either broadcast or as high volume foliar sprays to individual trees. Visual ratings of tree control at 30, 60, 90 days and 365 days after treatment were collected to determine the level of control. On the basis of visual ratings mechanical control provided up to 100% control and it was the most labor intensive method. Tree height was an important factor influencing level of chemical control in broadcast treatments. Treatment efficacy declined with increased tree height. Eastern redcedar control was greatest when picloram was a component of herbicide treatments either broadcast applied to trees or when individual trees were sprayed. Eastern redcedar control did not exceed 26% when triclopyr-containing treatments were applied. Broadcast applications of picloram + fluroxypyr at 5 pts/acre, picloram + 2,4-D at 6 and 8 pts/acre, and picloram used alone at 2 pts/acre provided excellent control (> 85%) of trees that were a foot or less in height. In contrast, these treatments provided poor control (< 60%) of trees that were more than 2 ft in height. Eastern redcedar control was excellent (> 85%) when individual trees were treated with premixes of picloram + fluroxypyr, or picloram + 2,4-D, applied at 1.5% and 2.0% (volume per volume) of product solution, and with picloram applied at 1.0 % solutions.
Keywords: eastern redcedar; range land; Nebraska; pasture; invasive weed

Invasion of *Parthenium hysterophorus* L. in north-east india & its management

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Background Parthenium hysterophorus L. family Asteraceae, an annual herbaceous weed causes severe health hazards & environmental problems. Objective To assess Parthenium growing region in National Highways & railway tracts of North East States of India (longitude 98058/ & latitude 24044/) through a systematic survey & managing it using biocontrol agents. Material & method Regular field surveys of Parthenium growing regions of 12 National Highways & 3 railway tracks were conducted during 2009 to 2011. Gynura cusimba, Amaranthus spinosa, Mimosa pudica, Cassia tora,Cassia occidentalis, Sida spinosa, Riccinus communis, Xanthium strumarium, Chromolaena. sp, Urena lobota & Chryopagon aciculatus were studied for their inhibitory effect on Parthenium. Aspergillus niger, Trichoderma viridae, Penicillium sp, Fusarium oxysporium, Alternaria alternata & Zygograma bicolorata were tested for their efficacy in controlling Parthenium. Results Growth of Parthenium was recorded in 12 National Highways & 3 railway tracts of North Eastern India. Riccinus communis, Amaranthus spinosa & Cassia tora showed maximum inhibition on root growth, stem growth & seed germination & minimum in dry matter production while minimum inhibition & maximum dry matter production was found in Chrysopagon aciculatus. Cassia tora, Xanthium strumarium & Amaranthus spinosa showed maximum allelopathic effect. Fusarium oxysporium exhibited maximum inhibition on seed germination & seedling growth of Parthenium. The adult & larva of Zygograma bicolorata were found to devour all the leaves of Parthenium except midrib significantly by reducing the height, shoot length, root length & biomass of Parthenium. Conclusion An integrated approach will be helpful in controlling Parthenium.
Keywords: Biocontrol; Parthenium hysterophorus; Zygogramma bicolorata; Allelopathic effect

Integrated management of Goldenrod (*Solidago canadensis*) mainly using biocontrol techniques in disturbed habitats in China

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Goldenrod (*Solidago canadensis* L.) is native to North America, which has already widely distributed throughout eastern China and still spreads to central and northern China, furthermore caused serious ecological trouble in these areas. Most of local governments involved in goldenrod infestation have initiated the actions of goldenrod control. Chemical control has been preferably applied for this weed normally. However, it is not always effective due to regrow from residual rhizomes and meanwhile large amount of herbicide input causes new environmental pollution. Hence, there needs to develop new sustainable control techniques for effective management of this weed. Sclerotium rolfsii, isolated from a destructive stem rot diseased goldenrod plants, was developed into a mycoherbicide for a biocontrol of this weed. This mycoherbicide was mass-produced using crop straw and hull as media. In spring and early summer, it was sprayed onto plowed habitats infested by goldenrod. In autumn, it was applied after cutting goldenrod and plowing soil. Combined with cutting and plowing, the mycoherbicide could completely infect rhizomes of goldenrod and demonstrated over 90% control efficacy in the invaded habitats. An inhibitor for flower bud differentiation was developed and applied at a large scale to completely prevent seed setting through inhibition of microspore and megaspore development. As a result, it can definitely help slow down speed of the weed spreading to new areas. The goldenrod stalk left was utilized as media for culture of dozen kinds of edible mushrooms. In conclusion, an integrated management approach has been established with combination of biological and mechanical control for rapid response, utilization and slowing spread for prevention of goldenrod.
Keywords: Invasive alien plant; Solidago canadensis; Goldenrod; Integrated management; Mycoherbicide

Selected grasses can control *Mikania micrantha*

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Mikania micrantha (Asteraceae) is a widespread herbaceous to semi-woody perennial vine invasive to South China. To date, pre- and post-emergent herbicide applications have been most effective in controlling the species. However, there is growing demand for ecologically safe methods. Certain tree species have been the only successful control for *M. micrantha*, but not all areas are suitable for tree planting. Therefore, other ecologically sound methods for control of M. micrantha are in critical need. We found that there were no or few *M. micrantha* in some grass community (e.g. *Panicum incomtum*, *Pennisetum purpureum*, and *Microstegium vagans*). These grasses might be a promising, robust and ecologically safe and appropriate control agents. Field and glasshouse experiments were designed to test the effect of these grasses and grasses communities on *M. micrantha*. We found seeds germination of *M. micrantha* was restrained and seedlings of *M. micrantha* could not survive long time in grasses communities. *M. micrantha* is difficult to climb to the top of these grasses, the plants cannot cover these grass. When grown with *P. incomtum* and *P. purpureum*, biomass and cover of *M. micrantha* decreased, and biomass of *P. incomtum* and *P. purpureum* increased. Therefore, the results indicated that *M. micrantha* could be deterred by some grasses. *P. incomtum* and *P. purpureum* are promising robust and ecologically safe and appropriate control agents.
Keywords: *Mikania micrantha*; biocontrol; *Panicum incomtum*; *Pennisetum purpureum*; *Microstegium vagans*;

Stem applications of herbicides for *Ailanthus altissima* control

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Among the arboreal weeds colonizing non-crop areas in the Apulia Region (South Italy), the invasive *Ailanthus altissima* (Mill.) Swingle (tree of haven) is one of the worst. It reaches the heart of protected areas and spreads everywhere in urban and sub-urban areas creating dense stands. Its management is very difficult because of its fast growth and mechanical treatments are ineffective due to root-suckers and resprouting shoots. Our study aimed at providing an eco-friendly chemical strategy for tree of heaven control minimizing herbicides use by stem treatment techniques, reducing risks for human health and environment. Three experimental field trials were carried out in different sites using three systemic herbicides available for control of shrubs and resprouting trees, registered for use in non-crop areas. Three types of stem treatments were compared, i.e.: cut stump, spaced cuts and stem injection. Standard application methods were modified and herbicides application rates were minimized. The best application season was considered, too. Plants treated were compared against the relevant control and untreated plants. Appearance and seriousness of phytotoxicity symptoms (leaf yellowing, browning or falling, twig distortion, branch death, stem splitting), and number of stump resprouts were recorded. The results of two years trials will be presented. Stem applications allowed a good control with low rates of herbicide and may offer many advantages, e.g.: low drift, no off-target effects, selectivity, minimal need of equipment, possibility of treatments in anthropic areas and minimal risk for the environment. Effective options to control A. altissima in non-cropland seem to be available.
Keywords: *Ailanthus altissima*; low doses of herbicides; stem application;

Poster presentations

Advances in spot spraying of herbicides on sports fields

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Weeds on sports fields are mainly controlled by band spraying of selective herbicides on the fields. In this paper we describe a new approach of detection of broad-leaved weeds on sports fields, to be able to reduce herbicide use on these fields by spot treatment. Common weeds on sports fields in the Netherlands are Bellis, Taraxacum, Plantago and Polygonum species. We have developed a vision-based system that uses textural analysis to detect broad leaf weeds against a grass background. After pre-processing, monochrome image tiles (0.03×0.03 m^2) are classified as grass or weed based on variance. A weed is detected when a sufficient number of adjacent tiles are classified as containing a weed. In a first experiment on a sports field, we collected images containing only grasses or broad leaf weeds and grasses. Over 80 % of the images were correctly classified as showing only grasses or grasses and weeds. We are now building with specialized companies (Arvoo, Tumoba and Donkergroen) a prototype for detection of broad-leaved weeds and selective application of herbicides to weeds on sports fields. The system consists of independent, one-meter wide modules. Each module has a camera system for detection of the weeds which is connected to four nozzles. We expect to be able to reduce herbicide use with this machine by more than 50 % compared to common practice. The vision-based detection system has already been successfully used for the detection of larger Rumex plants in pastures of dairy farms in the Netherlands, in that case the detection system controls a cutting device that selectively drills out the tap root of the weed. The key challenge in the sports fields project is to make the system effective on much smaller broad-leaved weeds without damaging the pitch.
Keywords: weed detection;precision agriculture; selective herbicides

Integrated management of *Phragmites australis* (common reed) along the platte river

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The non-native biotype of common reed (*Phragmites australis* subsp. australis) is an invasive species that is invading wetland habitats and other natural areas in many eastern states of the US, including Nebraska. This species can be found along the Platte River, from Wyoming to eastern Nebraska, and expanding. Therefore, a series of of studies evaluated common reed control along the Platte River using an integrated management approach based on herbicides (glyphosate or imazapyr), mowing, and disking, either applied alone or in combination. Total of three studies, disking followed by herbicide (study 1), mowing followed by herbicide (study 2), and herbicide followed by mechanical treatment (study 3) were conducted in 2008, 2009 and 2010 at three locations in Nebraska. Visual ratings, flowering percentage and stem densities were collected to determine level of control. On the basis of visual ratings, disking and mowing alone did not provide adequate control of common reed whereas control was significantly improved and lasted for third season (817 DAT) when disking and mowing was followed with herbicide applications. All treatments in disking followed by herbicide and mowing followed by herbicide had good (≥84%) to excellent (≥92%) control, which significantly ($P = 0.0001$) suppressed common reed for 817 DAT. An addition of a mechanical treatment following herbicide application did not improve common reed control.
Keywords: common reed; invasive plants; invasive weeds; Nebraska

The 'Weedviewer' for monitoring weeds on pavement

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Managers of pavement have to consider weed control when weeds affect the functionality, durability and/or aesthetic value of the pavement. To maintain the required visual street quality, regular monitoring of weed (re-)growth is necessary. Weed monitoring data are most commonly expressed in terms of coverage and height of green foliage above ground. Visual monitoring of weeds on pavement in the Netherlands is commonly based on the standard weed scale bars from the CROW Quality Catalogue (CROW is the Dutch technology platform for transport, infrastructure and public space). Quality is estimated by making use of visual assessments and comparing them to the CROW Quality Catalogue. This estimate remains in many cases a subjective estimate. It can have large financial consequences, as for example, a contractor does not fulfill his obligation according to this measurement. Therefore, there is need for a more objective method.The aim of this study is to develop an objective method for determining the amount of weeds on pavement: the 'Weedviewer'. The principle of the method is relatively simple: a digital photograph of a part of the pavement is taken, followed by automatic image analysis and calculation of the percentage of weed cover (percentage of green pixels). The HD camera images are visualized on a tablet PC. For the image analysis and calculation of the percentage of weed cover, the software program ImageJ and a specially developed Plug-in for this application is used. When starting ImageJ all jpg files in the appropriate directory are automat-ically scanned and the results are saved in an Excel file. The newly developed method will be fully in line with the standard scale bars of the CROW Quality Catalogue.
Keywords: weed management;pavement;monitoring;image analysis;

Integrated management of vegetation at archaeological sites to protect monuments and enhance the historical landscape - Thalis project *

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Native vegetation, an integral part of archaeological sites (AS), contributing to their character and beauty, if uncontrolled causes various major problems to the site. Conventional methods of weed control often cause additional deterioration to the monument and the environment. Aim of the project proposed is twofold: Primarily the development of weed control methods friendly to the environment and monuments and secondly the integration of these methods in the design of AS. 1st WP: Seven AS selected based on their geographic location will undergo a survey to record species and density of spontaneous vegetation and associated problems to the sites, as well as various types of surfaces with inert materials present and their effectiveness to deal with weed establishment. A log of plant species and types of inert material surfaces associated to problems caused to the AS will be developed, as well as a compiled GIS database of the above log suitable for mapping and spatial analyses of AS which allows to calculate and assess the spread and the effect of spontaneous vegetation. 2nd WP: Alternative methods will be developed and assessed in situ to manage unwanted vegetation, such as prescribed burning, soil solarization, use of appropriate aggregates for surfaces to accommodate visitor access, burial of mosaics not-displayed and selective use of herbicides and plant growth regulators. 3rd WP: Native herbaceous and shrubby species will be assessed for potential use in AS and protocols developed for their propagation and cultivation. Mixes of these species suitable for produce from nurseries and seed industries will be evaluated in laboratory plots and in situ as for the potential to establish a groundcover that prevents growth of destructive weeds and enhances the landscape. 4th WP: Guidelines that integrate methods friendly to the environment and ruins to control unwanted vegetation with design principles will give new space, function and semantic structure to AS.
Keywords: environmentally friendly weed control; ;design of historical landscape;; native vegetation;

Plant community restructuring successfully ousted invasive weed mile-a-minute (*Mikania micrantha*)

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Mile-a-minute is a perennial herbaceous to semi-woody vine of Asteraceae. A wide area field investigation conducted in south China in 2000-2001 inspired hope that restructuring vegetation invaded area into an environment unsuitable for mile-a-minute to live was highly possible. Two 10 hm2 survey plots in invaded areas within a closed off area intended for natural forest recovery were set up in 2001. Idealized criteria for a plant species as community restructuring agents were set up for species selection. Several important preset criteria were: fast growing, dense canopy, broad crown and able to grow >6m. Eighteen local tree species were selected based on their closeness to the criteria. Their saplings as community restructured agents were planted within those large patches completely covered by mile-a-minute in the two survey plots in 2001 and 2002. All fostering was terminated in December 2002. Two hundred and fifty-five trees were tagged and monitored in certain interval periods. Results indicated that, among eighteen species used, the saplings of Macaranga tanarius and Heteropanax fragrans grew particularly well under mile-a-minute stress. In 2006, they formed continuous close canopy and never were completely covered by mile-a-minute although without any human intervention. Some other species, such as Liquidambar formosa and Schima superba, could hardly survive in the same condition. Ten years after the restructuring, no vine could ever climb to the canopy. In conclusion, selection of proper species that would continue to grow in the present of mile-a-minute was crucial so that fostering would be minimized, and restructured community did ousted mile-a-minute permanently. This simple but effective measure could be used elsewhere.
Keywords: species selection;human intervention;community restructuring;Macaranga tanarius;Heteropanax fragrans;

Herbicide resistance in weeds and crops

Oral presentations

Mechanisms of glyphosate resistance in weeds

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Glyphosate was first introduced 40 years ago, in 1995 a new standard for simplified and efficient weed control was introduced with herbicide tolerant crops. In 1996 the first glyphosate-resistant weed species appeared due apparently to extensive repetitive use. Today there are some 22 species confirmed resistant globally (www.weedscience.org) in a variety of agronomic uses. Historically weeds have developed resistance by using principally three biochemical strategies. The most potent and common is target site resistance where an amino acid mutation in the target enzyme limits or even excludes the herbicide. Point mutations have been observed to afford immunity to some herbicides but not for glyphosate. EPSPS's with point mutations are found in at least 5 species but these provide weak resistance barely challenging the recommended field use rate. A second common mechanism of resistance has been chemical modification or metabolism. Selective herbicides that are safe to use in a crop rely on metabolism. The chemical modification of glyphosate has been rare in plants in particular with only recent examples of detectable metabolism appearing in some legumes and glyphosate resistant Digiteria sp. The third mechanism for resistance is to thwart the uptake and translocation of the herbicide by physical or physiological barriers. These mechanisms are distinctly weaker and were rarely described until interrogation of glyphosate resistance. Glyphosate seemed to be capable of ubiquitous movement and translocation in plants. Studies using 14C-glyphosate and in vivo 31P NMR have revealed that glyphosate can be sequestered in the vacuole, excluded from the cell and even apparently excluded from the chloroplast or titrated out by excess EPSPS.
Keywords: glyphosate;resistance;mechanism;EPSPS;

Resistance to glyphosate in Italian ryegrass populations from Arkansas, USA

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Resistance to glyphosate in weed species is a major challenge for the sustainability of glyphosate use in crop and non-crop systems. Glyphosate-resistant Italian ryegrass populations have been identified in Desha County, Arkansas, USA. This research was conducted to determine the resistance mechanism to glyphosate in Des03, Des05, and Des14 Italian ryegrass populations from Arkansas. Plants were analyzed for EPSPS gene sequence, EPSPS enzyme activity, and EPSPS gene copy number. The resistance level of selected glyphosate-susceptible (S) and -resistant (R) plants from Des03 population was also determined and correlated with EPSPS enzyme activity and EPSPS gene copy number of the same plants. EPSPS gene sequencing revealed that resistance to glyphosate was not due to target site mutation. Resistant plants in Des03 population had six-fold higher basal EPSPS enzyme activity and contained up to 100 more copies of EPSPS than the S plants. The resistance levels of selected R and S plants from Des03 population correlated with their EPSPS copy numbers and EPSPS enzyme activities. Therefore, resistance to glyphosate in Des03 population is due to increased EPSPS enzyme activity and amplification of the EPSPS gene. Dose-response bioassays showed that Des05 and Des14 populations were seven- and eight- fold more resistant to glyphosate, respectively, than the S population. Resistant plants from Des05 and Des14 populations had up to 122 and 444 EPSPS copies, respectively; whereas, the S population had only up to two copies. The average EPSPS copy number of Des05 and Des14 reflects the resistance level of the populations. This indicates that EPSPS gene amplification confers resistance to glyphosate in Italian ryegrass. This is the first report of EPSPS gene amplification in glyphosate-resistant Italian ryegrass. This mechanism may occur in other weed species. Future research in this area should investigate ways to mitigate EPSPS gene amplification.
Keywords: glyphosate;EPSPS copy number;dose response;Italian ryegrass;EPSPS inhibition assay;

Characterization of the resistance mechanism of hairy fleabane (*Conyza bonariensis*) to glyphosate

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Over use and misuse of glyphosate has led to the evolution of more than 20 glyphosate resistant (GR) weed species, worldwide. In this study we propose a mechanism of GR Conyza bonariensis, a widely spread troublesome weed in Israel. Shikimate analysis, as an accepted measure for glyphosate activity, was conducted for two GR hairy fleabane populations versus two GS populations. Plants were treated with glyphosate on mature leaves only or young growing leaves only (YLO). Shikimate was determined in mature leaves, young leaves and roots over time. High shikimate levels were recorded in the roots and young leaves of GS plants regardless the site of application, whereas in GR plants just young leaves of YLO-treated plants did accumulate shikimate. The results demonstrate the rapid movement of glyphosate to sinks in GS populations and the presence of sensitive EPSPS enzyme in both GS and GR biotypes. Indeed, PCR of the appropriate EPSPS DNA fragment confirmed this conclusion. Based on these results we hypothesized that an impaired translocation of glyphosate in GR plants might be involved in the resistance mechanism. 14C-glyphosate's auto-radiography of GR versus GS treated leaves over time suggests a delayed export of glyphosate to phloem in GR plants. On the other hand 14C-glyphosate's whole plant auto-radiography and 14C-glyphosate analyses resulted in a similar translocation pattern in all populations. These data support the hypothesis that GR mechanism is associated with an altered cellular distribution and phloem loading by sequestration of glyphosate in the vacuole possibly mediated by ABC transporters. We also

observed higher (two to five folds) expression and accumulation of anthocyanin in GR plants as compared with GS plants, particularly when grown under cold stress (16/10) and after glyphosate treatment. Altered 'behavior' of anthocyanin's ABC transporters may explain the purple phenotype of GR biotypes and the mechanism of resistance.
Keywords:glyphosate ;resistance mechanism ;shikimate ;vacuole ;ABC transporters;

Target-Site mutation associated with Glufosinate resistance in *Lolium perenne* L. *spp multiflorum*

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Dose-response, ammonia accumulation, enzyme activity and DNA sequencing studies were conducted to elucidate the basis for glufosinate resistance in an *L. perenne* L. *spp multiflorum* population. The glufosinate rates required to reduce growth by 50% (GR50) were less for the control populations C1 and C2, than for the resistant population. The GR50's were 0.15 and 0.18 for C1 and C2 respectively, and 0.45 for the resistant population, resulting in a resistance index of 2.8. Ammonia accumulation post glufosinate treatment for the resistant population was on average 1.5 times less than for the susceptible populations. The glufosinate concentration required to reduce the glutamine synthetase enzyme activity by 50% (I50) was greater for the resistant population compared to the susceptible populations. The I50's values were 4.3 and 3.7 for C1 and C2, respectively, whereas the resistant population had an I50 of 10.7, resulting in a resistant index of 2.6. Eighty-three percent of the plastidic GS gene was cloned and sequenced. One amino acid substitution was identified that may be associated with the reduced enzyme sensitivity. This is the first report of glufosinate resistance conferred by an altered target site in a weed species. This report, along with previous reports of glufosinate resistant *L. perenne* L. *spp multiflorum* populations, is a warning that the increased selection pressure from glufosinate in glufosinate-resistant crops could lead to a similar situation as is now occurring with the evolution of glyphosate resistant weeds in glyphosate-resistant crops.
Keywords: glufosinate resistance;target-site;*Lolium perenne ssp multiflorum*;

Evolved mutations conferring resistance to herbicides inhibiting protoporphyrinogen oxidase

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Resistance to herbicides that inhibit protoporphyrinogen oxidase (PPO) has been reported in only four weed species to date. The mechanism of resistance has been elucidated in two of these species, Amaranthus tuberculatus and Ambrosia artemisiifolia. In both of these species, resistance to PPO inhibitors results from a mutation in PPX2. This gene encodes the mitochondrial isoform of PPO; however, in some species, including A. tuberculatus, the mitochondrial PPO isoform may also be targeted to plastids. Dual targeting occurs due to the presence of two in-frame initiator methionine codons in PPX2, the first of which is followed by the coding sequence for a chloroplast-targeting signal. It currently is not known if the A. artemisiifolia PPX2 gene similarly encodes for dual-targeted PPO. Although resistance in both of these species is due to a PPX2 mutation, the mutations are different. In A. tuberculatus, the mutation is unusual in that it is a codon deletion, resulting in the loss of glycine at position 210 (deltaG210) of the PPO enzyme. In A. artemisiifolia, a more traditional point mutation results in the substitution of an arginine to a leucine at position 98 (R98L). Inspection of the wild-type PPX2 sequences from the two species provides an explanation as to why the different mutations have evolved. In A. tuberculatus PPX2, a small microsatellite (tri-nucleotide repeat) exists in the region encompassing the glycine 210 codon, and is thought to have enabled the deltaG210 mutation. A corresponding repeat does not exist in the A. artemisiifolia PPX2. The R98L mutation required only a single nucleotide change in the A. artemisiifolia PPX2, whereas the corresponding amino acid change in A. tuberculatus PPX2 would require two nucleotide changes.
Keywords: Amaranthus tuberculatus;Ambrosia artemisiifolia;resistance mechanism;DNA sequence;protox;

Herbicide resistance-endowing ACCase mutations in hexaploid wild oat (*Avena fatua*): What can we expect in resistance evolution in a hexaploid species?

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Hexaploid wild oat (*Avena fatua*) is a global crop weed and many populations have evolved herbicide resistance. We studied the molecular and biochemical basis of resistance in a ACCase target-site resistant wild oat population M3/5 and identified three known ACCase mutations (Ile-1781-Leu, Asp-2078-Gly, and Cys-2088-Arg). Interestingly, we also reported the first case of multiple (an accumulation of two and three) ACCase mutations in wild oat. Using ACCase resistance mutations as markers, we showed that the presence of three unlinked ACC gene loci that inherit independently of each other, following the Mendelian genetic model for a diploid species. RT-PCR (d)CAPS analysis demonstrated that all three ACCase resistance mutations in an individual are expressed and that each is harbored by one of the three Acc1 gene copies. In vitro ACCase activity assay however revealed that, each identified ACCase mutation confers lower level diclofop resistance compared to diploid grass species by the same mutation(s), likely due to additional susceptible gene copies in the hexaploid wild oat. These findings are important because: (1) frequently it is assumed that hexaploid plant species operate as diploids, both genetically and functionally, but here we clearly establish that this is not true in the hexaploid wild oat, as all ACC gene copies are transcribed/expressed; (2) additional copies of expressed susceptible ACC genes in different genomes (fixed heterozygosity) may buffer/dilute the effect of resistance mutations, and this may have impact in herbicide resistance evolution in hexaploid wild oat. Using herbicide resistance as an example, we provide insights for understanding herbicide resistance evolution that is more complex in polyploids than diploids.
Keywords: hexaploid wild oat (*Avena fatua*);ACCase herbicide resistance;ACCase mutation;Acc1;resistance evolution;

Low herbicide dose selection results in P450-based enhanced herbicide metabolism resistance in *Lolium rigidum*

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Lolium rigidum, an obligate cross-pollinated and genetically diverse species, is an economically important weed in Australian and world agriculture. *L. rigidum* is a resistance- prone species able to rapidly evolve herbicide resistance. We have demonstrated that recurrent selection of initially susceptible *L. rigidum* populations with sub lethal herbicide rates results in rapid (in three generations) evolution of herbicide resistance. The resistant plants show cross resistance across dissimilar herbicide groups. Here we report on studies of the mechanisms endowing rapid evolution of low dose selected diclofop resistance in L. rigidum. Resistance was not target- site based as ACCase assays showed that ACCase specific activity and herbicide sensitivity are similar in selected resistant versus unselected susceptible populations. Herbicide foliar uptake, translocation and metabolism studies using C14-labelled diclofop-methyl revealed no differences in diclofop uptake and translocation, but significant difference in diclofop metabolism between resistant and susceptible populations. The in vivo conversion of diclofop-methyl into phytotoxic diclofop acid and its further metabolism into non-toxic polar metabolites was assessed at 48 and 96 h post treatment using HPLC coupled with an in-line radioactive detector. The conversion of diclofop methyl to diclofop acid was found to be similar in resistant versus susceptible populations. However, the level of phytotoxic diclofop acid remaining in susceptible populations were from 1.8 to 2.7-fold higher than in the resistant populations. The lower level of diclofop acid in resistant populations was corresponding to 1.7 to 3.3-fold higher rate of diclofop acid detoxification. Some major diclofop acid metabolites chromatographically resemble those of wheat, and were 1.3 to 2.3-fold more abundant in resistant populations. Clearly, recurrent selection at reduced herbicide rates can result in rapid resistance evolution due to enhanced rates of herbicide metabolism likely involving cytochrome P450 monooxygenses.
Keywords: Low herbicide dose;herbicide metabolism;cytochrome P450;resistance evolution;diclofop methyl;

2, 4-D treatment induces herbicide susceptible *Lolium rigidum* become resistant to ACCase-inhibiting herbicides by enhanced herbicide metabolism

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Attempts to tank-mix ACCase-inhibiting grass herbicides with auxin dicot herbicides (2, 4-D, MCPA) for broad spectrum weed control has been found to result in reduced grass weed control due to antagonism between these two herbicide modes of action. The mechanism of the antagonistic effect of 2, 4-D on diclofop methyl in *Lolium rigidum* (annual ryegrass) was determined in this study. Glasshouse experiments showed that 2, 4-D amine treatment induced susceptible *L. rigidum* to become resistant to diclofop (and to a less extent to some other ACCase- or ALS–inhibiting herbicides), and the resistance induction is 2, 4-D dose and temperature dependent but is not inheritable. The well known P450 inhibitor malathion can reverse 2, 4-D induced resistance to ALS-inhibiting herbicide chlorsulfuron. From these results, together with other early published studies, we hypothesised that 2, 4-D treatment in grass species such as L. rigidum can induce overexpression of a number of P450 genes, enhancing herbicide metabolism and detoxifying these herbicides. 14C-labelled diclofop in vivo metabolism studies showed that (1) Foliar uptake and translocation of diclofop methyl was similar in the presence and absence of 2, 4-D. (2) The HPLC profile of diclofop metabolism was qualitatively similar but quantitatively different in the presence and absence of 2,4-D: conversion of diclofop methyl to diclofop acid was about 2-fold slower and metabolism of diclofop acid to non-toxic polar metabolites was 2-fold faster in the presence of 2,4-D. (3) Major polar diclofop metabolites are similar in L. rigidum and wheat but wheat metabolise diclofop 3-fold faster than Lolium. These results provide clear evidence that 2, 4-D treatment induces enhanced herbicide metabolism involving wheat-like P450 mediated metabolic pathway. Therefore, 2, 4-D can be used at high rates (4000-6000 g/ha) as an effective P450 inducer for herbicide-metabolising and resistance-endowing P450 gene discovery and cloning in *L. rigidum*.
Keywords: Herbicide resistance;2.4-D;Metabolism;P450;Diclofop;

Harvest weed seed control: an opportunity to manage herbicide resistance in weed populations

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Herbicide resistant weeds dominate Australian cropping and producers desperately need alternate control technologies. Crop and weed maturity is frequently synchronised with high proportions of total weed seed production entering the grain harvester (Lolium rigidum 88%, Raphanus raphanistrum 99%, Bromus spp. 73% and Avena spp. 85%). Subsequently, a number of systems have been developed to target these weed seeds during commercial grain crop harvest as they exit the harvester in the chaff fraction. Our evaluations of the following systems determined that they each have the potential to remove very high (>80%) proportions of total weed seed production. The chaff cart system involves the collection of the chaff fraction in a trailing cart with the collected chaff subsequently deposited in discrete piles. These piles can be a source of livestock feed but are typically burnt to destroy weed seeds. In the bale direct system of straw and chaff residues are collected by a baler attached to the harvester. Bales are removed from the field and subsequently used as a livestock feed source. To set up narrow windrows for subsequent burning, a chute is attached to the rear of the harvester to concentrate straw and chaff harvest residues into a narrow windrow (approx. 600mm). The burning of these windrows in the following autumn destroys any weed seed present. The Harrington Seed Destructor attached to the harvester as a trail behind unit, processes the weed seed bearing chaff material during harvest to render weed seeds non-viable. The long term use of harvest weed seed control systems has been proven to dramatically reduce in-crop weed populations. These results are providing the impetus for the continued adoption and use of harvest weed seed control in Australian cropping.
Keywords: seed destruction;chaff cart;windrow burning;

Managing glyphosate-resistant weeds in california orchards and vineyards

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Herbicide-resistant weeds have become a serious management issue in central and coastal California fruit tree, nut tree, and vineyard production systems. Recent decreases in the price of glyphosate, increasing fuel costs, and trends to reduced use of preemergence herbicides for regulatory, economic, or performance-related reasons have substantially increased the use of glyphosate in these cropping systems. The first case of glyphosate resistance in California, rigid ryegrass in Sacramento Valley orchards, was reported in 1998. In recent years, four additional glyphosate-resistant species (Italian ryegrass, horseweed, hairy fleabane, and junglerice) have become established in various production regions in the state. University research and extension efforts currently focus on four major areas: 1) documenting and characterizing existing populations and evaluating mechanisms of resistance; 2) evaluating alternative chemical control measures such as rotating modes of action, tankmix partners, and residual herbicides; 3) testing and demonstrating application technologies designed to reduce off target herbicide issues while increasing efficacy of available herbicides; and 4) educating growers and advisors about current and potential herbicide-resistant species and developing recommendations suitable for the numerous and diverse tree and vine productions systems that extend throughout the state. Developing techniques to minimize further selection and spread of glyphosate-resistant weeds in California tree and vine production systems is critical to ensure that herbicides with favorable economic and environmental qualities, such as glyphosate, remain available and useful for these systems and may require significant changes in grower attitudes and weed management practices.
Keywords: resistance;orchard;vineyard;glyphosate;

Glyphosate-Resistant weeds in Ontario, Canada

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In 2008, a giant ragweed biotype near Windsor, ON was confirmed to be the first glyphosate-resistant (GR) weed in Canada. Results from a survey have concluded that there are 47 additional sites in southwestern Ontario with GR giant ragweed. Field trials were established at eight sites with GR giant ragweed during the 2010 and 2011 growing seasons to evaluate preplant or postemergence herbicides in soybean. Control of giant ragweed increased with higher rates of glyphosate, but only at rates that are not economical for producers. The most effective tankmix was glyphosate + 2, 4-D ester; control ranged from 97 to 98%, 4 weeks after application (WAA). Sequential applications of glyphosate plus dicamba in dicamba-tolerant soybeans provided 100% control, 4 WAA at the three confined field trial locations. Glphosate resistant Canada fleabane (Conyza canadensis) was first confirmed in Ontario from seed collections in the fall of 2010. It is now confirmed that there are 8 fields in Essex County in southwestern Ontario with GR Canada fleabane. Field studies were conducted during summer of 2011 to determine the efficacy of herbicides applied preplant, preemergence, and postemergence for the control of GR Canada fleabane in soybean. Among the preplant herbicide tankmixes evaluated, saflufenacil (98%), saflufenacil/dimethenamid-p (96%) and amitrol (93%) provided the best control while chlorimuron (87%), cloransulam-methyl (87%) and 2,4-D ester (86%) were also effective in controlling GR Canada fleabane. Glyphosate alone or tankmixed with carfentrazone, glufosinate, paraquat, flumioxazin and chlorimuron+flumioxazin provided poor/inconsistent control of GR Canada fleabane in soybean. Among the preemergence residual herbicide treatments evaluated, metribuzin (100%), flumetsulam (98%) and cloransulam-methyl (95%) provided the best control. Glyphosate alone or in combination with chlorimuron, linuron, imazethapyr, clomazone, flumioxazin, flumioxazin+chlorimuron or pyroxasulfone+flumioxazin provided poor/inconsistent control of GR Canada fleabane in soybean. Among postemergence herbicide tankmixes evaluated, cloransulam-methyl (64%) and chlorimuron (51%) provided marginal control of GR Canada fleabane in soybean. Glyphosate alone or in combination with acifluorfen, fomesafen, bentazon, thifensulfuron, imazethapyr, imazethapyr+bentazon or glyphosate/fomesafen applied POST provided poor/inconsistent control of GR Canada fleabane in soybean. In dicamba tolerant soybean, dicamba provided fair to excellent control of GR Canada fleabane depending on timing.
Keywords: resistance;weeds;survey;soybean;

The Syngenta RISQ test: a universal early season method for detecting weed resistance to herbicides

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Herbicides are important tools for controlling weeds and protecting crop yields. Around ten different modes of actions account for 90 % of total herbicides applied. Over the years weeds have evolved resistance to major herbicides, often due to repeated application of the same modes of actions and limited diversity in agronomic practices. In order to limit the spread of resistance, quick, simple, cost-effective methods are required for confirming cases of field failures as early as possible. The most commonly employed method consists of the time consuming and laborious whole plant pot assays that rely on seeds collected at the end of the growing season. Here we describe an early season resistance detection assay based on seedlings collected prior to herbicide application in the field. The seedlings are transplanted onto agar containing pre-determined discriminating rates of herbicides and compared to sensitive and resistance standards. Survival rates are recorded based on new shoot and especially root development. Foliar, soil applied, systemic, contact, selective and non selective herbicides from eight commonly employed modes of actions were tested on relevant sensitive and resistant grass and broadleaved weeds representative of all major cropping areas and collectively characterised by different resistance mechanisms including target gene mutation/deletion/amplification as well as metabolism and impaired herbicide translocation. The results from the Syngenta RISQ test and the whole plant method were in very good agreement. Therefore, the

Syngenta RISQ test appears to be a very comprehensive and universal method for confirming resistance early in the season allowing for an educated choice of herbicides for effective weed control.
Keywords: Resistance detection;Bioassay;In-season method;Herbicide resistance;grasses and broad-leaved weeds;

Pollen-mediated gene flow in Sorghums: implications for herbicide resistant Sorghum

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There has been considerable interest in modifying the quality traits of grain sorghum using transgenic technology to enhance its nutritional value to both humans and animals raised for human consumption. In addition, at least one company in the USA is using traditional breeding technology to develop sorghum that is resistant to an ALS inhibiting herbicide. There is inherent risk in deploying transgenic or herbicide resistant grain sorghum because several related species (e. g. johnsongrass, shattercane, sudangrass) are capable of interbreeding with grain sorghum. Research is being conducted at the University of Nebraska to quantify several components of pollen-mediated gene flow from grain sorghum to shattercane and the fitness of F1 and F2 shattercane x grain sorghum populations relative to the parent lines. Results to date have shown that for synchronously flowering populations, the rate of outcrossing from sorghum to shattercane can average 16% within the source sorghum population and be as high as 2.6% within an individual panicle at distances of 200 m from the source. In addition, the F1 shattercane x sorghum population is at least as fit as both of its parents. Current research shows that multiple genotypes of grain sorghum and shattercane display substantial synchrony of flowering regardless of tillage system, planting date, or maturity group of the sorghum. Results of our research will be useful to Federal regulatory agencies in making science-based decisions about introducing transgenic grain sorghum in the USA and for agronomists developing best management strategies to maximize the value and longevity of herbicide resistant grain sorghums.
Keywords: gene flow;outcrossing;interbreeding;introgression;

Field validation of Chickpea (*Cicer arietinum* L.) tolerant to metribuzin applied post-emergent

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Weed management in chickpea (*Cicer arietinum* L.) has been an important issue worldwide. Lack of post-emergent herbicide options in chickpea hinders the production in Australia and developing herbicide tolerant chickpeas has become a priority. Metribuzin is used pre-emergent up to 285 g/ha in chickpea. However, chickpea cultivars are susceptible to post-emergent metribuzin. This abstract reports the field confirmation of two advanced breeding lines (IG96220 and S98167-CLIMA) tolerant to post-emergent metribuzin. These two lines were found through evaluating over 100 genotypes with divers genetic background. They had been chracterised by dose response under glasshouse conditions over two years. A field trial in 2011 tested 9 metribuzin treatments (4 pre and 4 post-emergent application and 1 control) in the two chickpea lines and one standard cv. Moti. The expermental design was Criss-cross with 3 replicates. The plot size was 22 m2 (12.2m x 1.8m). As expected, pre-emergent metribuzin at 210 g/ha had no biomass and grainyield reduction fro all three chickpeas, confirming the safe usage in all of them. For the post-emergent application, breeding lines IG 96220 and S98167-CLIMA had little biomass and grian yield reduction with rates up to 338 g/ha metribuzin, whilst cv. Moti suffered severe loss in biomass and grain yield. This post-emergent rate is comparable to the post-emergent metribuzin registered in narrow-leafed lupin in Australia. Tolerance at both pre- and post-emergent application provides extra flexibility in using metribuzin to control weeds selectively in chickpea crops. In addition, these two breeding lines have premium quality. They can be developed directly as tolerant cultivars or used as parents to transfer tolerance to other elite cultivars.
Keywords: chckpea;herbicide tolerance;metribuzin;post-emergent;grain yield;

Development of herbicide-resistant varieties of foxtail millet

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Developing herbicide resistance in forsaken small crops could be a way to maintain food and cultivation system diversity, otherwise they would disappear due to the impossibility or cost to control the weeds. It is the case with foxtail millet, Setaria italica, a small grain, preferentially autogamous, C4 cereal. Three different herbicide-resistant materials were developed using wild germplasm resources. They allowed: 1) to better characterize the resistance mechanisms and inheritance; 2) provide plant materials to test the efficiency of the crop resistance at field level; and 3) experiment on the possible flow back of the resistance gene to the wild relative and among varieties. The heredity of the resistance was maternal, nuclear recessive and nuclear dominant for resistance to atrazine, trifluraline and sethoxydim, respectively. In the three cases the resistance was due to a single nucleotide mutation: psbA-264 (atrazine), α2-tubulin-239 (trifluraline) and ACCase-1781 (sethoxydim). Resistance to trifluraline was not high enough to allow efficient weed control without crop damage, in contrast to resistance to atrazine and sethoxydim, which allowed further breeding and commercial release. However, trifluralin resistance can be used to maintain purity of male sterility lines. Yield of sethoxydim-resistant germplasm was even increased with respect to isogenic susceptible material. A pollen dispersal curve was measured. Both the wild relative and adjacent foxtail millet plants could be cross-fertilized at low frequency in the field. Phenotype admixture in adjacent fields was observed with the dominant gene only, the maternal resistance exhibiting the lowest dispersal risk.
Keywords: Sethoxydim;Trifluraline;Atrazine;Cultivar properties;Gene flow;

Gene flow and fitness variation in imidazolinone hrebicide resistant rice cultivaras and red rice (*Oryza sativa* L.)

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The imidazolinone-resistant rice cultivars provide selective red rice control. However, the fast evolution of imidazolinone-resistant red rice populations is challenging the utilization of this technology in southern Brazil. This study aimed to identify the origin, gene flow, fitness and the population dynamic of imidazolinone-resistant red rice. The resistance origin study was based on four microsatellites (SSR) and three single nucleotide polymorphism (SNP) markers in 176 red rice individuals. The imidazolinone resistance origin due to gene flow from resistant cultivars and independent selection occurred in 98.9 % and 1.1% of the individuals, respectively. The gene flow was studied in a field experiment based on the imidazolinone resistance trait and three SNP molecular markers. The mean gene flow rate from all rice cultivars was 0.0243%. Red rice was more receptive to pollen (0.0344%) than the susceptible cultivar (0.0142%). The gene flow from rice cultivars carrying three different ALS (acetolactate synthase) alleles was similar. The population dynamic evaluated on 27 red rice populations based on 24 SSR molecular markers indicated the occurrence of red rice seed migration. The within and among population variation was 74 % and 26%, respectively. The variation in fitness of the resistant rice plants was based on the germination parameters and showed that all the imidazolinone-resistant cultivars reached 50% of germination faster than the susceptible cultivar. These results suggest that red rice management should be based on the selection pressure reduction and mainly on the mitigation of the seed and pollen flow. The sustainability of herbicide-resistant rice cultivars is dependent on the development of new technologies for the prevention of gene flow to red rice.
Keywords: Population dynamic;imazethapyr;microssatelite;Clearfield;germination;

Poster presentations

Herbicide Resistant Weeds in China

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Herbicides have been used extensively and repeatedly in all major crops in China sine 1995, as a consequence, more than 10 weed species have evolved resistance to 9 major herbicide groups over the years, some herbicide resistant weed biotypes are becoming highly resistant to certain herbicides, e.g. the resistance index of flixweed (Descurainia sophia) is as high as 1700. Current status of herbicide resistant weeds in China and their possible mechanisms are discussed.
Keywords: Herbicide Resistant Weeds;Resistance;China;

Morpho-anatomical observations on leaf tissue of Lolium rigidum Gaud after glyphosate treatment

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In the last decade glyphosate resistance has been confirmed in many weed species. Glyphosate is regarded as a systemic herbicide that is usually translocated to all plant parts. Some plants withstand the glyphosate treatment and must be regarded as resistant. Based on calculated index of resistance (IR) between pop.of Lolium rigidum Gaudin we concluded that LR (resistant) population is 5.3 fold more tolerant to the glyphosate then LS (susceptible) and 1.9 fold more than LPR (presumably resistant). The goal of our research was to monitor which leaf parts are affected by glyphosate and how do the plants respond. Seeds of different populations of L. rigidum LR, LS and LPR were germinated, planted in pots and grown under glasshouse conditions (temp. 22.8/10.5oC day/night, 54.6% RH, 12:12h period). For monitoring morpho-anatomical changes we used glyphosate as a Touchdown® (500 g a.i. L-1), at doses 1, 2 and 4 L ha-1. Application was made by dipping into solution one half of one leaf per plant for each dose rate. Samples were collected 3, 7 and 24 h after application. Preparation of samples for TEM (Transmision electron microscopy) and LM (Light microscopy) was done according to methods described by Glauert (1975). Visual glyphosate effects in the form of leaf wrinkling coincided with changes in the shape and color (dose response test) were observed 17 days after treatment in plants of LS population. Plants of LS pop.were affected 90% after application of 2 L ha-1 of glyphosate, however LR and LPR plants were affected 10-20%. No simptoms on leaf parts were seen at 3 and 7 h after glyphosate treatment, except after application of the highest dose. This result confirmed susceptibility of all tested populations to 4 L ha-1 of glyphosate. Changes showed on mesophyll cells were destruction and agglutinations, respectively disappearance of cell walls. In treated plants the number of chlorophyll grains was lower then in control plants (for all tested pop.). In the first moment morpho-anatomical changes of the leaf tissue of LR population were not confirmed on LM population. Monitoring changes by TEM we could see damage in leaf tissue of LR plants after applaing glyphosate at 4 L ha-1 . The pictures showeddamage of epidermall cells, separation of the cell wall from plasmalema, but no damage of chloroplast grains. After treatment with 2 L ha-1 of glyphosate we have seen damage on leaf tissue of LS and LPR populations. Confirmed damage of cell walls, citolysis and disappearance of cells. Small damages were seen on epidermall cells, mezophyll cells and the cell form also changed. Contrary to the damages showed in tissues of LS and LPR populations, no big damages were observed in tissue of LR pop. after application of 2 L ha-1 of glyphosate. We did confirm lower number of cells in mezophyle compared to untreated plants. The pictures from LM and TEM showed damage of the cell walls, separation of cell walls from plazmalema and no damage to chloroplast and lamellas in all tested populations after application of 2 L ha-1 of glyphosate.
Keywords: resistance;glzphosate;lolium rigidum;morpho anatomical level;

Impacts of abiotic and biotic factors on Conyza bonariensis control in sub-tropical cropping region of Australia

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Conyza bonariensis is major problem across the sub-tropical cropping region, particularly in zero-tilled fallows where many populations have glyphosate resistance. To improve weed control, the impacts of weed age and soil moisture on herbicide efficacy (knockdowns and selective post-emergences) were quantified in three greenhouse and six field experiments. In the first, weed biomass of all glyphosate-resistant populations, following spraying with a field rate of glyphosate, was 70-98% of unsprayed irrespective of weed age or soil moisture. In the subsequent experiment, with older weeds of the same populations, the response to glyphosate was unaffected by differences in weed age and soil moisture for some populations, whereas the biomass of the other resistant populations was greater following spraying of older and/or moisture-stressed plants compared with smaller non-stressed plants. In two field experiments, the average efficacy of six glyphosate mixes and sequential applications (double knock) was reduced by an average of 1% when two-month old weeds were treated compared to one-month old weeds. However when applied to three-month old weeds, efficacy was significantly reduced by 3-30%. In subsequent two field experiments, the adverse effect of increasing weed age was negated by increasing herbicide rates for some treatments. Amitrole, glyphosate mixed with 2,4-D + picloram, and three double-knock treatments of glyphosate mixes followed with bipyridyl products provided 90-100% control of three-month old weeds. For ten wheat-selective herbicides, small increases in weed age of two weeks significantly reduced efficacy, whereas differences in soil moisture had less impact. Thus, weed control can be improved substantially by treating weeds within 1-2 months of emergence.
Keywords: fleabane;glyphosate resistance;IWM;conyza;double knock;

ALS resistant population of Galium aparine to post-emergence herbicides application in winter wheat

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Catchweed bedstraw is an annual troublesome broadleaved weed dispersed throughout Eurasia. It can cause severe problems in a wide range of climate and habitat but is mainly problematic in winter wheat fields and other winter sown crops. Field and greenhouse experiments were conducted to determine the response of catchweed bedstraw to chlorsulfuron, tribenuron-methyl, tribenuron-methyl plus thifensulfuron-methyl, dicamba plus triasulfuron and mesosulfuron-methyl plus iodosulfuron-methyl-sodium and possible resistance to these herbicides. Two hundred Galium aparine seed sample had been collected from different wheat growing areas. These accessions were tested for resistance to chlorsulfuron, tribenuron-methyl, tribenuron-methyl plus thifensulfuron-methyl, dicamba plus triasulfuron and mesosulfuron-methyl plus iodosulfuron-methyl-sodium at registration doses. Some accession exhibited the highest survival to treatment with field rates of these herbicides. The Weibull dose-response curve, an asymmetric sigmoid curve, was fitted to data to obtain ED10, ED50 and ED90. The dose-response studies conducted on plant aboveground biomass treated with the herbicides showed a good fit with model. Of the 200 accessions tested, 41 accessions did not controlled by ALS inhibitor when applied at recommended field rate. When effective dose values were evaluated for all herbicides, dose-response curves and the associated EDx levels gave to us, 5 accessions were resistance to ALS Inhibitor.
Keywords: ALS;dose response;sensitivity;herbicides resistance;

Resistant research and management of flixweed (*Descuminia Sophia*) in winter wheat fields in hebei province

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Flixweed (*Descuminia Sophia*) is the most important weed in winter wheat fields in hebei province, it can be selectively controlled by tribenuron-methyl which has been used in china for over twenty years, and some fixweed populations have been reported to evolve resistance to tribenuron-methyl since 2005. The objective of this research was to evaluate resistance levels of flixweed populations from different locations in winter wheat fields in hebei province and manage to control it more efficiently. There were 154 different flixweed populations collected from winter wheat fields in different locations of hebei province. Resistant populations screen, resistant mechanism research, herbicide screen and field experiments were performed from 2008 to 2011. The results showed that the resistant populations accounted for 80.5% in the 154 populations, including 56 low resistant populations (1100), and the HB-1 populations which were collected from shijiazhuang had the largest resistance indices (RI) of 1687. Target-site enzyme assay data indicated that 14 resistant populations enhanced acetolactate synthase (ALS) activity and evolved resistance to tribenuron-methyl. DNA sequence analysis revealed that besides position 197 there was another point mutation at position 208 of the ALS gene in one of the resistant populations. The data also showed that the resistant HB-1 populations had evolved cross resistance to herbicides with the same mode of action including imazethapyr, pyrithiobac-sodium, cloransulam-methyl, pyroxsulam and florasulam. Further herbicide screen revealed that the mixture of tribenuron-methyl and 2,4-D could control resistant flixweed efficiently in winter wheat fields and was safe to the wheat, on this basis, combined with agronomic practices such as alternate cropping, straw mulching, inter-tillage weeding, et al. could control resistant fixweed more efficiently.
Keywords: *Descuminia Sophia*; tribenuron-methyl; resistance indices; resistant mechanism;

Evolution of ALS target-site resistance mutations in *Raphanus raphanistrum*: expression of adapted fitness traits with and without herbicide selection

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Rapid evolution rates to ALS inhibitor herbicide resistance are dependent on (1) the ability of resistance mutations to sustain high level of plant survival with minimum plant damage under herbicide selection and (2) negligible pleiotropic effects on plant growth in the absence of herbicide selection. This study aimed to elucidate both processes associated with ALS herbicide resistance in the major Australian broadleaf weed Raphanus raphanistrum. In relation to the first goal (1), the level of plant protection (estimated as the average growth related fitness traits attained by treated versus untreated resistant plants over time, i.e. resistance decay) conferred by various ALS resistance alleles was assessed. For the second objective (2), the potential associated pleiotropic effects on plant growth (estimated as growth related fitness traits differences between herbicide untreated resistant and susceptible plants (i.e. resistance fitness costs) were evaluated. Genetically purified sub-populations comprised of individual plants homozygous for the previously known (Ser-197, Glu-376, Leu-574) and a novel (Tyr-122) ALS resistance alleles were employed. In vitro ALS activity assay and whole-plant analyses revealed that plants carrying the Tyr-122 allele displayed no reduction in growth-related fitness traits (biomass, leaf area, RGR, NAR, LAR) thus exhibiting the highest level of ALS herbicide (chlorsulfuron and metsusulfan) resistance. Resistance alleles Leu-574 and Ser-197 endowed intermediate resistance levels denoted by reduced growth-related fitness traits in plants subjected to ALS herbicide selection. In contrast, the Glu-376 resistance allele, although endowing survival under herbicide selection, was associated with plants that exhibited significant reductions in various growth-related fitness traits. Results from a series of experiments also indicated that none of the ALS herbicide resistance alleles (in homozygous status) impose major adverse effects on RGR, photosynthesis and competitive ability of ALS herbicide resistant plants under no herbicide selection. The results of this investigation infavour rapid evolution rates of ALS herbicide resistance in R. raphanistrum. The evolutionary and agronomic implications of the obtained results are discussed.
Keywords: resistance;ALS target-site mutations;evolution;fitness;Raphanus raphanistrum;

Biological characteristics of bensulfuron-methyl resistant and susceptible biotypes of *Ammannia arenaria*

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Ammannia arenaria was found to be spreading dramatically in paddy rice fields and caused great yield lost in China in recent years. The bioassay results confirmed that the weed was resistant to besulfuron-methyl, but the mechanism of strong competition and resistance of the weed were kept unknown. The aim of the experiment was to determine the biological differences between bensulfuron-methyl resistant biotype (RB) and susceptible biotype (SB) of *Ammannia arenaria*. The seeds of RB (NB143) and SB (HZ001) were simultaneously seeded in basins in green house, replicated experiments were conducted for season-long biological investigation concerning emergence, and growth, and florescence and fructification. The emergence dynamic of RB seeds were similar to SB with two emergence pinks in 4 and 12 days after seeding (DAS). The average height of the mature RB plants was 118.0 cm which was 26.2% lower than that of SB, the branch number was 115 and leaf number was 2198 per plant, which were 59% and 43.8% less than those of SB, respectively. The plant dry weight of RB was 34.3 g, which was 54.5% less than that of SB. However, the early florescence was at 41 DAS for RB, which was 16 days earlier than that of SB. The average capsule number was 3810 per plant for RB, which was 46.3% less than that of SB, but little difference was found concerning the seed number per capsule. The results indicated that there is fitness cost for bensulfuron-methyl resistant biotype of Ammannia arenaria, with smaller plant and less capsules, but the early florescence time was 16 days earlier than that of susceptible biotype, which might contributes to its strong competition ability in the paddy rice field.
Keywords: Resistance;Ammannia arenaria;Bensulfuron-methyl;

Ecological fitness costs of a clodinafop resistant littleseed canarygrass (*Phalaris minor* Retz.) biotype

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Globally, *P. minor* has been reported in many countries of the world, being one of the most troublesome grassy weeds in wheat. Many canarygrass populations have been reported to have evolved resistance to ACCase-inhibitors and/or other herbicides. In 2011, studies were conducted to determine the relative fitness and competitive ability of clodinafop resistant (R) littleseed biotype compared with a susceptible (S) biotype. R and S biotypes were grown under noncompetitive and competitive arrangement in the greenhouse. Under noncompetitive greenhouse conditions, growth of the R biotype was similar to that of the S biotype on the basis of shoot height, tiller number and plant biomass. However, seed production of R plants was slightly lower than the corresponding value for S plants. In addition, a replacement series study was conducted in a greenhouse using a completely randomized design (CRD) with four replications. The S and R biotypes were compared under five mixture proportions (0:100, 25:75, 50:50, 75:25, and 100:0) for shoot height, tiller number, plant biomass and seed number. The relative competitiveness among the biotypes was in¬vestigated using replacement series indices including relative yield (RY), competitive ratio (CR), relative crowding coefficient (RCC), and aggressiveness index (AI). In most cases, significant differences in competitive ability were revealed between R and S

biotypes, since CR > 1.0, RCC > 1.2 and AI > 0, indicating a clear fitness cost of R biotype under competitive conditions. The results of this study showed that the S biotype was superior to the R biotype under competitive conditions. However, more biotypes and fitness parameters must be measured before general fitness differences between biotypes can be determined.
Keywords: *Phalaris minor* Retz.;herbicide resistance;competitiveness;clodinafop;replacement series study;

Preliminary progress on the resistance of Japanese foxtail (*Alopecurus japonicus*) to haloxyfop-R-methyl

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The occurrence of *A. japonicus* populations resistant to haloxyfop-R-methyl in fields was demonstrated by whole-plant bioassay, which were collected from Jurong in Jiangsu province with a resistant index of 1331.68. The results of cross-resistance revealed that this resistant population was also resistant to some other AOPPs, in which the resistance level was: fluazifop-P-butyl >quizalofop-P-ethyl > fenoxaprop-P-ethyl. However, a relative low resistance level of this resistant population to sethoxydim was observed, which was a cyclohexanedione (CHD) herbicide sharing the same target site with AOPPs. It was also found that the resistance level of A. japonicus to haloxyfop-R-methyl from different years was increased by years, of which the relative resistant level exceeded 320 (by whole-plant bioassay). The cytochrome P450 monooxygenases (Cyt P450) and glutathione-S-transferases (GST, EC2.5.1.18) were found to be involved in A. japonicas resistance to haloxyfop-R-methyl, which inferred that the increased metabolic activity may be one of the resistant mechanisms in Alopecurus japonicus to haloxyfop-R-methyl. By PCR and sequence analysis of the ACCase gene in A. japonicas, five point mutations were found, which were Ala-1686-Thr, Arg-1734-Gly, Met-1738-Leu, Ile-1826-Asn and Ile-2041-Asn. The amino acid mutation (Ile2041→Asn2041) in resistant plant had been reported to confer resistance of A. myosuroides and Lolium rigidum to aryloxyphenoxypropionate (AOPP). The other mutant has not been reported and their role in haloxyfop-R-methyl resistance is still unknown.
Keywords: *Alopecurus japonicus*;haloxyfop-R-methyl;herbicide resistance;

The resistance breeding for IMI and SU herbicides and the uses on weed and broomrape parasite control in sunflower production

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Weed control and broomrape are the main problems in sunflower production in Turkey. CLEARFIELD® System has been used successfully by farmers since 2003 in Turkey and IMI resistant hybrids reached about 30% of areas because 60% of sunflower production in Turkey is infested by new virulent races of broomrape. Resistant to Sulfonylurea (SU) hybrids are also used widely in the world. The research continues to develop sunflower inbred lines resistant to IMI and SU herbicides by Trakya Agricultural Research Institute (TARI), Edirne, Turkey since 2004. Many sunflower IMI hybrids developed and tested in regional trials in recent years and one sunflower IMI hybrids was sent registration trials firstly by TARI in 2012. Additionally, SU herbicide resistant hybrids also developed in TARI program but they are not preferred by farmers due to less efficient control over broomrape and also key weeds such as Xanthium, Cirsium, etc..in sunflower production. Therefore, SU herbicide resistance should combine with broomrape resistance gene complying in same hybrids and TARI program focused mainly this goal. Similarly, developing IMI and broomrape resistance also in the progress and will end in near future too. However, ideal one in sunflower breeding program is complying both IMI, SU and broomrape resistance together so farmers decide unlimitedly which herbicide will use depending on weed composition in their fields. On the other hand, combining IMI and broomrape resistance will supply a better weed control in sunflower production, because to have an efficient broomrape control until flowering stage. As results, especially IMI herbicide resistance continue successfully currently in sunflower production and it will continue until to get IMI herbicide resistance in weeds and broomrape.
Keywords: Sunflower;Broomrape;Weed Control;IMI and SU Herbicide Resistance;

Multiple herbicide resistance in ribbed murainagrass (*Ischaemum rugosum*) an accession from Venezuela

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Rice growers of Venezuela have been observing failures to control ribbed murainagrass (*Ischaemum rugosum* Salisb.) with different herbicides. Greenhouse experiments were conducted to determine the level of bispyribac-sodium, profoxydim and propanil resistance in ribbed murainagrass accession from rice field of Guárico-Venezuela. The above-ground plant fresh biomass was weighted 21 days after spraying. Fresh weight data were converted to percentages of the mean untreated control. This test detected an R (IR90G) accession by comparison to a susceptible one S (IR143G). To quantify resistance levels using a dose response experiment, the accession IR90G (R) was treated either with bisyiribac-sodium 0, 20, 40, 80, 160, 320, 640, 1280; profoxydim 0; 20; 40; 80; 160; 320; 640; 1280 or propanil 0, 210, 420, 840, 1680, 3360, 6720 y 13440 g i.a. ha-1, while IR143G (S) was treated either with bispyribac-sodium 0, 2,5, 5, 10, 20, 40, 80 y 160 g i.a. ha-1; profoxydim 0; 1,25; 2,5; 5; 10; 20; 40 y 80 g i.a. ha-1 or propanil 0; 52.5; 105; 210; 420; 840; 1680 and 3360 g i.a. ha-1. The ratio of R to S ED50 was extremely high (> 1280 g a.i. ha-1) for bispyribac-sodium and for profoxydim, and intermediately high for to propanil (24.83 g a.i. ha-1). The results from these experiments provide evidence of the multiple-herbicide resistance in ribbed murainagrass from Venezuela to als-, accase- and photosystem II -inhibiting herbicides.
Keywords: Acetolactate synthase (ALS);acetyl CoA carboxylase (ACCase);photosystem II;multiple herbicide resistance ;

Molecular cloning of an EPSPS related gene and construction of SSH libraries from *Cirsium setosum* (Willd.) MB under glyphosate stress

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Cirsium setosum (Willd.) MB is a perennial herb that has developed a dominant population in the transgenic soybean fields in North China because of the frequent application of glyphosate for over 15 years. In the study, the accumulation of shikimate in *C. setosum* during the seedling stages were assayed after glyphosate treatment. The results show that after two days of treatment, the shikimate content was slightly higher than in the control and began to accumulate rapidly after treatment with two doses glyphosate, and then rapidly decreased after reaching the maximum, which suggest that *C. setosum* is not sensitive and highly tolerant to glyphosate. The full-length of an EPSPS related gene, which contains a 51 bp 5′-UTR of, a 1563 bp ORF encoding a 520 amino acid polypeptide with a molecular weight of 55.2 kDa, and a 133 bp 3′-UTR with a polyadenylation signal (AATAAA) and a poly (A), was cloned and designated as CSEPS (JN613412). The deduced amino acid sequence of CSEPS had characteristics of an EPSP synthase with three highly conserved active domains, and showed 94% identity with the 5-enol-pyruvylshikimate-phosphate synthase from *C. setosum*, respectively. Its differential expression in the different tissue and leaf developmental stages were demonstrated using real-time RT-PCR. One Suppression subtractive hybridization (SSH) libraries from *C. setosum* under glyphosate stress was constructed. Some ESTs were sequenced and analyzed with bioinformatics. They included known function genes associated with metabolism and energy of Cell wall-associated hydrolase, ect, and directly involved in photosynthesis of chlorophyll a / b binding protein, ect, followed for the transfer protein such as Major facilitator family transporter, drug resistance transporter and ribosomal protein, eukaryotic translation initiation factor and other genes involved in protein modification, processing, and protein synthesis, and cytochrome P450 monooxygenase, senescence-associated proteins and pathogenesis-related protein in response to stress.
Keywords: *Cirsium setosum* (Willd.) MB;EPSPS ;Glyphosate stress;

Multiple herbicide resistance in rigid ryegrass (*Lolium rigidum*) in Israel

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Resistance of *Lolium rigidum* to ACCase, ALS and EPSPS inhibitors is spreading in wheat fields in Israel and all over the world. Here we attempt to elucidate the mechanisms involved in resistant populations from Israel, using molecular and biochemical techniques. Seeds and surviving *L. rigidum* plants were collected from rain-fed and irrigated crops where chemical weed control has failed and examined in the greenhouse. The population from Ein Hamifratz (EMR) exhibited multiple resistance to ALS, ACCase and glyphosate as compared to the sensitive biotype (Alumim). Emr plants were highly resistant to ALS inhibitors due to two point mutations, Pro197 and Trp574 in the ALS target gene. In ACCase resistant plants we observed an enhanced metabolism in EMR population whereas in another multiple-resistant population from gilat a new alteration in the ACCase target gene from Ile2041 to Thr. Preliminary results indicate that glyphosate resistance in EMR population is based on impaired translocation of the herbicide. A better understanding of the mechanisms should assist us in planning sustainable practices to eliminate the deleterious outcome of herbicide resistant weeds.
Keywords: ALS;ACCase;Glyphosate;Lolium rigidum;

Biochemical and molecular basis of resistance to tribenuron-methyl in different *Descurainia Sophia* (L.) populations

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Two *Descurainia Sophia* populations, HB16 and HB08, were discovered in China and exhibited high resistance levels to tribenuron-methyl. Resistance ratio values of HB16 and HB08 were 130.38 and 168.81 respectively. The extractable acetohydroxy acid synthase (AHAS) activity was similar between resistant and susceptible populations. However, AHAS from HB16 and HB08 were less sensitive to inhibition of tribenuron-methyl comparing to susceptible population. The tribenuron-methyl I50 values for HB16 and HB08 were 43.04 and 44.94 greater than that of susceptible population respectively. Pro-197-Ser and and Pro-197-Leu mutations were identified in plants of HB16 and HB08 respectively. AHAS insensitivity of resistant Descurainia Sophia caused by Pro197 mutation may responsible for high resistance to tribenuron-methyl.
Keywords: acetohydroxy acid synthase;AHAS;Descurainia Sophia (L.);herbicide resistance;

Study on fitness of different backcross generations between glyphosate-resistant transgenic oilseed rape (*Brassica napus*) and four geographic populations of wild *Brassica juncea*

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The fitness components of backcross generation with the transgene between four populations of wild Brassica juncea (Xi'an and Qinghai, glyphosate susceptible, Maoshan and Nantong, glyphosate tolerant to 675g a.e.ha-1), and glyphosate-resistant transgenic oilseed rape were observed to assess the effect of various wild relative biotype on the ecological fitness of gene flow generation. The results showed that more than 40% backcross generations survived under selecting by 1500g a.i.ha-1glyphosate. In greenhouse, composite fitness of the first offspring of Xi'an reciprocal BC1 and the first offspring of BC1 using Maoshan wild B. juncea as paternal plants was lower than their respective wild B. juncea. The other first offspring of BC1 showed similar fitness to their

respective wild B. juncea. All BC2 demonstrated similar fitness to their respective wild B. juncea. In field, fitness of the first offspring of Xi'an BC1 was much lower than that of wild B. juncea, the other first offspring of BC1 had similar to or higher this vale than their respective wild B. juncea. The fitness of all reciprocal BC2 was similar to or higher than their respective wild B. juncea, especially the BC2 using Qinghai, Maoshan wild B. juncea as paternal plants. It may be concluded that the risk of gene flow from glyphosate-resistant transgenic oilseed rape to wild B. juncea because the first offspring of Qinghai, Maoshan and Nantong BC1 and four populations' BC2 could establish on natural environment.
Keywords: Brassica juncea var. gracilis Tsen et Lee;herbicide-resistant Brassica napus;backcross;fitness;gene flow;

A paraquat-resistant goosegrass biotype found in China

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Paraquat is one of the most widely used herbicides in the world. For many years paraquat has successfully controlled widespread biotypes of annual goosegrass (*Eleusine indica* [L.] Gaertn.)in China. This study reports confirmation that the Panyu biotype of goosegrass has developed resistance; the mechanism underlying that resistance was also investigated. In fields of banana in 2005, applications of paraquat (0.6 kg ai/ha) reduced the dry weight of the Panyu biotype 18.6% of the reduction obtained from the control herbicide (Basta), and in 2007 only 12.3%. In papaya fields, the reduction decreased from 16% to 3.3% for the same years. In greenhouse experiments, the ED50 of the paraquat-treated putatively-resistant biotype was 1.29 kg ai/ha, which was significantly greater than another biotype known to be susceptible from that region, and also other biotypes collected from provinces further away in Guangxi, Shandong and Hubei. Since it is highly likely that the defense reactions of these plants against paraquat is probably attributable to genes that control ferritin production, PCR was conducted to amplify the ferritin genes from both resistant and susceptible goosegrass biotypes. A 713-bp cDNA sequence particular only to the resistant biotype was identified and amplified, and BLAST analysis of the corresponding protein indicated 100% homology between this sequence and 4 retrotransposon fragments (GenBank accession numbers AAL68845, XP_002438378, AAL75973 and XP_002442043). Therefore it may be that the mechanism leading to paraquat resistance in this biotype is triggered by a particular retrotransposon upon paraquat exposure, initiating a series of resistance reactions.
Keywords: paraquat;goosegrass;Eleusine indica;Herbicide resistance;

Mechanism of multiple herbicide resistance in barnyardgrass (*Echinochloa crus-galli*) Brazil

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Several populations of barnyardgrass (Echinochloa crus-galli) resistant to imidazolinone and quinclorac herbicides are present in rice paddy fields in southern Brazil. However, the processes related to the evolution of this problem are unknown. The objective of this study was to evaluate the occurrence of increasing metabolic detoxification as the mechanism of resistance in populations of barnyardgrass resistant to imidazolinone and quinclorac herbicides originated from different regions of southern Brazil. Five experiments were conducted at field and greenhouse conditions by foliar and hydroponic solution application of the herbicides imazethapyr and quinclorac and of the inhibitors malathion, 1-aminobenzotriazole and piperonyl-butoxide. Six populations of barnyardgrass susceptible, resistant to imidazolinone and multiple resistant to imidazolinone and quinclorac herbicides were used. Previous studies were carried out in order to define the range of herbicide and inhibitors doses. Data were analyzed using dose-response curve and the Colby methods. The resistant factor between the resistant and susceptible populations ranged from 1.8 to 218.5 and 4.6 to 34.1 for quinclorac and imazethapyr, respectively. The application of the inhibitors reversed from 87 to 100% the resistance to quinclorac in two populations and 26-54% the resistance to imazethapyr in three populations. In addition, two populations previously classified as sensitive and resistant to the imidazolinone herbicides were also resistant to quinclorac, and this resistance was reversed with the application of the inhibitors. The mechanism of resistance to imidazolinone and quinclorac herbicide resistance in barnyardgrass in the populations analyzed is related to the increasing of herbicide metabolization.
Keywords: Imazethapyr;quinclorac;metabolization;inhibitors;imidazolinone;

The tolerance to imazethapyr in different leaf stages of dayflower, *Commelina communis* L.

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Dayflower (*Commelina communis* L.) is one of worst weeds in soybean field in Heilongjiang Province and more difficult to control at leaf stage. Using pot experiment and paraffin section technique, we investigated the relationship between the foliar surface features and dissection structure and the tolerance to imazethapyr in different leaf stages of dayflower. The studies showed that the tolerance to imazethapyr increased with leaf stage of dayflower and there was an inflexion in 3-leaf stage. The stomata density of epidermis decreased with leaf stage, but the thickness of foliar, palisade tissue, spongy tissue, upper epidermis, lower epidermis, and the length of 10 palisade tissue cell, compactness degree of palisade tissue increased with leaf stage. These changes of foliar surface features and leaf dissection structure are one of reasons of dayflower more tolerant to imazethapyr with leaf stage.
Keywords: dayflower;foliar surface features;leaf dissection structure;tolerance;weed;

Study on mutation in ALS of resistence to tribenuron-methyl in *Myosoton aquaticum*(L.) Moench

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Abstract: 【Background】 *Myosoton aquaticum* (L.) Moench, a winter annual to biennial weed in the Pink family, can not be controlled by tribenuron after the herbicide has been continuously used for several years. The biotype（R） collected from Zhumadian, Henan has emerged resistance to tribenuron-methyl and the resistance ratio up to 120.6 times.【Objective】 To understand the molecular basis of the resistance mechanism to tribenuron-methyl in M. aquaticum (L.) and to find the specific mutation sites in amino acid sequence of acetolactate synthase (ALS) in the resistant biotype(R) of *M. aquaticum* (L.) 【Method】 Fragments encoding the ALS were amplified and cloned from *M. aquaticum* (L.), susceptible (S) and resistant (R) biotypes to tribenuron-methyl, respectively, and sequenced subsequently. 【Result】 The result showed that the nucleotide sequence of R-biotype of *M. aquaticum* (L.) differed from that of the S biotype with one amino acid substitutions, of which, the amino acid substitution of Pro197 to Ser/Leu located in the highly conserved region Domain A. 【Conclusion】 The substitution of Pro197 might be responsible for the resistance to tribenuron-methyl in the R-biotype of *M. aquaticum* (L.) .
Keywords: resistence;*Myosoton aquaticum*(L.) Moench; acetolactate synthase; gene mutation;

The research on the injury mechanism of the corn by fomesafen

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Fomesafen is the main herbicide which is widely used in the soybean field in China. But it's easy to injure some sensitive crops as the long residue of fomesafen. In recent years, the planting area for the corn increasing, the residue of fomesafen affects the growth of the following crops , which influences the rational adjustment of planting structure. So it is significant to research injury mechanism of the corn by fomesafen. The paper research injury mechanism of the corn by fomesafen was accomplished with the technology of bioassay and biological chemical analysis. Corn showed obvious injury when the residue of fomesafen was 0.3 mg·kg-1, and it had obvious injury of residue in the 6th day. When the residue of fomesafen was more than 0.4mg·kg-1, it would affect the plant height, root length and fresh weight of corn, and the inhibition rate reached 31.20%, 25.08% and 66.42% in the 12th day. With the residue rate of fomesafen increasing, the content of the GSH(Glutathione) and activity of the GST(Glutathion S-transferases) would go up first and go down in the end, and the content got the highest point when the residue of fomesafen was 0.2 mg·kg-1. With the increasing of residue of the fomesafen, the content of chlorophyll and activity of protoporphyrinogen oxidize would go down. When the residue of fomesafen was 0.4 mg·kg-1, the inhibition rate of the protoporphyrinogen oxidize and content of chlorophyll were 90.48% and 69.34% in the 12th day.
Keywords: Corn ;Fomesafen ;Glutathione;Glutathion S-transferases ;Protoporphyrinogen oxidize;

Histological changes of snap bean (*Phaseolus vulgaris* L.) caused by herbicides

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The studies were conducted between 2010 and 2011. It evaluated the sensitivity of snap bean (*Phaseolus vulgaris* L.) to following herbicides: tribenuron - methyl, MCPA, metribuzin and linuron. The herbicides were applied at the rates of 100%, 10% and 2% of recommended doses, in the field and greenhouse experiments. In the field trials herbicides were used at the beginning of first trifoliate leaf stage and in greenhouse at 2 leaf stage of snap bean. The changes in morphology of plants and in the structures of tissues leaves were analyzed with the use of stereomicroscope, light microscopy and scanning electron microscope. We compared the leaf tissue structures of the plants treated with herbicides and untreated. There were significant differences in leaf cell responses to individual herbicides. Very strong changes in tissues structures occurred after application of all tested herbicides at the highest doses. Most destructive changes in the epidermal cells (primary cells, hairs and stomata), fragments of parenchyma and vascular bundles were observed after the use of linuron and metribuzin. Less necrotic cells were visible in the leaves after MCPA and tribenuron - methyl application. However, it led to hydathodes, vascular tissue and stomata deformations. We concluded that a thin cuticle and cell walls, a large number of stomata and trichomes in the epidermis of the young leaves are the features that are most susceptible to the toxic effects of analyzed herbicides.
Keywords: snap bean;herbicides;histology;

Resistance of japanese foxtail (*Alopecurus japonicus*) to ACCase-inhibitors in China

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The increasing use of ACCase-inhibiting herbicides has resulted in evolved resistance in key grass weeds infesting cereal cropping systems worldwide. Japanese foxtail (Alopecurus japonicus) is one of the most important grass weed in wheat in China with populations that have evolved resistance to fenoxaprop-p-ethyl which is one of the most common ACCase-inhibiting herbicides in wheat. The seeds of two Japanese foxtail populations were collected from wheat fields where the farmers complained that fenoxaprop-p-ethyl failed to controll Japanese foxtail in their fields and one susceptible population from road side for detecting cross-resistance and elucidating molecular basis of resistance. The experimental results showed that the two populations Aloja-JS10-R1 and Aloja-JS10-R2 expressed high resistance to fenoxaprop-p-ethyl with resistance index (RI) being 61.5 and 82.5, respectively. They also expressed high cross resistance to clodinafop-propargyl with RI being 18.3 and 20.7 and moderate cross resistance to clethodim and pinoxaden with RI ranging from 2.9 to 15.0. The susceptible ACCase gene fragment sequence of the Japanese foxtail

has very high homology with the black-grass (Alopecurus myosuroides). Comparison of the ACCase gene sequences of the susceptible and resistant populations with black-grass revealed that tryptophan at position 2027 of the ACCase gene was substituted by cysteine in population Aloja-JS10-R1, isoleucine at position 1781 of the ACCase gene was substituted by leucine in populations Aloja-JS10-R2. The study confirmed Japanese foxtail resistance to ACCase inhibitors being conferred by specific ACCase point mutations at amino acid position 1781 and 2027, and these two point mutations were also confirmed in Alopecurus myosuroides, Avena sterilis, etc.
Keywords: ACCase inhibiting herbicides;herbicide resistance; mutation detection;

Herbicide resistant *Echinochloa* species in Korea: cause and mechanism

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We conducted a series of experiments to confirm herbicide resistance in Echinochloa spp. collected in Korea, to examine socio-economic cause of herbicide resistant Echinochloa spp. and to investigate resistance mechanism. Herbicide dose-response study confirmed ACCase inhibitor and ALS inhibitor resistance in Echinochloa crus-galli and E. oryzicola. Long-term use of ALS inhibitors from those with low efficacy to high efficacy against Echinochlo spp. may be responsible for stepwise selection of herbicide resistant Echinochloa sp. Enzyme assay and herbicide dose-response study with metabolic enzyme inhibitor showed that enhanced metabolism may be most responsible for herbicide resistance although herbicide target enzymes, ACCase and ALS, may also be involved somehow. In this report, we will present geographical distribution of herbicide resistant Echinochloa spp. in Korea, and socio-economic cause and biological mechanism responsible for herbicide resistance in Echinochloa spp. Management of herbicide resistant Echinochloa spp. will also be discussed.
Keywords: ACCase inhibitor;ALS inhibitor;Echinochloa crus-galli;Echinochloa oryzicola;Herbicide resistance;

Multiple resistance to glyphosate and pyrithiobac in palmer amaranth from mississippi and response to flumiclorac

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Resistance to glyphosate in several Palmer amaranth populations was suspected in Mississippi, USA. Greenhouse and laboratory studies were conducted to confirm and quantify glyphosate resistance, quantify pyrithiobac resistance, and investigate interaction between flumiclorac and glyphosate mixtures on control of Palmer amaranth.. The GR50 values for two glyphosate resistant biotypes, C1B1 and T4B1, and a glyphosate-susceptible (GS) biotype were 1.52, 1.3, and 0.09 kg ae/ha glyphosate, respectively. This indicated that the C1B1 and T4B1 biotypes were 17- and 14-fold resistant to glyphosate, respectively, compared with the GS biotype. The C1B1 and T4B1 biotypes were also resistant to pyrithiobac, an acetolactate synthase (ALS) inhibitor, with GR50 values of 0.06 and 0.07 kg ai/ha, respectively. This indicated that the C1B1 and T4B1 biotypes were 7- and 8-fold, respectively, -resistant to pyrithiobac compared with the GS biotype, which had a GR50 value of 0.009 kg/ha. Flumiclorac was antagonistic to glyphosate by reducing glyphosate translocation. C1B1 and T4B1 absorbed less glyphosate 48 h after treatment (HAT) compared with the GS biotype. The majority of the translocated glyphosate accumulated in the shoot above the treated leaf (that contains the apical meristem) in the GS biotype and in the shoot below the treated leaf in the resistant biotypes, C1B1 and T4B1, by 48 HAT. The C1B1 biotype accumulated negligible shikimate levels, whereas the T4B1 and GS biotypes recorded elevated levels of shikimate. Metabolism of glyphosate to aminomethylphosphonic acid was not detected in any of the biotypes. Thus, multiple resistance to glyphosate and pyrithiobac exists in Palmer amaranth and the mechanism of glyphosate resistance is partly due to reduced uptake and translocation.
Keywords: Palmer amaranth;glyphosate resistance;multiple resistance;pyrithiobac;ALS resistance;

Multiple-resistance in *Lolium spp perenne multiflorum*

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Multiple-resistance in *Lolium perenne spp multiflorum* has evolved in many areas worldwide. In Oregon, the number of populations with multiple-resistance continues to increase. In order to manage the resistant populations, the resistance patterns must be determined. In this study, one population (CT) was collected from a Christmas tree plantation. Two populations (R2, R4) were collected from agronomic crop fields. The CT population is resistant to four herbicides with three different mechanisms of action: atrazine, hexazinone (8.6-fold), glyphosate (3.1-fold), and sulfometuron. The resistant indices for sulfometuron and atrazine could not be calculated because the 50% growth reduction for the CT population were not reached even with the highest rates applied, 3.9 kg ai/ha and 16 kg ai/ha, respectively, which are 48 and 16 times recommended field application rates. ALS sequencing in the CT population identified a Trp591 to Leu mutation which previously has been reported to contribute high level ALS resistance to three ALS inhibiting chemical families. The CT population was not resistant to gulfosinate, clethodim, sethoxydim, fluazifop, or pyroxasulfone. The other two populations, R2 and R4, were resistant to flufenacet (1.78-fold), quizalofop, and clethodim, but were not resistant to pyroxasulfone. The three populations have significantly different patterns of multiple-herbicide resistance. The number and diversity of Lolium perenne spp multiflorum populations with multiple-resistance is making management of this species very difficult in many agricultural systems, because of the lack of alternative herbicides.
Keywords: Multiple-resistance;*Lolium spp perenne multiflorum*;flufenacet;

Predicting the simultaneous evolution and dynamics of ALS- and ACCase- resistant barnyardgrass in rice systems in the southern United States

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United States ranks fourth in rice export, accounting for about 12% of global rice shipments. Rice production is mainly concentrated in the Mid-south U.S. where the environment is conducive for good rice yields. As in the rest of the world, barnyardgrass is the major weed of rice in the U.S., and herbicide-resistant barnyardgrass is a growing issue in this system. Currently, barnyardgrass populations resistant to propanil and quinclorac are widespread, and populations with resistance to clomazone and imazethapyr have been confirmed. The occurrence of herbicide resistance exerts enormous selection pressure on the few effective herbicide options left, notably the acetolactate synthase (ALS)- and acetyl-CoA carboxylase (ACCase)-inhibiting herbicides. With the widespread adoption of Clearfield?rice technology, the possibility of widespread evolution of resistance to ALS-inhibiting herbicides is a growing concern. The failure of ALS-inhibiting herbicides will eventually lead to tremendous selection for ACCase-inhibiting herbicides, threatening the sustainability of rice production in this region. The objective of this research is to understand the risks for the simultaneous evolution of barnyardgrass resistance to ALS- and ACC-ase inhibiting herbicides, and identify suitable practices for delaying resistance evolution. A simulation model was implemented in the STELLA?modeling software to predict resistance evolution. The model simulates resistance in 250 rice fields (field size: 150 acres) across the region. The risks of ALS and ACCase resistance under current management regimes are explored, and the effectiveness of some alternative strategies in delaying resistance evolution is investigated. Initial results suggest that use of residual PRE herbicides (such as clomazone) and inclusion of additional modes of action (notably fenoxaprop) are effective in delaying resistance to ALS- and ACCase- inhibiting herbicides in barnyardgrass. The biological, genetic, and management assumptions for the model are presented in a separate poster presentation.
Keywords: Herbicide resistance evolution;simulation modeling ;barnyardgrass;environmental stochasticity;Population dynamics;

Parameterization of the simulation model to predict the evolution of ALS- and ACCase- resistant barnyardgrass in rice

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A mathematical model is being developed to simulate the simultaneous evolution of barnyardgrass resistance to acetyl-CoA carboxylase (ALS)- and acetolactate synthase (ACCase)-inhibiting herbicides in rice. The goals of this research were to i) understand the risks of barnyardgrass evolving resistance to these herbicides under current management scenarios, and ii) identify strategies that will delay the evolution of resistance. The model was implemented using the STELLA?modeling software. The model framework includes three components: the demography of barnyardgrass, genetics of resistance (mode of inheritance, dominance, and fitness), and the response of barnyardgrass to management practices. The model accounts for the presence of density dependent effects on barnyardgrass survival and fecundity Additionally, the model incorporates stochasticity on some of the important variables that are stochastic in nature (e.g., seedling emergence, fecundity, etc.). Barnyardgrass emergence was classified into five cohorts and efficacies were assigned for each management option for each cohort. A barnyardgrass emergence curve developed using field collected data in Arkansas was used for this purpose. A mutation rate of 1e-6 was assumed and the initial genotype frequencies (RR, Rr, and SS) were calculated using the Hardy-Weinberg equilibrium. The model represented 250 rice fields each of 60 hectares in size, with a background barnyardgrass seedbank of 2000 viable seeds m-2. For each management scenario, the evolution of resistance was predicted for a 30-year period and resistance is considered to have evolved if the proportion of resistant seeds is >20% of the total seedbank. The poster contains more details on parameter estimation for the model.
Keywords: Herbicide resistance evolution;simulation modeling;model parameterization;Environmental stochasticity;Echinochloa crus-galli;

Occurrence trends of herbicide resistant weeds in paddy fields in Korea

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National Academy of Agricultural Science and eight province Agricultural Research & Extension Services of all the country investigated the occurring area of herbicide resistant weeds in paddy field of Korea. In order to estimate the occurring areas of herbicide resistant weeds, we collected paddy soils on August of 2011 and treated 30 kg ha-1 of pyrazosulfuron-ethyl+prriminobac-methyl GR. 167,081 ha, approximately 20.9% of cultivated area excluding organic and eco-friendly cultivated area was estimated to be infested by SU-herbicide resistant paddy field weeds. It was increased by 60,130 ha compared to 2008. It was occurred greatly in Chungchungnamdo by 47.6%, followed by 36.9% in Jeonranamdo, 25.7% in Chungchungbukdo, 20.5% in Gangwondo, and 13.0% in Gyeonggido, respectively. Monochoria vaginalis showed the highest with 65,313 ha, 39.1% followed by Scirpus juncoides, and

Cyperus difformis, respectively. These three species were evenly distributed and the most problematic weeds in the country. Lindernia dubia occurred at 13,964 ha (8.4%) and Echinochloa oryzoides was 5.1%.
Keywords: hernicide resistance;paddy field weeds;sulfonylurea;

Glyphosate timing and rate influences glyphosate efficacy and soybean yield in glyphosate–tolerant soybean

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Glyphosate is a broad-spectrum herbicide for post-emergence control of annual and perennial weeds and its traditional use has been limited in non-crop and orchard. The glyphosate-tolerant crop system provides growers a new way to use it. Glyphosate is effective, inexpensive and simple to apply, but application timing and rate may influence control efficacy. It is a great importance to determine the best application timing and rate according to the proportion of weed emergence, soybean growing stages and yield in order to make glyphosate contribute most to crop production. Field experiments were conducted in Hebei, China in biosafety controlled environment to determine glyphosate application timing and rate on weed control efficacy and crop yield in glyphosate-tolerant soybean. Glyphosate was applied at 0, 922.5, 1537.5, 1845, 3690, or 4920 g ai/ha when soybean, cultivar 07-1568, was at V3, R2 or R4 growing stage. An excellent weed control was provided when glyphosate applied at the rate of 922.5 g ai/ha at V3 growing stage of soybean. Weed control efficacy slightly declined with postponing of application timing, but that could be compensated by increasing application rate to 1537.5 g ai/ha. And there were no significant differences in soybean heights among all treated plots except plots applied at 4920 g ai/ha of glyphosate. Glyphosate applicated at V3 or R2 growing stages of soybean significantly increased yields by 59.1-50..8% and 31.8-24.5%, respectively, while no significant difference in soybean yield was observed between the glyphosate treatments at R4 stage and the untreated plots. It is concluded that the accepted application time and rate of glyphosate shoud be V3 at 922.5 g ai/ha or R2 at 1537.5 g ai/ha considering both weed control efficacy and crop yield.
Keywords: Glyphosate;Weed control;Glyphosate-tolerant soybean;

Distribution of resistant *Descurainia sophia* in Hebei Province and screening of substitute herbicides for tribenuron-methyl

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Sensitivity to tribenuron-methyl of *Descurainia sophia* biotypes collected from 17 counties of 7 cities in Hebei Province were tested to ascertain the distribution of the resistant ones in the province by means of pot experiments. The results showed that the ED50s were in the range of 0.027-70.038g/hm2, and their resistance indexes were in the range of 1-2594, in which 76.5% biotypes were higher than 10. The ED90s were in the range of 180.47- 211985.33g/hm2, with the resistance indexes in the range of 1- 1174.63, in which 64.7% biotypes were higher than 10. In summary, most biotypes of *Descurainia sophia* in Hebei have become resistant to tribenuron-methyl, and the resistance is significant. For Management, efficacy of several herbicides to resistant *Descurainia sophia* was tested by means of pot tests and plot experiments. The control effect of 36% carfentrazone-ethyl and tribenuron-methyl mixture wettable powder to *Descurainia sophia* sprayed during the turning green stage or the standing stage of wheat under the dose of 75 g/hm2 was more than 95%, which was also efficacious to *Galium aparine var. tenerum* and other broadleaf weeds So 36% carfentrazone-ethyl and tribenuron-methyl mixture wettable powder could be used as the efficacious herbicide in Hebei instead of tribenuron-methyl.
Keywords: Hebei;*Descurainia sophia*;Resistance;Tribenuron-methyl;Substitute for Tribenuron-methyl;

Multiple herbicide resistance in jungle-rice (*Echinochloa colona*) accessions from Venezuela

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Jungle-rice [*Echinochloa colona* (L.)Link.]is one of the two most troublesome weed in Venezuela rice fields. Ineffectiveness and availability of new products has led rice growers to shift their herbicide use. Jungle-rice accessions collected from fields located at Guárico and Portuguesa, where growers have been reporting failures in weed control, were screened for propanil and cyhalofop resistance together with a known susceptible accession (EC 114A) by two greenhouse bioassays. For detection test, herbicide treatments were: recommended rate of the commercial formulation either propanil (3360 g a.i. ha-1) or cyhalofop (234 g a.i. ha-1) and untreated control. The above-ground plant fresh weight was measured 21 days after spraying. Fresh weight data were converted to percentages of the mean untreated control. According with these results, nine out of ten accessions were resistant to propanil (89.5 %) at both regions, whereas four out of ten were resistant to cyhalofop, however, degree of cyhalofop resistance was much higher at Guarico (64.7%) as compared to Portuguesa (7.1%). To assess resistance levels using a dose response experiment, the accession EC33P (R) was treated either with propanil 0, 210, 420, 840, 1680, 3360, 6720 y 13440 g a.i. ha-1 or cyhalofop 0; 14,63; 29,25; 58,5; 117; 234; 468; 936 g a.i. ha-1, while accession EC114A (S) was treated either with propanil 0; 52.5; 105; 210; 420; 840; 1680 and 3360 g a.i. ha-1 or cyhalofop 0; 1,83; 3,66; 7,31; 14,63; 29,25; 58,5; 117 g i.a. ha-1. The ratio of R to S ED50 was extremely high (1078.43) for propanil, and high for cyhalofop (20.78). The results provide evidence of the multiple-herbicide resistance in jungle-rice from Venezuela to accase- and photosystem II -inhibiting herbicides
Keywords: Jungle-rice;multiple herbicide resistance;dose response experiment;acetyl CoA carboxylase (ACCase);photosystem II ;

Glyphosate resistance of hairy fleabane (*Conyza bonariensis*) in South Brazil.

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Hairy fleabane has been considered the most invasive glyphosate-resistant weed, being reported on five continents. In South Brazil, this weed has been found invading soybean fields. The use of cover crops during the winter season can delay the emergence and development of hairy fleabane in soybean areas. Dose response curve assay was conducted at the Federal University of Santa Maria to evaluate level of resistance to glyphosate in susceptible (S) and resistant (R) hairy fleabane from Brazil. The R biotype showed 13-fold resistance to glyphosate relative to the S biotype. A field experiment was conducted with cover crops: Italian ryegrass, common vetch, wild radish, lopsided oat, wheat and a fallow treatment, in an area previously to soybean planting. Twenty days before soybean planting the herbicides glyphosate (720g ae ha-1), glyphosate + 2,4-D (720g ae ha-1 + 1209g ai ha-1), glyphosate + 2,4-D (720g ae ha-1 + 1209g ai ha-1) / diuron + paraquat (100 + 200g ai ha-1), glyphosate + chlorimuron-ethyl (960 + 80g ai ha-1), glyphosate + chlorimuron-ethyl (960 + 80g ai ha-1) / diuron + paraquat (100 + 200g ai ha-1) were sprayed. No plants of hairy fleabane were observed 27 days after emergence of soybean, after wild radish and common vetch, independent of the herbicide applied. However, in the fallow treatment with glyphosate, 41 plants m-2 were observed. The association of 2,4-D or chlorimuron-ethyl with glyphosate and cover crops during the winter season, are efficient to control glyphosate-R hairy fleabane in soybean fields. An integrated weed management involving cover crops and alternatives herbicides is fundamental aiming to reduce the cost of resistance control and also avoiding the high selection of pressure imposed for alternative herbicides.
Keywords: weed control;herbicides;cover crop;

Molecular basis for resistance to fenoxaprop-P-ethyl in japanese foxtail (*Alopecurus japonicus* Steud.)

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Japanese foxtail, a common and competitive annual weed in winter wheat fields, can not be controlled by fenoxaprop-P-ethyl after the herbicide has been continuously used for several years. The resistant biotype was the generation of a population collected from Longji in Anhui province, a place where fenoxaprop-P-ethyl had been used for more than 12 consecutive years. To confirm and characterize the resistance of Alopecurus japonicus to fenoxaprop-P-ethyl, whole-plant bioassays were conducted in the greenhouse. The results of whole-plant bioassays revealed that AH15 was highly resistant to fenoxaprop-P-ethyl with the resistance index up to 1914.6. To confirm the molecular basis of resistance to fenoxaprop-P-ethyl in A. japonicus, the Acetyl-CoA carboxylase (ACCase) genes were sequenced and compared between susceptible and resistant biotypes. Analysis of the nucleotide and deduced amino acid sequences between the biotypes indicated that one substitution had occurred, isoleucine (Ile) by leucine (Leu) at position 1781, the substitution of Ile1781 might be responsible for the resistance to fenoxaprop-P-ethyl in the R-biotype of A. japonicus Steud..
Keywords: Molecular basis;resistance;fenoxaprop-P-ethyl;japanese foxtail;

The impact of glyphosate -tolerant soybean on arthropod community

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Glyphosate-tolerant soybean has been planted widely and provided an effective tool for weed control. However, one ecological concern regarding the potential effects of transgenic soybean on biodiversity of non-target organisms has been debated. Our study is aimed to identify the impacts on the invertebrate community, which transgenic herbicide-tolerant soybean may have. We performed it by using transgenic soybean MON87701RR2Y expressing CP4 epsps protein for glyphosate tolerance and Cry1Ac protein for lepidoptera pests. We investigated the abundance and diversity of arthropods on plants in field plots of transgenic soybean with spraying glyphosate, comparing with transgenic soybean without spraying glyphosate, and recipient cultivar over one growing season by direct observation sampling method. We found that there were no significantly differences in arthropod community structure parameters such as species richness S, Shannon-Wienner diversity index H, evenness index J and dominant index C among transgenic soybean, and recipient cultivar in different treatments. The species composition structure of non-target pest sub-community in transgenic soybean with spraying glyphosate, were similar to transgenic soybean without spraying glyphosate and recipient cultivar. In pest sub-community, soybean aphid Aphis glycines and silverleaf whitefly Bemisia tabaci were the dominant groups. The numbers of soybean aphids and silverleaf whitefly populations in transgenic soybean with spraying glyphosate were not significantly different from those of transgenic soybean without spraying glyphosate and recipient cultivar. Out of over 50 species groups examined, the most consistent differences between recipient cultivar and transgenic soybeans was higher numbers of lepidopteran pests in recipient cultivar (as would be expected) due to Cry1Ac gene in transgenic soybean. In natural enemy sub-community, green lacewing Chrysoperla sinica and spiders were the dominant groups. We did not find that the numbers of green lacewing C. sinica and spiders were reduced in transgenic soybean with spraying glyphosate comparing to other treatments. Therefore, the herbicide-tolerance transgenic soybean has no effects on arthropod communities in short term
Keywords: Glyphosate-tolerant soybean ;Impact;Arthropod Community;

Present scenario of herbicide resistance in *Phalaris minor* in India and management options

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Phalaris minor is the most troublesome weed of wheat in the Indo-Gangtic plains of NW-India under rice-wheat cropping system with the potential to reduce crop yield from 15-50% and complete crop failure in the extreme conditions. It was successfully controlled by isoproturon for over a decade, before resistance was observed in the early nineties. Isoproturon-resistant populations quickly evolved cross-resistance to diclofop-methyl within 2-3 years followed by fenoxaprop-P-ethyl (4-5 years) and clodinafop-propargyl (8-10 years). Presently there is no recommended herbicide without issues. Regeneration of the treated plant is the major cause of concern with Atlantis (meso + iodosulfuron), sulfosulfuron, and Accord Plus (fenoxaprop + metribuzin), the later one also affects tillering and crop injury in several wheat varieties. Differential response has also been observed in some populations of *Phalaris* to Accord Plus at lower rates which is a warning on the ensuing resistance with its continuous use. Pinoxaden is most effective among the existing herbicides, but that too does not control all Phalaris populations. The problem is further compounded due to emergence of several flushes of *Phalaris* and it is not possible to control all of them with a single application of the recommended herbicides, which is a common practice. Pyroxasulfone has been found effective against the resistant populations of Phalaris, but has poor efficacy against Avena ludoviciana, moreover its efficacy is affected by field conditions similar to soil applied herbicides (pendimethalin and trifluralin). Herbicide mixtures (clodinafop + metribuzin; clodinafop + pinoxaden and sulfosulfuron + metribuzin) have shown increased efficacy compared to their alone applications, but their long term fate is
Keywords: Multiple resistance;Management strategies;*Phalaris minor*;Wheat;Weed biology;

Resistance of *Alternanthera philoxeroides* (Mart.) Griseb and *Commelina communis* Linn.to glyphosate and paraquat in South China Citrus orchard

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Alternanthera philoxeroides (Mart.) Griseb and *Commelina communis* Linn.caused serious damage in citrus orchard in South China and they were particularly notorious for its resistance to the commonly used herbicides, glyphosate and paraquat. To provide a basis for future resistance management strategies, this study evaluated the resistance status of them, collected from 7 counties in Pearl River Delta, to glyphosate and paraquat in 2011. The results showed that the *Alternanthera philoxeroides* and *Commelina communis* populations generally had moderate to high resistance to glyphosate with resistance factor values ranging from 12.1 to 20.6. Resistance of them to paraquat was moderate to high with resistance factor values ranging from 10.6 to 27.3. These results indicate that resistance of *Alternanthera philoxeroides* and *Commelina communis* populations to the most commonly used herbicides, glyphosate and paraquat, have increased and are now generally moderate to high in citrus orchard in South China.
Keywords: Resistance; *Alternanthera philoxeroides* ;*Commelina communis*; glyphosate;paraquat;

Identification of a GH3 homologue in *Echinochloa crus-galli* (L.) P. Beauv. (Barnyard grass), and its differential expression in Quinclorac resistant and susceptible plants

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The GH3 family of genes are involved in auxin homeostasis. Here, we describe the isolation and characterization of a GH3 cDNA from Barnyard grass. The gene, designated EcGH3.1 (Genebank no: JN241678), has a 1,839 bp long open reading frame predicted to encode a protein of molecular mass 67.82kDa and pI 5.93. Sequence alignment showed that EcGH3.1 is a GH3 homologue. Its expression in response to Quinclorac treatment was monitored in the leaves of Quinclorac resistant and susceptible biotypes of Barnyard grass. Its constitutive expression level in the herbicide resistant leaves was double that in the susceptible ones. Following exposure to Quinclorac, the expression of EcGH3.1 rose rapidly and peakded at half an hour; but its relative expression level was markedly higher in the susceptible material. From 2 hour to 4 days after treatment, the expression level of EcGH3.1 in the susceptible plants had fallen to the background level, but in the resistant plants, the level was kept at half constitutive expression level.
Keywords: cDNA cloning; gene expression;GH3 gene family;

Absorption and translocation of penoxsulam in *Fimbristylis miliacea* resistant to ALS-inhibiting herbicides

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Fimbristylis miliacea (L.) Vahl is one of the most troublesome weeds in water-seeded rice fields in Southern Brazil. Recently, F. miliacea populations were confirmed resistant to ALS-inhibiting herbicides in rice fields. We aimed to investigate the absorption and translocation of penoxsulam in *F. miliacea* biotypes resistant (R) and susceptible (S) to ALS-inhibiting herbicides. An experiment, arranged in a split-split plot design with three biotypes [R(2) and S(1)] as main plot, six harvest timings as sub-plots and four plant sections as sub-sub plots, was conducted in a growth chamber at the University of Arkansas-USA during January to March/ 2011. Plants at the six-leaf stage were sprayed with nonradiolabeled penoxsulam at 25 g a.i. ha-1. 14C-penoxsulam was applied to the first fully expanded leaf, 3 μL of an herbicide solution containing 1.48 kBq. Plants were harvested at 2, 4, 8, 24, 48, 168 hours after treated (HAT) and divided into four parts: treated leaf, with radioactive penoxsulam, old leaves, new leaves and roots. Each treatment

was replicated four times. Plant tissues were oven-dried and oxidized. Radioactivity in each sample was quantified. Data were subjected to combined ANOVA, and means were separated by Fisher`s LSD at $\alpha = 0.05$. There was interaction effect between time of harvest and plant part. By 168 h after application, 69% of applied 14C-penoxsulam was absorbed. In general, negligible amount of penoxsulam was translocated into new leaves (0.74%), old leaves (0.36%) and roots (0.05%). This indicated that penoxsulam does not move in the plant. There was no difference in absorption and translocation of penoxsulam among the R and S biotypes of *F. miliacea*. Resistance to ALS-inhibiting herbicides is due to another mechanism, possibly an altered target site.
Keywords: Weed control;mechanism of resistance;penoxsulam ;

A rapid resistance detection test for Atlantis (mesosulfuron + iodosulfuron) against *Phalaris minor*

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Phalaris minor, the most ubiquitous weed of wheat in India has evolved multiple resistance to herbicides of several modes of action. No new herbicide molecule is available for its effective control. Resistance; however, is less to ALS inhibiting herbicides compared to ACCase or PSII inhibiting herbicides under field conditions, but some populations have shown reduced efficacy against Atlantis (pre mix of mesosulfuron + iodosulfuron) as well. It would be pertinent under these conditions to develop a rapid screening test, so that corrective measures can be adopted well in time to avoid significant yield losses. Seed collected from clodinafop-resistant and susceptible fields were subjected to dose-response trials under pots in the screen house. The same populations were used for seed and seedling bioassays for quick resistance detection test for Atlantis under lab conditions. There were discriminate variations among the 12 populations evaluated against Atlantis at different concentrations, but seed bioassay using Agar media was found to be most effective and easy to discriminate resistance to Atlantis in different P. minor populations compared to seedlings/cut leaves in herbicide solution or seedlings in Agar media. The test needs further validations under field conditions, where differential control of P. minor population by Atlantis is established.
Keywords: Resistance;detection;atlantis;bioassay;management;

Differential response and tolerance mechanism of palmer amaranth to Glufosinate

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Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) is a major weed problem in field crops across the southern USA. Glufosinate is one alternative tool for weed management. Palmer amaranth populations from Arkansas were evaluated for their response to 183, 365, and 730 g ai ha-1 glufosinate. The least and most sensitive populations to 730 g ha-1 glufosinate were used for tolerance mechanism studies. The LD50 values (95% CI) showed that differential tolerance to glufosinate exist among Palmer amaranth populations evaluated in this experiment. The LD50 was 230 to 568 g ai ha-1, with an average of 340 g ha-1 glufosinate for all populations being. Pra-C population was the least sensitive to glufosinate with an LD50 of 568 g ha-1; Lee-A was the most sensitive with an LD50 of 230 g ha-1. Results from glutamine synthetase (GS) enzyme activity assay showed that Pra-C had a higher basal enzyme activity than Lee-A. However, GS activity in both populations was similarly reduced as glufosinate dose increased from 0 to 1600 µM. The I50 for Lee-A and Pra-C populations was 257 and 361 µM, respectively. Both populations accumulated similar NH3 concentrations, with Lee-A and Pra-C accumulating 67 and 70 µg g-1 fresh leaf weight, respectively, in 72 h after treatment (HAT). Fifty percent of NH3 accumulation occurred within 6 HAT in both populations. The susceptible population Lee-A also showed higher ammonia (NH3) production in its leaves prior to glufosinate treatment than the tolerant population Pra-C. The GS enzyme sensitivity to glufosinate was lower in tolerant population than in the susceptible. However, tolerance mechanism is apparently dependent mostly on higher basal GS activity, which resulted into lower sensitivity to glufosinate. Protein quantification experiments and frequency evaluation of glufosinate-tolerant plants in Liberty Link cotton and soybean fields after one cycle of glufosinate-based weed control programs have been initiated.
Keywords: differential tolerance;glufosinate;Palmer amaranth;tolerance mechanism;

Resistance of *Ammannia arenaria* to ALS inhibitor herbicides in paddy rice field

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The Acetolactate synthase(ALS) inhibitor herbicides were used in paddy rice field for more than twenty years in China, a broad leaf weed *Ammannia arenaria* was reported to spread quickly and had caused great yield loss in several major rice producing provinces in China in recent years. The field test results showed that the efficacy of popularly used herbicide mixtures such as bensulfuron-methyl(49.4gai/ha)+pretilachlor(370.7 gai/ha), penoxsulam(19.5 gai/ha)+cyhalofop-butyl(97.5 gai/ha), and bispyribac-sodium(27 gai/ha)+cyhalofop-butyl(90 gai/ha) to *Ammannia arenaria* were very poor, the shoots fresh weight reduction were less than 10% at 45 days after treatment. But the combinations for MCPA(498.0 gai/ha)+carfentrazone-ethyl(30.0 gai/ha), and oxadiazon(360 gai/ha)+pretilachlor (450 gai/ha)+pyrazosulfuron-ethyl(22.5 gai/ha) were effective to control the weed with the shoots fresh weight reduction more than 90%. Susceptibility of sixteen samples of *Ammannia arenaria* to bensulfuron-methyl was tested. Most of them were resistant to bensulfuron-methyl, and A. arenaria biotype of NB0143-01, NB0145-02, NB0143-05 and JX007-01 were more resistant than others with resistance index of 124.4, 55.0, 45.0 and 42.7, respectively. The results indicated that the resistance of A.

arenaria to ALS inhibitors bensulfuron-methyl et al in regions of Ningbo and Jiaxing in Zhejiang province were serious, and these was the first report of *A. arenaria* resistance level to bensulfuron-methyl.(The work was funded by National Natural Science Foundation of China (No.31171863), Science and Technology Department of Zhejiang Province (No.2011C22076) and Natural Science Foundation of Zhejiang Province (No.Y3100191))
Keywords: *Ammannia arenaria*;resistance;Bensulfuron-methyl;ALS;

ACCase cross-resistance in *Lolium multiflorum* sub-populations from Oregon, USA

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ACCase-resistant *Lolium multiflorum* is one of the most difficult to manage weeds in USA wheat production systems. This study had two objectives: to determine the cross-resistance pattern of three sub-populations selected from a winter wheat field with history of ACCase-inhibitor herbicides applications in Oregon and to investigate the mechanism of resistance present in each *Lolium multiflorum* sub-population, exploring the target site-based mechanism. A greenhouse experiment was conducted to test four ACCase-inhibitor herbicides including pinoxaden, clethodim, sethoxydim and clodinafop for control of the three sub-populations. The three sub-populations were cross-resistant to at least two herbicides. One sub-population was cross-resistant to all herbicides tested. The partial cDNA of the ACCase CT domain of susceptible and resistant individuals was sequenced and compared. A point mutation was detected at the aminoacid position 2078, which resulted in an aminoacid change from aspartate to glycine in the resistant sub-populations. ACCase resistance in these Lolium multiflorum sub-populations is likely due to an altered target enzyme. Our results indicate the need to identify patterns of cross-resistance to ACCase-inhibitor herbicides, so that management of these sub-populations can be improved.
Keywords: Acetyl-coA carboxylase;aryloxyphenoxypropionate;cyclohexanodione;Italian ryegrass;herbicide resistance;

Echinochloa: echoing the 'Amaranthus' and 'Lolium' problems in the southern USA

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Over 20 yr, US rice yields had increased steadily from 4.9 mt ha-1 to 7.5 mt ha-1. This is attributed primarily to improved varieties and effective herbicides. Echinochloa crus-galli is a major weed problem in flooded (rice) and non-flooded crops (e.g. soybean, cotton, corn) worldwide. In Arkansas, southern USA, this species had evolved resistance to four herbicide mode-of-action (MOA) groups including propanil (PSII), quinclorac (growth regulator), clomazone (DOXP synthase inhibitor), and acetolactate synthase (ALS) inhibitors. We investigated resistant (R) biotypes from the Delta, Grand Prairie and White River zones where rice fields are sprayed annually with various combinations of clomazone, propanil, quinclorac, and ALS inhibitors (bispyribac, imazethapyr for Clearfield® rice, penoxsulam), among others. Selection for resistance continues in rotational crops sprayed with the same MOAs. One biotype studied from the Grand Prairie zone has evolved resistance to imazethapyr, propanil, and quinclorac and is cross-resistant to other ALS inhibitors. Evidently, this biotype has accumulated resistance genes with progressive selection. Experiments were conducted to begin to unravel the complex mechanisms that endow resistance to multiple MOAs in one plant and population. The mechanism of resistance to imazethapyr, propanil and quinclorac were investigated. Not all ALS-resistant plants carry target site mutations. There was strong evidence of cytochrome-P450 involvement with resistance to propanil and, in some instances, with resistance to ALS inhibitors, but not with resistance to quinclorac. Individual R plants behaved differently when treated with 4.48 kg ha-1 quinclorac ranging from moderate to no effect on the plant's growth. Elevated β- cyanoalanine synthase activity caused resistance to quinclorac in two of three quinclorac-R biotypes. It is evident that accumulation of resistance genes varies within and among populations. Multiple paths of population divergence in accumulation of resistance genes are emerging. This does not bode well for weed management.
Keywords: population divergence;resistance evolution;resistance mechanism;cytochrome-P450;β- cyanoalanine synthase;

Molecular cloning and expression analysis of an EPSPS gene from *Eleusine indica* in Guangdong Province of China

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Goosegrass (*Eleusine indica*) is considered one of the five "world's worst weeds" and has been reported to be a problem weed in 46 different crops in more than 60 countries. Nevertheless, recent reports have documented the appearance of glyphosate resistant biotypes of goosegrass in Malaysia. In this paper, we examine, compare and describe cloning experiments then analysis for the EPSPS. The EPSPS genes of glyphosate resistant and susceptible goosegrass biotypes collected from Guangdong Province were cloned and analyzed. RT-PCR method were used to obtain the EPSPs gene fragment from the biotypes of Eleusine indica, then the genes were compared with those published in GeneBank. The results showed that the C1145 (susceptible biotype)→T1145 (tolerance biotype) replaces Pro-381 with Leu-381 in resistant biotype, causing a non-conservative change of Pro for the hydrophobic Leu residue. This result coincides with former research, and this is the first report about the EPSPS enzyme mutation in *Eleusine indica* in China.
Keywords: *Eleusine indica*;EPSPs gene;RACE;

Sensitivity to rice herbicides in *Echinochloa* spp. populations from Italian rice fields

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Echinochloa species are among the most troblesome weeds in Italian rice fields. One of the major recent issues is the development of herbicides resistance in several populations. The objective of this study was to assess the sensitivity of 29 Echinochloa spp. populations (25 E. crus-galli and 4 E. phyllopogon) which were selected in 2010 in Italian rice fields where they repeatedly escaped herbicide treatments. The following herbicides were examined: penoxsulam (40 g/ha), cyhalofop butyl (300 g/ha), profoxidim (100 g/ha), byspiribac-sodium (30.6 g/ha), imazamox (35 g/ha). An untreated control was included for each population. The experiment was conducted twice in 2011 in the greenhouse. Plants grown in pots (4 plants/pot) were sprayed at BBCH stage 13-14. The treatments were arranged in a RCBD with tree replicates. Aboveground plant fresh weight was assessed at 20 days after treatment and efficacy was expressed as percent of weight reduction in comparison to untreated plants. The popoulations were classified in six classes: SS, highly sensitive (> 95% efficacy); S, sensitive (85-95%); MS, medium sensitive (70-85%); MR, medium resistant (50-70%); R, resistant (25-50%); RR, higly resistant (< 25%). The percentages of populations classified as R or RR were: penoxsulam 62%, byspiribac-sodium 83%, imazamox 55%, cyhalofop butyl 10%, profoxidim 7%. The percentages of SS and S populations were: penoxsulam 20%, byspiribac-sodium 3%, imazamox 17%, cyhalofop butyl 55%, profoxidim 79%. The results showed a low level of sensitivity towards ALS-inhibitors (penoxsulam, bispyribac-sodium, imazamox) in several populations and suggest the need to apply adequate management practices to mitigate the phenomenon and to deepen the knowledge on the actual degree and type of resistance.
Keywords: barnyardgrass;late watergrass;ALS;

A new herbicide resistance case in Northern cyprus: *Sinapis alba*

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Barley is the most common crop in Turkish Republic of Northern Cyprus (TRNC). Weeds are problem in barley as well as other crops. There are few registered herbicides to control broad leaf weeds in barley, 2,4-D and tribenuron-methyl, in TRNC due to small market, which causes frequent use of the same active ingredient that was tribenuron recently. Escaped *Sinapis alba* plants have been observed for 3-4 years in barley fields. A weed survey in early spring to find out common weed species was carried out and a weed control trial against *S. alba* was conducted. *S. alba* was recorded in all surveyed fields. It established through each field and was in high densities. In addition, the number of species recorded was a few. While 2,4 D Amin and 2,4 D Ethyl Hexyl Ester + Fluresulam were controlled efficiently S.alba, Tribenuron methyl at 1X and 2X rates, Thifensulfuron methyl+Tribenuron methyl or Chlorsulfuron did not control, which shows that herbicide resistance was evolved against sulfonylurea herbicides in the island. Furthermore, 40 populations were collected to test in greenhouse conditions, which were not controlled by herbicides. Preliminary results show that at least 7 populations have high level of resistance to tribenuron.
Keywords: barley;tribenuron;als;resistance;sinapis alba;

Developing a rapid, field assay detecting glyphosate resistant weeds

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Research on the development of a rapid, field assay to detect glyphosate resistant weeds utilizing the shikimate dehydrogenase (SHKD) system has begun. The SHKD assay is a rapid, colorimetric procedure for specifically detecting shikimate in plant extracts. However, there are many questions that need to be answered, before one can develop a robust, field assay kit for glyphosate resistance. The assay needs to be easy and as fool-proof as possible with few false positives or negatives. Questions include: what tissue to assay; how to extract the tissue; time lapse after glyphosate application to assay; how to supply the reagents for the SHKD assay in the field; and ability to distinguish between susceptible and resistant plants. A survey of multiple weed species shows major differences among the species in the rate of accumulation of shikimate in different plants parts. For broadleaf species, the young, rapidly expanding leaves accumulate shikimate the most rapidly whereas in grass species it is the youngest, fully-expanded leaf. The SHKD assay is able to measure differential shikimate accumulation in plant parts immersed directly in assay solution. Another alternative is to use leaf discs, which could provide a portable method for detecting resistance without revisiting the field. For some species, such as Conyza canadensis, leaf discs floated on glyphosate solutions can be assayed directly without extraction. However, tissue sampling and incubation containers need to be standardized and developed for each species. SHKD requires the presence of two active enzymes plus NADP as a co-factor. Retaining enzyme activity and storing NADP in a non-perishable form will require the development of a simple system for doing this.
Keywords: glyphosate;shikimate;resistance;

Aminomethylphosphonic acid reduced photosynthesis, iron, and magnesium in glyphosate-resistant and glyphosate-sensitive soybean

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Aminomethylphosphonic acid (AMPA) is formed in glyphosate-treated soybean [*Glycine max* (L.) Merr.]plants and known to decrease chlorophyll in both glyphosate-resistant (GR) and glyphosate-sensitive (GS) soybean. AMPA is less phototoxic than glyphosate, but its mode of action in plants is unknown. Field studies were conducted at the Northeast Agricultural University experiment station, Harbin, China to determine the effects of AMPA on iron (Fe), magnesium (Mg), and chlorophyll contents, photosynthesis rate, and leaf total nitrogen content in GR (Asgrow 4605RR) and GS (He Feng 55) soybeans. AMPA was applied to one-trifoliolate leaf stage soybeans at 0.1 and 1.0 kg ha-1, representing a scenario of 10% and 100% degradation of glyphosate (1.0 kg ae ha-1 use rate) to AMPA, respectively. Because AMPA effects were more pronounced at 1.0 than 0.1 kg ha-1 rate, only data for higher rate is presented. AMPA at 1.0 kg ha-1 reduced leaf Mg content by 84%, 79%, 75% and 19% at 3, 7, 14, and 28 days after treatment (DAT), respectively, in GR soybean, and 85%, 79%, and 64% at 3, 7, and 14 DAT, respectively, in GS soybean. AMPA reduced leaf Fe content by 43%, 33%, and 37.0% at 3, 7, and 14 DAT, respectively, in GR soybean and 44% and 38% in GS soybean at 3 and 7 DAT, respectively. AMPA reduced chlorophyll content by 52-82% during 3-14 DAT compared to nontreated plants in both soybean types. AMPA markedly reduced (79-88%) photosynthesis rate during 3-14 DAT in both GR and GS soybean compared to nontreated plants. Leaf total nitrogen content was not affected by AMPA at 3, 7, 14, and 28 DAT. These results suggest that AMPA could reduce Mg, Fe, and chlorophyll contents, and photosynthesis rate in both GR and GS soybean up to 14 DAT and plants can recover from the short period of stress by 28 DAT.
Keywords: AMPA;Soybean injury;Photosynthesis;Iron;Magnesium;

Agronomic management and benefits of herbicide resistant transgenic cotton hybrids

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Glyphosate resistant cotton revolutionized weed control in cotton. Introduction of Round up Ready cotton provided producers with greater flexibility in the timing of herbicide application and also offered a broad spectrum of weed control. Glyphosate tolerant crops will not cause any residual effect on succeeding crops. Enhanced glyphosate resistant (Round up Ready Flex) cotton was introduced in 2006. RR Flex cotton exhibits both vegetative and reproductive tolerance to glyphosate to be applied as post emergence at any growth stage, without risk of boll abortion. The technology has allowed growers to reduce or eliminate soil-applied herbicides and to abandon cultivation and has allowed a shift to conservation tillage. Glyphosate-resistant technology is going to gain tremendous acceptance in cotton producing states, with the majority of cotton area sown with cultivars containing herbicide-resistant trait. Increased dosages and an extended application time are beneficial since glyphosate provides broad-spectrum control of annual and perennial grasses, sedges and broadleaf weeds. RRF cotton has potential benefits, including an expanded window for POE glyphosate applications, enhanced application flexibility and convenience, increased production efficiencies, less dependence on selective spray equipment and the ability to tailor herbicide applications to intensity of weed infestation instead of cotton growth stage. However, they offer the farmer a powerful new tool that, if used wisely, can be incorporated into an integrated pest management strategy that can be used for many years to more economically and effectively manage weeds. This paper deal with the agronomic advantages of herbicide tolerant transgenic cotton hybrid.
Keywords: Glyphosate resistant;transgenic cotton hybrid;Round up Ready Flex;Broad spectrum weed control;Control efficiency;

The resistance of *Echinochloa spp*. to quinclorac in rice in Zhejiang Province

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The genus *Echinochloa spp*. is the most important grass weed in rice crops. Quinclorac is a highly selective auxinic herbicide, which is frequently used in rice primarily for the control of Echinochloa spp. However, resistant biotypes have evolved in the areas that the herbicide has been used widely over years of application. The resistance to quinclorac in 12 populations collected from Zhejiang Province is tested, and the result showed that the Chian population was the most susceptible, with a EC50 value of 25.952 g a.i./hm^2, populations from Xiaoshan and Taoyan were also susceptible, with resistance ratios of 1.14 and 1.48, respectively, the other biotypes were resistant to the herbicide, with resistance ratios ranged from 3.38 to 9.84. The experimental results demonstrated that the resistance to quinclorac have developed in Zhejiang Province and the resistance level is different in different regions.
Keywords: quinclorac;resistance;*Echinochloa spp*.;

Molecular mechanism tolerance of maize to chlorimuron-ethyl

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Chlorimuron-ethyl is a kind of sulfonylurea herbicide, for it has a high active and good control of broadleaf weeds that is widely used in the field of soybean of China. But for it has a long persistence and its residual in the soil, it is easily injury the following season

crop. This paper studied the molecular mechanism tolerance of maize to the chlorimuron-ethyl by the method of bioassay and semi-quantitative PCR. The results showed that: 1. By testing the sensitivity of nine kinds of maize for the chlorimuron-ethyl, Tunyu 88 and Fenghe 10 showed the stronger tolerance and Dongtian 3 showed the most sensitive to chlorimuron-ethyl. 2. There is significant difference of the GSTs activities among the different kinds of maize, the activities of GSTs of the tolerant varieties are higher than the sensitive varieties. 3. There are significant differences among three different maize varieties of GSTs mRNA expression. Tunyu 88 has the strongest GSTs mRNA expression, Fenghe 10 is the second and Dongtian 3 has the weakest GSTs mRNA expression. So the differences of the GSTs mRNA expression lead the drug resistance of different kinds of maize to the Chlorimuron-ethyl differently. Chlorimuron-ethyl can induce relative increasing expression of GSTs mRNA.
Keywords: maize;chlorimuron-ethyl;tolerant mechanism;GSTs;expression of mRNA;

Clearfield and clearfield plus production systems are effective tools to manage difficult-to-control weeds

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Variants of acetohydroxyacid synthase (AHAS) gene conferring tolerance to imidazolinone herbicides were discovered in plants through mutagenesis and selection, and were used to develop imidazolinone-tolerant crops. Imidazolinone-tolerant maize, wheat, rice, oilseed rape, sunflower, and lentil have been commercialized as Clearfield crops since 1992. The Clearfield production system, by combining Clearfield crops with imidazolinone herbicides, is able to control certain weeds that no other herbicide can control in some crops including weeds that are closely related to the crop itself and some key parasitic weeds. The Clearfield production system provides another option for farmers to control herbicide resistant weeds. Clearfield crops may be also used to prevent rotational crops from herbicide soil residue injury. Since the commercialization of Clearfield crops, several new AHAS gene variants have been discovered, and they confer a higher tolerance to AHAS inhibitors than older mutants. Additionally, stacking of two mutated AHAS genes was also used to confer enhanced tolerance to AHAS inhibitors. The crops with these new or stacked genes and improved AHAS-inhibitor tolerance have been commercialized recently as Clearfield Plus crops. The enhanced tolerance of Clearfield Plus crops provides farmers with flexibility to use an optimal combination of imidazolinone herbicides and a stronger spray or formulation adjuvant, and have a wider application window to improve weed control and reduce risk of herbicide carryover. The Clearfield Plus production system significantly enhances the effectiveness of Clearfield technology for weed management.
Keywords: AHAS gene;imidazolinone;herbicide-tolerant crop;Clearfield;Clearfield Plus;

New cases of glyphosate resistance in weeds in Latin America

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There are currently 12 weed species recognized as having evolved resistance to glyphosate in Latin America: *Conyza bonariensis* (Brazil, Colombia), *C. canadensis* (Brazil), *C. sumatrensis* (Brazil), *Digitaria insularis* (Brazil, Paraguay), *Echinochloa colona* (Argentina), *Eleusine indica* (Colombia, Costa Rica), *Leptochloa virgata* (Mexico), *Lolium multiflorum* (Chile, Brazil, Argentina), *L. perenne* (Argentina), *Parthenium hysterophorus* (Colombia), *Paspalum paniculatum* (Costa Rica), and *Sorghum halepense* (Argentina). On-going research to diagnose glyphosate resistance (GR) in Latin America through whole-plant dose response bioassays has now confirmed additional GR cases. Resistance has been confirmed in additional populations of *E. indica* from Colombia and Costa Rica and as new cases in Ecuador. Populations of *Chloris radiata* and *Leptochloa mucronata* (= *L. filiformis*) from Colombia have also evolved GR. None of the GR populations tested has cross resistance to either paraquat or fluazifop-butyl. GR is becoming increasingly important in Latin America, particularly in no-till production systems, plantation crops and transgenic glyphosate resistant crops.
Keywords: Glyphosate;Resistance;*Eleusine indica*;*Chloris radiata*;*Leptochloa mucronata*;

Fitness of weedy rice – herbicide tolerant rice hybrids: morphology and combinatory ability

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Herbicide resistant rice (HRR) is valuable for selective control of weeds with broad-spectrum herbicides. However, hybrids between HRR and weedy rice could persist in the agro ecosystems. This study was carried out to determine the combinatory ability between weedy and herbicide resistant rice and to identifymorphologicaltraits contributing to their persistence.Manual crosses between three weedy rice biotypes (*sativa*-like, intermediate and *rufipogon*-like) and two imidazolinone-herbicide resistant varieties were produced. A total of 337 putative hybrids were obtained. They were morphologically characterized and compared to their respective parental lines under greenhouse conditions by measuring plant height, tillering, and flowering time fortnightly. Their hybrid nature was preliminarily confirmed by PCRusing specific primers to amplify the mutation site in the ALS enzyme conferring herbicide resistance. H1 hybrids had a higher growth and tillering ability than parental lines, indicating hybrid vigor. Additionally, hybrids flowered earlier (at 95-100 days after seeding, DAS) than rice cultivars and weedy forms that flowered at 105-110 DAS and 115 DAS, respectively. On average hybrid plants set seed at 50 to 60%.PCR products using allele specific primers at the ALS mutation site allowed the identification of herbicide resistant and susceptible plants. Hybrids will be further characterized morphologically in H2 and H3 generationsand their fitness will be determined under competitive conditions in the greenhouse.

Biological control of weeds

Oral presentations

Regional sustainable management of common ragweed and alligator weed in subtropical China

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Common ragweed (*Ambrosia artemisiifolia*) and alligator weed (*Alternanthera philoxeroides*) are two of the worst invasive alien weed species in China. Both of them invaded into China in the 1930s, and spread rapidly since 1950s because of lack of native natural enemies. Now they have widely distributed in 21 and 18 provinces in China, respectively. They co-occur in most area of subtropical China and result in significant hazards. So the management of the two invasive weeds should be synchronically carried out. During our two decades' research process, we introduced and selected out three effective biological control insects. They are *Epiblema strenuana* and *Ophraella communa* for common ragweed control, and *Agasicles hygrophila* for alligator weed control. Host specificity, control efficiency, biological and ecological characteristics, mass rearing techniques, and field application techniques of these insects have been studied. With the collaboration of some organizations which have developed effective chemical herbicides and host-specific bio-herbicide for alligator weed, we evaluated and set up the combined control of alligator weed with natural enemy insect, pathogenic fungus and herbicides. We also developed replacement control and ecological restoration techniques for common ragweed. On these bases, we established integrated model for regional sustainable management of these two weeds under different environmental conditions, such as farmland, orchard, traffic line, forest, wasteland, watercourse, and scenic area. This integrated regional sustainable management system has been applied in subtropical China for many years and limits the spread of these two weeds effectively.
Keywords: *Ambrosia artemisiifolia*; *Alternanthera philoxeroides*; Biological control; Sustainable management

Prioritizing weed targets for classical biological control in China

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China is now the world's largest agricultural economy and one of the mega-biologically diverse countries in the world. Many of 400 or more non-native plant species introduced into China have the potential to invade both natural environments and agricultural systems thereby reducing endemic biodiversity and threatening food security. Even with the extent of the problem, to-date there has been only a handful of releases of classical biological control agents against target weeds in this region. Biological control, defined as the use of natural enemies to control invasive pest populations, constitutes an environmentally friendly and less labor-intensive approach for weed control compared to the more traditional methods of mechanical and chemical control. The most commonly used strategy in biological control of weeds is classical biological control (CBC) which targets alien invasive plant species in their exotic ranges through the introduction of natural enemies (arthropod or fungal pathogens) from the native range of the target plant species. Countries such as Australia, New Zealand, South Africa and the USA have a long-standing experience in integrating CBC as one control component into their weed-management programs where spectacular levels of control have been shown for some of the most invasive non-native plant species using this control method.
This presentation will illustrate the principles of CBC based on examples of previous and ongoing control programs against invasive plant species from around the globe such as Lantana camara, Parthenium hysterophorus and Mikania micrantha. We will present a list of suitable weed targets for CBC in China based on a recently developed prioritization tool for Australia. In addition, we will discuss the value and potential of this control strategy for China looking at documented and newly emerging invasive plant species in this region.
Keywords: classical biological control;invasive non-native plants;prioritization tool ;

Biological control of *Ambrosia artemisiifolia* in Europe: learning from the past

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Common ragweed, *Ambrosia artemisiifolia*, has uniquely raised the awareness of invasive plants. The main concern is its particularly large production of highly allergenic pollen that causes allergic rhinitis and severe asthma in over 20% of the population of affected areas. Furthermore, ragweed is presently the worst weed of major crops in North America and several countries in Eastern Europe. Its range is still expanding in Europe and is likely to accelerate under a changing climate. We plan to initiate and coordinate long-term management options such as biological control and vegetation management, as sustainable control measures are lacking in Europe. Ragweed is an excellent target for biological control and up to now Ambrosia has been subjected to classical biological control programmes in Russia, Australia, and eastern Asia with variable success, as Australia alone has implemented a successful biological control programme, resulting in a benefit to cost ratio of >100. Recently the first successes have also been documented for China. Building on the extensive studies on antagonists of ragweed in its native range in North America and on the biological control activities conducted worldwide, we recently proposed a set of seven prime candidate agents for a classical or inundative biological control of Ambrosia in Europe. Of special interest are agents with a very narrow host-range that reduce pollen and seed production, the stage most sensitive for long-term population management of this winter annual. Integration of biological control and of habitat management into existing short-term control measures may then lead to a sustainable management strategy of Ambrosia in Europe.
Keywords: Common ragweed; Non-native／Exotic weed; Biological control; Herbivory; Fungi

Biological control: the importance of plant tolerance of herbivory

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Exotic plant invasion poses great threat to global biodiversity, and biological control, which is based on the uncritically tested assumption that herbivory will cause plant fitness loss, is widely used to manage exotic noxious weeds. However, the impact of herbivore on plant performance ranging from positive, to neutral, to negative is determined by plant compensatory ability, which is thought to be common in invasive plant species. Nevertheless, the importance of tolerance of herbivory has received little attention in biological control, and we know little about the invasive plant tolerance dynamics after re-association with herbivores in invasive ranges.
We studied the role of plant tolerance of herbivory playing in biological control and tested the effect of the history of population exposure to herbivory on plant tolerance with invasive plant *Alternanthera philoxeroids*. The weed, native to South America, has invaded China in both terrestrial and aquatic habitats. A host-specific flea beetle, Agasicles hygrophila, was introduced to control this noxious weed in 1986, but has only been successful in aquatic habitats and has no or limited control in terrestrial habitats, though it can reach high densities in terrestrial habitats.
With common garden and greenhouse experiments, we found that *A. philoxeroids* were able to fully recover from continued herbivory in the terrestrial habitat, but failed in the aquatic habitat. Also, the grazed plants increased below-ground growth and reproductive root bud formation in the terrestrial habitat, but there was no such difference in the aquatic habitat. With greenhouse experiment conducted with plants from 14 populations around China that differed in whether A. hygrophila or the native insect Cassida piperata Hope were present. Treatment plants were exposed to herbivory by A. hygrophila for a week until 50% of the leaf area was defoliated, then grown for 80 days. Plants from populations with prior exposure to herbivory (of any kind) accumulated more root mass than populations without prior exposure.
Our finding suggest that the differing plant compensatory capacity may explain the different biological control efficacy of A. philoxeroids in aquatic and terrestrial habitats, and indicating that prior exposure to insects can stimulate plant tolerance of herbivory. Thus, we would recommend plant tolerance and its potential changes in plant tolerance in response to prior exposure to herbivory are considered in invasive plant management plans that employ bio-control agents.
Keywords: Biological control; Tolerance of herbivory; Flooding; Exposure history to insects; Alternanthera philoxeroids

Current status of the classic biological control of *Mikania micrantha* in the Asian-Pacific region, using the rust fungus *Puccinia spegazzinii*

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Mikania micrantha is a major invasive, alien weed in the tropical moist forest zones of the Asia-Pacific region. This neotropical vine is able to smother plants in agricultural ecosystems, agroforestry and native habitats. Conventional control methods have proven to be ineffective in the long-term and hence classical biological control (CBC) was considered as a sustainable, cost-effective and environmentally friendly option. A project was initiated at CABI, to investigate the potential of fungal pathogens as CBC agents for this weed in India. The rust pathogen, *Puccinia spegazzinii*, commonly found infecting M. micrantha in its native range, was selected and screened. The rust infects all aerial parts of the plant, leading to cankering and whole plant death. It is highly host specific –only infecting a limited number of species from the genus Mikania– and has a broad environmental tolerance. Prior to releasing the pathogen, most participating countries gathered base-line data on the environmental and socio-economic impact of the weed, to enable an accurate future assessment of the impact of the rust. The rust was first released in India in 2005, but due to Government restrictions, only a very small scale release programme was permitted. Unfortunately, although there was evidence that the rust had established on field populations, it has not been confirmed to persist. Nevertheless, other countries have continued implementing this strategy; mainland China in (2006), Taiwan (2008), PNG (2009), Fiji (2009). Most recently Guam has been given the go ahead to commence a release programme. In Taiwan, PNG and Fiji the rust has established, is spreading rapidly and is having a visible impact on weed populations. Data from field assessments in PNG show the impact to be significant.
Keywords: classical biological control;invasive non-native plants;*Puccinia spegazzinii* ;*Mikania micrantha*;Rust fungus;

Evaluation of *Curvularia lunata* strain B6 as a potential microbial herbicide to control barnyardgrass (*Echinochloa crus-galli*) in paddy field

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Curvularia lunata strain B6 was isolated from the diseased leaves of barnyardgrass (*Echinochla crus-galli*). The results of host range tests showed that this strain was pathogenic to barnyardgrass, wheat, barley, and corn, but not affect rice, several other crops, turf grasses and weeds species. The agent could severely infect barnyardgrass at the 1- to 2.5-leaf stages. The fresh weight reduction and the disease severity of the weed increased with increasing conidial concentration, dew duration. The results of two-year field trials showed that this strain could effectively control barnyardgrass and was very safe to rice plants.
Keywords: Barnyardgrass; *Curvularia lunata*; Biological control; Rice

Constraints on biocontrol of an invasive weed with a parasite plant

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The disparity restraint between invasive weeds and native plants by native stem parasitic plants indicates the potential for the native

stem parasitic plant to be exploited as biocontrol agent. Application of the parasitic plant in biocontrol requires a better understanding what is the bottleneck for the parasitic plant to control the invasive plant sustainable. In the south of China, the potential biocontrol agent *Cuscuta campestris* becomes sparse and *Mikania micrantha* gets abundant again in the fields where *M. micrantha* was controlled once. In this study, we identified three constraints on biocontrol of *M. micrantha* by *C. campestris*. First, a mismatch between the phenology of *C. campestris* and *M. micrantha* meant that *M. micrantha* was not abundant when *C. campestris* was growing most vigorously, and therefore was uninfected. Second, residues of M. micrantha inhibited the germination of *C. campestris*, and then the number of *C. campestris* seedlings could not increase very well. Third, the chance of parasitism was lower with the increasing host-dodder distance and host stem size, causing that there would be not many enough suitable *M. micrantha* stems for C. campestris seedlings to infect. In combination, the population of *C. campestris* could not grow by itself in the way of sexual reproduction. This study provides a strategy for the native stem parasitic plant to control the invasive plant. Furthermore, the populations of the native stem parasitic plant need to be cultivated artificially to a large number, and be dispersed in the invasive plant community to enhance biocontrol efficiency.
Keywords: Biological control; Parasite plant; Germination; Sprout; Infection

Field evaluation of a powder formulation of *Helminthosporium gramineum* Rabenh for control of barnyardgrass in rice

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The fungal pathogen, *Helminthosporium gramineum* Rabenh. f. sp. *echinochloae* (HGE), is under consideration as a bioherbicide for the control of barnyardgrass in rice. This organism has been shown to be virulent against a number of important weeds in rice but has not yet demonstrated sufficient reliability in the field to be commercially developed. The objectives of this study are to evaluate the weeds control effects and safety of a powder formulation of HGE conidia in rice field. The field experiments were conducted both in Xundian county, Yunnan province, and Fuyang county, Zhejiang Province, China in summer 2011. The powder formulation of HGE conidia were used at 7 days after rice transplanting at dosages of 6, 9, 12, and 18 kg ha^{-2}. Plant mortality and height of rice were recorded 14 and 28 days after treatment (DAT). The number of panicles and yield of rice were measured at maturity. At the Fuyang site, 71.9%-100% plant mortality and 49.3%-100% fresh weight reduction of barnyardgrass were recorded at 28 DAT. In the meanwhile, the powder formulation of HGE conidia also showed good control efficacies to *Cyperus difformis*, *Eleocharis plantagineiformis*, and *Monochoria vaginalis* in rice. While at the Xundian site, 81%-100% plant mortality of barnyardgrass were recorded at 28 DAT. And good control efficacies toward *Scirpus juncoides* Roxb and *Monochoria vaginalis* were also obtained. There were no significant adverse effects on the growth and yield attributes of rice plants observed both at Xundian and Fuyang sites. And the grain yields of rice in the powder formulation treatments were much higher than untreated control by 34.5-61.0%, even higher than herbicide treatment (60% butachlor EM at 990 gai ha^{-2}). The results of this study showed that the powder formulation of HGE conidia has the potential to be commercially developed.
Keywords: Bioherbicide; *Helminthosporium gramineum* Rabenh. f. sp. echinochloae (HGE); Formulation; Barnyardgrass control

Poster presentations

Production of *Fusarium avenaceum* spore on a simple medium with corn flour as sole substrate

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Laboratory and field experiments have shown the remarkable biocontrol efficiency and mechanism of action against *Avena fatua* by *Fusarium avenaceum.* Commercial application of F. avenaceum depends on the capability to produce massive and effective fungal spores or conidia on an industrial scale. Therefore, a cost-effective production system is required. *F. avenaceum* could sporulate fairly well on various liquid substrates, and the spores produced in submerged fermentation (SmF) were more effective. SmF should be the preferred cultivation method to be used in the commercial spore production of *F. avenaceum*. Most work on the production of F. avenaceum by SmF was carried out on defined culture media. Since the mass production of spores is an essential step for commercializing the production of F. avenaceum, development of a cost-effective medium, which has the functions of both substrate and carrier, would be more favorable. This study aimed to find a cheap substance that could serve as a growth substrate and carrier for *F. avenaceum*. An agriculture by-product, corn flour, was found an ideal substrate for this study. To increase the production of *F. avenaceum* spores from corn flour, some factors that affecting the performance of SmF, including temperature, initial pH, culture time and inoculum size were studied. The results showed that optimum spore productive condition for corn flour medium(CFM) was 28℃, initial pH 7.0, 7 d and 0.5% (V/V) initial inoculum ($1\times106mL^{-1}$). The present study provides a method to use corn flour as a simple and cheap substrate to produce spores of F. avenaceum on an industrial scale.
Keywords: *Fusarium avenaceum; Avena fatua*; Submerged fermentation; Corn flour; Optimization

Isolation and identification of pathogens from weeds in citrus orchard

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Sambucns chinensis, Artemisia argyi, Calystegia hederacea, Digitaria ischaemum, Oxalis corniculata are prevalent and important weeds in citrus orchard. Conventional methods like manual remove and chemical control have many limitations. Manual control was uneconomical and chemical control methods are environmental pollution, resistance to the herbicide. There is considerable current interest in the use of plant pathogenic microbes as agents of the biological control weeds. Plant pathogenic fungi isolated from five weeds in citrus orchard at Chongqing area. Through morphological, pathogenic and molecular method, four pathogens from Sambucns chinensis were identified as *Botryotinia fuckeliana, Fusarium equiseti, Alternaria tenuissma* and *Alternaria alternate*. One

pathogen from *Artemisia argyi* was isolated and identified as *Paraphoma* sp.. One pathogen from Calystegia hederacea was Alternaria alternate. One pathogen from *Digitaria ischaemum* was Maqnaporthe qrisea. Two pathogens from *Oxalis corniculata* were Alternaria alternate and Fusarium sp. JZ-Z7. Alternaria sp., *Fusarium* sp. and Botryotinia fuckeliana had stronger infection ability and high sensitive to different weeds. *Paraphoma* sp. as biological control agent was no report. According to the virulence and security, these pathogens will be potential mycoherbicides in citrus orchard.
Keywords: Pathogens; Weed; Citrus orchard; Mycoherbicide; Isolation and identification

Herbicidal activity and preliminary pathogenic mechanism of *Phoma herbarum* toxin against dayflower

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The development of microbial compounds would lessen the need for chemical herbicides and provide greater options for weed management. The strain of *Phoma herbarum* SYAU-06, isolated from the diseased leaves of dayflower in Benxi city of Liaoning Province, had a limited potential to be used as a biological agent against dayflower. In this article, herbicidal activity and preliminary pathogenic mechanism of the toxin from SYAU-06 was studied. The results showed that the toxin could severely damage the leaf, but there were no significant inhibition of the toxin from *P. herbarum* on the seed germination, radicle and germ elongation, plant growth of dayflower. *Commelina communis* and *Chenopodium album* was more sensitive to the toxin while soybean and peanut was tolerance. The pathogenic mechanism of the toxin against dayflower was studied through measuring cell membrane permeability, malondialdehyde (MDA) content and activities of poly-p-phenylene oxide (PPO), phenylalanineammonialyase (PAL), catalase (CAT) and peroxidase (POD). The results indicated that the increase of cell membrane permeability was correlated positively with the treated time and concentration of the toxin. Na+ and K+ increased 57.8% and 341.5% when plant leaves was treated with the toxin. The content of MDA increased with over-oxidation of cell membrane action and achieved 313.60 nmol/g. The activities of PPO, POD, CAT, PAL was extremely unstable and increased firstly and then decreased. The data was indispensable for the toxin developed as a natural herbicide, meanwhile, laid the foundation for its large scale application.
Keywords: Phoma herbarum; Toxin; Herbicidal activity; Pathogenic mechanism

Inoculation with arbuscular mycorrhizal fungi suppresses initiation of haustoria in the root hemiparasite *Pedicularis tricolor:* implications for biocontrol of parasitic weeds

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Plant parasitism and arbuscular mycorrhizal (AM) associations have many parallels and share a number of regulatory pathways. Despite a rapid increase in investigations addressing roles of AM fungi in regulating interactions between parasitic plants and their hosts, few studies have tested the effect of AM fungi on the initiation and differentiation of haustoria, the parasite-specific structures exclusively responsible for host attachment and nutrient transfer. In this study, we tested the influence of AM fungi on haustorium formation in a root hemiparasitic plant. Using a facultative root hemiparasitic species (*Pedicularis tricolor*) with a potential to form AM associations, we tested the effects of inoculation with two AM fungal species, *Glomus mosseae* and *G. intraradices*, on haustorium initiation in *P. tricolor* grown alone or with *Hordeum vulgare* 'Fleet' (barley) as host plant. The results showed that both AM fungal species dramatically suppressed intraspecific haustorium initiation in *P. tricolor* at a very low colonisation level. The suppression overrode inductive effects of the parasite's host plant on haustoria production and caused significant growth depression of P. tricolor. The significant role of AM fungi in haustorium initiation of parasitic plants was demonstrated for the first time. This study provides new clues for the regulation of haustorium formation and a route to development of new biocontrol strategies in management of parasitic weeds.
Keywords: Root hemiparasite; Arbuscular mycorrhizal fungi; Initiation of haustoria; *Pedicularis*; Orobanchaceae

Primary studies on pathogenic mechanism of *Fusarium heterosporum* toxin against alligatorweed

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Fusarium heterosporum Nees ex Fr. was a potential biological control agent against alligatorweed, *Alternanthera philoxeroides*, and cause serious disease of alligatorweed. Its crude toxin can injure the host and has potential performance of biocontrol also. The dynamic of cell membrane permeability, chlorophyll contents, content of malondialdehyde (MDA), reactive oxygen species (ROS) level, activities of peroxidase (POD), polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL), superoxide dismutase (SOD) and catalase (CAT) were determined in leaf 3~4 leaf-old seedlings of *A. philoxeroides*, which had been treated with F. heterosporum crude toxin at concentration of 1mg/ml and 2mg/ml for discussing pathogenic mechanism of toxin. The results indicated that the cell membrane permeability increased, the content of MDA continuously accumulated and the chlorophyll content decreased sharply in *A. philoxeroides* leaf along with the time extend of treatment. Compared with the control, one outstanding peak of POD at crude toxin concentration of 2mg/ml was observed at 48h after treatment, and with 6.19 times higher than that of CK. Simultaneously, while one peak observed at 96h after 1mg/ml treatment. One activity small peak of SOD was observed at 48h in 2mg/ml treatment, and the other was significantly increased by 180.1% at 72h. The CAT activity level was obviously higher than that of CK at 48h. There was no significant difference in PAL and PPO activity levels between treatment and control. The production rate of reactive oxygen species (ROS) reached the highest at 72h after treatment in 1mg/ml crude toxin and then decreased sharply.
Keywords: Fusarium heterosporum; Toxin; *Alternanthera philoxeroides*; Response

Alternanthera philoxeroides pathogens isolation and pathogenic factor research

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Isolated 3 fungal species from *Alternanthera philoxeroides*, AZ-1, AZ-2, AZ-3, respectively. Through the infected leaves, found AZ-1 as a pathogen which had strong pathogenicity, forming distinct spots after infect 15 hours, the leaves showed hygrophanous yellow 84 hours later, and the whole leaves turn yellow 5 days later. For AZ-1, using ITS1 and ITS4 primers amplified ITS region 589bp including 5.8S region, partial sequences of 18S and 28S regions. Analysis sequences in the NCBI, found it has the highest homology (99%) of *Nimbya alternanthera*; detected germinating weed seeds, found that germination length were significantly lower which dipped in the toxin compared with the control. Among these weeds, the inhibition of *Digitaria sanguinalis* (Linn.) Scop was strongest, *Poa annua* Linn. was medium, Alopecurus japonicus Steud was weakest; inoculation small hyphal on A. philoxeroides leaves surface, cultured several hours at 24℃ light culture box, and study the toxin mechanism by using Chlorophyll fluorescence imaging system (IMAGING-PAM), found that the inhibition of photosynthesis PS II electronic conduction activity, i.e. the material it's likely to be a novel photosynthetic system inhibitors.
Keywords: *Alternanthera philoxeroides*; *Nimbya alternanthera*; Toxin; Photosynthesis

Pathogenicity test of potential combining biocontrol

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To develop biocontrol agents as alternative management method to herbicide, the pathogenicity to *Avena fatua* L was tested by four actinomycetes strains which isolated from rhizosphere soil of infected weeds. The pathogenicity to A. fatua was tested by seeds germination of respective strains in vitro and inoculation experiment of combining actinomycetes strains in vivo. The safety of these potential biocontrol agents to major crops in Qinghai was tested by bioassay. The results showed that four strains presented intensive inhibiting effects on the germination of *A. fatua* seeds, the inhibiting rates of four actinomycetes strains were all above 85%. Under greenhouse conditions, combination amongY7+Y8+D9 and Y8+D9+Y10 to *A. fatua* in 1:1:1 ratio showed higher virulence than individual inoculums, the disease index reached 76.0 and 70.8 respectively. And they were safe to broad bean and pea of major crops. The results suggested that combining strains expressed significant potential bioherbicidal activity, they expressed complementary biocontrol activities by collaboration, so the combinations of Y7+Y8+D9 and Y8+D9+Y10 could selected as the potential bioherbicidal candidates for mycoherbicide to broad bean and pea. **Keywords:** Biocontrol actinomycetes; Combining strains; Pathogenicity; *Avena fatua*

Site specific weed management

Oral presentations

Advances in technology for site specific weed control

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In cropping systems, weeds compete with crops for resources. Without intervention, weeds will out-compete crops and reduce yields significantly. Advancements in technology have allowed for precision applications in agriculture, including weed management. Using vision systems to identify weeds and targeted applications to precisely place treatments at micro-rates, a new type of cropping system is developing, in which management at the individual plant scale can be realized. Even with advanced technology and computer decision support software, real-time detection and targeted control of weeds in crops remains a challenge. Biological systems are dynamic and plant growth and development is consistently changing. In addition, environmental conditions influence plant shape, leaf angle, and reflectance, which all affect recognition and application capabilities of a real-time micro-applicator and identification system. The manifestation of weeds depends on many factors, as soil type, nutrient status, crop, moisture conditions. Some weeds can be easily controlled mechanically, others can be easily controlled chemically and some weeds are very difficult to control. For the effective control of all these weeds in different crops and under different circumstances, diverse solutions are required since there is not one 'killing all weeds' method. Sensor-based equipment is being tested for accurate identification of weed pests in the field at the individual organism scale in real-time. Numerous research programs in the field of biological systems engineering in the US, Europe, and around the world are making powerful discoveries in robotics and vision systems for use in agricultural production systems, including optically-guided inter-row weed cultivators, autonomous tractors, and automated pruning and harvesting machine prototypes. In this presentation, a summary of these developments will be presented with examples specific to weed control in various cropping systems from the most advanced regions of the globe.
Keywords: precision agriculture;machine vision;targeted applications;micro-dose;sensors;

Reflectance indices as a diagnostic tool for weed control performed by multipurpose equipment in precision agriculture

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Several tools of precision agriculture have been developed for specific uses. However, this specificity may hinder the implementation of precision agriculture due to an increasing in costs and operational complexity. The use of vegetation index sensors which are traditionally developed for crop fertilization, for site-specific weed management can provide multiple utilizations of these sensors and result in the optimization of precision agriculture. The aim of this study was to evaluate the relationship between reflectance indices of weeds obtained by the GreenSeeker™ sensor and conventional parameters used for weed interference quantification. Two experiments were conducted with soybean and corn by establishing a gradient of weed interference through the use of pre- and post-emergence herbicides. The weed quantification was evaluated by the normalized difference vegetation index (NDVI) and the ratio of red to near infrared (Red/NIR) obtained using the GreenSeeker™ sensor, the weed dry matter, visual weed control and digital photographs, which supplied information about the leaf area coverage proportions of weed and straw. The weed leaf coverage obtained using digital photography was highly associated with the NDVI ($r = 0.78$) and the Red/NIR ($r = -0.74$). The weed dry matter also positively correlated with the NDVI obtained in 1 m linear ($r = 0.66$). The results indicated that the GreenSeeker™ sensor originally used for crop fertilization could also be used to obtain reflectance indices in the area between rows of crops to support decision-making programs for weed control.
Keywords: GreenSeekerTM;interspecific competition;corn;NDVI;Digital photographs;

Advances in variable rate application of soil herbicides

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Precision agriculture technology offers opportunities to optimize weed and disease control site specifically. The optimization takes place at the level of grids within the crop or field, or at the level of individual plants in the crop. In this paper we present results of studies on variable rate application of soil herbicides. The outlook for this and other types of variable rate application of pesticides, whether or not in combination with autonomous navigation, is discussed. We carried out dose-response experiments with different types of soil and herbicides under controlled conditions. The experiments confirmed that lutum and organic matter contents have a large effect on efficacy of the herbicides. We tested herbicides such as linuron, prosulfocarb, dimethenamid-P and isoxaflutole. We derived non-lineair dosing algorithms that related soil properties (lutum or organic matter) to minimum effective doses. In a second study, the pesticide fate model PEARL was applied to determine bioavailability of isoxaflutole and dimethenamid-P in response to varying degrees of soil organic matter. The results will be used to improve dosing algorithms. The different components for a variable rate application system for soil herbicides are available. Soil maps with spatial variation in soil organic matter or lutum can be made with different types of sensor technology. Spray technology is available to adjust doses at grids of about 10 to 50 m2. And even adjustment per nozzle is possible, but more costly. Finally, software packages are available to translate soil maps into dosing maps with known dosing algorithms. In 2012 we will test combinations of the various components on at least one commercial arable farm in the Netherlands. We will present first results at the IWSS conference. In addition, we summarize other successful systems of variable rate application of pesticides, such as variable rate application of potato haulm killing

herbicides using ground and remote (satellite images) sensing of crop reflection, and variable rate application of preventive fungicides.
Keywords: precision agriculture;soil properties;herbicide efficacy;dose optimization;soil sampling;

Site specific weed appearance in barley crop. Preliminary results

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Understanding the spatial dynamics of weed populations and the rate of their spread within fields is increasingly important as methods for the site-specific weed management. A field site (1000 m2) has been selected with barley crop (Hordeum vulgare L.) without any herbicide application. The aim of the study was to investigate the weeds continuous appearance or patchiness in relation to that allelopathic crop under two watering schemes; rain fed conditions and supplementary irrigation. The experiment has been carried out in the experimental station of AUA (Spata). For the monitoring of the soil water content, 16 HS sensors of Decagon Devices, Inc. were installed in the soil at 20 and 35 cm depth . Intensive survey of weeds were conducted over the course of 15 days during the growing period in order to assess the weeds growth in terms of their spatial distribution. The number of weeds were counted in 48 sapling units of 1m2 , following a grid sampling pattern with a cell size of 5m. The density and spatial distribution of the weeds varied widely within the field and between the 2 watering schemes. In general, the followed weeds, Malva sylvestris, Sinapis arvensis, Chamomilla recutita, Cardaria draba, Gallium aparine, Cirsium arvense and Calendula arvensis were recorded in the field in weed frequencies 92, 48, 48, 46, 23, 23 and 21%, respectively. Furthermore, the mean densities (weeds / m2) of the weeds were the followed in a diminished rank; M. sylvestris (6.4), S. arvensis (4.5), C. draba (4.2), C. arvense (3.1), C.recutita (2.5), C. arvensis (2.3) and G. aparine (1.7). The data showed strong spatial dependence of the weeds in terms of the soil humidity influenced by the two watering levels. Especially, the sampling units located in the north west side of the field has been shown to have relatively higher weed appearance. The weeds density maps achieved by spatial interpolation methods determined weed patchiness, providing the necessary data for a potential site-specific weed management
Keywords: spatial weed appearance;weed maps;barley;watering schemes;

New opportunities in three-dimensional weed sensing for site specific weed management (SSWM). Sagi Filin

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Site specific weed management can decrease herbicide usage by targeting only weedy areas. Implementation of such concept requires however autonomous identification means, mostly via 2D image analysis. Limitations in application of such models is however evident as they are subjected to varying illumination conditions, overlapping plants, high weed densities, and imaging position. All are leading to inaccurate detection and identification. Since plants are three-dimensional, it is only reasonable that their sensing will be carried out in such space. In this presentation we evaluate existing 3D sensing technologies for weed detection and characterization. We focus on two technologies: image-based stereo-vision and laser ranging. Imaging systems can offer a detailed description of the imaged plants but the conversion of color into geometrical 3D representation cannot be carried out directly and requires development of designated algorithms. We review approaches for 3D plant modeling and demonstrate application of such model. While 3D extraction from images cannot be obtained directly and the reconstruction success is a function of the algorithm's quality, laser technology offers direct 3D data in high level of accuracy and point density. As an active ranging sensor, it neither depends on external conditions nor image processing algorithms. Following a review of ranging concepts we demonstrate results of its application for weed and plant modeling and discuss prospective use. While presenting both concepts we show how 3D modeling can be harnessed to develop a spatio-temporal model that characterizes the relation between environmental conditions, plants biomass and growth parameters for setting their optimal control rate and timing.
Keywords: site specific weed management;imaging;stereo-vision;laser;

Spatiotemporal mapping of cotton weeds in Mediterranean regions using aspatial and spatial regression models

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Four perennial weeds were studied in cotton crop for 4 consecutive growing seasons (2007-2010), using as case study the main cotton cultivation zone in central Greece. The weeds were assessed in 298 sites with the use of weed densities, frequencies and uniformities. The Abundance Index (AI) which is highly depended on abiotic factors was also estimated. Soil samples from each sampling site were also analyzed for texture, organic matter, calcium carbonates, pH, cation exchange capacity and for K, Na, Mg and Ca. Cyperus rotundus appeared as the most abundant weed indicating its persistence and its severity among the recorded weeds in cotton crop, scoring an abundance index of 154.32 in 2007. Among the studied weeds, Convolvulus arvensis showed the highest correlation with soil properties and more specifically with clay content. Over the years C. rotundus C. arvensis and Cynodon dactylon presented a stable appearance. The spatial distribution of the weed densities and frequencies were evaluated using spatial autocorrelation Moran's I coefficient. The relationships between weed density and abiotic factors (soil and climatic properties) were assessed using ordinary least squares regression (OLS), and geographically weighted regression (GWR) while logistic regression and logistic geographically weighted regression were used to examine the relationships between weed uniformities and abiotic factors. GWR is a method that takes into account the spatial non-stationarity behavior of the parameters used. The results indicated that weed indices were spatially autocorrelated. GWR gave more accurate results due to its ability to embody spatial variability in models while it was shown that the logistic regression models used could predict weed occurrence sufficiently.
Keywords: Spatiotemporal mapping;cotton weeds;spatial regression models;

Advances in spot spraying of herbicides on sports fields

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Weeds on sports fields are mainly controlled by band spraying of selective herbicides on the fields. However, public perception and factual risks associated with this use, raises a demand for alternative approaches. In this paper we describe a new approach of detection of broad-leaved weeds on sports fields and selective control methods. Common weeds on sports fields in the Netherlands are *Bellis, Taraxacum, Plantago* and *Polygonum* species. We have developed a vision-based system that uses textural analysis to detect broad leaf weeds against a grass background. After pre-processing, monochrome image tiles (0.03×0.03 m^2) are classified as grass or weed based on variance. A weed is detected when a sufficient number of adjacent tiles are classified as containing a weed. In a first experiment on a sports field, we collected images containing only grasses or broad leaf weeds and grasses. Over 80 % of the images were correctly classified as showing only grasses or grasses and weeds. We are now building with specialized companies (Arvoo, Tumoba and Donkergroen) a prototype for detection of broad-leaved weeds and selective application of herbicides to weeds on sports fields. The system consists of independent, one-meter wide modules. Each module has a camera system for detection of the weeds which is connected to four nozzles. We expect to be able to reduce herbicide use with this machine by more than 50 % compared to common practice. First results of tests with the prototype will be available at the time the IWSS conference is held in 2012. The vision-based detection system has already been successfully used for the detection of larger *Rumex* plants in pastures of dairy farms in the Netherlands, in that case the detection system controls a cutting device that selectively drills out the tap root of the weed. The key challenge in the sports fields project is to make the system effective on much smaller broad-leaved weeds without damaging the pitch. The work presented is financially supported by the Dutch government as part of Water Frame Work directive.

Integrated management of *Phragmites australis* (common reed) along the platte river

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The non-native biotype of common reed (*Phragmites australis subsp. australis*) is an invasive species that is invading wetland habitats and other natural areas in many eastern states of the US, including Nebraska. This species can be found along the Platte River, from Wyoming to eastern Nebraska, and expanding. Therefore, a series of of studies evaluated common reed control along the Platte River using an integrated management approach based on herbicides (glyphosate or imazapyr), mowing, and disking, either applied alone or in combination. Total of three studies, disking followed by herbicide (study 1), mowing followed by herbicide (study 2), and herbicide followed by mechanical treatment (study 3) were conducted in 2008, 2009 and 2010 at three locations in Nebraska. Visual ratings, flowering percentage and stem densities were collected to determine level of control. On the basis of visual ratings, disking and mowing alone did not provide adequate control of common reed whereas control was significantly improved and lasted for third season (817 DAT) when disking and mowing was followed with herbicide applications. All treatments in disking followed by herbicide and mowing followed by herbicide had good (≥84%) to excellent (≥92%) control, which significantly ($P = 0.0001$) suppressed common reed for 817 DAT. An addition of a mechanical treatment following herbicide application did not improve common reed control.
Keywords: common reed;invasive plants;invasive weeds;Nebraska;

Biotechnology, molecular biology and genomics as tools for weed management

Oral Presentations

A comparative genomic study of herbicide target genes in sensitive and resistant weed biotypes

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The increased use of herbicides has imposed a strong selective pressure toward herbicide resistance among weed species. Over 372 herbicide-resistant weed biotypes in 200 species have been identified globally, including 21 with resistance to glyphosate (www.weedscience.org). To better understand the evolutionary effects of glyphosate selection on its gene target, 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), we undertook a comparative genomic study of EPSPS among nine weed species. We assess the feasibility of using low-depth paired-end Illumina sequencing to capture key evolutionary characteristics of EPSPS in both sensitive and resistant lines, and compare these results to transcriptome sequence data obtained by 454 pyrosequencing. For species which confer resistance by multicopy expression and amplification of EPSPS such as Amaranthus palmeri, we examine the intra-genome sequence diversity of EPSPS. This comparative sequence data will be used to identify the opportunities and limitations of different methods to manage and combat herbicide resistance.
Keywords: herbicide;resistant;weed;genomic;454;

Efficiency of DNA barcodes for weed identification: A case in Microula Benth. (Boraginaceae)

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DNA barcoding of global plant species using standard barcodes has been a major focus in the fields of biodiversity and conservation. The DNA barcodes can also be used as reliable tools to facilitate the identification of weed in the study of biosecurity, horticulture and agriculture. In the present study, we took the genus Microula as an example. The plants of Microula are wide spread weeds in western China. We sampled 114 individuals representing 29 species of Microula to evaluate 5 DNA barcoding candidate loci (ITS, matK, trnL-trnF, trnH-psbA and rbcL) for species discrimination of Microula species. These DNA barcodes, alone or in combination (five single loci and ten two-loci combinations), were tested using both tree-method and distance-method. The results showed that species discrimination by using ITS (87%) outperformed other single loci, and its primers successfully amplified and sequenced all samples. Meanwhile, the most effective two-region barcode was ITS + trnL-trnF (90%). Both candidate barcodes were effective in placing unidentified samples in known species groups. Our results suggest that DNA barcoding could be used for distinguishing weeds at the DNA level.
Keywords: DNA barcoding;weed identification;Microula;Boraginaceae;internal transcribed spacer (ITS);

Nucleotide variability and genetic regulation of seed shattering in Brazilian red rice ecotypes

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Seed shattering is one of the main traits that make the red rice a weed. A better understanding of the seed shattering regulation in red rice can be used to develop biotechnological processes to mitigate the problems caused by this weed. The objectives of this work were to determine the nucleotide variability and genetic regulation of seed shattering in red rice. For this, we performed gene sequencing and gene expression in real-time RT-PCR. The gene qSH1, commonly considered to be involved in seed shattering, had no effect on the evaluated genotypes. The expression of the genes OsCPL1 and OsXTH8 was directly related with seed shattering. In contrast, the expression of the gene OsCel9D was inversely related with seed shattering. The gene Os08g0512400 was polymorphic at 1271 bases upstream of the first base of the mRNA, where, in general, the genotypes with the T nucleotide had high seed shattering, and with the A nucleotide had low seed shattering. In addition, the exon 5 of the gene Os01g0849100 presented two SNPs at positions 2981 and 3057 bases downstream of the first base, which may be related to seed shattering. Thus, in addition to the known gene OsCPL1, the genes OsXTH8, OsCel9D, Os08g0512400 and Os01g0849100 are also related to the seed shattering in red rice. These results indicate that seed shattering in red rice has a more complex gene regulation than in cultivated rice.
Keywords: SNPs;gene expression;red rice;OsXTH8;OsCPL1;

Molecules and macromolecules trafficking between hosts and the parasitic weed *Phelipanche spp.*

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Broomrapes (*Phelipanche spp*. and *Orobanche spp*.) are holoparasitic plants that subsist on the roots of a variety of agricultural crops, establishing a direct connection with the host roots to exchange molecules and macromolecules.

To test for peptide movement between host and parasite we have generated transgenic tobacco plants expressing a cecropin peptide (sarcotoxin IA), under the control of the inducible HMG2 promoter. In this study it was demonstrated that sarcotoxin IA translocated from transgenic tobacco plants to the attached Phelipanche tubercles. Mannose 6-Phosphate Reductase (M6PR), is an essential gene to Phelipanche for water and nutrient uptake from the host. We transformed tomato plants with the M6PR as a target gene for silencing, using the inverted repeat technique. It was shown that the M6PR mRNA target gene was silenced in P. aegyptiaca tubercles or shoots grown on the roots of transgenic tomato, indicating movement of siRNA from host to parasite. To test for protein movement between host and parasite, we used transgenic tomato and tobacco lines targeting a Green Fluorescent Protein (GFP) to the companion cells or to the endoplasmic reticulum (ER) respectively. In this study it was demonstrated that GFP was transferred from the companion cells of a transgenic tomato to the attached Phelipanche tubercles or shoots through phloem connections. In another study, it was shown that CMV can move also from virus infested tomato plants to the parasite tubercles and shoots attached to the infested tomato plants. Understanding translocation and uptake of molecules such as siRNA, mRNA, viruses, peptides and proteins from host plants to the parasite is a key aspect of the success to optimize and develop parasite control strategies.
Keywords: Phelipanche spp.;GFP;M6PR;CMV;Parasitic weeds;

Evolutionary history of *Aegilops cylindrica* Host (jointed goatgrass)

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Aegilops cylindrica (jointed goatgrass), a species which resulted from hybridization between *Ae. tauschii* and *Ae. markgrafii*, is an important weed in wheat production in the USA. *Aegilops cylindrica* has the same center of origin and a common progenitor with hexaploid wheat (*Triticum aestivum* L.). The analysis of 4928 bp chloroplast sequence revealed two haplotypes. Two *Ae. cylindrica* accessions had the C-type cytoplasm of *Ae. markgrafii* and four had the D-type cytoplasm of *Ae. tauschii*. These results are in agreement with previous molecular studies which suggested that *Ae. cylindrica* formed recurrently through multiple hybridization events. The phylogenetic analysis of the nuclear sequences clearly separated the C genome from the D genome of *Ae. cylindrica* sequences. Within the D genome, two clades were observed. One clade included *Ae. taushcii ssp taushcii* and all the sequences of *Ae. cylindrica* D genome. The other clade includes *Ae. taushcii ssp strangulata* and the D sequence of wheat indicating that different subspecies of *Ae. tauschii* were involved in the origin of *Ae. cylindrica* and wheat. A phylogenetic study using partial sequences from four nuclear genes indicated that hexaploid wheat and *Ae. cylindrica* are close in age. As *Ae. cylindrica* and hexaploid wheat both originated in the Fertile Crescent at about the same time our results might suggest that the domestication of hexaploid wheat have favored the origin and establishment of *Ae. cylindrica* as a species. In the case of hexaploid wheat and probably *Ae. cylindrica*, agriculture was a key force in the origin of the new species where humans then selected which species would become a crop or a weed, respectively.
Keywords: *Triticum aestivum*;divergence;speciation;

Impact of transgenic insect resistance in introgressed wild Brassica populations

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Gene flow between crops and their wild relatives may lead to interspecific hybrids and result in the introgression in weed populations of any novel trait breeded in the crop. Transgenes are typically novel genetic constructions aimed to improve agronomic quality of crops. Consequently, introgression from genetically modified crops to their relatives might increase the fitness of receiving plants and impact the dynamics and invasiveness of related weeds. In particular, it is a concern in the case of oilseed rape, Brassica napus, and its wild relative B. juncea. Besides herbicide-resistance which directly impacts weed survival, other traits can be beneficial to weeds, such as disease and insect resistance. Two approaches are developed here to estimate how fast can increase the frequency of insect-resistant plants in a weed recipient population. For the first approach, we simulated insect-mediated damage by clipping leaves of different proportions of plants in artificial B. juncea populations. For the second approach, we applied insects on B. juncea x B. napus advanced backcross generations harboring a Bt transgene. Simulated damage did not result in per-plant and per-plot seed production difference in pure stands, but a significant penalty was observed in mixed-plant-type plots. However, growth conditions with decreased competition intensity erased these differences. Conversely, no difference was observed in mixed plots of Bt-transgenic and non-transgenic BC2 under insect attack, but the whole plot production increased with increasing proportion of resistant plants. This discrepancy was attributed to a halo effect protecting the non-transgenic plants, while this biotic interaction was not triggered by simulation.
Keywords: Gene flow;Transgene;Fitness;Insect resistance;

Expression of genes related to seed shattering in rice

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The understanding of seed shattering in red rice can be used to determine management practices to reduce the problems with this weed in flooded rice fields. The objective of this work was to characterize the expression of known genes related to seed shattering in contrasting rice genotypes. The expression of the three genes with proven effect on the abscission OsCPL1, Sh4 and qSH1 was

evaluated in red rice biotypes and rice cultivars. The gene qSH1 was not expressed in the region between the pedicel and the flower to ten days after pollination. The Sh4 gene expression was observed in the region between the pedicel and the flower. However, the expression of this gene did not show a direct relationship with the occurrence of seed shattering. The gene OsCPL1 was expressed in the region between the pedicel and the flower to ten days after pollination and showed a direct relationship with the level of abscission on red rice and rice genotypes. In the literature, it was demonstrated that OsCPL1 represses differentiation of the abscission layer during panicle development. However, in this study, the expression of OsCPL1 was related to activation of the abscission process. This discrepancy may be due to differences in OsCPL1 sequence. The literature shows that an SNP at the end of seventh intron at position 5498 of the gene, causing a 15-bp deletion of its mRNA as a result of altered splicing, triggers seed shattering. In contrast, none of the genotypes in this study showed the expected SNP. Of the three genes with proven effect on seed shattering, only OsCPL1 had a direct correlation on seed shattering.
Keywords: SNPs;gene expression;red rice;

Poster presentations

Hemin: a novel animal-derived plant growth regulator

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The hemin extracted from animals' (pig, cattle, etc.) blood is a biological source of iron, which was generally recognized by modern medicine. Hemin is widely used as a dietary supplement in the prevention of iron deficiency anemia in animals as well as human beings. Although hemin is generally recognized, its role in agriculture has never been reported. To reveal the potential value of hemin in agricultural crop production, we have carried out a variety of indoor and outdoor experiments in Zhengzhou and Lankao in Henan Province, Tai'an in Shandong Province and Qinghai Province in the past ten years. The results show that the spray or irrigation with 0.1-100 μM hemin could rapidly increase the expression of plant genes to improve stress tolerance and disease resistance. Hemin was able to induce the release of cGMP (cyclic guanosine monophosphate) *in vivo*, apparently signaling the plant response against drought, low temperature, saline, water logging, phytotoxicity, fertilizer damage and other adverse environmental conditions, as well as the prevention of a variety of plant diseases. In addition, the application of hemin could promote plant seedling growth, adventitious and lateral root development, and increase crop yields. Due to its affordability and environmental friendly features, hemin exhibits a wide range of prospects for agricultural applications. In summary, hemin is a novel animal-derived plant growth regulator with the characteristics of safety and environmental protection.
Keywords: Hemin;plant growth regulator;safety; environmental protection;

Isolation, identification and cDNA library construction of glyphosate-resistant Fungus（*Candida palmioleophila*）

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Glyphosate can control most weeds, and crops due to its non-selective nature and this limited its wide application during the cropping season. Glyphosate-resistant crops have reduced the cost of agricultural production, and therefore herbicide resistant transgenic crops have become key to agricultural research today. Many microoganisms have glyphosate-resistance. If glyphosate-resistance genes from microorganisms were cloned and transformed into crops and expressed, the phytotoxicity of crops from glyphosate would be reduced or avoided. New glyphosate-resistance genes could be isolated by cDNA library construction of glyphosate-resistant microbial stains. A glyphosate resistant fungus strain was isolated from sludge of a glyphosate factory waste stream by flask-foster enrichment technology. Based on its morphological, physiological and biochemical properties as well as the 18S rRNA sequence analysis result, the strain was tentatively identified as *Candida palmioleophila*. A cDNA library made by the total RNA extracted from the strain was constructed by SMARTer technology of Clontech company. The library quality was evaluated, and the results showed that the titer of primary cDNA library and amplified cDNA library were 2.58×106 cfu/ml and 3.42×109 cfu/ml, respectively, in a total library of about 2.58×106 cfu with a recombination rate of 97.6%. The inserted fragments were distributed from 500 bp to 3 kb, and most of the cDNA fragments were distributed around 1 kb. These results indicate that the strain TY-JM cDNA library is constructed successfully.
Keywords: Glyphosate; *Candida palmioleophila*; identification; cDNA library;

Study on the resistant- chlorimuron-ethyl characteristics of acetolactate synthase(ALS) in Aspergillus Niger (UVTR-H) by UV mutagenesis

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Sulfonylurea and imidazolinone herbicides are all ALS inhibitors which has been widely used due to their high activity, low toxicity, etc. Acetolactate synthase (ALS) is an important target enzyme in the herbicide research and is essential to plant and microbial amino acid synthesis . In this study, we created a highly resistant stain (UVTR-H) to Chlorimuron-ethyl by UV mutagenesis. Enzyme kinetic methods for the TR-H were obtained using a previous published method. The main results are as follows: (1)The ALS enzymatic activity of UVTR-H was 2.8 times higher than the original strain (TR-H) at high concentrations of Chlorimuron-ethyl; (2) Under the following optimal fermentation conditions, UVTR-H strain appeared to have the highest ALS enzyme activity: Glucose 20 g/L, NH4NO3 10 g/L, KCl 0. 5 g/L, MgSO4 • 7H2O 0.4 g/L, K2HPO4 1.2 g/L, FeSO4 0.1 g/L; initial pH 7.0, 2.5% inoculation, liquid volume 100 ml/250 ml, constant temperature culture 84 h at the 30 ℃ and 150 r / min; (3)The ALS enzyme kinetics studies have shown that the optimum temperature of the enzyme is 35 ℃, the best pH is 7.3; the initial reaction rate was 60.1 μg / ml • h, with a Km = 80 μg / ml, and a Vmax = 380 μg / ml • h using sodium pyruvate as substrate in the enzymatic reaction. .The Km and

Vmax were higher than the TR-H parental line and shows enhanced activity after mutagenesis. 0n the basis of these results, we hope to find new resistance ALS-genes.
Keywords: Aspergillus Niger;UV mutagenesis;ALS;Resistant-Chlorimuron-ethyl;Enzyme kinetics;

Soybean (*Glycine max*) response to simulated drift of glyphosate

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A field study was conducted during 2010 and 2011 at Harbin to evaluate the response of nontransgenic soybean to simulated glyphosate drift rates. A randomized block experimental design was used with four replications. The herbicides had been applied at 11.2, 56, 112, 168, 224, 336, 448 and 560g ai/ha, respectively (representing 1, 5, 10, 15, 20, 30, 40 and 50% of the usage rates of 1,120 g ai/ha glyphosate), when the soybean plants had reached the second fully expanded leaf stage. The following characters were evaluated: plant injury, plant height and fresh weight, root length and root fresh weight and nodule number. Glyphosate injured soybean, and visible injury ranged from 5 to 70% 14 d after postemergence (POST) application of 11.2~560 g/ha, plant height and fresh weight were reduced by 15 to 50% and 15 to 72%, respectively. Root length and root fresh weight were reduced from 224~560 g/ha glyphosate by 10 to 35% and 30 to 66%, respectively. Glyphosate at 11.2~336 g/ha had no distinct effect on nodule number, nodule number was distinctly reduced by 30 to 35% from 448~560 g/ha glyphosate. However, soybean recovered 28 d POST application of 11.2~112 g/ha glyphosate. Glyphosate at 168~560 g/ha reduced soybean plant height, fresh weight, root length and root fresh weight by 18% to 50, 15% to 45%, 10~50%, 45~80%, respectively, 28 d POST application. Glyphosate at 11.2 to 168 g/ha did not reduce soybean yield, However, soybean yield was reduced by 10 to 100% with applications of 224~560g/ha.
Keywords: *Glycine max* ;Glyphosate;herbicide drift;Crop injury;

Molecular mechanisms responsive to dehydration may impact the invasiveness of perennial weeds under global climate change

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Leafy spurge is an invasive perennial weed in the great plains of the US and Canada. The ability of this herbaceous weed to regenerate new shoot growth from an abundance of crown and root buds after severe abiotic stress is critical for survival. Due to its adaptable and aggressive nature, global climatic change has the potential to benefit the invasiveness of leafy spurge. To determine if the growth of crown and root buds is affected by dehydration-stress, a major component of the climatic change, leafy spurge was subjected to mild- and severe-dehydration treatments. Microarray analysis was then used to follow changes in molecular mechanisms in crown and root buds of plants exposed to dehydration treatments for 0-, 3-, 7-, 14- and 21-days. Transcriptome profiles revealed that 615 and 792 genes were differentially-expressed (P<0.005) in the crown and root buds, respectively, during dehydration treatments (0-21 days); 220 of these genes were common to both crown and root buds. Gene-set enrichment analyses was used to identify over-represented pathways and gene-ontologies, which included response to hormone stimuli, stress responses (heat shock, osmotic, oxidative, salt, and wounding), transport functions, carbohydrate degradation, binding (DNA and RNA, ion, and protein), cell cycle, and plant development. Further, sub-network enrichment analyses identified central hubs of over-represented genes involving mainly in stress and hormone responses (*DREB2A*, *ETR1*, *JAZ10*, *MYC2*), phosphorylation (*MPK6*, *NDPK2*), response to light (*bHLH*, *PHYB*), and gene silencing by microRNA (*mir172A*). Identification of these molecular mechanisms and their response to different levels of dehydration-stress may provide a better understanding of how leafy spurge adapts and survives under harsh environments. Further, the information may assist in devising management practices to reduce the spread and invasiveness of perennial weeds such as leafy spruge.
Keywords: Leafy spurge, dehydration-stress, global climate change, transcriptome analysis.

De novo assembly and characterization of the barnyardgrass (*Echinochloa crus-galli*) transcriptome using next-generation pyrosequencing

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Barnyardgrass (*Echinochloa crus-galli*) is one of the most troublesome weeds in rice production. Rapid evolution of herbicide resistance makes this weed to be one of the most resistant species. Sequencing Barnyardgrass' transcriptome by using Roche 454 GS-FLX platform will greatly help understanding the mechanism controlling the evolution of herbicide resistance in this weed species. 454 pyrosequencing generated 371,281 raw reads with an average length of 341.8 bp, which make up a total length of 126.89 Mb (NCBI accession number SRA). *De novo* assembly produced 10,142 contigs (~5.92 Mb) with an average length of 583 bp and 68,940 singletons (~22.13Mb) with an average length of 321 bp. 244,653 GO assignments were obtained (for contigs?), with 90,173 unigenes for biological process, 99,072 unigenes for cellular component and 55,408 unigenes for molecular function. A total of 6,092 unigenes with 2,515 enzyme commission (EC) numbers were assigned to 151 predicted KEGG metabolic pathways. The numbers of unigenes in different pathways ranged from 1 to 4424. Eight herbicide target-site gene groups and 4 non-target-site gene groups were determined in the resistant biotype of *E. crus-galli*, all of which are the potential candidate genes involving in herbicide resistance for further functional genomics research. Moreover, 7 types of genes were found compared with *Echinochloa* genes in NCBI, which could be benefit for phylogenetics in grasses. The susceptible and resistant biotypes of *E. crus-galli*, with and without treatment of three herbicides, were used to carry out the first large-scale transcriptome sequencing using 454 GS-FLX platform. Sufficient data provide a valuable resource on the genome of *E. crus-galli* and should be useful to weed science in the future (This is not conclusion. Conclusion should point out the main results and implication derived from the results)
Keywords: barnyardgrass; *Echinochloa crus-galli*; herbicide resistance; transcriptome; 454 pyrosequencing; *de novo* assembly; target site genes

Weed management in organic farming

Oral presentations

Effects of tractor weight, wheel placement and depth and timing of ploughing on perennial weeds in organically farmed cereals.

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Creeping perennial weeds such as *Elymus repens* (L.) Gould., *Cirsium arvense* (L.) Scop. and *Sonchus arvensis* L. are of major concern in organically grown cereals in the Nordic countries and elsewhere. To ensure optimum conditions for organic cereal growing, it is important to minimize compaction and soil inversion depth, as well as optimizing the effects on weeds by ploughing at a proper season. Two experimental series were conducted; (i) The relative effects of using light versus heavier tractors, shallow versus deeper ploughing and on-land versus in-furrow wheel placement during ploughing in spring were investigated in two organic rotations. (ii) A second timing experiment included the treatments soil cultivation (disc harrowing) followed by ploughing, and only ploughing, both carried out autumn or spring. Both experimental series were carried out under favourable soil conditions at two sites with the treatments repeated on the same plots during 3 years. Neither tractor weight nor wheel placement influenced the growth of the perennial weeds. Weed number and biomass were, however, mostly 50% lower with deep ploughing (25 cm) than with shallow ploughing (15 cm). *C. arvense* was, however, in some cases more than 90% lower compared to shallow ploughing. In the timing experiments spring ploughing decreased the growth of *C. arvense* and *S. arvensis* significantly compared to autumn ploughing. For *E. repens* timing of ploughing or bare fallow had no significant effect, the most important factor was whether disc harrowing was carried out (best control) or not. Our study showed that depth and timing of ploughing are of crucial importance and that the control efficiency is highly related to weed species and their varying growth rhythms during the growth season.
Keywords: perennials, ploughing, tillage, Cirsium arvense, Elytrigia repens, Sonchus arvensis

Comparison of control methods for eleven perennial species: anaerobic soil disinfection, chemical and mechanical control.

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During recent years it has become a great challenge to control perennial weeds. Experiments on two fields were setup to test the effectiveness of mechanical and chemical weed control strategies and anaerobic soil disinfection under fallow to control *S. arvensis*, *C. arvense*, *R. sylvestris*, *M. arvensis*, *C. sepium*, *R. obtusifolius*, *E. arvense*, *E. repens*, *S. palustris*, *T. farfara* and *P. amphibia*. A rod weeder mounted behind a rigid-tine cultivator was compared with a broadcast root knife operating at two working depths. Anaerobic soil disinfection comprised the incorporation into the plough layer of the weed biomass with or without 40 tons/ha fresh grass biomass and immediately covered with plastic sheets. The percentage cover preceeding every action during the growing season and the root dry matter present in the following spring were used to determine the level of control. The rod weeder reduced the cover with 90- 99% during the growing season, depending on the species. In spring 2011 the effect was still noticeable: root mass in the rod weeder treated plots was 86-99% less than in the control plots for all species, except for *T. farfara* and *M. arvensis*. These long term effects were better than the long term effects of the herbicides (14-83% control). For *M. arvensis* and *S. arvensis* the best control was obtained with the broadcast root knife operating at 15 cm depth (99% control during season and 94% next spring). The anaerobic soil disinfection gave good long term control for *R. sylvestris, C. sepium, E. repens, R. obtusifolius and P. amphibium,* varying from 88-98%. The highest long term control level obtained for *T. farfara* was 64% after treatment with MCPA. These results are a good starting point to develop effective alternatives to control perennials in crop rotations
Keywords: perennials; rod weeder; broadcast knife; soil disinfection; chemical

Potential use of cover crop mixtures and alternative termination methods in conservation tillage organic cropping systems

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Cover crops are often grown in monoculture and terminated with intensive tillage. Studies were conducted to determine the merits of growing multi-species cover crops and terminating them with less intensive tillage techniques. Experiment 1 consisted of a barley/field pea cover crop terminated by a disc, wide-blade tillage, flail mower, roller crimper, or roller crimper plus late-fall cultivation. Cover crop growth was terminated well with all treatments except the roller crimper required repeated applications every 3-4 weeks for complete vegetation kill. Weed biomass the following year in spring wheat was lowest with the previous flail mower or wide-blade tillage treatment and both of these treatments had fewer weeds than the traditional disc treatment currently used by farmers in this region. Spring wheat yield was similarly high (4400 kg/ha) with all cover crop termination treatments indicating that there is good potential to use less intensive tillage in cover crop systems. Experiment 2 treatments included barley, field pea or hairy vetch grown in monoculture compared with various two, three or four-species cover crop mixtures. Cover crop biomass at termination was greatest with monoculture barley and barley mixed with hairy vetch, oilseed radish or dwarf sunflower. Hairy vetch and field pea grown in monoculture produced the least biomass and they also contained the most weeds. Spring wheat yield in year 2 was greatest with the previous field pea cover crop; perhaps indicating the benefits of a nitrogen-fixing cover crop. The three and four-species cover crop mixtures resulted in similar wheat yields to that of monoculture barley or barley/field pea that are commonly

grown cover crops at present. Study results indicate that there are opportunities to improve the utilization of cover crops as organic farmers move to more conservation tillage cropping systems.
Keywords: cover crops; tillage intensity; weed biomass; roller crimper; cover crop mixtures

Effect of brassica cover crops and hazelnut husk mulch on weed control in hazelnut orchards

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Weed management is critical in hazelnut (*Corylus avellana* L.) production. Weeds reduce nutrient availability, interfere with tree growth and reduce hand harvesting efficiency. Field experiments were conducted from fall 2006 to 2010 to test effects of brassica cover crops and hazelnut husk mulch as alternative weed management strategies in hazelnut. The cover crop consisted of rape (*Brassica napus* L. var. oleifera), field mustard (*Brassica rapa* L.), oriental mustard (*Brassica juncea* L.) Czern.) and fallow with no cover crop. Hazelnut husk was surface applied at two thicknesses, 5 cm and 10 cm. Dry biomass production by the cover crops was relatively consistent among years with oriental mustard producing the most biomass. Throughout the growing seasons the cover crop reduced weed density, weed dry weight and the number of weed species when compared with fallow treatment. The most weed-suppressive cover crop was oriental mustard. Hazelnut husk applied as a 10 cm tick layer on the ground was also highly effective at controlling weeds up to 180 days after application and reduced total weed dry weight by 83% at the end of the season. Brassica cover crops or hazelnut husk may help control annual weeds in hazelnut orchard during early summer. However, these strategies should be combined with other methods like herbicide application or physical weed control for adequate weed management.
Keywords: mustard; rape; organic hazelnut; weed management; hazlnut

Response of pigweed and foxtail species to broadcast flaming

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Propane flaming could be an effective tool for weed control in organic cropping systems. However, susceptibility of major weeds to broadcast flaming must be determined in order to optimize its proper use. Therefore, field experiments were conducted during summer of 2008 at the Haskell Agricultural Laboratory, Concord, NE utilizing six doses of propane and four weed species, including green and yellow foxtail (Setaria pumila), waterhemp (Amaranthus rudis), and redroot pigweed (Amaranthus retroflexus) with the objective to determine their tolerance to flaming. Propane flaming and plant responses were evaluated at three growth stages for each weed species. The propane doses applied were 0, 12, 31, 50, 68 and 87 kg/ha corresponding to 0, 2.5, 6.5, 10.5, 14.4 and 18.4 gal/acre. Flaming treatments were applied utilizing an ATV mounted flamer moving at a constant speed of 6.5 km/h (4 m/h). The response of the weed species to propane doses was based on visual injury rating and percent biomass loss recorded at 14 days after treatment (DAT). In general, foxtail species were more tolerant than pigweed species. Waterhemp and redroot pigweed did not differ in their response to broadcast flaming, and were easily controlled (90% control) with a propane dose of about 60 kg/ha when flamed at early growth stages (3-5 leaf stage), however they needed a higher propane dose of about 90 kg/ha at later growth stages (9 leaf stage to flowering). Green foxtail was more tolerant than yellow foxtail regardless of the growth stage. Propane dose of 110 kg/ha was needed to provide 90% control of green foxtail regardless of the growth stage. In contrast, 90% control of yellow foxtail was achieved with propane dose of 80 kg/ha for any growth stage. It is important to point out that foxtail species started re-growing at about 14 DAT regardless of the growth stage flamed, whereas pigweed species did not re-grow, especially when flamed with doses above 60 kg/ha.
Keywords: flame; flaming; weeds; pigweed; foxtail

Role of dried jellyfish as an innovative means of organic rice production

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Organic rice farming comprises 0.13% of the total rice production in Japan. Grain yield is usually lower in these systems because weed control is challenging compare to conventional, herbicide-based production. The purpose of this study was to use jellyfish to improve weed control in organic rice production. Jellyfish are very abundant in many oceans, including the Japan-sea. Moreover, jellyfish interfere with commercial fishing. Desalinated-dried jellyfish (DDJ, small pieces of jellyfish which are desalinated and dried) mixed into soil before transplanting can effectively control weeds of rice field. Yields may further benefit from the nutrients released from the jellyfish, which are high in nitrogen (10-13%). We speculate that DDJ can serve as an agricultural material that replaces herbicides and the chemical fertilizer. There are some problems with the manufacture of DDJ. The desalination process requires considerable water, time, effort, and energy and carries a high cost. Preliminary studies were done to examine whether dried jellyfish (DJ) that has not been desalinated could control weeds and have a similar nutrient effect to that of DDJ in the rice cultivation. Weeds were effectively controlled by using DJ and the yield of rice was nearly the same as obtained when using DDJ. The use of DJ was effective in place of chemical fertilizer and herbicides in an organic rice farming system.
Keywords: weed control; nutrient effect; dried jellyfish; rice

Animal-source protein meals reduce weed growth

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Some animal protein meals are used as organic nitrogen sources and as growth promoters among organic growers. These products, like corn gluten meal, are high protein meals typically used as animal feed supplements. A greenhouse study was conducted to: 1) determine whether animal protein meals had herbicidal activity; 2) understand what protein meal rates kill weeds; and 3) determine weed species response to these meals. Blood, poultry, feather, and sardine meal were compared at three rates: 2,240, 4,480 and 6,720 kg/ha. Experimental design was a three by four factorial randomized complete block design with four replications. An untreated control was included for comparison. Weed species evaluated were Chenopodium album (CHEAL), Kochia scoparia (KCHSC), Amaranthus retroflexus (AMARE), Solanum physalifolium (SOLSA), Sonchus oleraceus (SONOL), Salsola tragus (SASKR), Setaria viridis (SETVI) and Echinochloa crus-galli (ECHCG). A 4:1 mixture of field soil and potting mix was used for growing the weeds. Weed seedling emergence and weed control were evaluated 21 days after planting (DAP) and 28 DAP. In addition, weed seedlings were harvested 28 DAP and dry weights recorded. KCHSC was not controlled very well by any of the protein meals. AMARE dry weights pooled across application rate averaged 35% of the control, with no difference among protein meals. There was a significant protein meal by application rate interaction for CHEAL dry weight. SETVI dry weight was reduced most by feather meal and poultry meal, averaging 5 and 14% of the control, respectively. SASKR dry weight was most affected by sardine meal and least affected by poultry and blood meal. ECHCG dry weight appeared to be the least affected weed by the protein meals. SOLSA was equally affected by the protein meals. SONOL appeared to be the most sensitive of the eight weed species evaluated averaging only 2% of the control.
Keywords: protein meal; blood meal; feather meal; poultry meal; sardine meal

Multi-species intercropping (navathaniyam): A cultural weed management strategy for organic farming systems.

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Development of sustainable agricultural systems mostly depends on effective weed and nutrients management. Weeds are the major deterrent to the development of more sustainable agriculture systems. Hence field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore under irrigated dry conditions to evaluate the organic sources of nutrients and panchagavya spray (a blend of five products obtained from cow) on the productivity of crops in the maize-sunflower-greengram system with nine treatments, of which six treatments are organic sources of nutrients with and without panchagavya foliar spray; two treatments were recommended dose of fertilizers with and without recommended foliar spray; and one non-manured or fertilized (control) in a randomized block design recplicated thrice. For the organic nutritional treatments the recommended dose of N was substituted through sowing of navathaniyam (a multi varietal seed mixture of nine crops viz., two cereals, two pulses, two oilseeds, two spices and condiments and one nitrogen fixing green manure ploughed in situ as green manure), biogas slurry and Sesbania aculeata and no P and K were applied. Intercroppping of navathaniyam brought out a significant reduction in weed density as compared to control. Among the different organic sources of nutrients, intercropping of Sesbania aculeata reduced weed dry matter production, while biogas slurry treatments enhanced weed dry matter production. Recommended dose of fertilizers with or without recommended foliar spray resulted in the maximum weed control efficiency. Intercropping of navathaniyam was found to be effective in controlling weeds of irrigated dry land crops.
Keywords: navathaniyam; panchagavya; weed dry matter production; weed control efficiency; biogas slurry

Mechanical control of Purple nutsedge (*Cyperus rotundus*).

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Purple nutsedge (*Cyperus rotundus* L.) is considered as the world's worst weed. Its aggressiveness and wide distribution are attributed to its ability to reproduce vegetatively by rhizomes and tubers and its high photosynthetic efficacy. It reduces yields and quality and interferes with harvest operations. Proliferation of tubers and the depths at which they occur make cultural and chemical control extremely difficult. Purple nutsedge tubers are sensitive to dry conditions and die if they lose more than 55% of their mass. This property was used to control the weed. A mechanical digger was developed, comprising of a transverse blade which penetrates the soil to a depth of 40 cm, followed by a pickup rods-conveyor that elevates the soil to another rods-conveyor used as a sieve. The gaps between the rods is such (17 and 13 mm in the pickup the sieve conveyors, respectively) that allows small soil particles to be sifted and fall back to the ground. Larger clods containing tubers or to which tubers are attached via rhizomes are conveyed along the rod-conveyor and fall behind the digger, on top of the small sifted soil particles. Thus, the treated layer of soil is rearranged in a way that the clods and nutsedge tubers are lifted to the upper soil layer and exposed to direct sun radiation under hot summer conditions. Given enough Degree-Days, the tubers dry out and die. Preliminary field tests conducted in 2010 indicated 90% reduction of purple nutsedge infestation. Results of laboratory and field experiments conducted in 2011 under various field conditions will be presented. The method has a high potential of success in controlling nutsedge while minimizing the use of chemicals. It may, therefore, also become a viable solution for the acute problem caused by purple nutsedge in organic farming.
Keywords: Mechanical control;Purple nutsedge;Cyperus rotundus;organic farming;

Poster presentations

Soybean and corn tolerance to multiple flaming.

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Propane flaming is a potential technique for weed control in both organic and conventional soybean production. Field studies were conducted in 2010 and 2011 at the Haskell Agricultural Laboratory of the University of Nebraska, Concord, NE to determine soybean and corn tolerance to multiple flaming treatments. A total of 9 treatments included: a weed-free control, weedy season-long, and broadcast flaming conducted once (at the VC-unfolded cotyledon, V2-second trifoliate, and V5-fifth trifoliate), two times (each at the VC and V2, VC and V5, and V2 and V5 stages), and three times (at the VC, V2, and V5 stages). In corn, broadcast flaming was conducted once (at the V2, V4, and V6 stages), twice (each at the V2 and V4, V2 and V6, and V4 and V6 stages), and three times (at the V2, V4, and V6 stages). All weeds were removed by hand weeding except the season-long weedy treatment. A propane dose of 45 kg/ha was applied with torches parallel with crop row and at the operating speed for all treatments of 4.8 km/h. Crop response was evaluated visually at 1, 7, 14, and 28 days after treatment (DAT), and effects on yield and yield components. Broadcast flaming conducted once (at the VC and V5 stage), as well as twice at the VC and V5 stages exhibited the lowest injury of about 5% at 28 DAT. Any treatment that contained flaming at the V2 stage resulted in as much as 40% injury at 28 DAT. The highest crop yields were obtained from the weed-free control (3.63 t/ha) and the plots flamed twice at the VC and V5 stages (3.43 t/ha), which were statistically similar. Soybean flamed at the V2 stage had lower yields (e.g., 1.24 t/ha at the V2, 1.04 t/ha at the V2 and V5, and 2.28 t/ha at the VC and V2). The lowest yields were in soybean plots flamed three times (VC, V2, and V5 stages), which yielded only 0.49 t/ha. This result suggests that soybean could tolerate a maximum of two flaming operations per season, at the VC and V5 growth stages. Corn exhibited excellent tolerance to flaming at all three growth stages (V2, V4, and V6), which resulted in less than 10% injury at 28 DAT. Broadcast flaming conducted twice (e.g., V2 and V4, V2 and V6, and V4 and V6) and three times (e.g., V2, V4, and V6) exhibited the highest visual injury of 10% at 28 DAT. The highest yields were obtained in the weed-free control (12.2 t/ha) and the plots flamed twice, at the V2 and V4 (12.3 t/ha), V2 and V6 (12.2), as well as V4 and V6 stages (11.7 t/ha), which were statistically similar. The plots flamed three times (V2, V4, and V6 stages) yielded 10.9 t/ha, which was 11% lower than the control yield, which would not be acceptable by producers. Results of this study suggest that corn could tolerate a maximum of two flaming operations per season.

Keywords: flaming; flame; corn; soybean; maize;

Spring wheat – grain legume intercrops effects on weeds.

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Intercropping, i.e., planting more than one crop species in a mixture, often results in better resource use in comparison with monoculture. Main objectives of this research were to evaluate the possible role of spring wheat and grain legumes intercrops for weed suppression. Field pea (*Pisum sativum* L.), narrowleaf lupine (*Lupinus angustifolius* L.), field bean (*Vicia faba* L.), common vetch (*Vicia sativa* L.) and spring wheat (*Triticum aestivum* L.) were sown as intercrops and pure crops. Intercrop design was based on the proportional replacement principle with mixed legume grain and wheat grain at the same depth in the same rows at relative frequencies of 50% : 50%. Crops were managed organically. Annuals dominated the weed flora (6–18 species), while perennials were less frequent (1–6 weed species). Principal weed species were Chenopodium album, Lamium purpureum, Viola arvensis, Cirsium arvense and other. Intercrops can be an effective tool for weed control. Spring wheat and legume-spring wheat mixtures had significant weed suppressive effects on the mass of annual weeds as compared with sole-cropped peas, lupine and bean. Only sole-cropped vetch had a similar weed suppressive effect on annual weeds as compared to spring wheat and their mixtures with legume crops. All spring wheat – legumes intercrops suppressed weeds similarly. Weed abundance in lupine was higher as compared to the other legumes in pure stands. Vetch had the best suppressing ability compared to all other legumes investigated. Differences were statistically different, except the pea stand. The number of perennial weeds varied irregularly among treatments. Differences were not statistically different. Number ranged from 1.3 to 8.0 plants m-2. Abundance of perennial weeds in the lupine and bean stand was higher than in the other stands of legume crops.

Keywords: spring wheat; grain legumes; intercropping; weeds

Effect of soil solarization on weed control in Birjand region.

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One of non-chemical methods of weed control is soil solarization which has been used as a way of controlling weeds, pests and diseases. In order to study the effect of soil solarization on seed germination of the pigweed, common lambsquarters, downy brome and mouse barley, a factorial experiment was performed based on RCBD with three replications during summer 2010. There were three factors: the first, the way of covering the soil as follows; the soil was covered with one layer of clear plastic, the soil was covered with two-layer clear plastic and; the soil was left uncovered (that is called control). The second factor was duration of coverage which was in three levels of 15, 30 and 45 days and the third factor was seed burial depth with three levels of zero, five, ten and fifteen centimeters. The results showed that maximum germination occurred in control treatment and the least germination occurred in the treatment of two-layer plastic. The germination percentage in field decreased by increasing the layers of plastic coverage and it also increased by increasing burial depths. The maximum percentage of decayed seeds were observed at two-layer plastic, one layer plastic and control treatments, respectively. Moreover, the percentage of decayed seeds increased by increasing the duration of solarization and it decreased by increasing burial depths.After solarization treatments, we came to this conclusion that the

concentration of sodium, calcium and magnesium decreased in relation to sodium uptake and soil pH, but the electrical coductivity (EC) increased.
Keywords: soil solarization; weeds; plastic coverage; seed decay; seed germination

Rice stems as mulch for weed control in orchards.

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Rice (*Oryza sativa* L.) is a primary food source for more than one-third of the world's population. As an important crop, rice has been intensively produced in the Bafra and Carsamba plains in Black Sea Region of Turkey. Its stems are not used and left in the field after harvest. They have been usually burned in the field causing environmental problems. This research aimed the investigation of usability of rice stems as mulch for weed control in orchards and was carried out in Black Sea Agricultural Research Institute, Samsun, Turkey. Rice straws were left in autumn 2010 and assessments were taken during spring 2011. The experiment consisted of treatment plots which were composed of 5, 10, 20 cm thickness of rice stems and control plots with no rice stems. Weeds covering area, weed species, weed density and weed biomass data were derived from experimental plots. The lowest weed covering area, weed species and weed density were found in the parcels with 20 cm thickness of rice stems. The weed covering area was the highest in control plots with 95%, while it was 75, 60 and 0% for 5, 10 and 20 cm thickness of rice stems respectively. Average dry weight of weeds was 1220 g/m2 in control plots. This was followed by the treatments of 5, 10, and 20 cm thickness of rice stems with 462, 247, 0 g/m2 respectively. As a result it appears that rice stems may be used as a weed control options in small organic orchards in the Region.
Keywords: Rice stem;weed control;mulching;orchards;

Diverse cover crop strategies for improved yield and weed suppression in organic cropping systems of the western USA maize-belt.

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The objective of this study was to determine the effects of cover crop diversity and termination method on weed populations, soil microbial community structure, soil nutrient availability, soil water content, and grain yield in a certified organic cropping system. Spring-sown mixtures of 2, 4, 6, and 8 cover crop species were included in a sunflower – soybean – corn crop rotation. Cover crops were terminated in late May using a field disk or sweep plow undercutter and crops were planted within one week. Cover crop biomass was greatest in the 6 species mixture (318 g m-2) and lowest in the 2 species mixture (114 g m-2) in 2009, but there was no difference among cover crop mixtures in 2010. Cover crop termination with an undercutter decreased weed biomass by 4% relative to the no cover control at 34 days after planting main crop (DAP) in 2009, but the combined effects of increasing cover crop diversity and termination with the undercutter increased weed suppression by 46% at 23 DAP in 2010. Undercutting cover crops increased soil nitrate availability (3.2±0.2 ppm) relative to incorporation with a disk (2.2±0.2 ppm) at 29 DAP in 2010. All cover crop mixtures reduced soil water prior to crop planting as precipitation became limiting, but cover crop termination with an undercutter increased soil water by up to 7.3% compared to the field disk during early crop growth. Microbial biomass, as measured by total fatty acid methyl ester extraction, was generally greatest following termination with an undercutter. Most importantly, cover crop termination with an undercutter increased corn and soybean yields by as much as 32 and 34% compared to the no cover control, respectively. While year one agronomic differences were largely due to termination treatment, the effects of cover crop diversity did begin to influence weed suppression in year two.
Keywords: legume; mustard; allelopathy; soil quality

Aquatic weed management

Oral presentations

The present spread of water hyacinth and strategies for its control.

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Water hyacinth (*Eichhornia crassipes* Mart. Solms) is the major aquatic weed in most tropical and sub-tropical countries of the world. The weed is found in its area of origin, South America, and in Central America, the Caribbean and USA, Subsaharian Africa, Egypt, South and Southeast Asia, Yangtse Delta and Taiwan in China, Australia and in islands of the Pacific. Although considered as a tropical plant, it can be also found in high altitude dams of the Andean zone. It has also been introduced in the recent past in countries of the Near East, such as Syria and Iraq. Once the water is dammed, the outbreak of the weed starts. Deforestation of surrounding areas of the dams leads to deposition of rich soil and manure into the water bodies, eventually causing high nutrient load and eutrophication. One of the best ways to prevent its fast reproduction is reducing the level of nutrients in water. Main strategies for its control are short-term effect, e.g. mechanical/manual and chemical removal, and long-term effect, biological control releasing host-specific insects, the weevils *Neochetina eichhorniae* and *N. bruchi*. Biocontrol is the most viable strategy from all points of view, good successes are found in countries, such as Australia, South Africa, in Lake Victoria, and more recently in Niger River Basin. However, the reduction of WH stand using biological control is only evident after several years of the first weevils release. Reduction of dense infestation takes time with the insect release. Implementation of mechanical or chemical control could be used to significantly reduce the WH stand followed by the release of the insects. Unfortunately, this combination is rarely practiced in most of the affected countries.
Keywords: hyacinth;water;control;strategies;

Sustainable options for the integrated management of invasive alien weed water hyacinth (*Eichhornia crassipes*) in aquatic systems.

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The aquatic weed water hyacinth is ranked among the top ten weeds world wide and is one of the most successful colonisers in the plant Kingdom. A native of Brazil, the weed has spread to other parts of the world, through initial intentional introductions for its aesthetic values in Africa, southern Asia and the USA. Integrated Weed Management becomes most suitable for managing severe infestations. The use of herbicides affects water quality and associated flora and fauna where as exclusive dependents on bio-control is a relatively slow process. Thus, often integration of a short-term control measure with bio control is inevitable. Allelopathic inhibition of water hyacinth by the dry leaf powder of the Indian medicinal herb Coleus amboinicus/aromaticus appears to offer a promising lead in this direction and integrating this allelopathic plant product with bio-control agent *Neochetina eichhorniae/bruchii* was reported successful in controlling the weed with in 45 days. Residues of 60 rice cultivars were screened for their allelopathic inhibition on water hyacinth in laboratory bio-assays as well as in micropond tests. Straw of highly allelopathic rice cultivar BPT suppressed the infestations of water hyacinth significantly. Among various modes tried for using this weed in order to affix the tag of utility for speeding up public participation in controlling this weed, mixing dried and powdered waterhyacinth in the daily ration for cattle, did not cause any adverse change in the health of animals. Utilizing water hyacinth as a manure, through composting and incorporation @ 6.25 t ha-1 favoured rice yields. Another mode of utility is attempted through TEMPO mediated extraction of nanofibers 5-100 nm thick which were used for making transparent thin film, transparent sheet, paper and transparent biodegradable nanocomposites.
Keywords: Integrated weed management;Invasive alien weeds;water hyacinth ;*Coleus amboinicus/aromaticus;Neochetina eichhorniae/bruchii*;

Post-emergence herbicidal management of water hyacinth (*Eichhornia crassipes*) in the water bodies of Tamil Nadu.

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Water hyacinth (*Eichhornia crassipes*) has become a major weed of rivers and dams, and nowadays it becomes a notorious weed problem in southern parts of India, it reduces access to and quality of available drinking and irrigation water. Hence, a study has been initiated to quantify the biological characteristics of water hyacinth and evaluate efficient post- emergence herbicide management in stagnant water bodies in Tamil Nadu, during 2008 to 2011. Tank culture experiments were carried out to quantify the biological characteristics and to evaluate herbicidal management of water hyacinth in RBD with three replications. The biological characters of water hyacinth indicated that the mother plants grow very fast from one week after inoculation up to six weeks after that the growth rate decreased, followed by seed maturation, senescence and ramet production. But in case of ramets they emerged from third week onwards, which grow fast up to six weeks. Due to this continuous growth process the multiplication of water hyacinth resulted in very high rate and cause enormous problems to the environment. Considering these situations, the tank culture experiment was conducted to evaluate the efficacy of different post emergence herbicides, such as paraquat, glyphosate and 2, 4-D Na salt on both water hyacinth plant and on aquatic ecosystem. The results revealed that spraying glyphosate at 10 ml lit-1 + ammonium sulphate 2% + 1% surfactant effectively reduced the weed density and its biomass considerably.
Keywords: Water hyacinth; ramet production ; herbicides;post emergence; biomass management;

Invasive aquatics: development of a Decision Support System for *Hydrocotyle ranunculoides, Ludwigia grandiflora* and *Myriophyllum aquaticum.*

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Hydrocotyle ranunculoides , Myriophyllum aquaticum and *Ludwigia grandiflora* are considered to be three of the most troublesome invasive alien aquatic weeds in the Netherlands and Belgium at present. These species can outcompete native flora, cause an anaerobic environment and obstruct watercourses. There is an urgent need for a decision support system (DSS) that provides both field operatives as well office- based managers with a tool to identify the most effective approach to prevent further spread from the contaminated area and to control the species. Herbicide application in waterways is not allowed in this region and mechanical control leads to fragmentation and spread. Although management units of watercourses are limited to borders, watercourses are not. Therefore, the aim of this project is to develop a cross-border DSS that is cost-effective and ecologically sound. The first steps towards that development were taken: alternative control methods were tested for their effectiveness. A propane burner at several daily intervals, hydrogen peroxide spraying treatments (0.0, 0.3, 3.0, 10 and 30%) and long term manual removal of leaves and stems with varying frequencies (weekly, every 2 weeks, once a month) at different levels of water surface coverage (~10, 50 and 100%) and nutrient levels (high and low) were compared in several greenhouse and field experiments. Flame burning was as effective as repeated two weekly manual removal in reducing the surface coverage for H. ranunculoides. Hydrogen peroxide treatments were nearly not as effective. On the long term, the repeated manual removal at the 10% surface coverage stage was most effective: leaf, stem as well as root mass were strongly reduced with this method. The results provide us with a good base for effective DSSs.
Keywords: *Hydrocotyle ranunculoides;ludwigia grandiflora;myriophyllum aquaticum*;alternative control;decision support;

Poster presentations

Experimenting two physical control methods of an invasive plant - European frogbit.

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European frogbit (Hydrocharis morsus-ranis L.) is a free-floating aquatic plant that is invasive in North America. It is native to Europe and was first introduced to North America in 1932. It has since spread south into the Great Lakes region. Because it has the potential to be ecologically, economically, and socially costly, it is important to devise an effective management strategy for controlling its spread. Our study was conducted in Oneida Lake, NY to gauge the effectiveness of two physical control methods - hand pulling and shading, and to assess the impact of each method on a number of water quality parameters as well as the impact of this plant on its invaded ecosystems. Results showed that European frogbit in small coverage increased chlorophyll concentration and benthic invertebrate richness whereas dissolved oxygen, nitrates, and phosphorus were not affected. After applying the two control methods, shading removed 100% European frogbit but there was no significant effectiveness of hand pulling. These methods did not affect nutrients when compared with frogbit infested sites or frogbit free sites, probably due to well mixing of the experiment area. However, both shading and hand pulling improved growth of submerged plants compared to frogbit infested sites but plant growth was still the best in frogbit free sites. Our study suggested both hand pulling and shading could be viable options for controlling and eradicating invasive European frogbit. Hand pulling needs to be conducted more frequently to be more effective and shading may be refined in the future to become more environment friendly.
Keywords: Invasive species;European frogbit;Physical control;Weed management;

Influence of environmental factors on propagation of *Pistia stratiotes* in southern Japan.

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Water body such as lakes and rivers in Japan has been infested with several alien aquatic weeds. Alligator weed (*Alternanthera philoxeroides*), parrot feather (*Myriophyllum aquaticum*), and water lettuce (*Pistia stratiotes*) which were designated as invasive alien species by the IAS Act (Law No.78, June 2004) have colonized in southern Kyushu (27 - 33N, 128 - 132E) in recent years. We determined some environmental factors (temperature, nutrient and pH in water, and light condition) which affect the growth and reproduction of the weed. P. stratiotes grew well and produced new plants from rhizomes in case of 10 - 30 ppm of NPK at 25 -30 C. The pH in water and light condition appeared to play an important role for their propagation, especially for their reproduction, not for the growth. The seedlings of the weed formed rhizomes and produced more numbers of new plants under longer photo-period but less strength of light-irradiation. These characteristics of *P. stratiotes*, which is one of the most troublesome aquatic weeds, could be useful information for the integrated weed management.
Keywords: *Pistia stratiotes*;invasive alien species;pH;light ;

Aquatic and woody weed vegetation in irrigation channels on the territory of AP Vojvodina and its control.

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Hydrosystem Danube-Tisa-Danube is anthropogenic ecosystem designed to solve water facility problems of AP Vojvodina, in the northern part of the Republic of Serbia. Aquatic weeds represent composite group of adaptive plants that inhabit water ecosystems. In some parts of the second rank channels of the South Backa Danube area at riverbanks huge weed populations are found consisting of species, such as *Amorpha fruticosa* L., *Asclepias syriaca* L., *Ambrosia artemisiifolia* L., *Solidago serotina* Ait. and Reynoutria japonica Houtt. The most distributed aquatic weed species are: *Carex hirta* L., *Ceratophylum demersum* L., *Myriophyllum spicatum* L., *Myriopyllum verticilatum* L., *Phragmites communis* Trin., *Typha angustifolia* L., and *Typha latifolia* L. In addition to aquatic weeds, one of the greatest problems in channels is also the presence of woody vegetation, which remains can cause reduced water flow and enhance microbial processes. Dominant woody weed species on the shoulders and slopes of the channels are mainly *Robinia pseudoacacia* L., *Populus alba* L., *Crataegus laevigata* (Poir) DC, *Populus nigra* L., *Prunus spinosa* L. *Rubus caesius* L., *Morus* sp. and *Populus tremula* L., and in some areas *Sambucus nigra* L. and *Salix alba* L. also occur. This paper also describes ecological and phytocenological analysis of some aquatic and woody weed species. Phytocenological screening of vegetation in hydromeliorative channels of South Backa was accomplished according to the method of Braun-Blanquet (1964). Determination of plants was performed according to “Flora SR Srbije“ (1970-1980), Flora Europaea (1964-1980) and Felföldy (1990). On the territory of AP Vojvodina control measures of aquatic and woody weed vegetation are mechanical and chemical.
Keywords: aquatic weeds;woody weeds;drainage channels;phytocenology;control

Parasitic weeds

Oral presentations

The parasitic weeds problems in China-past and present situation.

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Parasitic weeds of *Orobanche* spp. and *Cuscuta* spp. have long being a problem in Chinese agricultural production. The problems of these two kinds of parasitic weeds in China are deteriorating. Although some of them are used as Chinese medicinal herbs. Sunflower production in China is mainly in north China and the total yield ranks number three in the world. Therefore, *Orobanche* problem occurs in areas of north China. *Orobanche cumana* infestation of a sunflower field was first recorded in Zhaoxian county of Heilongjiang Province in 1959. In Huailai county of Hebei province it was reported that in 1991, 3000 to 4000 ha of sunflower fields were infested by *O. cumana*, which was 80% of the total sunflower planted and the yield reduction was 30-50%. In Shilou county of Shanxi Province *O. cumana* was discovered in 2003 on sunflower. In Dingbian County of Shaanxi Province crop loss due to *O. cumana* was up to 48% in 2002. *Cuscuta* was reported more than 2200 years ago in a book called "Lüshi-Chunqiu" and in ancient China it was mainly reported as a Chinese medicinal herbs. They were *C. chinensis* Lam., *C. australis* R. Brand, and *C. japonica* Choisy. *Cuscuta* occurred in both north and south China where they parasitize a wide range of hosts. *Cuscuta* reported to be used in control invasive plants like *Eupatorium coelestinum* L, *Mikania micrantha* H.B.K., and *Solidago canadensis* L. The biological control of Cuscuta by the use of fungi including *Colletoirichum gloesporioides* (Penz.) f.sp. *cuscutae* has been studied. More research on *Cuscuta* has been conducted than that of *Orobanche* in China, but there are a few papers published internationally. The research level is very preliminary compared with other countries. More attention needs to be paid on both scientific research and practical control of these parasites. The problems caused by these parasitic weeds in China, their use as medicinal herbs, and the control measures, in the past, at present and in the future will be presented and discussed.
Keywords: *Orobanche*; China; *Cuscuta*; control; medicinal plant

Predicting the potential future geographic distribution of *Striga* under climate and land use change.

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As parasitic weeds of the genus *Striga* (Orobanchaceae) are a major constraint to agriculture of the semi-arid regions in Sub-Saharan Africa, *Striga´*s actual and future distribution needs to be estimated urgently, in order to better and more efficiently target available *Striga* management strategies. Using innovative GIS-based modeling complemented by greenhouse and field studies, our research aims to better understand the present geographic distribution of *Striga* species and to predict potential future expansion areas of these dangerous weeds. Parameters determining the presence or absence of *Striga* were analyzed and available data complemented by new studies on *Striga* ecology and seed bank dynamics gained in green house and field studies at the University of Hohenheim and ICRISAT, Mali. Based on the present geographic distribution and the factors affecting it, different climate and land use projections will be applied to indicate areas that will become susceptible to *Striga* in future. The outputs of this approach will directly support and target crop improvement research and variety (maize, sorghum, pearl millet) dissemination in *Striga*-affected areas, and provide important decision support tools for technology development and integrated *Striga* management strategies. The aim of our work presented here is to provide the necessary information to fill in the current knowledge gaps in *Striga* research considering the geographic distribution.
Keywords:*Strigahermonthica*; climate change; parasitic weeds;Climate Envelope model;

Severity of *Striga hermonthica* (Del.) Benth parasitism on small-scale maize farms in Benue State, Nigeria.

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Striga hermonthica is a serious constraint to maize production in Benue state and Nigeria as a whole. Most often very farmers experience total yield lost in heavily infested lands. Extensive and intensive surveys were carried out in the year 2010 in the three agricultural zones of Benue State to determine the extent or status of *Striga hermonthica* (Del.) Benth. infestation on maize in low input farms. For the extensive surveys, structured questions in form of questionnaire were the instrument used to obtain information from farmers. These were administered through the Extension Staff of the Benue State Agricultural and Rural Development Authority (BNARDA). An intensive survey was conducted on a maize/cassava intercrop farm mainly infested with *Striga hermonthica* in Waapera village, Ushongo Local Government Area in Benue State, Nigeria. The results of the surveys indicated a widespread occurrence of *Striga hermonthica* in all the agricultural zones of Benue State, with the Northern zone having the highest level of infestation (62%) followed by Eastern (46%) and then central (16%) zones. On the farm where intensive survey was carried out, there was total crop failure (100% grain yield loss) due to *Striga hermonthica* parasitism on maize. It was concluded that *Striga* is a serious weed and a major constraint to maize production in Benue State. Also, that the management practices employed by farmers in the State are not helping the problem of *Striga* infestation. This is the major reason why farmers cannot cope with *Striga* parasitism and many of them have stopped growing maize. It is recommended that an integrated management strategy for *Striga* control be employed by farmers to help reduce *Striga* problem in small holder farms.
Keywords:*Striga hermonthica*;maize;parasitism; Nigeria

Survival of seeds of the parasitic weed *Phelipanche aegyptiaca* in compost.

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Cattle manure is a main source for the compost industry in Israel. The manure collected from the farms as rough material is transferred to the compost production center. The manure is always contaminated with weed seeds; most of them lose their viability during the compostation procedure. Recently, heavy *Phelipanche aegyptiaca* infestation was detected in tomato greenhouses. It was suspected that the source of this inoculum is the added compost. Hence, the ability of *P. aegyptiaca* seeds to survive the compostation procedure was investigated in a three consecutive experiments by placing *P. aegyptiaca* seeds in a compost pile in three different depths for different periods of time. We found that the in-pile temperatures varied from 45-50^{0}C in the depth of 120 cm from the top of the pile, to >65^{0}C in the upper 50 cm of the pile. Long term experiments have showed that all the seeds inserted into the compost pile for periods of a month or more, did not survive. Prevention of seed germination was achieved after a good compost practice, keeping the pile aerated and wet by using special machinery. The minimal time needed to control *P. aegyptiaca* seed viability was also studied in short time course experiments carried out in the field and in the lab. Results from both experiments indicated that seeds that remained for 4 to 6 hrs at 55 - 65^{0}C totally lost their germination viability. The outcome of our research indicates that properly made compost is safe for use as an organic fertilizer and in case of *P. aegyptiaca* infestation the seeds lose their germination viability after short periods of time at 55 to 65^{0}C.
Keywords: parasitic weed; *Phelipanche aegyptiaca*; compost; cattle manure.

Survival of seeds of parasitic weeds in cow manure.

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In Israel, cattle manure is collected in a solid state from farm yards and as liquid slurry from reception pits. These are removed and spread directly in the field or processed in composting sites before spreading. This manure may contain weed seeds including parasitic plant seeds originating from the imported grain feeds and local hay and plant feeds, and has a high potential to be disseminated and infest farmers' fields. The aim of this study was to test the viability of the seeds of *Phelipanche aegyptiaca* and *Cuscuta campestris*, after passing through the cow digestive system, in farm slurry and in compost piles. The following seed treatments were applied before testing their viability in the lab: 1. Seeds of *P. aegyptiaca* and *C. campestris* were inserted for 72 h *in-situ* into fistulated cows and *in-vitro* in an artificial cow stomach. 2. Seeds were submerged in a slurry pit and removed periodically. 3. Seeds were inserted into a compost pile for different durations and tested. Results of the *in-vitro* and *in-vivo* seed incubation tests indicated that *P. aegyptiaca* did not survive the 3 day passage through the cow stomach while 9-36% of *C. campestris* seeds germinated. *P. aegyptiaca* did not survive submersion of 1 month in the cattle slurry while 22% *C. campestris* germinated even after 5 months of submersion. *P. aegyptiaca* seeds placed for 6 hours in a compost pile completely lost viability while *C. campestris* retained 4% viability after 42 days in the pile. We conclude that the hard coated *C. campestris* seeds can survive cow stomach digestion and long periods in the tested manure types while *P. aegyptiaca* seeds lose viability in the same conditions.
Keywords: *Cuscuta*; *Phelipanche*; compost.

Interspecies protein trafficking endows the parasitic flowering plant dodder (*Cuscuta* spp.) with a host-specific herbicide tolerant phenotype.

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The flowering parasitic plant dodder attacks many important crops and is a threat to global food security. Selective dodder control with herbicides without damaging host plants is very difficult because the parasite and host are symplastically connected. Transgenic herbicide tolerant crop technologies were expected to significantly improve dodder control; however, dodder control was unsatisfactory with glyphosate- or glufosinate-tolerant crops sprayed with glyphosate or glufosinate, respectively. For instance, dodder tendrils are sensitive to glufosinate before establishing parasitism with hosts, but become largely insensitive to glufosinate after parasitizing glufosinate-tolerant crops. The objective of this research was to study how dodder (*C. pentagona*) interacts with transgenic glufosinate tolerant hosts, conferred by the glufosinate detoxifying enzyme phosphinothricin acetyl transferase (PAT), to survive glufosinate treatment. PAT-transformed and non-PAT-transformed soybean and canola plants were used as hosts for dodder. Dodder growing on PAT-transformed soybean and canola survived glufosinate treatment after dipping the tendrils for five seconds into solutions containing 0.36 and 0.72 g/L of glufosinate. In contrast, dodder growing on non-PAT-transformed soybean and canola were killed by the same glufosinate treatments. PAT interspecies trafficking from PAT-transformed soybean and canola hosts to the parasite was detected by ELISA. PAT concentration in dodder tendrils was about 1/1000 of the PAT level in leaves of PAT-transformed hosts on a fresh weight basis. Using reverse transcription PCR we were unable to detect PAT mRNA interspecies trafficking. In conclusion, our data show that acquisition of a host-specific phenotype was due to interspecies protein trafficking. This finding significantly extends our understanding of host/parasite interactions and provides an empirical basis for novel approaches to parasitic weed control by preventing interspecies trafficking of targeted enzymes.
Keywords: dodder; interspecies protein trafficking; glufosinate; parasitic weed.

Nutrient strategies of root hemiparasitic *Pedicularis* species (Orobanchaceae).

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Parasitic biology of *Pedicularis* L. (Orobanchaceae) has been under investigated despite the wide distribution of the genus in the northern hemisphere and potential ecological significance. To better understand the parasitic aspects of the root hemiparasites, host-parasite interactions were investigated with two sympatric *Pedicularis* species, *P. rex* and *P. tricolor*, at two different developmental stages. Growth parameters and number of haustoria were measured in the root hemiparasite grown with either a host plant or a plant of its own species in pot experiments. In addition, effects of parasitism and intraspecific on growth and biomass allocation in four host species belonging to three major functional groups (grasses, legumes and forbs) were investigated. Total biomass productivity per pot was calculated for all species pairs with a host. Both hemiparasites showed growth and development without a host. The two Pedicularis species showed obvious host preference in terms of shoot biomass and shoot P content, but preferred different host species. Interactions between *Pedicularis* species and their hosts depended on both species identity and developmental stages of the partners. Overall, *P. rex* showed much weaker growth response and less damage to host than *P. tricolor*. Heterotrophic benefits of the root hemiparasites correlated positively with number of haustoria. However, competition from host may have strong influence on growth of the hemiparasites in a few cases. Interspecific variations were observed among different host species in their responses to intraspecific competition and parasitism. The two *Pedicularis* species have very different patterns in host-parasite interactions and hence their impact on plant community structure and productivity may be very different.
Keywords: Root hemiparasitic plant; Orobanchaceae; host dependency; host selectivity; haustoria.

Seed germination stimulants for *Phelipanche ramosa* produced by oilseed rape.

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Phelipanche ramosa causes severe damages to oilseed rape (*Brassica napus*) in southern France. Since oilseed rape is a non-host of arbuscular mycorrhizal fungi, this plant seems to produce only small amounts of strigolactones (SLs), representative germination stimulants for root parasitic weeds. *Brassica* species produce glucosinolates which are enzymatically converted to isothiocyanates (ITCs), and ITCs were reported to induce germination of *P. ramosa*. In the present study, identification of germination stimulants produced by and released from oilseed rape was examined by LC-MS/MS, GC/MS and germination assays with seeds of *P. ramosa* and *Orobanche minor*; SLs induce seed germination in both species but ITCs are active only on the former. Although known SLs were not detected in the ethyl acetate extract of oilseed rape root exudates by LC-MS/MS, distribution of germination stimulation activities on *O. minor* and *P. ramosa* seeds after RP-HPLC separation of the extract clearly indicate that oilseed rape plants exude novel SLs. 2-Phenylethyl ITC was detected by GC/MS from the fractions which showed high germination stimulation activities to *P. ramosa*. These fractions did not induce *O. minor* seed germination. Then, 21 ITCs were examined for *P. ramosa* seed germination stimulation and some important structural features of ITCs for exhibiting *P. ramosa* seed germination stimulation have been uncovered. All the ITCs examined did not germination of *O. minor*. These results demonstrate that ITCs are important germination stimulants for *P. ramosa* and thus *P. ramosa* has developed a special seed germination strategy to parasitize oilseed rape.
Keywords: germination stimulant;*Phelipanche ramosa*;oilseed rape

Glyphosate inhibits the translocation of macromolecules in the parasitic association between Egyptian broomrape (*Phelipanche aegyptiaca*) and tomato (*Solanum lycopersicum*).

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Egyptian broomrape (*Phelipanche aegyptiaca*) is an obligate root parasite which is considered a serious threat to Mediterranean agriculture. *P. aegyptiaca* tubercles function as a strong sink that develops entirely on solute supply from the host plant. Glyphosate is an herbicide that inhibits the biosynthesis of aromatic amino acids, by inhibiting EPSPS. Since EPSPS is a key enzyme in the shikimate pathway, application of this herbicide has additional mechanisms that affect the plant's function. One mechanism involves limited carbon translocation from source tissues into the plant sinks. We hypothesized that glyphosate limits the translocation of phloem solutes from tomato to the parasite. To examine our hypothesis, a cross-bred transgenic tomato line that expresses resistance to glyphosate and green fluorescent protein (GFP) that moves long-distance in the phloem was used. GFP exhibited a specific trafficking pattern in the early stages of parasitism. In the control treatment, most of the attachments appeared 4 to 8 days after germination. During that period, a gradual increase in tubercle fluorescence was observed, indicating accumulation of GFP. In plants that were foliar-treated with glyphosate on the day of *P. aegyptiaca* germination, the attachments occurred similarly to the control treatment, but a week later, tubercle fluorescence started to decrease and finally disappeared. These findings imply that glyphosate weakened the sink strength of the tubercles and actually inhibited solute translocation from the host to the parasite. Consequently, the parasite was deprived of its nutrient supply, leading, shortly thereafter, to its control. Although GFP is a medium-size molecule, we assume that its transport dynamics resembles that of assimilates and amino acids.
Keywords: *Phelipanche aegyptiaca*; Egyptian broomrape; GFP; glyphosate; host-parasite interaction.

Soybean resistance to dodder induced by Acibenzolar-S-methyl.

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Soybean dodder (*Cuscuta australis*) is a parasitic weed on soybean that can significantly reduce the growth and yields of the crop. One ofthe effective ways to control the weed is to induce the resistance of soybean, which has not been reported in China and abroad. The effects and security of acibenzolar-S-methyl (ASM)- induced soybean resistance to soybean dodder, the activity of enzymes related to induced resistance, the construction of SSH-cDNA library of genes inducing different expressions of soybean, and the analyses of the function of these genes were studied in this project. Results of our studies demonstrate that ASM could induce the resistance of soybean to soybean dodder and mitigate the harm by dodder caused to the soybean. ASM itself has no effects on dodder, but it could increase the resistance of soybean to the dodder parasite by inducing the expression of related genes, producing a series of resistant responses, and elevating the activity of enzymes related to resistance. ASM is safe to soybean at a concentration of 300mg/L. Application of ASM to control soybean dodder could be by spraying or irrigation, and spraying could be at seven days before the parasite attachment or three days after the parasite attachment. The results from lab and greenhouse suggested that spraying of ASM at a concentration of 100-250mg/L could reach 99.7% control. An integrative employment of ASM and other control methods will be an effective approach to control soybean dodder.
Keywords: induced resistance; effects and safety; resistance-related enzymes; cDNA library;

Renewing the interest in biological control of parasitic weeds: use of strigolactone-degrading microbe.

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The potential of using biological agents for managing broomrapes (parasitic weeds of *Orobanche* and *Phelipanche* genera) has been studied since decades. Despite the interesting results and the promising publications produced, the transferability to the field and the marketability of the findings is still very limited. Seed germination is a key phase of the parasitic plant life cycle, and begins with the secretion of secondary metabolites (mainly strigolactones - SLs) from the host roots that induce germination. SLs have also been reported to act as signals for arbuscular mycorrhizal fungi. Based on these considerations, biological control was approached differently than the past: microbes could detect and degrade SLs, then preventing germination of parasitic weed seeds. If these microorganisms were "rhizosphere competent", *i.e.* able to grow along the root system of the host plant, they could be used as biocontrol agents, as a "physiological" barrier against parasitic plants. Three strains of different fungi were considered for their capability to metabolize SLs, *i.e.*: one of *Fusarium oxysporum* having potential as biological agents of *P. ramosa*; one strain of *Trichoderma harzianum* (a promising biopesticide); and one of *Botrytis cinerea* (a necrotrophic pathogen). Experiments were carried out on different natural SLs and derivatives, as well as on the synthetic stimulant GR24. SLs were added to actively growing liquid fungal cultures or to liquid cultures after mycelium removal, and the reduction in SLs content was determined both directly, by using LC-MS/MS techniques, and by testing the stimulatory effects of the treated SLs to *P. ramosa* seeds. Differences were observed among microorganisms, treatments and compounds used.
Keywords: parasitic weeds; biological control of weeds; strigolactones

Interaction between phosphorus and desmodium on *Striga hermonthica* (Del.) Benth. incidence and maize yield in western Kenya.

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Average maize yield of 1.0 ton ha^{-1} by small scale farmers in western Kenya is mainly constrained by parasitic weed *S. hermonthica*. Desmodium is shown to produce stimulants causing germination of *Striga* seeds. The potential role of phosphorus in enhancing stimulant production has not been investigated. This study evaluated the influence of phosphorus on desmodium stimulatory effect in *Striga*. Two desmodium species (*D.uncinatum* and *D.intortum*) were intercropped at four phosphorus fertilizer rates (0, 23, 46 and 69 kg P_2O_5 ha^{-1}) applied as SSP with susceptible H 513 maize variety at two farms naturally infested with *Striga*. The factorial experiment was laid on a randomized complete block design (RCBD). Data was collected on *Striga* emergence at 8, 10 and 12 weeks after crop emergence, *Striga* seed bank, *Striga* biomass, maize biomass, and grain yield. Data was subjected to statistical analysis (ANOVA). Significantly different means were separated using Least Significant Difference (LSD). Desmodium plants minimally suppressed *Striga* emergence when still young but increased as the plant matured. Application of phosphorus at 46 and 69 kg P_2O_5 ha^{-1} significantly reduced seedbank compared to the control after three continuous cropping seasons. *Striga* seed numbers positively correlated with *Striga* density at both sites. *Striga* density reduced significantly as seed population declined with season. *D.uncinatum* triggered relatively high *Striga* emergences during the first two seasons at Ngiya. Fertilization of *D.uncinatum* at 69 kg P_2O_5 ha^{-1} induced a mean reduction in *Striga* density of 65% compared to 36% in unfertilized treatment while *D.intortum* had a corresponding reduction of 76% and 47% respectively. . We recommend application of phosphorus at 69 kg P_2O_5 ha^{-1} and 46 kg P_2O_5 ha^{-1} for both sites for the realization of a faster reduction of seedbank and density in fields heavily infested with *S. hermonthica* seeds.
Keywords: Desmodium;phosphorus;seedbank;*Striga* emergence; yield

Integrated management of witch weed (*Striga asiatica* L.) in early planted sugercane (*Saccharum officinarum* L.) under red sandy loam soils of Tamil Nadu.

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Sugarcane (*Saccharum officinarum* L.) is one of the most important cash crops in India and in Tamil Nadu, it is cultivated in an area of 2.2 lakh (10^5) hectares with 244.60 lakh tons of sugarcane, with an average productivity of 110 t ha^{-1}. Especially in Western and North Western Zones of Tamil Nadu more than 50% cane is cultivated in red gravel soils and infestation of *Striga asiatica* is also more in this type of soils. Considering these situations field experiments were conducted in the farmer's field to evaluate an efficient herbicidal management technique for the control of *S. asiatica* in sugarcane. Field experiments were conducted during the main season of 2009-10 and 2010-11 in the farmer's field of Tamil Nadu. Trials were laid out in RBD with three replications. PE Atrazine 1.0 kg ha^{-1} ; 2,4-D Na salt 1.0 kg ha^{-1} + urea 1% + soap solution 1% as POE; Directed spray (DS) of 20% urea of *Striga* plants; DS of 5% ammonium sulphate on *Striga* plants; DS of paraquat 0.5% on 70-75 DAP; PE Atrazine 1.0 kg ha^{-1} 2,4-D Na salt 1.0 kg ha^{-1} + urea 1% + soap solution 1% as POE + mulching with cane trash on 120 DAP and unsprayed control. Reduction in density and dry weight of *S. asiatica* with better control efficiency was achieved with POE of 2,4-D Na salt 1.0 kg ha^{-1} + urea 1% + soap solution 1% on 70 - 75 DAP. Productivity and profitability of sugarcane increased by POE of 2,4-D Na salt 1.0 kg ha^{-1} + urea 1% + soap solution 1% and PE of atrazine 1.0 kg ha^{-1} +2,4-D Na salt 1.0 kg ha^{-1} + urea 1% + soap solution 1% as POE on 75 DAP followed by mulching with cane trash on 120 DAP.
Keywords: sugarcane; *Striga asiatica*; control efficiency; cane productivity; profitability.

Combining resistance to *Striga hermonthica* with tolerance to drought in maize.

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Striga hermonthica is a root parasitic plant that inflicts severe damage on cereals, with maize being the most susceptible. The impact of *Striga* is severe on crops wreaked by drought, which frequently occurs in *S. hermonthica* infested maize production fields in the savannas of West and Central Africa. A breeding strategy targeted to these zones should consider development of cultivars that combine drought tolerance with parasite resistance. As a short-term breeding strategy, we screened *S. hermonthica* resistant maize inbred lines under controlled drought stress imposed from four weeks after planting to harvest. *S. hermonthica* resistant inbred lines selected for some levels of drought tolerance were used for developing single-, three way-, and top cross- hybrids, which were included in separate trials evaluated under controlled drought stress, optimum growing conditions, and artificial *S. hermonthica* infestation in multiple locations in Nigeria since 2008. Significant differences in grain yield were detected among hybrids in the various trials planted under the three growing conditions notwithstanding the presence of significant location x hybrid interactions. We identified some hybrids in the different trials that out-yielded the commercial hybrid check by more than 50% under controlled drought stress and by more than 80% under artificial infestation with *S. hermonthica*. These hybrids also sustained lower *Striga* damage symptoms and supported fewer emerged parasites in comparison with commercials hybrid check under *S. hermonthica* infestation. Most of the selected best hybrids were competitive to the commercial hybrid checks under optimum growing conditions. These results highlight the potential that exists to combine resistance to the parasite with drought tolerance in a single hybrid without compromising desirable performance under favourable growing conditions. Deliberate breeding efforts will still be needed to further enhance the levels of resistance to *S. hermonthica* and tolerance to drought in single hybrids targeted to areas affected by the two stresses.
Keywords: *Striga hermonthica*; root parasite; drought stress.

The contribution of advanced technologies for broomrape (*Orobanche* and *Phelipanche* spp.) management.

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The broomrapes (*Orobanche* and *Phelipanche* spp.) are obligate root parasites that in the initial part of their life cycle grow in the soil subsurface and therefore are hard to be detected. It was found that in the underground stages broomrapes are highly sensitive to herbicides, therefore information for spatial distribution of broomrapes and quantification of their developmental stages is important and can contribute to management success. In this presentation two approaches for enhanced broomrape control efficacy will be discussed: (a) quantification of the temporal variation and prediction of broomrape parasitism by a thermal time model; (b) estimation of the spatial variation of broomrape infestation within a field and between fields by the use of Geographical Information Systems (GIS) and other advanced technologies for parasitic weed mapping and field history data storage. This will allow mapping the spatial distribution of broomrape in the field and utilizing this data for the use of Site Specific Weed Management (SSWM). Special attention will be given to the development of an integrative approach. An example of a decision support system for rational management of Egyptian broomrape in processing tomato will be presented.
Keywords: Egyptian broomrape; *Phelipanche aegyptiaca* ; tomato; *Lycopersicon esculentum*.

A thermal-time model for predicting the parasitism of *Phelipanche aegyptiaca* in carrot (*Daucus carota*).

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The root parasite *Phelipanche aegyptiaca* is a major problem in carrot in Israel. Growing carrot in infested fields may result in severe damages and even total yield losses. Low rates of glyphosate applied sequentially on the host foliage, is effective when applied at the early development of the association, namely tubercle formation, post attachments and pre-parasite emergence. Knowing the precise timing for herbicide application is essential for crop safety and control efficacy, however at present, information is scarce and limited. Therefore the objective of this study is to develop a robust model for predicting the initial parasitism of *P. aegyptiaca* in carrots. Similar models have been developed for predicting the parasitism of *P. aegyptiaca* in tomato, *Orobanche minor* in red clover, and *O. Cumana* in sunflower. In these models, thermal time was computed by converting soil temperature data to the thermal time units - growing degree days (GDD) using a linear equation. This equation is not valid for predicting the parasitism of *P. aegyptiaca* on carrot roots, probably due to a decline in the carrot plant development in the supra-optimal temperatures during the earliest and latest sowing dates. To overcome this lack of information, several linear and non-linear equations were tested. Data were collected from 12 fields studies, during 2010-2012 confirmed that the beta function equation can robustly predict the tubercle growth stage (1-2 mm) in the carrot crop throughout the temperature range prevailing under field conditions. This prediction model can provide the required information for timely herbicide application for adequate parasite control without causing crop damage.
Keywords: broomrape; carrot; thermal-time; model; degree-days.

The resistance mechanism to imidazolinones herbicides of a novel tomato mutant HRT1 for broomrape management.

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Orobanche and Phelipanche spp., commonly known as broomrapes, are dicotyledonous holoparasitic flowering plants that cause heavy economic losses in a wide variety of plant species. In Israel P. aegyptiaca is the most destructive pest in tomato. Successful broomrape control was achieved with aceto lactate synthase (ALS) inhibiting herbicides, specifically with the imidazolinones and sulfonylurea herbicides. Development of a tomato variety resistant to the imidazolinones herbicides may serve as a reasonable approach for P. aegyptiaca control in tomato. The tomato mutant HRT1 was obtained by ethyl methane sulfonate mutagenesis of the commercial tomato line M82. The mutant tolerated high rates of the imidazolinone herbicides pulsar (imazamox), cadre (imazapic) and arsenal (imazapyr). ALS activity from HRT-1 and M82 tomato lines in the presence of imidazolinones and sulfonylurea herbicides was determined in-vivo using crude enzyme extracts. ALS extracted from the parental tomato line M82 was more sensitive to imidazolinone herbicides than the ALS of HRT1. ALS from both tomato lines was equally sensitive to the sulfonylurea herbicides. These results indicate that the resistance of HRT1 to the imidazolinone herbicides is due to a change in the herbicide's target site on the ALS molecule. Moreover, comparison of the nucleotide sequence of the M82 and HRT1 ALS genes revealed four mutations in the HRT1 nucleotide sequence. One of them is a substitution of Alanine to Valine in position 194. This substitution corresponds to the conserved Alanine205 in Arabidopsis. The other 3 mutations are in non-conserved regions.

Management of *Phelipanche aegyptiaca* in mustard and tomato in North-West India.

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Broomrapes (*Orobanche* and *Phelipanche* spp.) are annual holoparasitic weeds that are one of the major biotic constraints to tomato, mustard, sunflower, tobacco, faba bean and lentil crops in the different parts of the world. Mustard (*Brassica juncea*) is the most remunerative crop in the sandy soils of north-west Indian states under rainfed or limited irrigation conditions, where *Phelipanche aegyptiaca* is causing yield reduction to the tune of 40-75% depending upon the level of infestation. Similarly, its association with tomato which was the most remunerative crops in several locations in the vicinity of Delhi is causing havoc to small farmers who were reaping good harvest a few years back. The management of broomrape is often difficult due to its close association with the host for all part of its life cycle. There is limited choice for crop rotation going by the growing conditions. Efforts were made to lower its menace by using different kind of organic (neem seed, cotton seed, castor seed cake) and inorganic fertilizers under field conditions where heavy infestation of *P. aegyptiaca* was observed in the previous years in mustard, but to no avail. Similarly, screening of different cultivars and seed treatment with oil or herbicides was not found effective in lowering the yield loss. Post emergence application of a non-selective herbicide, glyphosate at 55 and 112.5 g ae ha^{-1} at 20-25 and 50-55 days after sowing in a plot size of 500 m^2 at dozens of farmer's field trials provided encouraging results. However, applying glyphosate even at two growth stages of mustard has not been able to provide complete relief and there is lack of consistency at different locations. The paper will discuss the efforts made in the management of *P. aegyptiaca* infestation in mustard and tomato using herbicides.
Keywords: *Brassica juncea*; glyphosate; *Lycopersicon esculentum*; economic loss; management.

Poster presentations

Effect of salinity on seed germination of *Cuscuta campestris* Yunck.

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During their growth crop plants are usually exposed to different environmental stresses which limit their growth and productivity. This study explored whether different salinity influences seed germination of *Cuscuta campestris*Yunck. The aim of this study was to determine the reaction of *C. campestris* at different salt concentrations, because of the possibility of predicting its spreading to areas with saline soils. Twenty seeds of *C. campestris* were placed in Petri dishes filled with 5 mL of a salt solution with different concentrations of NaCl (5, 10, 20, 40, 160, 320 μM). Water only was added to the control variant. The number of germinated seeds was recorded daily (germination rate), and the final percentage of germination and seedling length were measured after 18 days. All the experiments were carried out in the dark in an incubator (Binder CE) at 25^{o}C. Solutions were drained and replaced every second day in order to minimize changes in salinity from evaporation. Each experiment was conducted twice. The results were processed by STATISTICA 7.0 software and a LSD test was used to determine the significance of differences found between treatments with different salt concentrations. Concentration–response curves were generated and EC50 values determined using Excel VBA macro Biossay 97. Germination percentage was negatively affected by salt concentrations in Petri dishes. Increasing salt concentration tended to decrease germination. On the other hand, the effect of salt concentrations on seedling length was insignificant. Final percentage of germination ranged from 0.00% (in the 320 μM NaCl) to 15.63% (in the 5 μM NaCl), while it was 21.25% in the control variant. Germination rate ranged from 2.31 to 5.25. Salt concentration inducing a 50% inhibition of seed germination (EC_{50}) was 44.45 μM NaCl.
Keywords:*Cuscuta campestris*Yunck.; seed germination; seedling length; salt concentration; germination percentage.

Expressed sequence tag (EST)-intron length polymorphism (ILPs) as a molecular tool for the identification of *Cuscuta* species.

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Most species of the genus *Cuscuta* are quarantine weeds in many countries. The seeds of *Cuscuta* are usually sheltered in grain, feed, forage and vegetable seeds. The identification of the genus *Cuscuta* is mainly based on morphological characters. However, it is difficult to distinguish *Cuscuta* species from each other morphologically. In this study, we used EST-ILPs to distinguish 5 species of *Cuscuta*: *C. japonica*, *C. engelmanii*, *C. australis*, *C. campestris* and *C. approximate*. The result of ILP-PCR showed that: (1) there was a 250bp diagnostic band in *C. engelmanii*, while using primer IP9; (2) there was a 240bp diagnostic band in *C. japonica*, while using primer IP4; (3) Using *Cuscuta* polymorphism of intron genotype characteristics can distinguish the five species of *Cuscuta*. Using ILP marker to identify the species of *Cuscuta* provides a new method of identification for quarantine. This method can meet the detection requirements for quarantine of *Cuscuta* at entry ports.
Keywords: EST; ILP Marker; *Cuscuta*; seed; identification.

Programmed cell death facilitates the dispersion of dodder.

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Dodders can survive on a weak or dead host for many days (2-3weeks) and keep on branching and elongating. When dodder stem segments are manually isolated from their hosts, they still have strong potential of self-elongating. Such behavior helps the parasite spread. In this study, analyses on morphological and physiological features of the mature stems of dodder (*Cuscuta campestris*) have been performed after they were artificially isolated from the host. Independent dodder shoot survived and continued the apical elongation growth in a moistened environment for almost 2 weeks without any additionally nutrient supplement, reaching a final length of about 3 fold of its original length. During the process, the basal cells of dodder shoots show a typical phenomenon of senescence induced programmed cell death (PCD), including the altered cell ultra-structure and the detection of "DNA laddering". Dodder stem sections experienced gradual senescence and programed death from the basal segments to the apex including changes of the cell morphology and carbon level indicating that the elongation of isolated dodder sections are mainly dependent on the nutrition support of the senescent basal end. Different from aging induced plant senescence, this form of dodder degradation may serve as a model of plant senescence and PCD. This study will help unveil the parasitic nature of dodder and the involved assimilate translocation of plant nutrition starvation responses.
Keywords: dodder; programmed cell death; senescence; DNA laddering; carbon translocation.

The resistance of different sunflower varieties to *Orobanche cumana* Wallr. in seedling stage.

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The Inner Mongolia sunflower planting base accounts for 38% of the total national sunflower planting area, it is the largest one in China. However，the parasitic weed *Orobanche cumana* Wallr. causes severe damage to sunflower here. Therefore，selecting the resistant sunflower varieties is important for the breeding and production practice. We divided 31 varieties of sunflower seedlings into five grades according to their resistance to *O. cumana* in 2010：immune, highly resistant, resistant, susceptible and highly susceptible. In June 2011, we sowed two immune varieties (T012244 and MGS), three resistant varieties (Bai Kui Za No.9, Bai Kui

Za No.6 and S-31) and a highly susceptible variety in flowerpots in glasshouse. Then we calculated the parasitism rate of sunflower roots every 20 days during a 2 month period. The results showed that in seedling stage, the average parasitism rate of confectionery sunflower, oil sunflower and edible, oil concurrently used sunflower were 92.12%, 97.62% and 45.55%, respectively, and the average parasitism degree of three types were 7.51, 6.72 and 1.70, respectively. No *O.cumana* parasitized the sunflower roots 20 days after sowing (DAS). Forty DAS *O. cumana* parasitized most sunflower roots except T012244 and MGS, and parasitism was more serious at DAS in the other four varieties. The results suggested that T012244 and MGS were immune to *O. cumana* in the seedling stage and could be appropriate varieties for further research to breed highly resistant varieties.
Keywords: sunflower; *Orobanche cumana*; parasitism rate.

A multidisciplinary integrated approach for alleviating broomrape damage in Israeli agriculture - an emergency national project, 2010-2013.

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Broomrapes (*Orobanche* and *Pheliphanche* spp.) cause severe damage to vegetables and field crops worldwide. In Israel, during the last decade, the significance of infested fields has increased dramatically, causing heavy damage or even total yield losses. Egyptian broomrape (*P. aegyptiaca*) is the most abounded and devastating species among broomrapes throughout Israel, parasitizing a wide host range. Therefore, broomrape was identified as a national significant pest and a national research and development project was initiated aiming at providing the farmers with an integrated management economical solution for crop production in broomrape infested fields. This project which is a joint effort of the Israeli Ministry of Agriculture, The Vegetable board and several research institutes was established as a three year-project (2010-2013). The project consists of nine research groups encompassing topics related to both fundamental aspects of broomrape biology and applied management strategies, including soil disinfestation, pesticide application and phyto-sanitation. *P. aegyptiaca* in tomatoes and carrots was selected as the main model for the host-parasite systems. The specific topics include: a) developing a decision-support system, for effective control with herbicides in carrots and tomatoes, based on a phenological model of *P. aegyptiaca*; b) detection and quantification of the broomrape seed-bank in the soil; c) spatial distribution of broomrape in infested areas using tools of Geographical Information Systems (GIS); d) soil disinfestations and adoption of effective control measures to reduce the seed bank in heavily infested soils; e) phyto-sanitation and assuring broomrape-free farm machinery, equipment and compost; f) physiological aspects related to host-parasite relationship; g) optimization of herbicides action in plants and soil and h) remote sensing of broomrape-infected plants. This interdisciplinary project may provide an integrated approach for managing broomrape on a wide scale of the intensive agriculture in Israel.
Keywords: Integrative broomrape project; Egyptian broomrape; control.

Modelling approach for the prediction of parasitism dynamics in the root holoparasitic broomrapes (*Orobanche* and *Phelipanche* spp.).

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The broomrapes (*Orobanche* and *Phelipanche* spp.) are obligate root parasites. Most of their life cycle takes place in the soil subsurface. Knowledge of the parasitism stage is essential to effectively control the parasite using herbicides. Therefore, specific methodologies and technologies have been recently developed and will be presented. The use of an in-situ non-destructive video camera, the minirhizotron, to monitor the subsurface developmental stages of the parasite on the host's root system is only one example. Modeling approach for predicting the parasitism dynamics has been developed for *O. minor* in red clover, *O. cumana* in sunflower, and *P. aegyptiaca* in tomato, sunflower and carrot. The parasitism dynamics of all parasite-host systems is strongly temperature related and therefore enables us to use the thermal time approach for estimating the parasitism dynamics. The relations between the parasitism dynamics and GDD are characterized as a sigmoid pattern. This pattern is specific for individual host-parasite systems and the number of attachments and emerging shoots can be estimated by different equations e.g. Sigmoid, Logistic, Gompertz (both three-parameter) and Weibull (four parameters with lag phase). Few examples of model calibration and field validation will be given and discussed. The Weibull equation adds a biological dimension to the model that the Sigmoid, Logistic and the Gompertz equations lack, as the lag phase allows estimating the precise timing of first parasite attachment to host roots and its flowering above soil surface. This information is crucial in any attempt to develop control strategies and decision support systems for management of this parasitic weed.
Keywords: broomrape; thermal time; parasitism dynamics; model.

Integrated *Cuscuta* management in legume fodder lucerne (*Medicago sativa*) and Leafy vegetable (*Amaranthes viridis*).

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Cuscuta species have become a serious problem especially in crops like lucerne, onion, chillies, pulses and green leafy vegetables. It is an obligate parasite that attacks stems and leaves of host plants and germinates independently without any stimulant. Later on, the emerged seedlings search for a suitable host plant and send their suckers (haustoria) and live at the expense of host plants. In Tamil

Nadu, lucerne and leafy vegetables (*Amaranthes viridis*) are found to be infested sporadically with *Cuscuta chinensis*, especially in Western and North Western agro ecological zones of Tamil Nadu. Use of resistant cultivars, prevention of new invasion, crop rotation, tillage and management of irrigation water are found to be helpful in reducing the menace of *Cuscuta chinensis*. In pulses, pre-emergence application of pendimethalin and fluchloralin showed promising results in the management of *Cuscuta chinensis*. Hence, field experiments were conducted during 2010-11 to manage *Cuscuta chinensis* in lucerne and leafy vegetable (*Amaranthes viridis*) with pre and post-emergence application of pendimethalin, fluchloralin, paraquat and imazethapyr. The effect of these treatments was compared with hand removal of *Cuscuta* and an uncontrolled check. The trials were laid out in randomized block design with treatments replicated thrice. Related biometric and phytotoxic observations on crop plants and parasitic weed *Cuscuta* were observed. Results of the field experiments revealed that in lucerne, pre-emergence application of pendimethalin 1.0 kg ha^{-1} at 3 days after sowing or hand removal of *Cuscuta* recorded lower density and dry weight of *Cuscuta* with higher green fodder yield. In leafy vegetable (*Amaranthes viridis),* hand removal of *Cuscuta chinensis* (or) post-emergence directed application of paraquat at 0.80 kg ha^{-1} at 20 days after sowing resulted in lower density and dry weight of *Cuscuta chinensis* with higher green leafy vegetable yield and better economic returns.
Keywords: *Cuscuta*; lucerne; leafy vegetables.

Broomrape (*Orobanche cumana*) control in tribenuron-tolerant sunflower.

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Introduction of imidazolinone- and tribenuron-tolerant sunflower hybrids is a revolutionary advancement in sunflower production. Imidazolinone herbicides and tribenuron provide broad-spectrum weed control in sunflower, including broomrapes. The objectives of our studies were to investigate the possibility of broomrape control and crop response in tribenuron-tolerant sunflower. Field and greenhouse dose-response experiments were conducted to quantify the tolerance of two tribenuron-tolerant sunflower hybrids (Sumo 1PR and Sumo HO) to seven rates of imazamox (0-400 g a.i.ha^{-1}) and tribenuron-methyl (0-360 g a.i.ha^{-1}). Field trials were conducted in three years in northern Serbia to determine efficacy and comparison of tribenuron (11.25, 22.5, 45 and 67.5 g a.i.ha^{-1}) and imazamox (36, 40, and 48 g a.i.ha^{-1}) for broomrape control in tribenuron- and imidazolinone-tolerant sunflower hybrids. Plants of hybrid Sumo HO were sprayed with five doses of tribenuron and mixture of tribenuron and imazamox. Herbicides were applied at eight-ten leaves and broomrape control was evaluated on two or three occasions from sunflower flowering to harvesting. Imazamox in imidazolinone-tolerant sunflower proved more effective in broomrape control than tribenuron in tribenuron-tolerant sunflower. The application of the higher rate of tribenuron (45 and 67.5 g a.i.ha^{-1}) resulted in 72-100% broomrape control at the time of sunflower flowering. At harvesting, the efficacy dropped, but seed yield was about two-fold higher on tribenuron treated plots compared to the untreated. Sumo HO hybrid exhibited high level of tolerance to tribenuron, and plants of this hybrid tend to maintain normal growth after application of the higher rates of tribenuron, and lower rates of imazamox.
Keywords: broomrape; sunflower; tribenuron-methyl; control; tolerance.

Induction of sunflower broomrape (*Orobanche cumana*) seed germination by some hybrid maize (*Zea mays* L.) varieties and their parents.

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Root exudates and root, shoot and rhizosphere soil extracts of some hybrid maize varieties (Xun 20×5212, Zheng 58×5212, 3206×340X, 3255× 335) and inbred lines were tested as stimulants for inducing the germination of sunflower broomrape seeds. The root exudates and its extracts as well as rhizosphere soil extracts of the maize varieties showed significant differences in their induction of germination. Across the four stimulants (exudates/extracts), the variety, 3255×335 had the strongest stimulation of seed germination and the highest germination rate of 36.4%. Shoot extracts of maize seedlings showed negligible effects on germination at the three extract concentrations (undiluted, 10- and 100-fold dilutions) studied. The undiluted root extracts failed to induce germination, however, when the extracts were diluted to 10-, and 100-fold they induced a reasonable germination that varied significantly among varieties and inbred lines. Screening of 151 maize inbred lines grown in the field using methanol and distilled water extracts of leaves produced few lines able to induce high germination of sunflower broomrape seeds.
Keywords:sunflower broomrape;*Orobanche cumana;*maize;*Zea mays*; seed germination;

Induction of sunflower broomrape (*Orobanche cumana*) seeds germination by different soybean (*Glycine max*) varieties.

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Both laboratory and pot experiments were conducted for identify sunflower broomrape seeds germination induction ability by soybean as a "trap crop" at different growing stage (three leave stage; five leave stage; branching stage; flowering stage and beginning of pod bearing period). Four commonly used soybean varieties (Beidou 18, Fengdou 3, Zhonghuang 13 and Heinong 44) were used in the experiments. The methanolic extracts of rhizosphere soils, root, stem and leaf of soybean at different growing stages were subjected for the induction germination of sunflower broomrape seeds. The results indicated that Zhonghuang 13 have a higher ability to induce sunflower broomrape seeds germination among the varieties tested. In addition, root methanolic extracts displayed higher germination rate of sunflower broom rape seeds than that of stem and leaf. The most germination induction stage of soybean against sunflower broomrape is at three to five leave stage of soybean growth.

Keywords: soybean;sunflower broomrape;trap crop;methanolic extracts;germination

Light and scanning electron microscopy studies on the *Phelipanche ramosa* L. Pomel development parasitizing tomato plants.

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Phelipanche ramosa belongs to the widely spread broomrapes, has the wide host range and causes severe yield losses to numerous important cultivated plant. *P.ramosa* has not been a threat to Polish agriculture so far. However, due to the changing global climate it may become a problem for Polish vegetables. In the present work, we review the histological/cytological studies investigating the structure of *Phelipanche ramosa* (tubercle, stem, flower) and its connection to tomato plants - host. We attempted to identify the particular parasite tissues in order to understand the relationship between structure and mechanisms of parasitism. Fragments of parasite: underground-tubercle with fragments of tomato plants, aboveground-stem, flower (style, anther, pollen) in various stages of development were fixed with chromic acid, acetic acid, formalin, dehydrated with ethanol, and for light microscope: embedded in paraffin, cut, stained with safranin and light green. For scanning electron microscope material was dried in CPD (Critical Point Drying) and sputter – coated with gold. Morphological and histological study was made with the use of stereoscopic Olympus SZX16, light Nikon Eclipse 80i microscopes with digital systems for picturing and scanning electron microscope Jeol JSEM-S1. We have analyzed the epidermis, parenchyma and vascular elements. We identified stomata and different forms of multicellular hairs covering almost whole parasite. Anthers released numerous pollen grains on the stigma surfaces. Ovaries formed seeds of different sizes and shape, but with a similar surface structure. The tubercles covered with a cork-like tissue, and parenchyma cells contained starch grains. Xylem cells were the dominant elements of the vascular bundles in the stem and tubercles.
Keywords:*Phelipanche ramosa*; tomato;histology

Germination stimulating activity of strigolactone mixtures.

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In the rhizosphere, strigolactones (SLs) induce seed germination in root parasitic weeds and hyphal branching in symbiotic arbuscularmycorrhizal fungi. In plants they act as a novel class of plant hormones inhibiting shoot branching. SLs consist of tricyclic-lactone (ABC-ring) and methyl butenolide (D-ring), connected with an enol ether bridge. The C-D ring moiety is the essential structure for exhibiting germination stimulation activity and substituents on the AB ring modify their potencies. Since plants exude not a single SL but mixtures of SLs, composition of SL mixtures may be more important than a single SL in host recognition by root parasitic weeds and also by AM fungi. Therefore in this study, SL mixtures were examined for their germination stimulation on the seeds of root parasitic weeds. The effects of SL mixtures on seed germination were tested at concentrations from 10^{-13} M to 10^{-7} M. GR24 and Milli-Q water were used as positive and negative controls, respectively. In the case of *Orobanche minor*, germination stimulating activities of orobanchol, orobanchyl acetate and their stereoisomers were not affected when they were mixed each other at all concentrations tested. By contrast, significant reduction in activity was observed for solanacol and its stereoisomers when they were mixed with the corresponding acetates. The effects of SL mixtures on the seed germination of other parasitic weed including *Phelipancheramosa* will also be discussed.
Keywords:strigolactone;germination stimulating activity; parasitic weed

Germination stimulants for root parasitic weeds produced by faba bean.

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The root parasitic weeds, witchweed (*Striga* spp.) and broomrape (*Orobanche* spp.), are causing serious damage to agricultural production around the world. In the Mediterranean region, faba bean (*Viciafaba)* is one of major hosts of *O. foetida* and *O. crenata*, and thus extensive efforts have been devoted to the breeding and screening of resistant cultivars. Reduced production of germination stimulants would be a good trait for resistance to root parasitic weeds since they need these chemicals to commence their parasitic lifecycle. In this study, therefore, germination stimulants produced by faba bean were examined. Faba bean seedlings were grown hydroponically and root exudates were adsorbed on activated charcoal. The root exudates adsorbed on charcoal were eluted with acetone. After evaporating the acetone *in vacuo*, aqueous residue was extracted with ethyl acetate (EtOAc). The EtOAc extracts were washed with basic phosphate buffer, dried, and concentrated in vacuo. These samples were subjected to LC-MS/MS analysis and germination test using seeds of clover broomrape (*O. minor*). Faba bean was found to produce orobanchol and orobanchyl acetate by LC-MS/MS analysis using multiple reaction monitoring (MRM). In addition to these strigolactones, unknown peak was observed in the channel for detecting fabacyl acetate and 7-hydroxyorobanchyl acetate. In the germination test after RP-HPLC separation, the fraction containing unknown peak exhibited distinct germination activity. Then, the active compound was further purified and analyzed by LC-MS/MS. Sodium adduct ion $[M + Na]^+$ was detected at *m/z* 427 along with a fragment ion $[M + Na – 97]^+$ which is characteristic to strigolactones as a result of the loss of the D-ring moiety.
Keywords:strigolactone;germination stimulant;faba bean;

Analysis of endogenous strigolactones using plant cell cultures.

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Root parasitic plants and arbuscular mycorrhizal fungi receive strigolactones (SLs) as host recognition signals in the rhizosphere. In host plants, SLs play a key role in the regulation of shoot branching. Despite their important functions, the biosynthesis pathway of SLs has not yet been fully elucidated. Establishment of SL biosynthesis pathway and subsequent studies on its regulation will enable manipulation of their physiological functions. As it is in general difficult to characterize endogenous SLs in plants since their levels are extremely low, we attempted to analyze endogenous SLs using plant cell cultures as a tool for study of SL biosynthesis. Suspension cell cultures of *Arabidopsis* and rice were separated into cells and culture media before their stationary phase. The neutral ethyl acetate-soluble fractions were examined by a bioassay using seeds of root parasitic plant *Orobanche minor*. Remarkable activities on the germination stimulation were found in both the cells and culture media. In order to know whether the germination stimulants are SLs, the extracts were analyzed by LC-MS/MS. It was shown that both the cells produced SLs including orobanchol, orobanchyl acetate and 7-hydroxyorobanchyl acetate, and also released these SLs to the culture media. Furthermore, we investigated SL metabolisms by a feeding experiment using the suspension cell cultures with deuterium-labeled SLs. Deuterium-labeled 5-deoxystrigol was converted into several monohydroxylated metabolites that were different from the known monohydroxylated SLs such as strigol, orobanchol and sorgomol, and most of them had no germination-stimulation activity on *O. minor* seeds. Feeding experiments using plant cell cultures would shed light on unknown pathways in SL metabolism.
Keywords: strigolactone;plant cell culture; rice;*Arabidopsis*;metabolism

Characterization of strigolactones produced by tobacco plant.

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Witchweeds (*Striga* spp.) and broomrapes (*Orobanche* and *Phelipanche* spp.) are root parasitic weeds causing enormous losses of agricultural production. The seeds of these parasites germinate when they perceive germination stimulants released from their host and some nonhost plants. Among the germination stimulants, strigolactones (SLs) appear to be of primary importance because SLs induce hyphal branching of arbuscularmycorrhizal fungi in the rhizosphere. In addition, SLs also work as plant hormone inhibiting shoot branching *in planta*. Tobacco (*Nicotianatabacum* L.) is a host of *Phelipancheramosa* L. and *P. ramosa* causes severe damage and yield loss (up to 70%) in tobacco. In the previous study, we found that the root exudates of tobacco contained at least six different germination stimulants including 4 SLs;solanacol, a didehydrostrigol isomer, orobanchol and 2'-*epi*-orobanchol. However, these assignments should be confirmed as the structure of orobanchol has recently been revised. About 100 tobacco plants (cv. Michinoku No.1) were grown hydroponically and the root exudates collected. The ethyl acetate extracts of the root exudates were analyzed by reversed-phase HPLC-MS/MS and also by chiral-HPLC-MS/MS. Optically pure synthetic standards were used to determine the stereochemistry of natural SLs in the extracts. Consequently, the germination stimulants produced by this tobacco cultivar were identified as orobanchol, *ent*-2'-*epi*-orobanchol, orobanchyl acetate, solanacol, and two novel SLs, solanacyl acetate, and *ent*-2'-*epi*-5-deoxystrigol.
Keywords: Strigolactones; germination stimulants;tobacco; parasitic weeds

Strigolactones in root exudate from rice plants.

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Strigolactones (SLs) are germination stimulants of root parasitic weeds, hyphal branching factors of symbiotic arbuscular mycorrhizal fungi and a novel class of plant hormones inhibiting shoot branching. In the present study, characterization of SLs from root exudate of rice (*Oryza sativa* cv. Nipponbare) was carried out. Rice plants were grown hydroponically with tap water and root exudates collected by using activated charcoal. The root exudates were eluted with acetone, and the aqueous residue after evaporating the acetone under reduced pressure was extracted with ethyl acetate. The bioassay-guided purification of germination stimulants on *Orobanche minor* seeds revealed that rice plants exude five known SLs including 7-oxoorobanchyl acetate, orobanchol, orobanchyl acetate, and *ent*-2'-*epi*-5-deoxystrigol. In addition to these SLs, four monomethoxy-SL isomers and some other minor SLs were detected. The structural elucidations of these novel SLs are in progress.
Keywords: rice;strigolactone; parasitic weeds

Environmental aspects of weed management

Oral presentations

Differential metabolic responses to monosulfuron in three nitrogen-fixing cyanobacteria.

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Nitrogen-fixing cyanobacteria are vital photosynthetic microorganisms that contribute to soil fertility by fixing atmospheric nitrogen and are also important for maintaining ecosystem stability. These microorganisms can be very sensitive to herbicides because they have many characteristics of higher plants. Six days after the application of monosulfuron (N-[(4'-methyl) pyrimidin-2'-yl]-2-nitrophenylsulfonyl urea) at 0.03 to 0.3 nmol L-1 under laboratory conditions, growth of the nitrogen-fixing cyanobacteria: Anabaena flos-aquae, Anabaena azollae, and Anabaena azotica was stimulated, but at higher concentrations (30 to 300 nmol L-1) protein synthesis was inhibited. The production of 16 amino acids in A. flos-aquae was reduced from 7 to 69% with increasing monosulfuron concentration. Application of monosulfuron at 3 to 300 nmol L-1 substantially inhibited in vitro ALS activity as indicated by I50 inhibition index values of 3.3, 65.2, and 101.3 nmol L-1 for A. flos-aquae, A. azollae, and A. azotica, respectively. In contrast, extractable ALS activity was not affected in these algal species with monosulfuron treatments ranging from 0.03 to 300 nmol L-1except in A. flos-aquae at higher concentrations (30 to 300 nmol L-1). The most sensitive species to monosulfuron was A. flos-aquae, followed by A. azollae and A. azotica. Molecular analyses showed that the genomic DNA of A. azollae and A. azotica differed in only one amino acid. Results from photogenetic analyses revealed a high degree of homology between these algae. In contrast, the genomic DNA of A. flos-aquae differed from that of A. azollae and A. azotica in 44 and 45 amino acids, respectively. Our findings support the view that monosulfuron toxicity in these three nitrogen-fixing cyanobacteria is due to its interference with protein metabolism via inhibition of branch-chain amino acid biosynthesis, and particularly ALS activity.
Keywords: Acetolactate synthase;nitrogen-fixing cyanobacteria;non-target effects;herbicide;monosulfuron;

Atrazine degrades faster with repeated use in New Zealand soils.

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In New Zealand maize (*Zea mays*) is generally grown as a monoculture and atrazine has been used repeatedly to control weeds for over 30 years. Such use lead to herbicide resistance in *Chenopodium album* and in Persicaria maculosa (*Polygonum persicaria*) in the 1980's. Since then atrazine continued to be used but with the addition of post-emergence herbicides to control the resistant weeds. In recent years many maize farmers have noticed shorter period of effective broad-leaf weed control. As New Zealand was the first country to observe enhanced degradation of EPTC + antidote some 30 years ago, we investigated if atrazine suffered a similar fate. Soils were collected from each of the major maize growing regions of the North Island. Six of the soils were from fields with a long history of atrazine use while a seventh soil was from a site never exposed to atrazine. The soil samples were passed through a 4 mm sieve while still field-moist. One half of each soil was then sterilized by autoclaving for 3 cycles. Soil subsamples were fortified with atrazine equivalent to 3.0 kg/ha (twice the recommended field rate) and incubated at 10, 20, or 30°C for 1 – 35 days. Atrazine residues were determined by HPLC after incubation. Atrazine degradation in the sterilized soils was similar, with DT50's of 31-50 d at 20°C and 15-25 d at 30°C. In comparison the DT50's for the unsterilized soil with no previous atrazine exposure were 30 and 11 d for 20 and 30°C respectively while those for the other unsterilized soils ranged from 5-13 d at 20°C and 3-10 d 30°C. As expected, degradation in the sterilized soils followed 1st order kinetics, however, the decay rate in unsterilized soils was up to five times faster and could not be explained by simple exponential decay.
Keywords: Atrazine; Degradation; Enhanced; Microbial; Half-life;

Persistence of nicosulfuron in New Zealand maize fields.

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Nicosulfuron is often used for post-emergence control of weeds in grain and silage maize crops in New Zealand. As silage crops are harvested earlier than grain crops and are immediately followed by a winter crop, the chances for damage to sensitive species are high. The persistence of four residual herbicides used in maize crops was investigated in three field trials during 2008/09 growing season. Herbicides included atrazine and acetochlor applied pre-emergence and mesotrione and nicosulfuron post- emergence. Soil samples were collected to a depth of 10 cm at silage harvest (about 3 months after application) and bioassayed in the glasshouse using mustard (*Sinapis alba*). The results showed small but phytotoxic residues only of nicosulfuron and only at the site with least rainfall. A subsequent glasshouse study investigated whether the differences in persistence of nicosulfuron were due principally to soil characteristics (four soil types) or rainfall (amount and timing). Heavy rainfall (50 mm) 1 or 2 weeks after application caused greater leaching and reduced residues more than light (10 mm) or moderate (25 mm) rain applied at similar times. Also, phytotoxic residues of nicosulfuron disappeared faster in soils with low pH and high organic matter. Further field trials during 2009/10 and 2010/11 growing seasons investigated persistence of nicosulfuron applied post-emergence at 60 g ai/ha. Glasshouse bioassays showed no phytotoxic residues at the silage harvest time in four trials. However, residues were measured at one site, with 83%, 50% and 27% damage to mustard plants compared to the untreated control at 3, 4 and 5 months after application, respectively. Soil at this site had a pH of 7.2 compared to values between 5.6 and 6.1 at the other four sites.
Keywords: persistence;nicosulfuron;maize;residual activity;bioassay;

Microbial degradation and tillage decrease residue of fomesafen in the soil.

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Fomesafen is the major herbicide of soybean in China, representing 60%-70% of the herbicide used. In recent years, the increase of the resistance weeds and changing weather, the applied dosage of fomesafen has increased in soybean. There is residue of fomesafen in the soil that affects the growth of the rotational crops, it also influences the production of agriculture and the adjustment of the structure of the crop cultivation. This research examined ways to decrease residues of fomesafen in the soil and injury potential of the sensitive crops by combining the method of tillage and microbial degradation. Results indicated that concentration of fomesafen residues decreased 50% in the over-turning of 10-20cm soil layer, the inhibition ratio of fresh weight of sugar beet was decreased from 36% to 17%, the concentration of residue fomesafen was decreased by 80% with the over-turning 20-30cm soil layer, the inhibition ratio of fresh weight of sugar beet was decreased from 36% to 14%. By soil treatment with the fungi, the degradation rate of residue of fomesafen was increased 30%. And using the technique of microbial degradation the inhibition ratio of fresh weight of sugar beet was decreased from 36% to 8%. With the method that combining the over-turn different soil layer and soil treatment with microbe, the degradation rate of residue of fomesafen was increased to 98%. There is no difference of fresh weight of sugar beet between the treatment and CK, and the growth of sugar beet isn't influenced by the residue.
Keywords: Formsafen ;Residue ;Microbe;Degradation ;Tillage;

Photochemical degradation of pyrazosulfuron-ethyl in aqueous solution.

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Pyrazosulfuron-ethyl, one of sulfonylurea herbicides, is used to control annual and perennial grasses and broad-leaved weeds in rice production. The persistence and degradation of the herbicide has been among the research interests of environmental scientists. However, these studies mainly focused on microbial degradation and chemical hydrolysis, little data was published on the photodegradation of pyrazosulfuron-ethyl in aqueous solution. In this paper, photodegradation of pyrazosulfuron-ethyl has been investigated in aqueous solution at different irradiation wavelength ranges and pH. Spectrophotometric methods have permitted to determine the pKa values in the ground state and in the first singlet excited state. Intermediate products and Kinetics were identified using HPLC–UV or HPLC–MS analyses. The pKa(S1) and pKa(S0) values obtained from the formula are 3.82 and 5.02, respectively. Kinetics measurements have shown that photodegradation was faster in acidic medium but more efficient in basic medium, when the sulfonylureas were in their ionic form. The half-lives of pyrazosulfuron-ethyl under UV light and simulated sunlight were found to be 27 and 152 min, respectively. The identification of the photoproducts are 4,6-dimetoxypyrimidine-2-yl aminocarbonylsulphamic acid, 2-ureido-4,6-dimetoxypyrimidine, and 2-amino-4,6-dimethoxypyrimidine. Degradation pathway has been proposed: carbon–sulfur cleavage, nitrogen–sulfur, and photohydrolysis of the sulfonylurea bridge. We can conclude that under simulated sunlight conditions the herbicide pyrazosulfuron-ethyl degrades slowly, and photodegradation behaviors can occur within the sulfonylurea family, depending on the chemical structure of the two chromophoric components and the irradiation wavelengths.
Keywords: Pyrazosulfuron-ethyl;Photodegradation;Sulfonylurea herbicides;

Studies on the persistence of carfentrazone Ethyl 20% + Sulfosulfuron 25% WDG (PREMIX) in wheat and soil under west Bengal climatic condition.

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Carfentrazone ethyl and sulfosulfuron are used in wheat. Carfentrazone ethyl, belonging to chloropropionic ester group, is a post-emergence applied for control of a wide range of annual grass weeds in different cereal crops including wheat. It is a post emergence herbicide to control weeds through the process of membrane disruption which is initiated from inhibition of enzyme protoorphyrinogenoxidase. Sulfosulfuron belonging to pyrimidinylsulphonylurea group is a post-emergence herbicide used for the control of a wide range of annual grass weeds in different cereal crops including wheat. It mainly acts as acetyl-CoA carboxylase enzyme inhibitor and causes chlorosis leading to growth retardation of target plant.The test chemical i.e. mixture of Carfentrazone Ethyl and Sulfosulfuron was applied in wheat field at two doses (T1= 45 g a.i. ha-1 and T2= 90 g a.i. ha-1) along with untreated control (T3). Samples of wheat plant and soil were collected periodically and analysis was done at the Pesticide Residue Laboratory, Bidhan Chandra Krishi Viswavidyalaya. Samples of wheat plant and soil were analyzed with GC – ECD for carfentrazone ethyl residues and its metabolite, and sulfosulfuron was analyzed by HPLC. From the result it revealed that Carfentrazone ethyl and Sulfosulfuron residue degrades with time and it follows 1st order kinetics. In untreated control soil & plant samples no residue was detected.
Keywords: persistence;carfentrazone-ethyl;sulfosulfuron;residue;GC/HPLC;

Determination of glyphosate in green tea, made tea and tea liquor after derivatisation with 9-fluorenylmethyl chloroformate by LC-ESI-MS/MS.

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Tea is a popular beverage throughout the world and valued for its specific aroma and flavor as well as health-promoting properties. Management of pests in tea plantation depends on the use of broad-spectrum pesticides. The contamination of pesticide in tea is a potential threat to the health of tea drinkers. Glyphosate is one of the most frequently used herbicides in tea plantation. Its popularity as a broad spectrum, non-selective, post-emergence and systemic herbicide has remained for about 30 years. Because of its wide use and health effects it is necessary to analyze its content in tea. The aim of this work is to optimize and validate a sensitive and selective method for glyphosate from green tea, made tea and tea liquor. For the method, standards of glyphosate, FMOC-Cl were used. Purified water along with dichloromethane, sodium hydroxide, hydrochloric acid was used for extraction. The extracts were analyzed with Waters LC-ESI-MS/MS system. The tea sample was extracted with NaOH and dichloromethane by sonication, shaking and again sonication followed by centrifugation. The supernatant was neutralized with HCl and derivatised using FMOC-Cl reagent and borate buffer. To the sample extract, borate buffer was added and vigorously shaken. Then FMOC-Cl was added to it, vortexed and centrifuged. The clear sample was filtered and analysed with LC-ESI-MS/MS. In this study we have demonstrated a successful combination of extraction from tea and derivatisation of glyphosate with FMOC-Cl. The method was reproducible (Horwitz ratio <0.5 at 100 ng/g). The recoveries of glyphosate were between 80% and 110% with relative standard deviation less than 15%. The effect of matrix on the compounds was removed using matrix matched calibration standards.
Keywords: Glyphosate;Residue;Green tea;Made tea;LC-MS/MS;

Effects of long-term irrigation with reclaimed wastewater on the efficacy and fate of trifloxysulfuron-sodium activity in the soil.

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Long-term irrigation with reclaimed wastewater (RWW) is known to affect the physical, chemical and biological properties of the soil. The sulfonylurea herbicide trifloxysulfuron-sodium (TFX) is commonly used for post emergence application in cotton. TFX is an ALS inhibitor who is stable in the soil for several months and can carry over to rotational crops; however, we observed that its residual activity in RWW-irrigated soils is much shorter than that recorded in fresh water (FW)-irrigated soil. In this study we monitored the activity/dissipation of TFX applied on RWW-irrigated soil as compared to FW-irrigated soil. High weed infestation (mainly Amaranthus palmeri) was observed in the TFX-treated soil along with a sharp decline in its herbicidal activity, suggesting rapid dissipation of TFX in the soil. Sorghum bicolor response to TFX in RWW irrigated soil was significantly lower than that grown the FW-irrigated soil. Sterilized RWW irrigated-soil exhibited higher TFX activity versus non-sterilized soil. These data imply that TFX activity in RWW-irrigated soil is probably affected by microbial activity. Breakthrough curves will be conducted in order to examine TFX movement and leaching through RWW and FW irrigated soils. Furthermore, degradation experiment with 14C-TFX will be conducted to evaluate the degradation rate of TFX in the soil and to analyze the metabolites created in the process.
Keywords: ALS inhibitors;carry over;dissipation;soil;microbial activity;

Environmental forecasting distribution of saflufenacil, used as pre-planting treatment in soybean crops under no-till system.

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The use of the concept of fugacity has the sense that specialists may apply the model developed and validate in different countries and define the tendency of molecular fugacity to the more vulnerable compartment. This paper aimed to use the model of fugacity level 1, as a way to support the pre-evaluation of the environmental distribution of saflufenacil, applied in management of soybean crops, implanted under the direct plantation system. The physiochemical properties of saflufenacil used were: molecular weight (500.9 g/mol), vapor pressure (2x1014 Pa), constant octanol-water (4.4), solubility (25 g/m3), Henry's constant law (4.06x10-15 Pa m3/mol) and organic constant carbon (32.5). The volume (m3) of air compartments (6x109), water (7x106), soil (4.5x103), sediment (2.2x103), biota (7), leaf (9.2x102), root (3.7x103) and stem (4.6x103). The density parameter, in kg/m3 were 1550, 1200, 820 and 850, for the compartments soil, sediment, leaf, root and stem, respectively. For the compartments soil and sediment, 2% of organic fraction of carbon was used. The parameters calculated for each compartment were the capacity of fugacity (mol/m3Pa), (mol/Pa), fugacity (Pa), concentration (mol/m3) and quantity (%). The saflufenacil trend's for the compartments, in decreasing order were: soil (37.83%), root (19.00%), stem (17.14%, sediment (14.32%), water (11.67%), leaf (0.01%), air (1,64x10-14%) and biota (1.54x10-29%). The preliminary conclusion of the current evaluation about the risk of contamination by using saflufenacil in the soybean was that the compartment soil is the most vulnerable variable and it may be carried out in a relatively simple form the physic-chemical properties of the herbicide by using the model of fugacity level 1.
Keywords: saflufenacil;soybean;no-till system;fugacity;

Efficacy of buffer strips in reducing flufenacet and isoxaflutole runoff from two soils cultivated with maize.

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Herbicide runoff may represent a threat to surface water. The study, carried out in 2009-2010 at Carmagnola, Italy, aimed to assess the efficacy of buffer strip in reducing runoff of flufenacet and isoxaflutole. Buffer strips of different widths covered by spontaneous weed vegetation were realized at the downstream hedge of six plots (1050 m2; 0.5% slope) cultivated with maize. Four plots (TF plots), have 37.1% sand, 57% silt, 5.9% clay, while two plots (RIVA plots) have 18.6% sand, 63.1% silt, 18.3% clay. In TF plots four different buffer strip widths were tested: 0 m (TF0), 2 m (TF2), 4 m (TF4), and 6 m (TF6). In RIVA plots, two widths were tested: 0 m (RIVA0), 6 m (RIVA6). All plots were treated with flufenacet (240 g/ha) and isoxaflutole (50 g/ha). Runoff waters were

collected using automatic samplers. After extraction by SPE, determination of both herbicide was performed by GC-MS, with a quantification limit of 0.05 µg/L. In 2009 the highest concentration of flufenacet were found in RIVA0 (67 µg/L). In TF plots concentrations were not higher than 14.9 µg/L (TF4), without significant differences between plots. The reduced efficacy of buffer strips was due to the poor vegetative cover present at time of the first runoff events. During 2010, the highest concentrations of flufenacet were always detected in runoff waters from unbuffered plots. Isoxaflutole was found only in 2009 at the first runoff event with concentration ranging between 2.7 µg/L (RIVA0) and 5 µg/L (RIVA6). Across the years, flufenacet was detected up to 53 (TF plots) and 60 (RIVA plots) days after treatment in 2009 and up to 115 (TF0) and 153 (RIVA) days after treatment during 2010. Flufenacet has shown a higher risk of water contamination than isoxaflutole, particularly in the soil with higher clay content.
Keywords: buffer strip;flufenacet;isoxaflutole;runoff;surface water;

Poster presentations

Managing water hyacinth through its use as dried cattle feed.

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In the state of Tamil Nadu, South India, Veeranam lake and its distributaries form a major irrigation source that covers the large portion of rice tracts of the State with area of 18,000 ha. Water hyacinth (Eichhornia crassipes (Mart.) Solms) has invaded considerable proportion of Veeranam distributaries. Hence, a study was carried out at Annamalai University for effective management of E.crassipes using it as cattle feed. Eight months old calves were selected for the field trial for a period of 180 days. Calves were offered both fresh as well as dried Eichhornia Sp. Fresh weed was rejected by the animals whereas powdered weed after sun drying which was included in the cattle feed at 5 % was consumed by the animals. There was no abnormal clinical symptoms noticed with the calves which were fed with 5% dried E. crassipes and the blood count and liver enzymes exhibited a normal physiological range. There was no deviation in the weight of the calves. There was no symptom of indigestion. The study revealed that utilization of the weed as a dried cattle feed ingredient was found to be safe and effective method of bio-control of E.crassipes.
Keywords: Invasion;cattle feed;calves;Eichhornia crassipes (Mart.) Solms;Veeranam lake;

Environmental factors associated with time of fomesafen application affects the level of crop injury.

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Fomesafen herbicide is used for broad-leaved weed control in the common bean crop (*Phaseolus vulgaris* L.). Ten field experiments were conducted to evaluate the effect of environmental factors on efficacy. For each experiment, treatments were 0, 30, 55, 80, 90, and 100% of the label rate. Herbicide applications were selected based on a wide range of environmental conditions. Crop responses were used as the model to evaluate herbicide efficacy. Dependent variables assessed at the time of herbicide application included environmental conditions (relative humidity, air temperature, wind speed, and photossintetically active radiation). There was a high correlation for each combination of two of all the variables evaluated at the time of the herbicide application. Maximum herbicide injury to the crop was 25% when assessed at 7 days after spray, and decreased at latter assessment times. Photossintetically active radiation was the environmental variable most important to determine the impact of fomesafen on *P. vulgaris*. It should be pointed out that a path analysis would be needed for a complete understanding of the complexity involved in this project, but, this would require around 15 set of data for each variable studied.
Keywords: correlation analysis;conceptual map;selectivity;

Weed control technology with low concentration ethanol in protected cereal crop cultivation.

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Weed control is of fundamental importance when planting cereal crops, particularly during the establishment phase. Weeds compete for nutrients, water and light, and can severely threaten the survival and early growth of newly planted crops. Field experiment was conducted at the Department of Functional Crop, Milyang, Korea to evaluate the effect of ethanol treatment on the weed control efficacy in cereal crops in protected vinylhouse. Three treatments like water, 1.0% and 2.0% ethanol at 100ℓper ㎡ were applied and covered with vinyl on 10 days before millet seeding. After that, millet seeds were sown on June 20 at 60x10cm planting distance and weed control efficacy was recorded at 30 days after seeding based on the dry weight. Weed control efficacy of 94-97% was observed in both 1% and 2% ETOH. Yields of foxtail millet at 2% and 1% concentration were 343kg 10a-1, 239kg 10a-1, respectively. Weed dry weight in control treatment was 31g per ㎡, weed dry weight in 1% and 2% ETOH were 2.0g per ㎡ 0.8g per ㎡, respectively. Soil oxidation-reduction potential was recorded -200∼-400 ㎷ after treatment 2 days. In this method about three times more expensive than the soil disinfectant are expensive. However, because the effect of soil disinfection, even considering that this is economical. This disinfection mechanism is caused by anaerobic soil disinfection (ASD), not by direct influence of the ethanol. The mechanism of ASD will be studied in the next few years with some of these products by measuring gases and fatty acids and microbial shifts in relation to efficacy.
Keywords: ethanol;faxtail millet;greenhouse;soil disinfection;weed;

Preparation of bacterial agent degrading nicosulfuron from Bacillus subtilis YB1.

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Nicosulfuron, a sulfonylurea herbicide, is mainly used for weed control in corn . The effective application dose for it is much lower than that of traditional herbicides. Nicosulfuron is soil mobile and causes groundwater contamination. Even low remains of nicosulfuron in the soil may still cause phytotoxicity to some sensitive crops. So it has important practical significance to study nicosulfuron degradation. Bacillus subtilis YB1 is isolated and kept in our laboratory and it is a bacterium with highly degrading nicosulfuron. Making the fermentation broth into microbial agents used in field not only enable the agents to meet the wettability and dispersion requirements of the wettable powder , but also to ensure that the activity of the bacteria. Fermentation broth mixed with calcium carbonate （5:2） was sprayed drying to powder, which was added appropriate wetting and dispersing agent to be made into WP. By biocompatibility experiment and orthogonal test, the best wetting agents, dispersants and carriers were screened out, a better result was goted after determine the biological activity of the preparation. The results showed that the wettability time was 37 s, the suspension percentage was 66%, the bacillus survival rate was 65% after the heat storage and the degradation rate of nicosulfuron was 66%. The formulation of WP: 4000CFU/mLYBI,5% HK, 3% EFW, 0.5% sodium alginate, with calcium carbonate up to 100%.
Keywords: Bacillus subtilis YB1; Nicosulfuron;degradation; agents;

Selection and identification of a fungi strain TR-H capable of degrading chlorimuron-ethyl and their growth and degradation characteristics.

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Abstract: A fungi strain, coded as TR-H which could utilize chlorimuron-ethyl as carbon and energy source for growth, was isolated and screened from the soil applied with chlorimuron-ethyl for long term. Based on its morphological, physiological and biochemical properties as well as the 18S rRNA sequence analysis result, the strain was tentatively identified as Aspergillus niger. The conditions for degrading chlorimuron-ethyl were natural pH value, 30℃ and 5.0mL of the inoculated quantity for 7 days respectively. In this condition, the degradation rate on chlorimuron-ethyl of 10mg L-1 achieved 96.4%. The degradation mechanism and metabolites of chlorimuron-ethyl strain TR-H were investigated in this paper.
Keywords: chlorimuron-ethyl;HPLC-MS; degrading bacteria TR-H;metabolites;

Herbicide pollution of surface water in the Muda irrigation scheme, Malaysia.

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Studies investigated pollution of water with the thiobencarb, propanil, pretilachlor, 2,4-D, MCPA, metsulfuron, bensulfuron, and pyrazosulfuron. Non-recycled (N-RCL) and recycled (RCL) water were included. Sampling was conducted on the drainage canal system out around the planting time for of the wet season 2006/2007 and the dry season 2007. HPLC-UV and GC-ECD were used to detect the herbicide residues in the water samples. Pollution levels showed that 71% and 52% of the water samples collected during the wet and dry season, respectively containing the eight herbicides studied more than 0.05 μg/L. Overall total mean of concentration of eight herbicides studied during the wet season (4.51 μg/L) was significantly lower ($p>0.01$) than the dry season (6.66 μg/L). The highest composition was thiobencarb with the average concentration was 27.09 μg/L, followed by propanil, pretilachlor, 2,4-D and MCPA was 14.75, 6.31, 3.40 and 2.46 μg/L, respectively. Meanwhile the average concentration of sulfonylurea group such as pyrazosulfuron, bensulfuron and metsulfuron was only 1.32, 0.51 and 0.38 μg/L, respectively. The variation of water pollution tend to be contaminated by pretilachlor, propanil and thiobencarb at maximum rate occurred at early stage of planting season within 1-2 week after seeding, followed by 2,4-D, MCPA, pyrazosulfuron, bensulfuron and metsulfuron at lately stage started from the third week after seeding until the maximum tillering phase. During the wet season the surface water of the RCL area was more polluted than the N-RCL area. Meanwhile during the dry season the water pollution between RCL and N-RCL areas was similar
Keywords: Herbicide;N-RCL/RCL Irrigation System;Water pollution;

The isolation of clomazone degrading bacteria and the research of its degradation effects.

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Aiming at the problem of potential carryover of long residual pesticide's residue to rotational crops, taking clomazone as a model pollutant, its degrading-bacteria enrichment and isolation and identify, its analytical method of biometrics, characterization of its biodegradation and bioremediation of clomazone contaminated soil by isolates were studied systematically, the main study results are as follows: 1. Three bacterial strains which could decompose clomazone were isolated by selective enrichment from soil exposed to long residual herbicides spills. Named as W2,Y1,X, based on the morphological appearances and physiological characteristics,W2 was identified as Methyloeoccus sp, Y1 and X were identified as Bacillus sp. 2. This research was found out the optimal culture condition. The optimal sugar content of W2 and Y1 was 0 percent, and X was 0.5 percent; The optimal temperature range of W2 and

Y1 was 20℃ to 37℃,and X was 25℃ to 41℃; The optimal range of pH of W2 was 6.0 to 9.0, that of Y1 and X was 6.0 to 8.0; the optimal initial concentration of clomazone of W2 was 200mg•L-1, that of Y1 and X was 100mg•L-1. 3. The bioassay methods of clomazone in sterilized and unsterilized soil media were set up. The correlative curves between logarithm of clomazone's concentration(y) and rate of inhibition chlorophyll content(x) in maize DongNong 250 in unsterilized soil media as followed: when the clomazone concentration was in the range of 0-50μg•kg-1 , y＝-6.2876x+2.2393,and its coefficient of correlation r=0.9926**, in the range of 50-1000μg•kg-1 ,y＝27.723x-139.79,and its coefficient of correlation r=0.9761**; The correlative curves between logarithm of clomazone's concentration(y) and rate of inhibition chlorophyll content(x) in maize DongNong 250 in sterilized soil media

Keywords: clomazone;degrading bacteria;biodegradation;

Timing of rainfall occurrence on herbicide runoff.

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Heavy rainfalls can promote herbicide runoff reducing weeds control and enhancing environmental contamination. Therefore, we evaluated the effect of rainfall and their times of occurrence on herbicide runoff in a simulated rice paddy. We tested rainfall levels (5, 10, 25 and 50 mm) and timing of rainfall occurrence after herbicide application (0, 1, 3, 5, 7, 10, 15 and 25 days after herbicide application) and herbicides (clomazone, penoxsulam, bispirybac-sodium, propanil, imazethapyr, imazapic, and imazapyr). The volume of runoff was collected and herbicide quantification was performed by LC-MS-MS. Herbicide runoff was observed in all periods of analysis and rainfall levels tested, with the exception of imazapyr, which was not detected in none of the samples. The herbicides clomazone and penoxsulam have higher runoff than the other herbicides evaluated and imazapyr did not runoff. Precipitation levels have significant influence on herbicide runoff. Herbicide runoff is higher when the rainfall occurred shortly after herbicide application.

Keywords: runoff;rice paddy;environmental contamination;heavy rainfalls;herbicide;

Environmental fate of imazamox in paddy fields.

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Imazamox is a post-emergence herbicide used to control weedy rice weeds in combination with tolerant rice varieties. This study, carried out in 2010 at Vercelli, Italy, was aimed at assessing the behavior of imazamox in water and sediment of rice fields managed, since 2002, according to the following different cultivation systems: A) straw and liquid manure incorporated in autumn and rice seeded in flooded field, B) straw incorporated in autumn and rice seeded in flooded field, C) straw incorporated in autumn and rice seeded in dry field. Imazamox was applied at 35 g/ha twice at 2-4 leaf stage. Water (from flooded fields and inlet/outlet floodgates), and soil samples were collected at different intervals from herbicide application. Extraction of imazamox from water and soil was performed with SPE and by using a CaCl2 solution, respectively. Extracts were analyzed by HPLC. Imazamox was found in inlet water (≤1 μg/L), while in outlet water its concentration ranged between 0.2 to 10.6μg/L. In paddy water, high concentrations of imazamox (up to 10.6μg/L) were found in the first days after treatments. After the second treatment, the highest concentration of imazamox was observed in paddy water of system C), likely due to the great crop canopy and thus to the gradual release of the chemical from rice foliage. In soil, the highest concentration after the first treatment, was 130.9 μg/kg in system C). Two weeks after the second treatment, the herbicide was not longer detected. Dissipation of imazamox in soil and water was influenced by timing of herbicide application and by the crop canopy, in particular in system C). Its presence in inlet water indicate a discharge from paddies upstream.

Keywords: imazamox;water ;soil;paddy fields;herbicide;

Isolation and identification of a degrading bacterium to herbicide butachlor.

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From the sludge polluted by butachlor for a long time, the degrading bacterium to butachlor was selected through enrichment culture with combination of High Performance Liquid Chromatography (HPLC) detection and then named as Y-1. Through the analysis of morphological characteristics, physiological and biochemical characteristics, and 16SrDNA sequence homology, Y-1 was identified as Pseudomonas sp.. Through the research of the degradation character of Y-1 in different ambient conditions, the optimal conditions were found as follows: the intial concentration of butachlor of 20mg•L-1, inoculum concentration of 5%, pH of 7 and temperature of 30℃. The degradation rate of Y-1 for butachlor reaches 76% after the cultivation for 7days in optimal conditions, which shows the excellent degradation ability.

Keywords: herbicide;butachlor;degrading strain;Pseudomonas sp;degradation characteristics;

Natural products and allelopathy

Oral presentations

The chemical cross talk between rice and barnyardgrass.

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The chemical cross talk between rice (*Oryza sativa* L.) and barnyardgrass (*Echinochloa crus-galli* (L.) Beauv) which is one of the most noxious weeds in rice cultivation was investigated. Allelopathic activity of rice was increased by the presence of barnyardgrass seedlings or barnyardgrass root exudates. Momilactone B concentration in rice seedlings and momilactone B secretion level from rice were also increased by the presence of barnyardgrass seedlings or barnyardgrass root exudates. As momilactone B possesses strong growth inhibitory activity and acts as an allelochemical, barnyardgrass-induced rice allelopathy may be due to the increased momilactone B secretion. Barnyardgrass root exudates was then purified and a key compound which induced rice allelopathy and momilactone secretion was isolated.
Rice may be aware of the presence of neighboring barnyardgrass plants by detection of the key compound in barnyardgrass root exudates, and this sensorial function may trigger a signal cascade resulting in increasing rice allelopathy through increasing production of momilactone B and secretion of momilactone B into the rhizosphere. Therefore, rice allelopathy may potentially be an inducible defense mechanism by chemical-mediated plant interactions between rice and barnyardgrass and the induced-allelopathy may provide a competitive advantage for rice through suppression of the growth of barnyardgrass.
Keywords: chemical interaction; induced-allelopathy; momilactone; *Oryza sativa*;

Allelopathy – Does it have a future in weed management?

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People have been aware of allelopathy for centuries, but its potential role in weed management has been studied and predicted by scientists for only less than a century. For about fifty years there has been an increasing worldwide effort to incorporate allelopathic traits of some crop varieties into weed management strategies and practices. For the most part, the promise of allelopathy to significantly reduce synthetic herbicide use has not materialized. Allelopathy has provided some weed management advantages in a few cases, yet there are no cultivars sold because of their allelopathic traits. The potential of conventional breeding of more allelopathic crop varieties, as well as transgenic approaches to enhancing allelopathy, will be discussed. Rice, fescue, and sorghum will be used as examples of plant species that have considerable potential for weed management via allelopathy. There are potential environmental benefits and risks of each type of allelopathic crop, and these factors will affect future adoption.
Keywords: allelopathy; allelochemical; transgenic;

Manuka oil, a natural herbicide with preemergence activity

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Natural herbicides approved in organic agriculture are primarily non-selective burn-down essential oils applied POST. Multiple applications are often required due to their low efficacy. To address this problem, the in vivo herbicidal activity of manuka oil, the essential oil distilled from *Leptospermum scoparium* (J.R. et G. Forst), was tested on selected broadleaf and grass weeds. While manuka oil exhibited good POST activity when applied in combination with a commercial lemongrass oil-based herbicide, it ultimately demonstrated interesting PRE activity, providing control of crabgrass seedlings at a rate of 3 L ha-1. Manuka oil and its main active ingredient, leptospermone, were stable in soil for up to 7 days and had half-lives of 18 and 15 days, respectively. The systemic activity of manuka oil addresses many of the major limitations normally associated with natural herbicides. Additionally, its soil persistence opens up a multitude of new possibilities for the use of manuka oil as a tool for weed management and may be a potential bridge between traditional and organic agriculture.
Keywords: herbicide; phytotoxin; mode of action; organic;

Eucalyptus spp. allelopathic activity for weed management.

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Conservation farming systems such as minimum or no-tillage and stubble retention have been widely adopted as a means of increasing soil moisture availability and subsequent crop yield. However, conservation farmers have relied heavily on herbicides for weed management to compensate for the lack of cultivation. Heavy reliance on herbicides has given rise to concerns about the rapid development of herbicide resistance and herbicide residues in the environment, thereby threatening the continued success of conservation farming systems. It is therefore imperative to discover new compounds with novel modes of action to combat this ever evolving herbicide resistance in weeds.
It has long been recognized that some *Eucalyptus* species are capable of suppressing understorey vegetation growth via allelopathy. *Eucalyptus* spp. contain a rich source of bioactive constituents, which have been reported to cause phytotoxicity to a number of weed species and various field crops. The bioactive compounds in *Eucalyptus* spp. oils could possess potential commercial value for further exploitation as natural herbicides.
Eucalyptus spp. are members of the Myraceae family and are native to Australia. There are about 800 *Eucalyptus* spp. readily available in Australia. This research was to screen these *Eucalyptus* species for their herbicidal activities and their potential in weed management. This study reports the differential allelopathic potential of four *Eucalyptus* spp. (*E. salubris*, *E. dundasii*, *E. brockwayii* and *E. spathulata*) on the germination and seedling growth of a broad range of important agricultural weeds in Australian farming systems, including winter weeds as annual ryegrass (*Lolium rigidum*), barley grass (*Hordeum* spp.), wild radish (*Raphanus raphanistrum*), and wild oats (*Avena* spp.).
Keywords: allelopathy; *Eucalyptus*; weeds; essential oils;

Berberine, a root growth inhibitor from *Coptis chinensis*, and its effects on the aquatic invasive species *Pistia stratiotes* and *Alternanthera philoxeroides*

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The extract of *Coptis chinensis*, a widely used traditional Chinese medicine, showed root inhibition effects on the invasive plants *Pistia stratiotes* and *Alternanthera philoxeroides*. The active ingredient was identified as berberine by TLC and mass spectrography. Berberine at a concentration of 25 μg/mL caused complete rot and collapse of *P. stratiotes* (2-3 leaf stage) at 15 d after treatment. The IC_{50} value of berberine on the fresh weight of *P. stratiotes* after 7 d of exposure was 7.65 μg/mL. Berberine inhibited the growth of new roots of *A. philoxeroides*. Fifteen days after the treatment, the average number of new roots in the control was 10.3. In contrast, no new roots were produced by plants treated with 50 or 25 μg/mL berberine, and the average number of new roots at lower concentrations (3.125, 6.25 and 12.5 μg/mL) was less than three, which was significantly lower as in the control. Moreover, the average length of new stems in the control was 5.7 cm at 15 d after treatment compared to 1.4 cm at 50 μg/mL and 0.6 cm at 25 μg/mL, which was significantly lower as in the control, indicating that berberine inhibited the growth of new stems in *A. philoxeroides*, too. Cycb1:GUS activity of *Arabidopsis thaliana* was also affected in transgenic roots under berberine treatment, indicating that berberine had a possible effect on cytokinin. The discovery of the root growth inhibitor berberine as well as a further understanding of its mode of action could lead to the development of biorational approaches to weed control, especially to the control of invasive weeds. As berberine is safe and its cost is not high, its use for invasive weed control seems promising. Furthermore, this study indicates that certain native species agents in invaded regions can be an effective and environmentally benign alternative to traditional biological control.
Keywords: berberine; *Pistia stratiotes*; root growth inhibitor;

Weed-pathogenic Sphaeropsidales: good sources of unknown metabolites with herbicidal potential.

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Microbes are an enormous and only partially explored source of bioactive metabolites. Phytotoxins are produced by plant pathogenic fungi during host-pathogen interactions, and have received considerable attention in particular to understand the development of diseases and consequently to set up strategies for disease control. These toxic metabolites differ for their chemical structure, the ecological and environmental role, and the mechanism of action. They can cause macroscopic effects such as leaf and stem chlorosis and necrosis, reduction of rootlet development, wilting and inhibitory effects on seed germination. Several studies have considered the possibility of using such metabolites as tools in biological and integrated weed management, e.g. novel and environmentally friendly herbicides, biomarkers for the selection of more efficacious biocontrol agents, templates for novel compounds, and sources of unknown mechanisms of action. In the latest years our attention has been focused on fungal pathogens of weedy species, aiming at discovering unknown metabolites with herbicidal properties. In particular, pathogens producing necrotic symptoms on leaves and stems, and belonging to the order of Sphaeropsidales, producing pycnidia, proved to be particularly promising for discovery of bioactive metabolites. Among them, research carried out on species belonging to the genera Ascochyta, Phoma, Phyllosticta and Phomopsis and pathogenic to weed species such as Chenopodium album, Cirsium arvense, Sonchus arvensis and Carthamus lunathus, allowed to produce, purify, and chemically and biologically characterize a number of novel compounds having unusual chemical structures and interesting biological properties. The most recent findings will be reported.
Keywords: natural herbicides;weed pathogens;biological control;bioactive compounds;

Prospects of botanical herbicides in system of crop intensificationin the Gangetic Inceptisols of India.

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Food security in agriculture has to face new challenges, especially in developing countries like India with currently >1 billion people (18% more than in 2001) but also global with expected 9 billion people by 2050. The 'System of Intensification' (best management practice) seems the best way to face this challenge and, therefore, biological weed control as one of the major concepts of this methodology, is gaining impetus. Production losses due to pests in India are around 33% and out of this weeds alone cause 37%. Thus, the productivity of many crops could be increased by using botanical herbicides that reduce these losses by managing weeds in an eco-friendly way. Field studies conducted since 2003 in India to evaluate the pre-emergence activities of various botanical herbicides revealed promising results. Especially extracts (3-5%) of *Tectona grandis, Calotropis procera, Ageratum conyzoides, Ocimum tenuiflorum, Physalis minima, Blumea lacera, Amaranthus tricolor, Parthenium hysterophorus* and *Calotropis gigantea* proved effective in several crops as compared to an untreated control, a weed free check and a synthetic herbicide. The botanicals showed a better weed management than the control with an 11-70% higher productivity in several crops. No crop phytotoxicity was observed from any of the botanicals used. The soil microflora population was also greater in botanicals than in herbicide treated plots. Presently, 10 more botanicals are under investigation of which root extracts of *Bambusa vulgaris* and leaf extracts of *Cucumis sativus* seem most promising. In conclusion, botanical herbicides provide a great prospect to reduce hand weeding and synthetic herbicides and to increase crop productivity by managing weeds without much disturbing biodiversity and the environment.
Keywords: System Intensification; Botanical herbicides; weed management

Detoxification of metolachlor in rice seedling using extracts from *Zanthoxylum bungeanum.*

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Herbicide safeners are chemicals that protect crop plants from unacceptable injury caused by herbicides. They fulfill an important role in crop protection. Chloroacetamide herbicides such as metolachlor are used worldwide. However, these herbicides can easily harm rice seedlings and seriously affect rice yield and quality. Using herbicide safeners is the most effective measure to resolve this issue. However, currently there are few safeners available for rice, and most of them are chemically synthesized posing new latent environmental risks. Botanical safeners have the advantages of high efficiency, low cost and being environmentally-friendly. Thus, developing botanical safeners is of great significance and urgency. *Zanthoxylum bungeanum* is a spicy plant that has been widely studied in medicine and as a food. However, it has only rarely been studied for use in agriculture, and there are no papers reporting its use as herbicide safener. For this reason, a detoxification experiment with extracts from *Z. bungeanum* was carried out at Hunan Agricultural University in 2011. The extracts were obtained via CO_2 supercritical fluid extraction. Direct-seeded rice seedlings at the one-leaf stage were treated either with metolachlor, metolachlor+femclorim, metolachlor+extract, or H_2O_{dd}. Plant height, root activity, and chlorophyll content were investigated five days after treatment, and the tiller number was assayed on the tenth day. The metolachlor treatment with the extract had a significant effect on rice plant height, root activity and tiller number compared to the metolachlor treatment alone. The extracts treatment resulted in 85.7% recovery of plant height and 89.3% recovery in root activity. Application of the botanical extract safener enhanced this recovery approximately 2-fold for plant height and 3-fold for root activity. However, there was no significant difference on chlorophyll content between the treatments. The results indicated that the *Z. bungeanum* extract has a more efficient effect on metolachlor detoxification in rice seedlings than femclorim.
Keywords: detoxification; metolachlor ;rice seedling; *Zanthoxylum bungeanum*;

Poster presentations

Screening and identification of insertion mutants from *Bipolaris eleusines* by mutagenesis based on restriction enzyme-mediated integration.

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Ophiobolin A is a sesterterpenoid-type phytotoxin and may be an important candidate for the development of a new crop-protection agent or a pharmaceutical product. The restriction enzyme-mediated integration (REMI) method was used to introduce the plasmid pSH75 into the ophiobolin A-producing filamentous fungus *Bipolaris eleusines* Alcorn & Shivas. A total of 323 stable transformants were obtained and all of them were capable of growing on a PDA medium containing 200 µg/ml hygromycin B. The transformation frequency was about 4-5 transformants/µg plasmid DNA. An ophibolin A-deficient transformant (B014) was assessed and the presence of hph gene in this transformant was confirmed by PCR. The cell-free cultural filtrates of this transformant showed significantly less inhibition on mycelial growth of the fungal pathogen Rhizoctoni solani but little effect on barnyard grass as opposed to that of the wild type B. eleusines. There was no detectable amount of ophiobolin A in B014 samples measured by HPLC. This research suggests REMI as a potential approach for improving the production of ophiobolin A by B. eleusines via genetic engineering to up-regulate certain genes responsible for desired biosynthetic pathways.
Keywords: Insertional mutagenesis;Ophiobolin A-deficient mutant;REMI;Transformation;

Allelopathy and allelopathic substances in red pine.

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The vegetation under red pine (Pinus densiflora L. Sieb. et Zucc) forests is sparse compared with some other forests which have dense undergrowths of herbaceous plants, even though sunlight intensity under the red pine forests is enough for these herbaceous plants to grow. One possible reason for the sparse forest floors may be a strong allelopathic activity of red pine. Many investigations

have been conducted to identify the allelochemicals in red pine. Several phenolic acids and their related compounds were isolated from pine needles, bark and the soil under pine trees as putative allelopathic substances. However, these compounds are universal in many plant species and their growth inhibitory activities were not sufficient to cause growth inhibition of herbaceous plants. Therefore, the allelopathy of pine forest cannot be distinguished from that of other plant forests based on these compounds. Aqueous methanol extracts of red pine needles inhibited the growth of roots and shoots of seven test plant species including weed speciesin a dose-dependent manner. The aqueous methanol extract of red pine needles was analyzed and two main inhibitory substances were isolated and determined by spectral data as 9α,13β-epidioxyabeit-8(14)en-18-oic acid and abscisic acid-β-D-glucopyranosyl ester (ABA-GE). The threshold of ABA-GE and 9α,13β-epidioxyabeit-8(14)en-18-oic acid for growth inhibition was 0.1 μM and 0.1 mM, respectively. The concentration ABA-GE and 9α,13β-epidioxyabeit-8(14)en-18-oic acid would be 2.5 μM and 0.13 mM, respectively, in soil water of the pine forest floors. Thus, the concentrations of both inhibitors in the soil water are over the threshold of the growth inhibition. Therefore, these substances may provide the competitive advantage for red pine through inhibition of the growth of other plants, and may be in part responsible for establishment of sparse forest floors of red pine.
Keywords: allelopathy; growth inhibitor;Pinaceae;pine forest;

Weed control efficiency of bioherbicides and their impact on grain yield of wheat (*Triticum aestivum* L.)

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Among non-chemical weed management techniques, the direct use of allelochemicals as natural herbicides is considered an option for weed suppression. To study the potential of allelopathic plants water extracts as a weed management tool in wheat, a field experiment was conducted during 2010 at Agricultural University Peshawar, Pakistan. Randomized Complete Block (RCB) design was used with split plot arrangement. There were two main plots (pre and post application) of plant water extracts and eight sub-plots containing different weed control techniques (i.e., sorghum extract, sunflower extract, parthenium extract, common reed extract, johnsongrass extract, rice straw extract, herbicide (Logran Extra)) and a weedy check. The results showed that pre-emergence application of plant water extracts proved to be superior to their post-emergence application in respect of weed control. Pre-emergence application of extracts of Phragmites australis and Helianthus annuus gave 68 and 65% weed control, respectively. Minimum fresh and dry weed biomass of 188 kg/ha and 94 kg/ha, respectively was recorded under the pre-emergence application of Phragmites australis. Sorghum extract treatment gave maximum grain yield of 5015 kg/ha in comparison to the weedy check that gave only 2701 kg/ha. Results suggest that Phragmites australis and Helianthus annuus could be successfully incorporated in weed management approaches in wheat.
Keywords: bioherbicides;plant extracts; pre-emergence;weed control; wheat;

Potential allelochemicals from *Sorghum halepense*.

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The potential allelochemicals of the exotic invasive weed, *Sorghum halepense*, were investigated. Fourteen metabolites belonging to flavonoids, phenolic acids, cyanogenic glycoside were obtained from the whole *S. halepense* plant. Structures were determined on the basis of their spectroscopic characteristics. Six isolated flavonoids and five isolated phenolic acids were first reported in *S. halepense*. All isolated compounds have been assayed on the dicotyledon *Lactuca sativa* (lettuce) and the monocotyledon *Triticum aestivum* (wheat) to test their stimulatory or inhibitory effects on seed germination and radical elongation. At a concentration of < 0.5 mM, ethyl p-hydroxybenzoate and dhurrin delayed the germination speed of the test species. Ethyl p-hydroxybenzoate demonstrated the strongest delaying effect among the phenols and a similar effect was found with apigenin among the flavonoids. In contrast, p-hydroxybenzaldehyde and luteolin had no effect on the germination at any concentration at any stage. The inhibitory activity of ethyl p-hydroxybenzoate and p-hydroxybenzaldehyde was greater than that of the other compounds. This is the first report of ethyl p-hydroxybenzoate being a potential allelochemical in *S. halepense*. The study suggests that the isolated phytotoxins might contribute to the invasion success of *S. halepense*. The temporal variation and ecological implication of these potential allelochemicals in *S. halepense* should be investigated further.
Keywords: allelopathy;allelochemicals;ethyl p-hydroxybenzoate;*Sorghum halepense*;

Iva xanthifolia seed extracts control germination and growth of plants.

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False ragweed (*Iva xanthifolia*) is an annual weed that causes serious problems in agronomical environments. It can produce a large number of seeds and spread rapidly. It is also reported to inhibit growth of plants in its surroundings. Bioassays and chemical analysis were used to study the allelopathic effect of False ragweed seed extracts on germination and growth of plants. False ragweed seed water extracts had different degrees of inhibition on many plants germination and growth. It was most active against the germination and growth of cucumber seeds, with a maximum inhibition rate of germination of 79.5%, and a maximum inhibition rate of root length of 87.9%. The IC_{50} of False ragweed seed water extracts on the germination of cucumber was 24.3 mg/mL, and on the root length was 11.0 mg/mL. After extraction and partitioning with petroleum ether, carbon tetrachloride, chloroform, methanol, the chloroform phase showed the strongest inhibition on cucumber. The IC_{50} of the chloroform phase on the germination and root length of cucumber were 5.1 mg/mL and 0.4 mg/mL, respectively. Further separation by high-speed countercurrent chromatography (HSCCC), yielded fractions containing phenols, amines, esters and organic acids that had a high allelopathic potential with IC_{50} on cucumber root length of 0.1 mg/mL. This was 100times greater than the original extract. False ragweed seed extracts showed strong allelopathic activity. It has the potential to the herbicides development. (Supported by Youth Science Foundation of Heilongjiang Province of China (QC2010123))
Keywords: False ragweed; germination; growth; inhibition; seed extracts;

Herbicidal activities of *Aralia armata* (Wall.) Seem. on five invasive weed species.

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The herbicidal activities of methanol extracts of *Aralia armata* (Wall.) Seem., were tested against the invasive weeds, *Mikaina micrantha, Bidens pilosa* Lin., *Conyza bonariensis* (L.) Cronq, *Pistia stratiotes* L. and *Alternanthera philoxcroides* (Mart.) Griseb. Preliminary studies showed that after 7 days, at a concentration of 5.0 mg/mL, the inhibition rates of *A. armata* extracts on the species tested were 79%, 81%, 88% and 100% respectively. Further studies showed that methanol extracts of *A. armata* exhibited significant inhibition activities on *P. stratiotes, C. bonariensis* and *B. pilosa* with IC_{50} values of 0.342, 0.409 and 0.697 mg/mL, respectively. Six chemicals, HF-a, HJ-b-a-I, HJ-b-b-I, HJ-b-a-II, HF-b-I, and HF-b-II were isolated from the stem of Aralia armata by silica gel column chromatography.
Keywords: *Aralia armata*;herbicidal activities;invasive weed;

Herbicidal activities and the active ingredient of *Torricellia tiliifolia* DC. against *Pistia stratiotes.*

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Methanol extracts of *Torricellia tiliifolia* DC. displayed distinct herbicidal activities against *Pistia stratiotes*, causing root rot and leaf chlorosis. Methanol extracts of stems of *T. tiliifolia* showed obvious activity, causing a corrected mortality of 922% on leaves of *P. stratiotes* with rotten and detached root at a concentration of 5000 μg/mL and 120 h after treatment. The corrected mortalities of leaves of *P. stratiotes* caused by the partition fractions of ethyl acetate, water and chloroform were 89%, 77% and 68%, respectively. Forty-one chemicals were isolated and identified from *T. tiliifolia* by HPLC, sephadex LH-20, 1H-NMR, 13C-NMR, DEPT, HMMC, HMQC, COSY, NOESY, MS and HRMS. Cleomiscosin C, cleomiscosin A and syringin exhibited herbicidal activities on *P. stratiotes*. At a concentration of 50 μg/mL and 120 h after the treatment, corrected mortalities of leaves of *P. stratiotes* were 812%for the three tested compounds, which is not different from that obtained with glyphosate. Moreover, these three compounds inhibited the growth of *P. stratiotes* and caused rotten root, chlorosis and dead leaves.
Keywords: Cleomiscosin;herbicidal activity;*Torricellia tiliifolia*;*Pistia stratiotes*;

Evaluation of the toxicity of the essential oil from citrus peel on weeds.

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In China, large amounts of citrus peel residues are produced during citrus postharvest and market circulation. In this study, the toxicity of the essential oil of citrus peel was investigated against seven weed species. The results showed that the essential oil at （5, 10, 25, 50 and 100 μl） demonstrated different degrees of inhibition on the germination rate of the weed species. At lower concentrations, the essential oil was ineffective in inhibiting germination of *Echinochloa crus-galli* (L.) Beauv., *Eclipta prostrata* (Linn.) Linn. and *Ceratium glomeratum*, but the germination rate of *Cyperus difformis* L., *Cyperus iria* L., *Amaranthus retroflexus* L. and *Polypogon fuga* X N. decreased between 75 to 100% compared to the control. The main component in the tested essential oil is d-limonene whose effect on *E. crus-galli* and *A. retroflexus* was also investigated: Soils treated with d-limonene (1.0×104, 2.5×104, 5.0×104, 1.0×105 and 5.0×105 ppm) were used to grow *E. crus-galli* and *A. retroflexus*, respectively. Results showed that the seedling growth was not significantly inhibited. However, when d-limonene was applied on leaves, most of them withered one day after the treatment, and the inhibitory effect increased with increasing concentration. After seven days, the inhibitory effect of low concentrations was reduced, but the inhibitory effect of high concentrations was maintained. When different concentrations of d-limonene were applied on medium grown plants of *E. crus-galli* and *A. retroflexus*, there was no inhibitory effect. In conclusion, the essential oil obtained from citrus peel was toxic to weeds. Further studies are now needed to investigate the mechanism of this toxic effect.
Keywords: Citrus peel;weed;essential oil;d-limonene;

Allelopathic effect of hairy vetch and red clover on weed control.

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Hairy vetch (*Vicia villosa* Roth.) and red clover (*Trifolium incarnatum* L.) can suppress the growth of other plants such as weeds because of a vigorous growth and allelopathic effects. Therefore, these plants are often used for weed control or as a cover crop. However, it is not clear to what extent allelopathic effects contribute to weed suppression. The objective of this study was to determine the allelopathic effect of these two species on lettuce growth. According to the sandwich method, the inhibition of radical growth of lettuce was 31% with red clover, 19% with hairy vetch, and 20% by Chinese milk vetch. Furthermore, dry weight of lettuce plants when grown in the same pot as the donor was only 3.8 mg with hairy vetch, 5.2 mg with red clover, 5.6 mg with Chinese milk vetch, while 6.8 mg in the control (lettuce only). On the other hand, under field conditions, there was no effect on weed

control when these plants were incorporated into the soil. Thus, results show that even though an allelopathic effect of red clover and hairy vetch was detected under controlled conditions, there was no effect in the field. Nevertheless, the nitrogen accumulation by incorporation of red clover and hairy vetch was 18.5 g/m² and 12.5 g/m² respectively, due to an active nitrogen fixation by the nodules. This indicates that hairy vetch and red clover are used as cover crops because of both, control of weeds and input of nitrogen.
Keywords: Allelopathy;Hairy vetch;*Vicia villosa*;Red clover ;*Trifolium incarnatum*;

A reliable bioassay methods for evaluation of the allelopathic potential of rice.

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Rice production has become highly dependent on herbicides. Allelopathy in rice may be one of the potential biological ways to manage weeds. Screening the allelopathic potential of rice varieties is the first step to identify elite rice genotypes with elevated levels of allelopathic activity. In this study, three bioassay methods such as the relay seeding on filter paper (RSF), the relay seeding in agar (RSA), and a rice root exudates bioassay (RE) were used to test and compare the allelopathic potential of nine rice lines on the target weed barnyardgrass (Echinochloa crus-galli). The three methods showed a similar tendency in evaluating the allelopathic potential of rice; however, there existed significant differences among the different bioassay methods and an interaction between bioassay method and rice lines. RE gave the highest suppression values and a correlation efficiency of 0.98 and was thus considered as an ideal bioassay method for the evaluation of the allelopathic potential.
Keywords: rice allelopathy; bioassay methods; comparison;

Allelopathic effects of aqueous distillation fractions from *Eucalyptus* species on silverleaf nightshade (*Solanum elaeagnifolium* Cav.) and their chemical composition.

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Field observations have identified that there is limited vegetation within the dripline of four *Eucalyptus* species: *E. salubris, E .dundasii, E. brockwayii* and *E. spathulata* in Australia. The phytotoxicity of essential oils from these four *Eucalyptus* species has been confirmed by our previous work (to be published). The aim of this study was to further assess the allelopathic potential of water soluble essential oils (in brief, soluble oils) on the important weeds, silverleaf nightshade (*Solanum elaeagnifolium* Cav.). The soluble oil is the aqueous fraction produced and collected during the distillation process. The fresh leaves of the four *Eucalyptus* species mentioned above were used for the extraction of soluble oils and seeds of silverleaf nightshade were used for the bioassays. Secondly, the chemical compositions of the soluble oils from the four *Eucalyptus* species were determined by GC-MS. Our results showed that the soluble oils had strong inhibition on the germination and seedling growth of silverleaf nightshade. The inhibition index increased with the increased concentrations of soluble oils. The inhibitory effect varied between the soluble oils of different *Eucalyptus* species. The soluble oils from *E. salubris* demonstrated the highest inhibitory activity on the weed tested, with 100% of germination inhibition and seedling growth inhibition. The GC-MS analysis revealed that the main compounds, such as 1,8-cineole, trans-pinocarveol, pinocarvone and globulol, in the soluble oils also can be found in the corresponding essential oils (water insoluble fractions), indicating that the soluble oils from eucalyptus leaves may contribute to the field allelopathic effect observed on weeds.
Keywords: allelopathy; chemical composition; *Eucalyptus*; silverleaf nightshade; weeds;

Invasive species

Oral presentations

A multi-forked approach to understand plant invasions: combining historical records, niche-modeling and experimental studies.

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Biological invasions still remain an enigma to ecologists and evolutionary biologists. We will present a holistic approach to better understand invasions by combining (i) historical data to reconstruct the spatio-temporal invasion routes, (ii) niche modeling to follow potential changes in niche limits across these invasion routes, and (iii) experimental data on performance of the invader across multiple environments and for populations from both the native and introduced range. We will illustrate this for the European native and highly invasive Centaurea stoebe (Asteraceae), which experienced an exceptionally high shift in cytotype frequency and climatic niche during its invasion into North America. Both diploid (EU2x) and tetraploid (EU4x) cytotypes occur in Europe, but only tetraploids have been recorded so far in North America (NA4x). In EU, the 4x cytotype expanded its range from SE towards N and W, mainly facilitated by disturbance, but niche limits of both cytotypes remained fairly stable. In NA, we identified two focal introduction points both around 1890, one in the pacific North West (SW Canada) and one at the Atlantic coast (NY). Niche limits changed only little during the invasion in the East, but they largely expanded in the West, being more pronounced in disturbed habitats. In the talk, main emphasis will be given to disentangle pre-adaptation (through differences in traits and plasticity of EU2x vs. EU4x) from post introduction evolution (EU4x vs. NA4x) to explain differences in the spatio-temporal dynamics of the observed range expansions and invasion routes, using our extensive experimental data. We will conclude by outlining the strengths and limitations of this novel multi-forked approach and advocate its broader use for other study systems.
Keywords: cytotypes;polyploidiy;niche modelling;experiments;Centaurea;

Invasion by Canada goldenrod (*Solidago canadensis*) has dramatic negative impacts on community structure.

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Invasive species have been shown to decrease local species diversity. However, few studies have compared the community impacts of invasive plants in both their native and invasive ranges. Studying invasive species in both their native and introduced ranges is critical to understanding the underlying mechanisms of successful invasions and the long-term succession of the invaded community. *Solidago canadensis* L. is one of the most troublesome terrestrial invasive weed species in China. We compared *S. canadensis* dominant communities with control sites (adjacent to *S. canadensis* populations but without the species) in both the invasive range (China) and native range (USA). *Solidago canadensis* had a significant negative effect on a variety of measures of community structure: in the invasive range, we found species richness decreased by 50%, evenness decreased by 43%, phylogenetic diversity decreased by 27%, and α-diversity decreased by 45%. Furthermore, there was a significant negative correlation between the numerical abundance of S. canadensis and species richness, evenness, phylogenetic diversity and α-diversity of the community. Surprisingly, in its native range, S. canadensis also decreased species richness, evenness, phylogenetic diversity and α-diversity by 14%, 29%, 14% and 42%, respectively, but any correlations between the numerical abundance of goldenrod and these community measures were either not significant or lesser in magnitude compared to the invasive range.
Keywords: control site;field survey;native / invasive range;species assemblage;alien weed;

Adaptive plasticity of plant traits to various resource supply and competition is related with common ragweed (*Ambrosia artemisiifolia* L.) successful invasion.

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Besides being a weed in various cropping systems, common ragweed is also considered a major allergenic plant due to production of pollen, which causes severe health problems in humans. Causes of invasiveness of alien plant species are an important research topic in plant ecology and of considerable applied relevance. It is very likely that functional traits of plant species, such as the ones related to physiology, biomass allocation, growth rate, size and fitness, promote invasiveness, but progress in the search for traits underlying ragweed invasion has been slow. Series of field and pot experiments have been conducted over the years 2009-2011 in the USA and Slovenia focused on the plant traits response to competition and resource availability, which could explain ragweed invasion success. The ragweed biomass allocation to the shoots in response to the N supply displayed a high plasticity in contrast to the roots which displayed low plasticity. Addition of N resulted in limited effect on leaf and stem partitioning. Similarly, root dry matter production was not affected with N addition. N level influenced the vertical leaf, stem and total dry matter distribution with a greater allocation to the top stratus of the ragweed plants. Under high intraspecific competition ragweed displayed a stronger aboveground than

belowground intensity of competition, compared to low-density stands. Ragweed resource-use traits exhibited high adaptation to unproductive sites, however more plastic response to water availability compared to N availability was observed. Ragweed response to competition with Lolium multiflorum L. suggested that ragweed is a poor competitor when there is high resource availability; however in the shortage of nutrients and water, the intensity of interspecific comp
Keywords: common ragweed;plant traits;competition;resource availability;adaptive plasticity;

High per-capita effect of a plant invader on its neighbours away but plant size matters at home.

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Impact of exotic plant invaders can be driven by either resource competition reflecting biomass and demography, or by interference competition associated with a per capita effect, such as through allelopathy. We aimed at identifying the type of impact of the invasive plant Centaurea stoebe in its native European range as compared to its introduced North American range by growing it in pairs with either 15 European or 15 North American neighbours. Interestingly, old co-evolved neighbours responded to C. stoebe size, while new "naïve" neighbours simply responded to the presence or absence of C. stoebe. Moreover, the biomass of both European and North American C. stoebe plants decreased with increasing biomass of European neighbours, but was not affected when growing with North American neighbours. Our results indicate that inherently high per-capita effects of C. stoebe may contribute to their invasion success neighbours in North America. Thus, control management reducing the density of an exotic invader may not result in vegetation recovery, as it is expected to happen in the native range.
Keywords: per-capita effect;impact of plant invader;biogeography;C. stoebe;competition;

The sustainable management of parthenium weed (*Parthenium hysterophorus* L.) under a changing climate.

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Parthenium weed (*Parthenium hysterophorus* L.) is a weed of global significance and has become a major weed in Australia as well as in many other countries of the world. No single method alone has proven effective in its management. Studies have revealed that the plant owes its success, in part, to the very high output of viable seed which is maximized under warm (28-35°C) and wet (field capacity) soil conditions (c. 20,000 per plant). Cooler conditions, however, (18-25°C) lead to lower seed production given the reduced rates of seed formation and fill. Very large soil seed banks can build up in infested pastures (c. 5,000 to 30,000 viable seeds m-2) and current management options do not seem to be able to reduce them below a threshold of c. 5,000 viable seeds m-2. Even when parthenium weed is present at low densities (two plants m-2) there is a significant negative effect upon plant community biodiversity. Moreover, the large number of viable seeds found in roadside vehicle wash-down facilities shows that parthenium weed is effectively spreading through the attachment of seed to vehicles. CLIMEX mapping is being used to monitor spread and predict future areas that may be at risk. On-going work is being conducted on the genetic make-up of parthenium weed populations around the world, their likely susceptibility to biological control, and their mode of spread. New management options may include sowing desirable suppressive pasture species into infested land. Such species have proven to work well with the already released biological control agents, and together form a management strategy that can reduce parthenium weed biomass by 47 % and decrease seed production to nearly zero. However, climate change studies indicated that this management option may be reduced in its effectiveness in the future with a rise in the atmospheric CO_2 concentration.
Keywords: biological control; *Parthenium hysterophorus*; seed production; suppressive species; climate change;

The current and potential geographic distribution of parthenium weed in Pakistan.

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Parthenium hysterophorus L., commonly known as parthenium weed, is an invasive weed of global significance that has become a major weed in Pakistan and many other parts of the world. In Pakistan, this weed threatens natural and agro-ecosystems of the northern Punjab and many parts of the Khyber Pukhtunkhwa Province. Earlier studies conducted before 2000 indicated that parthenium weed is present only in the northern districts of the Punjab. However, a recent survey in 2010 showed that this weed is rapidly spreading from the northern to the southern districts of the Punjab Province including Okara, Pakpattan, Sahiwal, Khanewal, Multan and Bahawalpur districts. The current distribution of the weed in Pakistan lies well within the projection of a CLIMEX predictive model developed for the species. The model indicated that there are many more areas within Pakistan that are suitable for parthenium weed growth, both under present and future climate scenarios. When an irrigation scenario was added into the CLIMEX program, more parts of the southern districts of Pakistan (Indus river basin) became suitable for parthenium weed growth. In Pakistan, the parthenium weed has not reached its full potential range and is likely to undergo range expansion and likely to become more widespread in the future.
Keywords: Parthenium weed;Pakistan;potential distribution;CLIMEX;climate change ;

Assessment of potential invasive of biofuel crops proposed in Beijing using the Australia Weed Risk Assessment.

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Bioenergy crops are developed rapidly in China. As desirable traits for bioenergy plants overlap with those of invasive species, it is necessary to assess potential risk of promising bioenergy plants that might become invasive. Ten taxa under exploration as biofuel crop in Beijing region were evaluated for potential invasiveness using the Australian Week Risk Assessment system (WRA) for the first screening, then those taxa with scores 1-6 were further evaluated by a secondary screening tool. Helianthus tuberosus, Miscanthus floridulus, Panicum virgatum and Phalaris aruadinama were found to have a high probability of becoming invasive. Around donax, Miscanthus giganteus , Miscanthus purpurascens, Sorghum bicolor (sweet), Pennisetum purpureum and Triarrhena lutarioriparia have a low probability of becoming invasive, and can be cultivated as bioenergy crops.
Keywords: biofuel crop;weed risk assessment;potential invasive;

Potential geographical distribution of *Avena sterilis L.* in Europe.

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Global climate change is a major concern for the future sustainability of our development. There will be large alterations over the global ecosystems, where predictions indicate a reduction around 10-20% of world agrosystems production. Climate change might have a deep effect on crop protection. Especially affected would be the weed flora, altering the competitive interaction crop-weed, impacting on weed biodiversity and on weed geographic distribution. *Avena sterilis* L. (sterile oat) is one of the most extended and harmful specie in Mediterranean climate. The emergence of sterile oat is very dependent of temperature and rainfall. Therefore, it is very likely that geographic distribution of A. sterilis might be affected by climate change. The objective of this study was to simulate the effect of various climate change scenarios. A specie niche model for A. sterilis was developed using CLIMEX. The model calibration was done with eco-physiological data from the literature and was validated with independent data worldwide. Two contrasting climate scenarios were used to project the potential distribution of A. sterilis in Europe under future climate: A2 representing a low-emission scenario and B2 a high-emission scenario. Under both future climate change scenarios, the range of suitable climate for sterile oat in Europe is projected to extend further from Mediterranean regions northward in Scandinavia, Ireland and England and eastward into east Europe (balcanians countries). In contrary, countries in the Mediterranean area, from Portugal to Greece will become unsuitable under the low-emission scenario (B2 scenario) and mostly unsuitable for persistence under the high-emission scenario (A2 scenario).
Keywords: cereals;Climate Change;CLIMEX;

MaxEnt-based prediction of potential distribution area of *Mimosa pigra* in China.

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Mimosa pigra L. (Mimosoideae), a woody shrub native to tropical America from Mexico to Argentina, is now widespread throughout tropical wetlands in the world, especially in Australia and South East Asia. It is a highly invasive and damaging weed and forms impenetrable near mono-specific thickets, which have caused greatly reduced biodiversity. This weed competes with pastures, hinders mustering of livestock, posing a threat to the pastoral and tourism industries. The climate in South China is similar to that in South East Asia. Hence, there is the risk of M. pigra invasion in China. But the potential distribution area of M. pigra in China is unknown to date. In this study, we predict the potential distribution area of M. pigra in China using the MaxEnt model, with temperature and precipitation as environment variables (including Bio1, Bio4-7, Bio10-17; Tmin1-12; Tmax1-12; Prec1-12). A total of 901 samples for distribution data of M. pigra downloaded from the web of Global Biodiversity Information Facility (GBIF) were used for this study. Our results show that the potential distribution area of M. pigra in China includes Taiwan, Guangdong, Guangxi, Hainan, Yunnan, Sichuan, and Tibet provinces. The proportion of potential distribution area in Hainan is the largest (99.94%), followed by Taiwan (70.08%) and Yunnan (24.51%).Highly suitable areas are mainly in Hainan, Taiwan and Yunnan provinces. At present, the weed has not been found in mainland China, but it has invaded Taiwan. Therefore, effective measures should be taken to prevent Mimosa pigra from invading mainland China.
Keywords: MaxEnt;Mimosa pigra;potential distribution area;prediction;

Preliminary study on a potential biological control agent of Canada thistle, *Cirsium arvense*.

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Cirsium arvense (L.) Scop. (Asteraceae), originating in Europe and Asia, is a widespread perennial weed of arable crops and grasslands in the temperate zones of both the northern and southern hemispheres. It is a particularly troublesome and noxious weed in North America. Six insect natural enemies were studied as biological control agents and released in North America and several other natural enemies were introduced accidentally. Thus far, however, none have been able to halt the spread or reduce the impact of Canada thistle in North America. There are many examples of coevolved pathogens having a narrower host range than insects. Indeed, intra-species specificity is common with rust pathogens. Since host specificity is the main hurdle to implementing biological

control of *C. arvense* in North America, it was decided to concentrate on coevolved fungal pathogens during renewed foreign exploration. Since the Asian range of the weed has had relatively little attention, surveys for fungal pathogens were conducted in Inner Mongolia and Xinjiang and Gansu provinces in China between 2009 and 2011. The most promising pathogen for classical biological control of Canada thistle collected during these surveys is a species of white blister 'rust', *Pustula* (*Albugo*) (Albuginales, Oomycetes), which was found attacking leaves, stems and inflorescences at nine field sites out of 37 both in Xinjiang and Gansu. The fungus was recorded as *Albugo tragopogonis* from *C. arvense* in both western Europe and North America, but it is rare, certainly in the UK according to Herb IMI/Kew records. Comparing the results of surveys in 2010 and 2011 in Xinjiang and Gansu, we found that the prevalence and outbreak of this 'rust' might have a close relationship to rainfall. In 2011, spore germination and preliminary inoculation tests of this 'rust' have been conducted but the results were negative.
Keywords: *Cirsium arvense*; natural enemies; fungal pathogens; *Albugo tragopogonis*; biological control;

Reproductive capacity and seed germination characteristics of *Parthenium hysterophorus* L.

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Parthenium hysterophorus is an alien weed with strong invasiveness and spreading rapidly in southern China, and Junan in Shandong province. The successful invasion of this weed might be related to its reproductive traits and strong adaptability of seed germination to environmental conditions. We studied the reproductive capacity and seed germination characteristics of *P. hysterophorus* in greenhouse and laboratory experiments. The results showed that *P. hysterophorus* could reproduce clonally mainly through stems. However, its sexual reproductive capacity was much stronger. A single mature plant could produce approximate 10 thousands of seeds. Seed germination of *P. hysterophorus* was affected by environment factors. Acidic conditions could accelerate its seed germination, and it was the best when pH was 6. It did not require any additional nutrition and P contention for germination, but the percentage of germination was significantly decreased as the salt concentration increase. The germination could be inhibited by the buried treatment and no seedling emerged when seeds were planted 2.0 cm deep.
Keywords: *Parthenium hysterophorus*;reproductive capacity;seed germination;

Seed anatomical morphology of exotic invasive plant: *Solanum rostratum*.

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Solanum rostratum Dunal, an invasive species, caused significant damage to natural ecosystem, agricultural production and human health in many countries. Seed and fruit structure of *S. rostratum* was examined by SEM and stereomicroscope. The anatomical microstructure and ontogenetic of the seed were studied. Two different kinds of ultrastructures were found on the surface of testa, differing in arrangements of fingerlike projections and the number of tilted holes. These structures may be related to its wide adaption to various environments. Knowledge obtained in this study would provide useful information in classifying *Solanum* species and understanding its distribution.
Keywords: *Solanum rostratum*;seed;morphology;anatomy;ultrastructure;

The research between *Mikania micrantha* and *Macaranga tanarius*.

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Mikania micrantha kunth is an exotic weed species, which is an extremely fast growing, sprawling vine. Now it widely spreads in China, especially in Guangdong province. We focus on several ways to control it, but there are serious disadvantages existing in the ways except ecological control, which can control *Mikania micrantha* and finally kill it. During the research about ecological control we found a fact outdoors that *Mikania micrantha* could not cover *Macaranga tanarius*, or could not grow well under the trees, some even die. I do not know whether it is natural or made by people. So I did experiments to test it. I had three experiments, called experiment A,B,C, each experiment repeated 6 times. In experiment A, there were 4 *Mikania micrantha* around the *Macaranga tanarius , which was planted in the middle of the flowerpot with the fixed size. They were watered two times every day, and the sunshine* was enough. In B, there were 6 *Mikania micrantha*, in C, 8 *Mikania micrantha*. Other factors were the same. The result was that *Mikania micrantha* could not cover *Macaranga tanarius*, and the growth conditions of *Macaranga tanarius* in these three experiments were not significant. The following step is to find out why.
Keywords: *Macaranga tanarius*;*Mikania micrantha*;

The Permitted List approach for plant imports –it works for Western Australia.

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After some high-profile weed incursions due to species not being named on a Prohibited List, Western Australia switched to a Permitted List approach to new plant imports in 1997. Western Australia now has some 47 000 Permitted species, 66 species that are restricted in some way, and 832 species that are Prohibited entry to the State. A comprehensive database is maintained to assist with assessing plant species and dealing with enquiries from quarantine officers and plant importers. The presentation will give more comprehensive statistics and information about weed risk assessments.
Keywords: quarantine;weed risk assessment;Permitted list;Prohibited list;

Poster presentations

The enemy release and EICA hypothesis revisited: the fundamental difference between specialist and generalist herbivores.

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The success of invasive plants has been attributed to their escape from natural enemies and subsequent evolutionary change in allocation from defence to growth and reproduction. When we test the ERH and EICA hypothesis, it is necessary to incorporate the fundamental difference between specialist (feeding on one or a few closely related plant species) and generalist (feeding on several non-related plant species) herbivores. We predict that plants introduced into areas where their specialist herbivores are absent but generalist herbivores are present, may evolve decreased defences against specialist herbivores and increased defences against generalist herbivores. We tested these predictions by common garden experiments in China in which alligatorweed (Alternanthera philoxeroides) plants from the native (Argentina) or introduced (USA) range were grown. We tested whether there are defense syndromes (e.g., plants have traits against herbivory that may occur together and increase defense efficiency) between native and introduced populations by measuring several traits related to defense. We tested the correlation between all pairs of traits and grouped the populations into defense syndromes according to their traits. We found two distinctive syndromes between Argentina and USA populations: invasive USA populations showed higher defense traits to their specialists and lower traits against their generalists than native Argentina populations. Meanwhile, no significant changes in allocation from defense to growth or reproduction were observed in our study. Hence, the absence of specialist herbivores in invasive populations resulted in the evolution of lower defense against specialists and higher defense against generalist herbivores, but not increased growth and reproduction.
Keywords: biological invasion;defence;generalist/ specialist trade-off;herbivory;stem diameter;

Case studies – cordgrass (*Spartina alterniflora*) control domenstration at Ningde, Fujian, China.

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In order to reduce the loss caused by Spartina alterniflora. The Fujian provincial government developed some regional projects to eliminate cordgrass in a safe way since 2006. Until 2009, 4 effective methods were developed, and the demonstrations were started since 2009 in Fujian coast. The main results and findings are as follows: 1) From 2009 till 2011, more than 20 ha. cordgrass was controlled by belowground (-10cm) cutting at Er'du, Ningde. In this study, only once belowground cutting result in more than 99% control rate. The cost of this method by manual work is around 12,000 RMB ha-1. 2) From 2010 till 2011, more than 40 ha. cordgrass was controlled by cutting aboveaground plus the role of Littorina irrorata at Er'du. In this case, only 2-3 times aboveground cutting was needed under the pressure of this bio-control agent. The cost by manual work is around 9,000 RMB ha-1. But the precondition is the necessary population density of snail, and only in the summer time could result in satisfied results. 3) From 2010 till 2011, more than 40 ha. cordgrass in Xiapu county was controlled by 75% Sulfometuron Methyl WP. The herbicide was mixed with sand before implication, and the dosage is 10,125g a. i. ha-1for once application, and the cost is around 4,500 RMB ha-1. This herbicide is friendly to non-target animals, while is not safe to mangrove and algae. 4) Demonstration of 10.8% haloxyfop-R-methyl EC was conducted as the same as Sulfometuron Methyl. The dosage is 32.4g a. i. ha-1, and the cost is around 3,450 RMB ha-1. This herbicide is friendly to mangrove, while not safe to non-target animals. Conclusion can be made that each method has its advantage and shortage, users can choose one depend on the application conditions and restriction factors.
Keywords: Domenstration;Control;Spartina alterniflora;Cutting;Chemical;

Assessment of common cocklebur (*Xanthium strumarium* L.) fitness. c

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Fitness investigation is important for the estimation of survival, reproduction and spread of invasive weed species in an ecosystem. Significance of *Xanthium strumarium* L. as invasive weed in row crops is increasing across the Balkan Peninsula and its widespread all over Serbia, especially in the northern and central parts of the country. The main objective of this study was to assess fitness of this species under field conditions, depending on the application of nicosulfuron. The experiment was conducted near Belgrade in 2008 and 2009 on alluvial black marsh soil. Two populations of *X. strumarium* (XS-P1 and XS-P2) were sown in containers and transplanted to the field when the first pair of leaves developed. Experimental design was a completely randomized block design with four replications. Plot size was 5×4.2 m (21 m2). Interrow spacing was 24 cm and the distance between rows 70 cm. Plants were treated with nicosulfuron in two pairs of leaves. Nicosulfuron (Motivell, 40 g a.i.L-1, SC, BASF, Germany) was applied in the amounts of 0 (control), 10, 20, 40, 60 and 80 g a.i.ha-1. Vegetative parameters (plant height, fresh weight and leaf area) and relative chlorophyll content were measured just before herbicide application and 14, 30, 47 and 63 days after herbicide treatment (DAT) in 2008 and 16, 33, 48, 64 DAT in 2009. After the maturity burs production (burs weight plant-1 and burs number plant-1) was measured. In general, fitness of *X. strumarium* populations depended on the year in which the sampling was conducted and was

better for population XS-P1 vs. XS-P2 under conditions without nicosulfuron. Opposite results were obtained when nicosulfuron was applied. Therefore, nicosulfuron was found to have a great impact on *X. strumarium* fitness. Based on these results a strategy for the prevention of spread of this weed species can be developed.
Keywords: common cocklebur ;fitness;vegetative parameters;relative chlorophyll content ;burs production ;

Survey on alien invasive weeds in farmlands in Hubei Province, China.

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Abstract: 1. Rationale for research: there is a lack of information about the occurrence of alien invasive weed species in Hubei Province, China. 2. Objectives: to clarify the alien invasive weed species, its occurrence frequency and harm to crops in farmlands and to provide basic data for future survey. 3. A brief description of methods and materials used: alien invasive weeds in 1010 fields whose area was more than 1000 m2 were surveyed with seven scales by visualization of weed dominance to crop in 2007. 4. Results: in wheat fields, there were 11 alien invasive weed species, accounting for 23.40% of the total weed species, among which, Avena fatua, Veronica persica, Brassica juncea var. gracilis and Geranium carolinianum were the worse weeds. In oilseed rape fields, there were 15 alien invasive weed species, accounting for 14.02% of the total weed species, in which, A. fatua and V persica ranked top 2 of 11 worst weeds. In paddy fields, the only invasive weed Alternanthera philoxeroides has become main weed with its occurrence frequency of 61.60%. In cotton fields, there were 15 alien invasive weed species, accounting for 17.24% of the total weed species, in which, Amaranthus retroflexus, Eleusine indica and Euphorbia maculate were the worse weeds. 5. Conclusions: there were 23 alien invasive weed species in wheat, oilseed rape, rice paddy and cotton fields in Hubei Province, which belonging to Asteraceae (8), Poaceae (2), Amaranthaceae (2), Euphorbiaceae (2), Solanaceae(1), Phytolaccaceae(1), Leguminosae (1), Umbelliferae (1), Brassicaceae (1), Geraniaceae (1), Malvaceae (1), Plantaginaceae (1) and Scrophulariaceae (1).
Keywords: Hubei Province;armland;alien invasive weed;

***Ambrosia* spp. - An allergenic invasive plant in Israel.**

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The genus Ambrosia (Ragweed) is a member of the Asteraceae family and includes over 40 species. The Ambrosia grows in temperate regions with a continental climate, it originates from north-America, spreading to Europe, Asia and Australia. In recent years Ambrosia spp. invaded vast areas in Israel. The most common species in Israel is Ambrosia confertiflora which is frequently found in the "Hefer" Valley, spreading all over the country. Another species growing in Israel is Ambrosia tenuifolia, with a far less spread. Contrary to the species (A. trifida and A. artemisiifolia) growing in North America and Europe which are annual, the species growing in Israel are perennial plants. The annual species were observed several times in Israel but failed to gain a continuous establishment. The Ambrosia spp. plants growing in North America and Europe are well known for their high allergic effects, impacting over 15 million people in the USA. The Ambrosia pollen allergenic effects increase with exposure. Global warming enables the plants to extend and enlarge their distribution and lengthen their flowering time, producing much larger amounts of highly allergenic pollen. It is still unclear if the species growing in Israel are allergenic as well: it is one of the research questions which we try to answer. Additional aims are identification and mapping the distribution of Ambrosia spp. in Israel as well as recording their response to herbicides. Our presentation will demonstrate the current distribution of Ambrosia in Israel, the human allergic reaction to pollen extracts and a comparison of sensitivity to different Ambrosia species. It appears that the invasion paths of the Ambrosia spp. in Israel were via imported seed shipments, spread along streams, rivers and railway tracks and by the movement of contaminated soil (containing vegetative organs). The spread of the Ambrosia spp. is very fast and threats biodiversity and crop safety. It produces large amounts of seeds and spreads also by rhizomes. Our experiment showed that a single pot (10 L) of dry soil taken from the vicinity of wild plants grew into 50 mature plants within just one month, later growing more than 670 shoots during 5 months.
Keywords: Human Allergic;Herbicide;Pollen allergenic effect;Invasion path;Ambrosia;

Distribution survey and risk assessment of *Oxalis latifolia* Kunth in Yunnan of China.

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Biological invasions challenge the socioeconomic and ecosystems worldwide．Thus，Distribution Survey and risk assessments of alien species are extraordinarily important．*Oxalis latifolia* Kunth is a worldwide invasive weed with powerful abilities to reproduce and adapt to different environmental conditions．Currently，this species has occurred incidentally in Yunnan Province with several small patches．Due to the climate and environment in Yunnan Province, which just favors the propagation of *Oxalis latifolia* Kunth, Distribution Survey and Risk Assessment of this weed are necessary. Although this weed was first found in Kunming, its distribution area has extended to central Yunnan Province, including Kunming, Chuxiong and Yuxi State at present. *Oxalis latifolia* Kunth has spread to out-Yunnan. Because of its biological and ecological traits and the difficulty to control，we assessed the invasive risk of this invasive weed by quantitative assessment method．Seven first-class grade indices and 14 second-class grade indices are used for the assessment with full marks of 100．And the risk score of the invasive species is as high as 73，which suggests a high

invasiveness and risk．Therefore，full attention should be paid to the invasion of *Oxalis latifolia* Kunth in order to avoid its outbreak in Yunnan Province．
Keywords: *Oxalis latifolia* Kunth;biological invasion;Yunnan;distribution survey;risk assessment;

Effects of *Oxalis latifolia* Kunth on plant community and physical-chemical properties of soil.

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Oxalis latifolia Kunth，indigenous to South America，is one species of Oxalidaceae．It was first discovered in China in 2011．It widely spreads in Kunming Yunnan China. Soliva anthemifolia is regarded as one of the regional adventitious noxious weeds．It has been listed as one of the main exotic weeds and important alien invasive species in China by National Quality Supervision Inspects Quarantine General Bureau．The effects of *Oxalis latifolia* Kunth on plant community and physical—chemical properties of soil in its habitat were studied through the survey of communitv plots and laboratory analysis．The results showed that the invasion of *Oxalis latifolia* Kunth changed the structure of plant community Significantly and decreased the plant diversity．Meanwhile，it increased pH value and soil water，while had no obvious effects on the contents of organic matter and alkali—hy— drolyzable nitrogen．Nutrition contents in soil increased after the invasion, which could favor the growth of *Oxalis latifolia* Kunth．
Keywords: invasive weed;*Oxalis latifolia* Kunth;plant community;physical—chemical properties of soil;habitat;

Competition of Thai water clover and aliens water clover.

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The study on competition of two native Marsilea, Glossy Leaf Water Clover, Glossy Leaf WC, (Marsilea scalaripes D.M. Johnson) and Water Clover (Marsilea crenata C. Presl) with two introduced Australian native Marsileas, Commn Nardoo (*Marsilea drummondii* A.Braun) and Banded Nardoo (*Marislea mutica* Mett.) was aimed at determining the ability of Thai water clover to compete against alien Nardoos. The experiment was done by replacing or substation method with fixed population in pots for 6 weeks. The Glossy Leaf Water Clover show the lowest competition ability, can compete with the two alien Nardoos only if the populations of the aliens are lower. The habit of small leaf area, short petiole and less branching of Glossy Leaf WC, comparing with the other, may effect long term competition. The Water Clover which has some advantageous characteristics such as fast growth, the longest shoot length of the four species, high leaf number and branches, can compete with the other 3 species. Moreover the plant shows higher growth in interspecific competition than that of intraspecific competition.
Keywords: water clover;common Nardoo;Banded Nardoo;native water clover;alien ornamental plant;

Take strict precautions against alien weed invasion.

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According to statistics, China's soybean trade accounts for more than half of the world. And the soybean imported increased continuously over the past few years.Quarantine officers found, each ship soybeans can be detected more than 40 kinds of weeds, including at least more than 4 kinds of quarantine. Calculated in accordance with the relevant statistical data, per ship (66,000 tons) soybeans imported from U.S. and Brazil can be detected about 132 tons of weeds, and 13 tons from Argentina. So it is very difficult to quarantine and supervision work .To analyze the potential geographical distribution and the risk assessment of invasion & establish for the weeds intercepted in imported soybeans, has an important role in quarantine and supervision work.
Keywords: soybean;alien weed;quarantine;supervision;

Range expansion of hybrids between two ecotypes of cogongrass (*Imperata cylindrica* (L.) Beauv.) in northern Japan.

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Cogongrass (*Imperata cylindrica*) is an invasive perennial grass widely distributed in the world. Two ecotypes (common ecotype (C-type) and early flowering ecotype (E-type)) are found in Japan. The C-type is common in south-western parts of Japan and an invasive weed there, whereas the E-type is distributed sporadically including northern parts of Japan. Recent global warming is likely to result in the range expansion of C-type in northern parts of Japan, and the putative hybrids between two ecotypes have been observed in the region. The present range of two ecotypes in northern parts of Japan was compared with that in 1980's. The natural hybridization between two ecotypes was clarified using nuclear and chloroplast DNA marker. Through artificial crossing between two ecotypes, reproductive strategy of this weed is also clarified. C-type did not expand its range, but hybrids between two types expanded in northern parts of Japan. Range expansion of cogongrass through hybridization resulted from global warming will be discussed.
Keywords: Global warming;hybridization;Imperata cylindrica;range expansion;cogongrass;

Survey on quarantine alien anvasive weed *Solanum carolinense* L. in different ecosystems of Tamil Nadu.

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A survey of weed flora in different ecosystems (i.e. cropped, non-cropped, waste disposal and derelict areas) during kharif and rabi seasons (2008 to 2010) was conducted in eigth districts of Tamil Nadu. The focus of the weed survey was to detect new invasive weeds and increase the preparedness for exotic weeds invasions. Solanum carolinense L., a listed, quarntine weed, was observed in 88 places of different survey spots in eight districts; viz., Coimbatore, Salem, Dharmapuri, Krishnagiri, Dindugal, Nilgiris, Erode and Vellore of Tamil nadu. Plants found during the survey were about one meter tall, armed, with small spines. Solanum carolinense L., stems were erect and possessed stellate hairs, greenish to purple in color. Leaves were alternate, typically lance-ovate, lobed, with spines on midrib and veins. The inflorescence, an axiliary raceme with branches, had compact clusters of flowers. The flowers of Solanum carolinense were five lobed and corolla was white to lilac or purple in colour. The flower had stellate pubescence externally and was glabrous internally. It contained five stamens filaments, which were yellowish green in colour. Stigma was dark in colour and the superior ovary was glandular, pubescent and whitish in colour. The deeply lobed calyx (five lobes) and tube was purple green in colour. The immature fruit was green in colour, turning orange and yellow. The fruit, a single, globular berry, contained 120 to 240 seeds. Seeds were flattened, roundest with a peak yellowish to orange brown. The semi hard, woody stem had hairs and thorns all over the plant, making it difficult for farmers to remove the plant manually.
Keywords: Survey;Solanum carolinense;Incidence;Ecosystems;Alien Invasive Weed;

Effects of gibberellin (GA_3) on growth regulation and cutting-based control of smooth cord grass, *Spartina alterniflora*.

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In order to make clear the growth regulation of cordgrass (*Spartina alterniflora*), and to develop a better way to control this invasive weed. The effect of gibberellin (GA_3) on the growth of cordgrass, and the combination of cutting aboveground with GA_3 was studied at Ningde, China in 2009. The main results and findings are as follow: Effects of GA_3 on the growth and development of Spartina. In this study, the sensitivity of cordgrass to GA_3, and the effects of GA_3 on the growth of cordgrass were depending on the season: After treated with 1,000 mg/L GA_3 in March, the density and the number of tiller are significantly higher ($P<0.05$), and the soluble saccharide content of rhizome was significantly lower than control ($P<0.05$). After treated with 1,000 mg/L GA_3 in August, and 500 mg/L or 1,000 mg/L GA_3 in September, the seed production was significantly higher than control ($P<0.05$). After treated with 500 mg/L or 1000mg/L GA_3 in May, the height of plant was significantly higher ($P<0.05$), but the density, tiller number, soluble saccharide content of rhizome, spike number, and seed production were significantly lower than control($P<0.05$). In addition, 32.25% plant exhibited lodging after treated by 1,000mg/L GA_3 in May. Effects of GA_3 on cutting-base control of Spartina In May, the cordgrass was firstly treated with 500 mg/L or 1,000 mg/L GA_3 and then cut above ground after 15 d, 30 d and 45 d. The control efficiency of cutting was significantly improved in the experimental groups of cutting after 30 d and 45 d. This result provided a possible way to reduce the cutting times. In a conclusion, GA_3 has different influence to the growth of cordgrass in different applied timing; May is the optimal season when GA_3 is used to improve the control efficacy of cutting aboveground.
Keywords: *Spartina* alterniflora;growth regulation;cutting;improve;

Efficacy evaluation of foliar-applied herbicides on *Solanum rostratum*.

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Eight postemergence broadleaf herbicides were selected to evaluate their control efficacy against buffalobur (*Solanum rostratum*) at florescence in July, 2011. 30d after treatment, the experiment revealed that all 8 herbicides inhibited buffalobur growth with significant differences in efficacy among these herbicides. It was shown that triclopyr and picloram performed best with 100% control of buffalobur, Fluroxypyr checked buffalobur effectively with 86.20~95.58% control. Glyphosate and glufosinate-ammonium offered good control efficacy on buffalobur, paraquat and picloram did not produce high control efficacy, while 2,4-D butylate had weak effect in controlling of buffalobur. Triclopyr, picloram and fluroxypyr can effectively control buffalobur, and the herbicides can be used for different invasion habitats in accordance with the herbicide performance.
Keywords: herbicide;foliar-applied;Solanum rostratum;control efficacy;

Effect of resource supply on common ragweed (*Ambrosia artemiisifolia* L.) nitrogen and water use efficiency.

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Common ragweed (*Ambrosia artemisiifolia* L.) is a major weed of agronomic crops, and is also considered to be a serious public health problem. A pot experiment was conducted in 2011 to determine the effect of various nitrogen (N) (10, 100 kg/ha) and water supply regimes on nitrogen and water use efficiency of ragweed. Ragweed plants increased their dry matter production with increased water and N availability. Nitrogen use efficiency (NUE) was decreased with higher level of N supply and was not influenced by water availability. Mean nitrogen residence time (MRT) was longer at low N and water levels. In contrast, nitrogen productivity (A), NUE and water use efficiency (WUE) were all increased with enhanced water supply. A trade-off between parameters of NUE was attributed to differential response of A and MRT to soil fertility and water supply. Results of our research confirmed that ragweed resource-use traits are adapted to low fertility environments. However, ragweed's greater plasticity in response to water availability compared to N availability suggest, that water supply plays important role in its invasion success and in combination with disturbance ragweed might further spread into more productive environments.
Keywords: ragweed; invasive; resource availability; water use efficiency; nitrogen use efficiency

Common ragweed (*Ambrosia artemisiifolia* L.) tolerance to salinity.

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Common ragweed (*Ambrosia artemisiifolia* L.) is becoming a health and economic threat as it spreads around Europe and other regions. It is particularly abundant along the roadsides, from where it can migrate further on the agricultural land. The vegetation on the road verges is subjected to large quantities of deicing salt, however ragweed seems to be adapted to increased salinity in the soil. To test the tolerance of common ragweed to salt, salt solutions of various concentrations (0, 20, 40, 100, 200 mg/kg Na+) were applied at to plants grown in pots at two growth stages (at sowing and at V6 stage). Increasing salt solutions concentration, applied at the sowing, significantly decreased ($P<0.001$) the ragweed dry matter production. Even the lowest salt concentration (20 mg/kg) reduced ragweed dry matter by 85%. With further increase of salt concentration no further retarding effect on ragweed dry matter production was observed. At V6 growth stage, regardless of applied salt solution concentration, no effect of salt on ragweed dry matter production could be determined. On the basis of these results we can conclude that ragweed is very susceptible to salt in the germination and early growth stage, whereas at later growth stages, its growth is not affected by increased salinity.
Keywords: ragweed;invasive;growth;salinity;tolerance;

Aminopyralid, a new active substance for long-term control of invasive and noxious broad-leaved weeds in Chinese grassland.

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Aminopyralid is a new systemic herbicide in the pyridine carboxylic acid class under development by Dow AgroSciences. Aminopyralid has become an essential tool in invasive weed management in range, pasture and non crop areas across the globe since its launch in 2005. Overall, aminopyralid has a favourable toxicity profile, with no evidence of teratogenicity, mutagenicity, carcinogenicity, endocrine or adverse reproductive effects. Aminopyralid produces no significant soil or water metabolites except CO2 and exhibits very low acute or chronic toxicity to mammals, birds, fish and aquatic invertebrates. GF-871 is an SC formulation of the active substance, aminopyralid, it is the first new product to be developed specifically for the control of invasive and noxious weeds of grassland in China. This paper presents results from four field trials set up to test the efficacy of aminopyralid against the key weeds: Ligularia narynensis (LGLNA) and Aconitum leucostomum (AAOSS). Aminopyralid at 60, 90 and 120g ae/ha gave effective control of LGLNA and AAOSS. As these weeds are considered to be prohibiting pasture productivity in China because of their significant infestation and toxicity, Aminopyralid will be a useful tool for the weed control needed to achieve sustainable livestock industry growth.
Keywords: aminopyralid;Ligularia narynensis;Aconitum leucostomum;

Using genetic and age information to reconstruct invasion by privet (*Ligustrum vulgare*).

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Privet (*Ligustrum vulgare* L.) is an invasive plant that threatens sensitive habitat in natural areas of the eastern United States. We used genetic and age information to reconstruct the history of invasion and spread at two scales. We sampled and georeferenced established privet patches in a 133-ha public natural park in Ohio, and obtained genetic information from privet in surrounding states. Using two chloroplast DNA markers we identified two haplotypes in the park, suggesting multiple invasion events. ArcGIS maps of haplotypes show a geographically mixed distribution pattern. Haplotypes varied geographically among parks in Ohio and surrounding states, consistent with privet naturalizing in eastern states and moving west. We determined the ages of all the samples by counting annual growth rings. Age class distributions and numbers of privet patches during invasion showed that the oldest patch formed in 1971 followed by a 20-year period of few new highly dispersed colonies. This lag phase was followed by a 15-year period with a linear increase of about 20 new patches per year. Most patches formed during the lag phase were located at the edge of contrasting habitats places where activities of animals and sunlight are high. Nearest neighbor analysis showed changing patterns of dispersal and random patterns of spatial aggregation over time. Global Moran's I calculated in each year suggested a trend of clustering during invasion, and the local Gi* statistic identified clusters of patches influenced by landscape factors. Early colonizing

haplotypes did not become the dominant haplotypes. Mapping invasive plants in early stages may predict spatial distribution in later stages and can assist in control efforts by identifying invasion hot spots and cold spots.
Keywords: molecular markers;haplotypes;dendrochronology;invasion history;patch expansion;

How does DNA C-value influence plant invasiveness? A test with five Vicia species.

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It is reported that DNA C-value negatively correlates with plant invasiveness. However, the relationship is still under suspicions for the paucity of data on systematic experiments testing all the important links in the questionv"How does DNA C-value influence plant invasiveness?" Convictive evidences would inevitably come from the relative studies on congeners with different DNA C-values and invasive abilities. Therefore, we investigated the hypothesis with a group of ideal species, i.e., *Vicia sativa*, *V. tetrasperma*, *V. hirsuta*, *V. tenuifolia* and *V. faba*. The invasive abilities of these five Vicia species vary much, with highest invasiveness for *V. sativa*, lowest for *V. faba*. We examined a serial of cytological and life history indices of the five species and conducted regression analyses between these indices and DNA C-values, respectively. Here we show that plants with lower DNA C-values are prone to have smaller masses of total chromosomes, karyons, cells and seeds, quicker mitosis and seedling growth rate, higher seed production and shorter generation time. The results are supportive for the idea applying DNA C-value to evaluate plant invasiveness, while the application should be assisted with other indices.
Keywords: DNA C-value;Invasiveness;Regression;Vicia;

Survey of weeds in vegetable in Northeast and Central Region.

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A weed survey in vegetable planting areas in the northeast and the central region of Thailand, which aims to clarify weed diversity in agricultural areas, was conducted during October 2007- September 2010. Totally, 240 weed species from 164 genera of 59 families were recorded from 194 plots of 43 vegetable types in 7 provinces of the northeast and 11 provinces in the central region. The family Poaceae showed the highest diversity and relative frequency at the family level, followed by members of the Asteraceae. While *Amaranthusviridis* L. of Amaranthaceae show the highest relative frequency for individual species, followed by barnyardgrass (*Echinochloa crus-galli* (L.) Pal.). Seven species of weeds which have not been reported in Thailand before were found, they are Corchorus sp., *Microcarpea minima*, *Spigeliaanthelmia* L., *Basilicumpolystachyon* (L.) Moench ,*Eleutherantheraruderalis* (Swartz) Sch.-Bip.,*Spermacoceexilis* (L.O.Williams) C.Adams, and another species of Asteraceae which is still being identified.
Keywords: weed diversity;agricultural weeds;common weed;major weed;noxious weed;

ESENIAS: A regional network on invasive alien species.

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An invasive alien species (IAS) is not only a problem for a given country. There are many examples of invasive alien species, including plants, rapidly crossing political boundaries and causing problems in neighboring countries. IAS requires a regional, and even worldwide (global) approach and cooperation. Several regional networks on IAS have been functioning efficiently, such as NOBANIS in North and Central Europe, CIASNET in Caribbean etc. A new network, the East and South European Network on Invasive Alien Species (ESENIAS) was established at the meeting "EEA/EIONET Workshop on Networking on IAS in West Balkan Countries and Their Neighbors" organized by European Environment Agency (EEA) in cooperation with the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, University of Forestry and Ministry of Environment and Water of Bulgaria in Sofia on 17-18 October 2011. The idea of new networks was discussed in two previous meetings in 2010: "EEA/EIONET Workshop on Invasive Alien Species in West Balkan Countries" organized by (EEA) with collaboration with IUCN/ISSG in Zagreb, Croatia and "2nd Workshop on Invasive Alien Plants in Mediterranean Type Regions of the World" organized by EPPO, EEA, the Council of Europe, Igdir University and the Turkish Ministry of Agriculture in Trabzon, Turkey. The main goals of ESENIAS are to establish regional cooperation in the West Balkan Countries, to aid in early detection, eradication, control and mitigation, to develop a common database on IAS for the region and to raise awareness of the problem among decision makers and the general public. ESENIAS brings together experts on biodiversity, environmental management and pest control from national and regional environmental and agriculture departments, the scientific community and organizations working with invasive alien species. The development of this network aims at a more effective implementation of the Aichi Target 9 of the Strategic Plan for biodiversity 2011–2020, adopted during the tenth meeting of the Conference of the Parties of the Convention on Biological Diversity (CBD COP10, which took place in Nagoya, Aichi Prefecture, Japan, in October 2010). Aichi Target 9 states that "by 2020,

invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment". Current members of network are Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Kosovo under UNSC Resolution 1244/99, FYR Macedonia, Montenegro, Serbia and Turkey. It is expected that network will in the future also include neighboring countries of current members such as the south European countries and, countries in Mediterranean and Black Sea area.
Keywords: network;invasive alien species;ESENIAS;balkan;mediterranean;

Development of a control strategy against *Cyperus esculentus* (L.) in Switzerland.

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Cyperus esculentus is an invasive alien plant species; the monocotyledonous weed is abundant mainly in regions of intensive vegetable growing and adjacent agricultural farming. The weed propagates in producing many small tubers in the soil; and once the tubers are present, an invasion of the field is predictable. Most herbicides killing superficial parts of the weed do not hamper the formation of new tubers. For estimating the efficacy rate of some herbicides on tubers, pot trials were carried out in the glasshouse. Double dose of herbicides was applied on pots, filled on the one hand with a common loamy soil and on the other hand with a black organic soil. The herbicide was incorporated in the soil after treatment and tubers, seedlings, and adult plants were planted into pots (4/pot each, with 10 replications). 110 days after the treatment new tubers were counted. The most efficient herbicides are tested in the 2012vegetation period in the field with normal dose; again in a normal loamy soil and in a black organic soil. Herbicides are applied alone and in combination with incorporation into the soil. These trials are going on and no results are obtained yet. For pot trials, several efficacies of herbicides on tubers were obtained. Herbicides as flazasulfuron, halosulfuron, lenacil, metribuzin and sulfosulfuron suppressed the formation of new tubers almost completely, while herbicides as flurochloridone, imazamox, metsulfuron and triflusulfuron allowed the formation of around 50 new tubers per pot; herbicides as carbetamide, napropamide and prosulfocarb obtained no reduction on formation of tubers. Up to 120 new tubers were counted in untreated pots. A successful control strategy must include the efficiency of herbicides on the reduction of formation of new tubers.
Keywords: herbicide;soil cultivation;pot trial;field trial;

Strengthening farmers capability for weed management in developing countries

Oral presentations

Helping farmers manage weeds for higher yields of direct-seeded rice: the Sulawesi experience.

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Farmers in Sulawesi are direct seeding rice rather than transplanting, as labor is in short supply, but yields are low and weeds are a constraint. Using approaches of adaptive management, we worked with farmers in four villages for 2 years to develop better weed management practices and other management options. In 2008, after rapid rural appraisal of farmers' weed management practices we conducted "benchmark" field trials to quantify yield losses and to identify problem weeds. Trials were established in farmers' fields to evaluate reduced seeding rates using the plastic drumseeder and alternative herbicides. On farmers' fields, grasses and sedges were the problem weeds, causing yield losses ranging from 5% to 19% in 2008-2009 dry season (DS) and 3% to 20% in 2009 wet season (WS). Usual practice for farmers in South Sulawesi was to apply the herbicides 2,4-D, MCPA or sulfonyl urea in transplanted rice while in direct-seeded rice in Southeast Sulawesi, 2,4-D was applied followed by spot weeding. These herbicides gave poor control of the predominant weeds. Among the five herbicides evaluated in 2008-2009 DS in South Sulawesi, penoxsulam (60 g/ha at 7-10 days after planting [DAP]) and cyhalofop-butyl (1 L/ha at 10-15 DAP) were selected by farmers. These were evaluated against 2,4-D (1 L/ha at 25-30 DAP) in 2009 WS. Penoxsulam reduced weed biomass and gave higher yields, and was selected by farmers to replace 2,4-D and MCPA. In 2009 DS, farmers in Southeast Sulawesi compared the plastic drumseeder against their local drumseeder. A herbicide trial, using penoxsulam, fenoxaprop (120 g/ha at 10-14 day after seeding [DAS]) and 2,4-D, was superimposed. Farmers saw that the IRRI drumseeder delivered lower seeding rate, they modified it to perform better in deep muddy condition by removing two of the original four drums and made it more sturdy by reinforcing weak parts. Penoxsulam controlled weeds better and had higher yields in both seeders. A poster and a video were produced to document and promote the improved direct seeding and weed management practice to other rice producing districts in Sulawesi. The experience of Sulawesi demonstrated that involving farmers early in the research process gave dividends in terms of rapid research progress and farmer acceptance of the results.
Keywords: adaptive management; weed management;Sulawesi; participatory approach; direct-seeded rice;

Weed management is a key to mitigate food crisis.

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A food crisis is emerging, particularly in economically –poor regions, as a result of increased prices of basic foods as cereals. Domestic food prices are rising and these are affecting access to food of low-income population groups. The situation is likely to worsen in future as the world's population is expected to grow, and food production needs to rise by 50-60 per cent to meet growing demands.
Agriculture in the developing world relies on the production of more than 500 million small farms, supporting food for nearly 2 billion people, while the expenses of the governments on agriculture in these regions are insignificant, usually averaging 4 per cent of public expenditure. The problems of inadequate food supply can only be solved when farmers' productivity increases, enabling them to cultivate many hectares (ha) of land, with a production satisfying hundreds of families. Modernization of agriculture of developing countries is a real need and weed management should play a basic role. Almost 40% of a farmer's field activities on average are related to hand- weeding carried out by the family, mainly women and children. In some countries of West Africa, one man/day is required for weeding a rice plot of 500 m2; equivalent to 200 man/days for one ha. Increased productivity will only be achieved with effective implementation of integrated weed management (IWM), which should include crop rotation with less reliance on monocropping and with greater crop diversification, introduction of improved cultural practices, and rational use of herbicides, which may enable farmers to increase their cultivated area by 10 to 20 times. Farmers' training on strategies of IWM will be essential to improve crop food production.
Keywords: Agriculture;Productivity;Herbicides;

Herbicide registration and management in China.

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The status of herbicide registration and new policies of herbicide management in China were investigated. Some problems concerning herbicide registration and management are pointed out and some approaches of effective solutions for these problems are discussed. Productivity, yields and supply of herbicide products have satisfied the demands of agricultural production in China, and production has increased such that the country has been a net exporter over the last ten years. However, there are some problems in new herbicide development, new application techniques, new data requirements of mixture of herbicides and mixture of herbicides with some fertilizers, the management of long persistence herbicides, crop damages, weed resistance, new invasive weeds. Improvements in the registration process and management of new products is required to overcome these problems to ensure safe use of agricultural products and sustainable development of agriculture in China.
Keywords: Herbicide; Registration; Management;

Poster presentations

Changing scenario of women participation in weeding due to paradigm shift in rice cultivation.

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At global level, 2.7 billion people, mostly in Asian countries, rely on rice as the major source of food. The International Rice Research Institute (IRRI) estimates that by 2025 A.D the number will rise to 3.9 billion people. In India, women constitute 48 per cent of the total population and out of these nearly 78 per cent actively participate in agriculture and its allied activities. In agricultural sector, crop husbandry activities at farm level are the major areas of economic activity for rural women.
Women contribute to several different activities in rice cultivation including sowing, transplanting, weeding, harvesting and storage of grain produce. Weeding is important in rice to increase productivity, and this is mostly performed by women. It is also a tedious and "back braking" operation. Weeding requires 30 to 120 man days/ hectare depending on the location and rice cultivation method. Weeding is however a source of income and livelihood for rural women. The introduction of weeding equipments and use of herbicides in rice cultivation has led to a change in the patterns of women's participation. A conceptual framework of farm women employment, the out migration of women and patterns of migration, and changes in weeding operations are discussed in this paper. The perceptions among women folk who perform the tasks and their reflection on the changing scenario in rice cultivation are also discussed. The study is an outcome from a survey by team of scientists from multiple disciplines in Department of Rice, and it covers a major rice growing districts of Tamilnadu state in India.
Key words: changing scenario,weeding, shift in rice cultivation

Influence of intercropping in maize on weed growth and the performance of associated crops.

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Field experiments on intercropping in maize crop were conducted during 2008 and 2009 at Agriculture Research Institute, Tarnab Peshawar, Pakistan. The experiments were laid out in a randomized complete block design comprising of 11 treatments, including weed free sole maize (WFMz), weedy check sole maize (WCMz), sole Frenchbeans (Fb), sole mung-beans (Mb), sole sunflower (Sf), intercropping maize-1-row+Frenchbean-1-row (MzFb 1:1), maize-1-row+Frenchbean-2-rows (MzFb 1:2), maize-1-row+mungbean-1-row(MzMb 1:1), maize-1-row+mungbean-2-rows (MzMb 1:2), maize-1-row+ sunflower-1-row (MzSf 1:1), and maize-1-row+sunflower-2-rows (MzSf 1:2). The treatments significantly affected the weeds and crop parameters. Weed density (136 weeds m-2) and fresh biomass (2769 kg ha-1) were highest in the WCMz and Mb, respectively. The intercropping treatments resulted in 35-56% reduction in weed population. All the intercropping treatments showed 6.5 to 23.9% increase in the yield of maize over weedy check, except that in MzSf 1:2. Overall highest average grain yield of maize (3886 kg ha-1) was recorded in WFMz with 30.6% increase in yield over the WCMz (2695 kg). Among the intercropping treatments, maize yield was highest (3543 kg ha-1) in MzMb 1:1, where the yield was 23.9% higher than the WCMz; though it was at par with the MzFb 1:1 (3232 kg ha-1 with 16.6% yield increase over WCMz). The computed land equivalent ratio (LER) ranged between 1.023-1.294. Similarly, the cost benefit ratios (CBRs) ranged between 1.27 and 1.67. Among the intercropping treatments, highest CBR (1.64) was computed for MzSf 1:2, followed by MzMb 1:2 (1.58). Thus, intercropping reduced weed population, boosted maize performance, enhanced land utilization and increased farmers' monitory advantage.
Keywords: Intercropping;maize/corn;french bean;mungbean;sunflower;

Herbicide application and formulation

Oral presentations

Assessment of corn injury from glyphosate application using biological responses and airborne remote sensing.

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Glyphosate drift onto off-target sensitive crops can reduce growth and yield and is of great concern to farmers and pesticide applicators. Detection of herbicide injury using biological responses is tedious. The feasibility of using remote sensing as a sensitive method to detect herbicide injury was investigated. The objective was to correlate vegetation indices (VIs) derived from aerial multispectral imagery with biological responses to crop injury. In a field study in 2011, glyphosate was applied at 0, 0.01, 0.05, 0.1, 0.2, 0.5, and 1X (X = 0.866 kg ae/ha) to non-glyphosate-resistant corn at the 4-leaf stage. Plant height, shoot dry weight, and chlorophyll, and multispectral imagery (Geospatial Systems MS4100 camera on an Air Tractor 402B agricultural airplane) were acquired at 1, 2, and 3 weeks after application (WAA). Corn yield was recorded at harvest. Corn was dead with the 1X rate at 1 WAA. Plant height, shoot dry weight, and chlorophyll content decreased gradually with increasing rate regardless of WAA. Corn yield decreased from 1% at the 0.1X rate to 92% at the 0.5X rate. Similar to biological responses, the VIs from aerial imagery, NDVI (normalized difference vegetation index), SAVI (soil adjusted vegetation index), RVI (ratio vegetation index), and GNDVI (green NDVI) also decreased gradually with increasing glyphosate rate regardless of WAA. Pearson correlation analysis revealed that the VIs were highly correlated with biological responses regardless of WAA and as well as with yield. For example, At 1 WAA, the correlation coefficients for NDVI were 0.76, 0.79, 0.70 and 0.70; for SAVI were 0.76, 0.79, 0.70 and 0.70; for RVI were 0.75, 0.77, 0.68 and 0.68; and for GNDVI were 0.76, 0.79, 0.68 and 0.67 with plant height, shoot dry weight, chlorophyll, and yield, respectively. These results suggest that the biological responses were highly correlated with the VIs and aerial multispectral imagery technology could be used as an alternative method to detect corn injury from glyphosate drift.
Keywords: remote sensing; glyphosate drift; drift injury; multispectral imagery; vegetation indices;

Low dose responses of different glyphosate formulations on plants.

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Although glyphosate clearly has real and potential commercial uses as a growth regulator at low doses, its main commercial significance has been as an herbicide. An important prerequisite for low dose applications gaining significance is a high efficiency and reliability of effects. This, however, seems to be a major constraint, especially regarding the approach of increasing yield by glyphosate hormesis. Glyphosate is marketed in various formulations, but potential disparities in low dose responses are unknown. Therefore, this study evaluated the expression and reliability of hormetic effects of different glyphosate formulations as a possible means for glyphosate hormesis to be more reliably and sustainably be achieved. Four commercial products sold in Germany (Glyfos, Glyfos Supreme, Glyfos Dakar, and Roundup Speed) were evaluated in germination assays with lettuce. Experiments were conducted as dose-response assays and evaluated for root length and shikimic acid production. In bioassays with exposure of seeds, none of the commercial formuations induced hormesis, while all formulations showed a similar hormetic effect if methanol pre-treated seedlings were exposed. Evaluating the reliability of the observed hormetic effect showed that the effect could only be reproduced in one out of three repeats independent of the formulation used. Hence, results indicated that in controlled bioassays the induction of hormesis by glyphosate is independent of the formulation used and requires a preconditioning, although this does not ensure a hormetic effect. Therefore, the reliability of glyphosate hormesis may remain a major constraint for potential practical uses of this phenomenon despite new formulations claiming a safer response.
Keywords: crop enhancement; dose-response; growth stimulation; hormesis;

Phelipanche aegyptiaca control in tomato by drip chemigation of imazapic – application of HYDRUS 2D/3D.

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Drip chemigation of imazapic for Phelipanche aegyptiaca control in tomato has yielded inconsistent results. In order to improve control we must understand water and herbicide movement in the soil. HYDRUS 2D/3D is a numerical model describing water and solutes movement and uptake in variably saturated soil. The aim of this research is to adopt the HYDRUS 2D/3D model to improve broomrape control by administration of imazapic via drip chemigation. In a field experiment we drip chemigated 0, 6.0, 12.0, 18.0 and 24.0 g ai ha-1 of imazapic (Cadre® 240 g/l imazapic). Herbicide distribution in soil samples was analyzed by LC-MS/MS one

and 21 DAA and broomrape infestation, tomato development and yield were evaluated as well. In vitro studies were performed to examine the response of P. aegyptiaca to imazapic in soil and Petri dish, recording seed germination and number of attachments to tomato roots. In the field we detected imazapic mainly under the drip line at depths of 10 to 30 cm. The average concentration of imazapic 21 DAA was reduced by 68% (from 7.8 to 2.5 ppb). The high rate of imazapic prevented emergence of new P. aegyptiaca inflorescences, but damaged tomato plants and subsequently significantly reduced fruit yield from 21 kg m-2 in the untreated control to 11 kg m-2. In pots the minimum lethal concentration for inhibiting P. aegyptiaca development was 5 ppb. Preconditioned seeds and seedlings in Petri dish were not affected by the herbicide even at the extreme concentration of 5000 ppb, whereas parasite seedlings were sensitive after attachment at 2.5 to 5 ppb. We conclude that in order to insure the efficiency of imazapic on P. aegyptiaca it should be delivered to the root system in the precise location, timing, and concentration. These parameters can be further optimized with the HYDRUS 2D/3D model.
Keywords: broomrape;herbigation;solute distribution;

TopShot™ 60OD a one-shot rice herbicide for use in direct-seeded and transplanted rice in ASEAN countries.

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TopShot™ 60OD is a premix formulation of 10 g ai Penoxsulam + 50 g ai Cyhalofop-butyl/liter. Penoxsulam, a triazolopyrimidine sulfonamide rice herbicide, provides good control of Echinochloa spp, annual sedges and many broad-leaf weeds. Cyhalofop-butyl, an aryloxy phenoxypropionate rice herbicide, provides good control of many grassy weeds such as Echinochloa spp, Leptochloa chinensis, and other annual grasses.TopShot™ 60OD is a broad-spectrum herbicide product with post-emergence and residual weed control activity that controls many important grasses including Echinochloa spp. and Leptochloa chinensis, as well as many broadleaf and sedge weeds with excellent rice tolerance in ASEAN rice growing countries. This paper will discuss the value of the combination product of penoxsulam + cyhalofop-butyl, a unique herbicide product that can be used to increase rice productivity under diverse rice cultures in direct-seeded as well as transplanted rice in ASEAN countries. Small plot field research trials and on-farm demonstration trials were completed from 1998 to 2011. Multi-location and multi-season field trials across ASEAN countries over 13 year period and large plot size on-farm demonstrations in grower fields in 2003-2011 demonstrated that when TopShot™ 60OD was applied as a foliar post-emergence treatment at 7 to18 days after sowing or transplanting, 1.0- 1.25 liter product/ha provided >90% control of all common weeds in rice, resulting in 20-50 % yield increase when compared with non-herbicide application. Both active ingredients in TopShot™ 60OD are highly efficacious for controlling Echinochloa spp. and each has a different mode of action, so TopShot™60OD is a good tool for ECHSS resistance management in rice.TopShot™ 60OD has demonstrated excellent rice crop safety.
Keywords: Penoxsulam;Cyhalofop-butyl;Direct seeded rice;Transplanted rice;efficacy andn crop tolerance;

What does a reduced herbicide rate mean anyway?

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Recommended herbicide rates control weeds at their sensitive stages of development and ensure high mortality. Effective herbicide rates in fields can vary tremendously, because of spray boom movements and a rough field surface. Other times, reduced rates are used to save money, to prevent unwanted side-effects e.g. leaching of a compound into ground water and to comply with public peer pressure. Can we reduce recommended rates and still achieve acceptable effect on weeds? Effect of reduced rates on the weed flora is also heavily debated in the development of resistant biotypes of weeds.Reduced rates are always relative to some recommended rates that ensure producer to live up to his product liability. Recommended rates are based on worst case scenario for weed control and even a 50% reduction might only change the efficacy of the herbicide marginally because the asymptotic properties of a dose-response curve do not make an effect unambiguously defined by its sheer field rate.Perhaps we should abandon talking about reduced rates and talk about reduced effects on weeds, If 70% effect is good enough, would we feel more comfortable by striving at a 90% effect? This dilemma is haunting farmers where public pressure on pesticides use is strong. Where development of resistant biotype use is an issue, the difference between 70 and 90% efficacy may govern the rapidity of development of herbicide resistance.On the basis of intensive work with the dose-response curves in fields and inevitable changes of the weed flora of Scandinavia, we will attempt to provide a conceptual framework for what reduced rates actually means, and look at how we can be more specific by defining efficacy instead of herbicide rates.
Keywords: Dose-response; herbicide resistance; Weed flora shift;

Water quality, an underestimated factor influencing herbicide efficacy in dry regions of South Khorasan, Iran.

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*Water is the primary carr*ier for herbicide applications. Spray solutions commonly contain 95% or more water. Water pH, hardness, alkalinity, and turbidity can affect herbicide efficacy. Most of South Khorasan waters are classified as hard waters and farmers often apply herbicides using these hard waters. This usually results in weaker herbicide efficacy and obliges farmers to significantly increase herbicide rates. In order to evaluate the effect of water quality and adjuvant (ammonium sulfate) on glyphosate efficacy for weed control in a barberry garden, a factorial experiment based on RCBD with three replications was conducted at the Research Garden in the Faculty of Agriculture, University of Birjand in 2010. Experimental factors were water quality in three levels : soft water, medium hard and hard water (hardness based on parts per million of calcium carbonate), glyphosate dose in four levels: 2, 4, 6 and 8 ltr.ha^{-1} and ammonium sulfate in two levels: 0 and 6 kg.ha^{-1}. Results showed that reduction percentage of weeds density and weight increases with herbicide dosagethe. Soft water treatment significantly showed the most effective weed control. with, The highest and the lowest control percentages belonged to soft water with glyphosate dose of 8 ltr.ha^{-1} and hard water with glyphosate dose of 2 ltr.ha^{-1}, respectively. In addition, the results showed that ammonium sulfate didn't have any special effect on glyphosate

efficacy, but had greater impact on the control of broad-leaved compared with narrow-leaved weeds. The effect of different factors on control percentage increased over time, we observed the highest control percentage at 90 days after spraying.
Keywords: weed density; dry matter; water hardness; herbicide carrier; weed biomass;

The spread, evaporation, penetration of topramezone in giant foxtail (*Setaria faberii* Herrm) affected by two different mode adjuvants and efficacy test.

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Topramezone is a newly registered post-emergence herbicide that can be applied to corn fields to control a range of annual grasses and broadleaf weeds. Methylated soybean oil (MSO) is sold as a tank-mixing additive for topramezone and other herbicides in China and has a good performance in enhancing efficacy. We did some research on the enhancing mechanism of this new adjuvant product. We selected giant foxtail (Setaria faberii Herrm) as a model weed and cultivated it to 5-6 leaves in greenhouse condition. Topramezone solution at 4-fold recommended dosage alone, adding organosilicone and MSO at recommended dosage are prepared and also tap water as control. We tested the spread area and evaporation time of different topramezone solution and tap water which are added with food color additives by dropping fixed volume droplets on the surface of the fifth leaf. We also tested the penetration of the above 4 different solutions in the plants 2, 6, 24, 48 hours after herbicide treatment (HAT) by washing the leaves with distilled water first, extracting the leaves and then measuring the concentration of topramezone in the plant extract and washing water using mass spectrometer. To test the efficacy of topramezone added with MSO, we used IMAGING-PAM M-series Chlorophyll Fluorometer and tested the Fv/Fm value at 2, 3, 4, 5 days after application. Results indicate that the spread areas of droplets were smaller with MSO than with organosilicone but larger than without adjuvant. The droplets of topramezone solution with MSO evaporated slower than with organosilicone and without adjuvant treatments; the amount of topramezone penetrated into the plants was more when added with MSO than with organosilicone and without adjuvant, especially from 6 hours.
Keywords: topramezone; adjuvant; MSO; efficacy;

Effect of new herbicide ZJ0273 on root growth and its cell viability of two oilseed Brassica species with different susceptibilities.

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Oilseed rape is threatened significantly by weeds resulting in 15.8-50% loss of oilseed yields. For eradicating weeds,a newly developed post-emergence herbicide propyl
4-(2-(4,6-dimethoxypyrimidin-2-yloxy)benzylamino)benzoate (ZJ0273) is recently becoming popular in China. In order to define the safety and mechanism of this novel herbicide to oilseed rape, this paper described the response of root growth and root-tip cell viability in two cultivars of rapeseed Brassica napus cv. ZS 758 and B. rapa cv. Xiaoyoucai to various concentrations of ZJ0273 treatments. Effects of ZJ0273 treatments on root growth of rapeseed seedlings were investigated by various physiological measurements. Root cell viability and microscopic structure were studied based on FDA-PI double staining and transmission electron microscopy. Results indicated that the root growth of both species was negatively affected by ZJ0273, especially for B. rapa, the root length and number of root tips were inhibited more than 80% under 100 mg/L ZJ0273. Otherwise, there was a slight inhibition on root oxidizability and membrane permeability of B. napus under 10 and 100 mg/L ZJ0273 treatments, compared with B. rapa which was obviously inhibited on root cell viability and induced cell membrane disintegration. The absorbable capability of Fe was enhanced by 10 mg/L ZJ0273 treated in both species, while other elements (including K, Ca, Mg, B) was inhibited severely. Furthermore, electron micrographs showed that microscopic structure of B. rape root was more seriously affected by ZJ0273 than B. napus. B. napus is more tolerant than B. rapa under stress of ZJ0273. Rapeseed seedlings are very sensitive to ZJ0273 at germination stage, especially for B. rapa. The application of 10 mg/L is safe for B. napus.
Keywords: oilseed rape; ZJ0273; root oxidizability; membrane permeability; DA-PI;

Developing controlled release herbicide formulations for reduced soil and water contamination.

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Herbicide controlled release formulations (CRFs) are designed to reduce undesired herbicide leaching and increase herbicide concentration at the top of the soil for improved herbicidal activity and reduced soil contamination. The past decade we have designed a variety of CRFs based on modified clay-minerals. For the design of classical CRFs the clay surface is modified from hydrophilic to hydrophobic by adsorbing small organic cations (organo-clays). More recently we developed CRFs based on micelle-clay composites for sulfonylurea herbicides which pose a serious problem due to their high solubility and mobility in the soil. Solubilization of metolachlor in micelles enabled to increase the percent of active ingredients in the CRF by 4-folds in comparison with classical organo-clay CRFs. A bioassay showed that these metolachlor formulations significantly reduced leaching in addition to improving herbicidal activity. Recently we have studied the effect of soil wetting and drying cycles (WDCs) on metolachlor fate applied as the commercial and as CRF. Surprisingly, the metolachlor (technical grade) release from the soil subjected to WDCs was higher than its release from the untreated soil. We suggest that soil aggregation, significantly higher in the untreated soil, traps the herbicide reducing release. Furthermore, metolachlor leaching, applied as the commercial formulation, was high and increased with WDCs while its leaching from the CRF was moderate even when subject to WDCs. A bioassay with soil columns demonstrated

similar results and presented enhanced weed control by the CRF. These results emphasize the advantage of the CRF over the commercial formulation even when the soil is subjected to WDCs.
Keywords: formulations; controlled release; clay;

Carbon-Seeding technology: Applications for weed management in seed production and beyond.

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Activated carbon slurries are used to protect crop plants such as landscape ornamentals and horticultural transplants by inactivating soil-applied herbicides around the rooting zone of the crops. A similar application of this method of plant protection is often referred to as carbon seeding. Carbon seeding involves utilizing a band of activated carbon, generally applied at a rate of 28 kg ha-1 in a 2.5 cm band, sprayed over the crop seed row during planting followed by a broadcast application of a soil active herbicide. The activated carbon adsorbs the herbicide, thus protecting the germinating crop seeds underneath the carbon band through seedling emergence. The carbon seeding method allows use of herbicides that would otherwise injure or kill the crop species. This seeding method in combination with the use of herbicides including diuron and pronamide applied at 2.24-2.88 kg ha-1 and 0.14-0.28 kg ha-1 respectively, is routinely used in Oregon, USA, for establishment of cool-season grass crops grown for seed including perennial ryegrass (Lolium perenne L.) and tall fescue (Festuca arundinacea Schreb.). The diuron and pronamide control grass weed species including annual bluegrass (Poa annua L.) that, if not managed during grass seed stand establishment, can cause significant yield loss and reduce seed quality. Carbon seeding techniques for the production of native grass and forb seed also have been developed, but this technique should not be limited to seed production cropping systems. There is significant potential to develop carbon seeding techniques and equipment for weed management in other types of cropping systems and for native plant community restoration efforts.
Keywords: activated carbon; seed production;annual bluegrass; soil active herbicides; perennial ryegrass;

Old phenoxy herbicides, new trick. Herbicidal ionic liquids.

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For more than 60 years phenoxycarboxylic acids such as MCPA and 2,4-D have been successfully used in agriculture as postemergence herbicides for control of annual and perennial broad-leaved weeds. In recent years the manufacturers develop the production of these compounds in the form of esters because of their greater efficacy compared to the salts. However, the disadvantage of esters is their high volatility. This problem may be solved by transformation of herbicides to the ionic liquid forms which bring new benefits as ultra-low volatility minimized drift potential, decreased odor and improved handling characteristics. Ionic liquids (ILs) are salts of bulky organic cations and organic/inorganic anions having melting points below 100oC. We synthesized several herbicidal ionic liquids (HILs) with MCPA or 2,4-D in anion and their biological activity has been investigated under field conditions. The experiments were carried out in winter wheat. The experimental design was a randomized block with four replications, plot size was 16.5 m2. The applications were made at the end of tillering (BBCH 30) using a small plot spraying equipment with XR 11003 flat-fan nozzle with a water volume of 200 L ha-1. The new forms of 2,4-D were applied at rates corresponding to 450 g ha-1 of a. i. The results show that HILs are more active than salt formulations and their activity are comparable to esters. In our experiments the control of numerous broad-leaved weeds was 79-82%, 11-20% and 78%, respectively. HILs were safe to the winter wheat plants and no residue of herbicide in grains was found.
Keywords: ionic liqiuds; MCPA; 2,4-D; dicot weeds; efficacy; winter wheat;

Controlled release formulations composed of synthetic auxins and 3-hydroxybutyric acid oligomers.

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The deployment of herbicides as foliar or soil sprayings requires an excessive amount of herbicide formulations or multiple replications, for the reason that a significant part of active ingredients is removed from the target site by evaporation, or leaching into the soil. A prolonged effectiveness of herbicides may be obtained by applying controlled release formulations (CRF) with active ingredients mechanically entrapped or chemically bound to the matrix [1, 2]. The aim of our research took into account the CRF containing auxinic herbicides chemically bound to (R, S)-3-hydroxybutyric acid oligomers, being synthesized via the ring opening polymerization of β-butyrolactone initiated with potassium carboxylates of 2,4-D, MCPA and Dicamba [3]. These products were characterized by the size exclusion and reverse phase liquid chromatography, proton magnetic resonance and electro-spray mass spectrometry in order to determine their chemical structures and molecular weight distributions [4]. The formulations demonstrated the reduced vapor pressure and water solubility. Determinations of the herbicide effectiveness were carried out vs. the selected plant material: monocots (crop) and dicotyledonous plants (weeds) in the greenhouse and field conditions [5]. Conventional formulations containing dimethylammonium salts of the studied herbicides were used as references. The oligomeric formulations exhibited comparable effectiveness as the reference formulations and confirmed the occurrence of CR in the time range of 2 - 6 weeks. We

concluded that the studied formulations were active during prolonged periods of time, which helped to avoid replications of spraying and to reduce the total amount of active ingredients needed. They were easier to store, affected less risk to personnel, as well as, caused less pollution of soil and groundwater.
Keywords: auxinic herbicides;controlled release formulation;ring opening polymerization; herbicide effectiveness

Poster presentations

Influence of additives on efficacy of fenoxaprop-p-ethyl and dynamic surface tension of droplets.

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Weeds are one of the most important limiting factors for crops. Therefore, weed control is a significant management practice for crops production that should be carried out to ensure optimum yield. The options for the chemical control of grass weeds in cereals crops are limited and strongly rely on post-emergence herbicides inhibiting acetolactosynthase and acetyl CoA carboxylase. The aim of this research was to determine the influence of different additives on the efficacy of ACCase inhibitor, fenoxaprop-p-ethyl (Puma®) herbicide applied with hard water (350 mg/l $CaCO_3$). The greenhouse experiments were conducted using fenoxaprop-p-ethyl applied post-emergence at reduced rate (50% of recommended rate e.g. 34,5 g/ha active ingredient) to common oat (Avena sativa) as tested plants with ammonium nitrate 2% v/v, ammonium sulphate 2% v/v, citric acids 0,2% v/v, potassium phosphate 0,1% v/v, EDTA 1 % v/v, various methylated rape seed oil and organosilicone surfactant. Two additional treatments were also sprayed: recommended rate alone and recommended rate with distilled water as well as control not treated with herbicides. Visual assessment and fresh weight reduction of tested plants was dependent on herbicide efficacy. The parameter of surface tension for all tanks-mix combinations was studied in the laboratory. A drop of solution was used to measure the surface tension with optical tensiometer (Theta Lite) on a clean and dry Parafilm® surface. The largest decrease of dynamic surface tension did not cause the best efficacy. The results indicated significant efficacy and reduction of common oat (*Avena sativa*) fresh weight in the case of applying fenoxaprop-p-ethyl with citric acid or ammonium sulphate-both treatments with methylated rape seed oil. The best results were obtained when methylated rape seed oil was added alone to tested herbicide.
Keywords: herbicide; adjuvant; surface tension;

Factors that affect herbicide activity: 1-light.

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Some herbicide molecules are readily degradable by light and may have their efficacy reduced in conditions of high irradiance. On the other hand, systemic herbicides need plenty of photosynthesis to translocate within the plant. One greenhouse experiment was conducted with the objective to evaluate the effect of light on the efficacy of weed control of three post-emergence systemic herbicides. A factorial arrangement of treatments was designed and the factors consisted of herbicides (bispyribac, glyphosate, and sethoxydim) and light levels (0.1, 4, 16, and 100% of daylight). The model plant used to evaluate the herbicide efficacy was Avena sativa (cv. URS Charrua). The herbicides were applied at label rates, using a back-pack sprayer delivering 160 L.ha-1 water volume. Air temperature during spray was 15 Cº. The reduction of light level decreased the efficacy of sethoxydim and bispyribac, mainly when assessed at 7 days after treatment (DAT). Increasing the light level increased the efficacy of glyphosate.
Keywords: sethoxydim; glyphosate; bispyribac;

Factors that affect herbicide activity:2- dust.

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Theoretical analysis supports the idea that dust cover on the weed leaves reduces herbicide efficacy. A field experiment was conducted to evaluate the effect of dust cover on the efficacy of several herbicides. A factorial arrangement of treatments was designed and the factors consisted of: herbicides (2,4-D, ammonium-glufosinate, diuron+paraquat, glyphosate, saflufenacil), and dust cover (with and without). The model plant used to evaluate the herbicide efficacy was Ipomoea grandifolia (Dammer) O'Donell. The herbicides were applied at label rates using a back-pack sprayer delivering 160 L/ha-1 water volume. At the time of the herbicide spray the air temperature was 32 Cº and the air relative humidity was 40%. The dust cover on the weed leaves has decreased the herbicide efficacy of most herbicides, mainly on early assessments dates. The efficacy of 2,4-D, when sprayed alone or in mixture with any of the other compounds, was less affected by dust and could rescue the weed control of all compounds. At 30 days after the herbicide spray, there were no differences between dust or dust-free plots, for any of the herbicides tested.
Keywords: 2;4-D; ammonium-glufosinate; diuron+paraquat; glyphosate; saflufenacil;

Effect of temperature and foliar applied thifensulfuron methyl on soybean safety.

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Polygonum convolvulus, Chenopodium album and Equisetum arvense were the difficult control weeds expect Commelina communis, Sonchus brachyotus and Cephalanoplos segetum in soybean fields, all of these weeds are widespread and seriously impact soybean

growth. Imazethapyr and Fomesafen could control these weeds in high concentration, but these herbicides have an effect on planting structural adjusting because of the long residence time, Thifensulfuron Methyl have the character of hydrolyze in soil, non-volatile, non-photolysis, safe for succeeding crops and having outstanding effect on weeds. The research set three seeding time, spray Thifensulfuron Methyl at five growth and development period of soybean, with the purpose of exploring effect of spraying Thifensulfuron Methyl at different sowing time and different growth and development period on weeds and security of soybean. The result was that as the temperature increased herbicides had good effect on weeds and increased security on soybean. It was safety on soybean before two piece of ternate period, but when temperature was inferior to soybean growth temperature, high humidity in field and the soybean plant is vulnerable, Thifensulfuron Methyl was not safety on soybean, but also cause drug misadventures.
Keywords: Thifensulfuron Methyl; foliar applied herbicide; drug misadventures; safety on soybean;

Laboratory toxicity of 20 herbicides against bengal dayflower (*Commelina bengalensis* L.).

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Owing to a sprawling growth habit, Bengal dayflower has become a troublesome weed throughout warm temperate regions of China. To screen more suitable herbicides against Bengal dayflower, pot experiments were conducted to evaluate the toxicity of 20 post emergence herbicides against Bengal dayflower. Sequence of 20 herbicides laboratory toxicity from the highest to the lowest and IC_{90} was as follow: carfentrazone-ethyl (1.15 g ai ha^{-1}) > lactofen (1.55 g ai ha^{-1}) > flumioxazin (1.92 g ai ha^{-1}) > fluoroglycofen-ethyl (6.83 g ai ha^{-1}) > thifensulfuron-methyl (10.92 g ai ha^{-1}) > metribuzin (13.46 g ai ha^{-1}) > nicosulfuron (14.60 g ai ha^{-1}) > oxyfluorfen (16.51 g ai ha^{-1}) > mesotrione (17.30 g ai ha^{-1}) > paraquat (19.51 g ai ha^{-1}) > MCPA-sodium (22.55 g ai ha^{-1}) > acifluorfen (23.28 g ai ha^{-1}) > rimsulfuron (27.48 g ai ha^{-1}) > fomesafen (33.19 g ai ha^{-1}) > fluroxypyr (33.46 g ai ha^{-1}) > 2, 4-D butylate (54.44 g ai ha^{-1}) > clomazone (58.31 g ai ha^{-1}) > oxadiazon (92.16 g ai ha^{-1}) > bentazone (298.51 g ai ha^{-1}) > isoproturon (363.59 g ai ha^{-1}). The IC90 of 20 herbicides was less than their own recommended dose. Therefore, all 20 herbicides are expected to be used to control Bengal dayflower effectively in field.
Keywords: Bengal dayflower;herbicide;laboratory toxicity;

N-phenyl-2-(4,6-dimethoxy-2-oxypyrimidine)-6-chlorine-benzyl-amine, a new selective pre-emergent Herbicide for weed control in cotton.

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N-phenyl-2-(4,6-dimethoxy-2-oxypyrimidine)-6-chlorine-benzyl-amine is a highly active herbicide, which belongs to a novel class of chemistry. The compound is de novo synthesized in good yield, and the structure is confirmed by 1H NMR, IR, MS, microanalysis, and X-ray. The herbicidal activity, crop safety and selectivity of this compound were assessed under greenhouse and field conditions. The results showed that this compound exhibited excellent herbicidal activity against many grass weed species such as Digitaria sanguinalis (L.) Scop., as well as broadleaf weeds such as Amaranthus retroflexus L. 80 to 100% control of D. sanguinalis, Eleusine indica, A. retroflexus and Portulaca oleracea, as indicated by fresh weight reduction, was obtained in filed evaluation at two sites (Shandong and Hebei) by pre-emergent application at rates of 90~180 g(a.i.)/ha. No significant damage and fresh weight reduction were observed for the cotton plants when compared to the control plants. This compound exhibits low mammalian toxicity and favorable environmental profile. These results suggest that the compound has potential as a new selective pre-emergent herbicide in direct seeded cotton.
Keywords: Oxyprimidinebenzylaniline;new herbicide;herbicidal activity;cotton;

Multifunctional adjuvant formulations for glyphosate.

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Glyphosate efficacy is affected by many environmental, biological and application factors, including presence of hard water ions in spray mixture. Activator adjuvants incorporated in the herbicide formulations by manufactures or added to the spray mixtures by users often overcome effects of unfavorable conditions, provide better spray retention and/or increase foliar absorption, which results in enhanced herbicide efficacy. However, a single-component adjuvant rarely affects all of the important factors responsible for herbicide efficacy. Thus, to optimize glyphosate performance under a wide range of environmental, application, and biological conditions, several homogenous, liquid adjuvant formulations that include ammonium sulphate, organic acids, non-ionic and ionic surfactants, pH buffers and humectants were invented. Effects of these adjuvants that were incorporated in glyphosate formulation on C14-glyphosate absorption and plant fluorescence were determined in a laboratory and greenhouse settings using hard water at the level of 300 mg/L. Abuthilon theophrasti was selected as a test species because of its higher tolerance to glyphosate versus other weed species, due to the presence of calcium in the cuticle. Efficacy of glyphosate formulations containing build-in adjuvant system and similar tank-mixed adjuvants were tested against Elymus repens in the field. Data on glyphosate absorption and fluorescence indicate that the herbicide formulations containing multi-component adjuvant system were more consistent in various conditions and performed better than a reference commercial Transorb Technology™ formulation containing single component adjuvant when used at the same acid equivalent rate and under hard water conditions. Experiments conducted in the field condition confirmed better glyphosate efficacy when applied with built-in or tank-mix multifunctional adjuvants and indicate also that glyphosate rate may be significantly reduced without reducing herbicide efficacy.
Keywords: glyphosate; adjuvant; formulation; efficacy;

Studies on influence of imazethapyr injury to soybean growth and yield.

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Imazethapyr is an excellent herbicide of soybean fields. It was one of the important herbicides of soybean fields in Heilongjiang Province. Because of its high activity in soil, it frequently caused injury to succeeding sensitive crops. Therefore, its use has been limited in some areas, but it still being used as the main herbicide in soybean continuous cropping area. The purpose of this study was to examine the influence of different doses of imazethapyr on soybean growth and yield, explore the relationships between serious of injury with soybean yield loss, and establish primarily the regression equation of imazethapyr injury with soybean yield loss. Also, provide theoretical and technical basis for the safe use of imazethapyr. Material and Methods: Using a plot trial method, different doses of imazethapyr were applied in the field to create different degrees of injury .The influence of the different injury levels on soybean growth and yield was examined. Results, plant height, fresh weight, leaf numbers, pod number strains, strains of grains, soybean yield and other traits decreased as the soybean injury levels increased. The level one injury is ascribed to minimal impact and level five is ascribed to greatest impact injury. Imazethapyr injury level and soybean yield loss was positively related to polynomial regression equation y = 0.9295 x2 - 0.3577 x - 1.0450, R2 = 0.9974. Imazethapyr injury two levels (double the normal doses) is low, the soybean yield average loss is lower than 5.7%. Imazethapyr injury levels three to five, a gradual increase in soybean yield loss, level five injury was exhibited at eight times the normal dose, the average yield loss was 29.8% (19.9% -39.7%). Conclusions, Soybean growth and yield and the degree of injury increased with the increasing doses of imazethapyr.
Keywords: imazethapyr; injury; soybean; roduction; regression equation;

Adjuvants affected fomesafen performance to broadleaf weeds in soybean.

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Soybean is one of the most important crops in China, especially in Heilongjiang province with crops cultivated on over 4 million hectares. The most negative factor for soybean production is weed competition. Fomesafen was the most extensive applied herbicide in soybean around China. However recently, fomesafen usually caused crop injury, reduced crop yield as fomesafen has a longer residual period and higher applied dose. Adjuvants have the potential to improve fomesafen efficacy. Field experiments were conducted in 2009 and 2010 in NEAU, China to describe fomesafen efficacy with several adjuvants for broadleaf weed control, included Amaranthus retroflexus, Xanthium strumarium, Solanium nigrum and Abutilon theophrasti. Generally, weed control efficacy was influenced by adjuvants. Fomesafen had different performance on the four weeds and adjuvants increased the control effectively. The Solanium nigrum control was lower than other three weeds with all dosages from 131.25 to 506.25 ga.i./hm^2, with or without adjuvants. The Xanthium strumarium control was the best in all four weeds, which was completely controlled at 506.25 ga.i./hm^2, or with fomesafen at 375 ga.i./hm^2 plus adjuvants. The control of Amaranthus retroflexus and Abutilon theophrasti was among the Solanium nigrum and the Xanthium strumarium, and with the fresh weight control (95%–100%) at 506.25ga.i./hm^2 alone or at at 375ga.i./hm^2 with adjuvants, or at 506.25ga.i./hm^{2}with Zhujinji(NIS), Jingfuwa(MSO) or FG(organosilicone adjuvant) respectively. The results indicated that mixing adjuvants with fomesafen improve weed control, FG was the best adjuvant, which provided more enhancement to fomesafen than UAN, Zhujinji or Jingfuwa. Jingfuwa was the second best adjuvant, or similar to Zhujinji, on all four weeds. UAN had the least synergistic effect on fomesafen. The Solanium nigrum was more difficult to control and the Xanthium strumarium had the most susceptibility to fomesafen alone or with adjuvant.
Keywords: fomesafen; adjuvant; broadleaf weed control;synergistic effect;

Safety of herbicide sigma broad on Isatis (*Isatis indigotica* Fort.) seedlings and photosynthetic physiology mechanisms.

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A study was performed to explore the safety and photosynthetic physiology mechanisms of sulfonylurea herbicide Sigma broad (mesosulfuron-methyl + iodosulfuron-methyl sodium) to Isatis (Isatis Indigotica Fort.) seedlings. In a pot experiment, biological weight, leaf area, photosynthetic pigment content, photosynthetic rate (Pn), chlorophyll fluorescence characteristics, and P700 parameters of Isatis seedlings were analyzed 10 days after Sigma broad was treated at 5th leaf stage. The results showed that biological weight, leaf area, total chlorophyll, chlorophyll a (Chl a), chlorophyll b (Chl b), and carotenoids content (Car), Pn, transpiration rate (Tr), stomatal conductance (Gs), PSⅡ maximum quantum yield (Fv/Fm), PSⅡeffective quantum yield Y (Ⅱ), PS Ⅱelectron transport rate (ETR (Ⅱ)), photochemical quenching (qP), quantum yield of regulated energy dissipation in PS II (Y(NPQ)), maximal P700 change (Pm), photochemical quantum yield of PSⅠ (Y (Ⅰ)), PSⅠelectron transport rate (ETR (Ⅰ)), and quantum yield of non-photochemical energy dissipation due to donor side limitation in PSⅠ(Y (ND)) decreased with the increasing of herbicide concentration, while chlorophyll a/b (Chl a/b), stomatal limitation value (Ls), initial fluorescence (Fo), quantum yield of non-regulated energy dissipation in PS II (Y(NO)) and quantum yield of non-photochemical energy dissipation due to accepter side limitation in PSⅠ(Y (NA)) increased. Thus, ≥ 823.5 mg • L-1 Sigma broad were extremely unsafe to Isatis seedlings, resulting in the damage of chloroplast, PS Ⅱ and PS Ⅰ structure, interfering with the light absorption, electron transport and its distribution between PSII and PSI, declining cross-membrane proton gradient, conversion and synthesis of ATP and NADPH. So, CO2 fixed amount and photosynthetic rate decreased, but the growth of Isatis seedlings was inhibited significantly.
Keywords: Herbicide; Isatis; Safety; Photosynthetic Physiology Mechanisms;

Effect of adjuvants on overcoming antagonistic effects of spray carrier water salts on glyphosate and 2,4-D+MCPA efficacy in licorice (*Glycyrrhiza glabra*).

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Licorice is a noxious weed species for crop lands in Iran while in other countries it is considered as a medical plant. Therefore greenhouse and field trials were conducted to evaluate the effect of urea ammonium nitrate (UAN), Diammonium sulfate (AMS), Ammonium thiosulfate (ATS) and Ethylene diamine tetra acetate (EDTA) in offsetting antagonistic effects of Clacium (Ca) and Magnesium (Mg) ions and two natural water sources on glyphosate and herbicidal mixture 2,4,-D+MCPA performance in Licorice at University of Tehran, Iran in 2010 and 2011. Results of this study showed that Ca ion was more efficient than Mg in reducing the efficacy of both used herbicides in licorice. Overall, adding adjuvants increased efficacy of both herbicide and their effects on herbicide performance was depended on spray carrier salts and dose of used herbicide. With increasing herbicide dose detrimental effects of salts in spray carrier water on herbicide activity declined. UAN and AMS had higher ability than other used adjuvants in reducing adverse effects of present salts in spray carrier water and originated from licorice tissues. UAN had the highest efficacy in overcoming the antagonistic effect of cations on herbicidal mixture 2,4-D+MCPA while AMS was the most efficacious adjuvant in increasing the performance of glyphosate on licorice. According to this study it could be concluded that UAN, AMS and ATS in addition to their chelating properties, increase the herbicide absorption. Results of this study revealed that the licorice tissues act as a source of antagonistic ions for both used herbicide.
Keywords: Antagonistic effects; Glycyrrhiza glabra; Urea ammonium nitrate; Ammonium thiosulfate; Diammonium sulfate;

The effect of herbicide on weed control in sunflower.

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A study was conducted to investigate the efficacy of pre-emergence and post-emergence herbicides for weed control in sunflower. A field experiment was conducted at the Lopburi Agricultural Research and Development Centre, Phraphutabhat District, Lopburi Province, Thailand, during April-October 2011. The experiment was laid out in a randomized complete block design with four replications and 17 treatments, including applications of pendimethalin, butachlor, propisochlor, metolachlor, acetochlor, oxyfluorfen, oxadiazon, clomazone, flumioxazin, fluazifop-p-butyl, quizalofop-p-tefuryl, fenoxaprop-p-ethyl, clethodim, imazethapyr and imzaquin at rates of 1.88, 1.5, 0.68, 1.88, 1.88, 0.15, 0.94, 0.75, 0.19, 0.19, 0.13, 0.13, 0.28, 0.09 and 0.09 kg a.i./ha, respectively, and compared with the treatments using labor and untreated check. The results revealed that flumioxazin and clomazone are toxic to the germination of sunflower seeds. The severe toxicity symptoms of imazethapyr and imzaquin on sunflower were twisted/curled leaves and growth inhibition resulting in death in 15 days. The herbicides butachlor, metolachlor, acetochlor, oxadiazon, fluazifop-p-butyl, fenoxaprop-p-ethyl and clethodim can be used to control weeds including Digitaria ciliaris (Retz) Koel, Echinochloa colona L., Boerhavia diffusa L., Trianthema portulacastrum L. and Corchorus olitorius L. These herbicide-application treatments tend to have similar weed control in sunflower. Forty-five days after application, dry weight of emerged weeds showed significant differences with untreated check. Application of fluazifop-p-butyl and clethodim gave 2286.00 and 2312.25 kg/ha of sunflower seeds, respectively, the highest and statistically significant difference when compared to other treatments in the experiment. Next in performance are butachlor, acetochlor, fenoxaprop-p-ethyl and the treatment using labor, which gave 1945.56, 2004.25, 2037.56 and 2020.44 kg/ha of sunflower seeds, respectively.
Keywords: herbicides; weed control; sunflower;

The efficiency of adjuvants combined with mesosulfuron-methyl on Tausch's goatgrass (*Aegilops tauschii* Coss.).

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Tausch's goatgrass (*Aegilops tauschii* Coss.) is one of the most economically important grass weeds in winter wheat growing regions in China. The morphology and growth habits of tausch's goatgrass are similar to winter wheat because it is the D genome donor of common wheat. Furthermore, the application of broadleaf herbicides year by year and the lack of adequate grass weed herbicide make it difficult to control in wheat field. Mesosulfuron-methyl registered for post use in winter wheat fails to control Tausch's goatgrass above 3 stages. Experiments were conducted in greenhouse to evaluate the effects of adjuvants combining with mesosulfuron-methyl on tausch's goatgrass control and the safety on winter wheat. The results showed that mesosulfuron-methyl at 11.25 g/ha with adjuvants enhanced herbicide performance and obvious effect was observed in tausch's goatgrass 7 d after treatment (DAT). Control efficacy of tausch's goatgrass in biomass increased at 30 DAT with the addition of adjuvants comparing with mesosulfuron-methyl alone. Adding 0.3% oil concentrate (COC), 0.1% methylated seed oil (MSO) or 0.1% non-ionic surfactant (NIS) in the solution increased control efficacy in biomass to 96.73%, 95.67% and 94.50%, respectively, while the efficacy of mesosulfuron-methyl alone was only 63.46%. Mesosulfuron-methyl at 11.25 g/ha with adjuvants did not cause visible injury in winter wheat at 7 DAT but reduced wheat height by 10.91~14.56% at 30 DAT. MSO and non-ionic organosilicone (OSL) did not reduce wheat biomass while NIS and COC reduced wheat biomass by 14.49% and 11.43%, respectively . It was concluded that mesosulfuron-methy with 0.1% MSO in solution significantly increased control efficacy of tausch's goatgrass when applied at 3 leaf stages with no crop injuries.
Keywords: Tausch's goatgrass; Adjuvants; Mesosulfuron-methyl;

Studys on isolation, identification and characterization of an clomazone-degrading Bacteria W2.

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Clomazone has been widely applied in soybean field owing to its high efficiency and low toxicity. However, serious influence to succeeding sensitive crops such as corns, potatoes, sugarbeets greatly restricted the rational rotation, due to the validity period of clomazone lasting as long as 16 months. In order to ensure food safety and protect agricultural ecological environment, the residue problem of clomazone should be solved urgently. The process of degrading clomazone in soil relies mainly on microbial activity. One bacterial strain was screened from the soil exposed to long residual clomazone by the method of high-pressure enrichment. This bacteria strain W2 was identified as Methyloeoccus sp. based on the morphological features and physiological characteristics. To

optimize of the condition of clomazone degradation by W2, three factors were studied including soil moisture, amount of fertilizer applied and amount of inoculation. The degradation rates of bacteria W2 under several conditions were operated by orthogonally rotational combination design. The results demonstrated that degradation rate was affected significantly by the aforementioned factors in the following order : the soil moisture content > the amount of fertilizer application > the amount of inoculation. Values of: inoculation varied from 8.19mL/kg to 11.81mL/kg, soil moisture content ranging from 18.6% to 20.84%, and the amount of fertilizer application ranging from 1.83g/kg to 2.52g/kg, the degradation rate was above 60% in soil containing clomazone 500μg/kg after 30 days, while degradation half-life was shortened by 63% compared to natural degradation. It is determined that the method and the standard of bio-bacterial application used in this research is successful for solving the residue problem of clomazone.
Keywords: Clomazone; Degradation Bacteria W2; Isolation and Identification; Degradation Characterization;

Clio a broad spectrum post emergence corn herbicide.

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Clio (Topramezone) is a novel 4-HPPD inhibitor herbicide for post emergence weed control in corn. It is effective against most major broadleaf weeds and has excellent activity on large number of grass weed species common to corn, including Eleusine indica and Echinochloa sp., while displaying excellent tolerance to all types of corn. The product was applied on sweet corn at BBCH 14-15 and weed stage of 3-5 leaf stage with Randomized complete block design. Common corn weeds tested was Echinochloa crus-galli, Eleusine indica, Amaranthus viridis, Chenopodium album, Elipta alba, Physalis angulata. At 14 days after application, Echinochloa crus-galli and Eleusine indica was not significantly controlled by Atrazine at rates of 402-750gAI/Ha providing a weed gap. Combination of 13.4gAI/Ha Topramezone and Atrazine 335gAI/Ha (lower rates) however provides good control (>95%) to all of the weeds tested. No phytotoxicity on corn was observed for all treatments. Topramezone at low rates provides a significantly better spectrum of control for corn weeds**.**
Keywords: Topramezone; Clio; Corn; Herbicide; Post emergence;

Synthesis and herbicidal activities of novel pyrazolyl pyrimidine derivatives as potent bleaching herbicides.

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Bleaching herbicides attractd organic chemists due to good selective toxicity and low-use rate. In this study, a series of novel pyrazolyl pyrimidine derivatives which showed excellent bleaching herbicidal activities were designed and synthesized. Their structures were characterized by 1H NMR spectroscopy and elemental analyses. The herbicidal activities of target compounds 3a-3v were assessed. All novel compounds caused strong bleaching activities to Digitaria sanguinalis L. with concentration of 100 mg L-1, and a few compounds 3h, 3i, and 3p caused strong bleaching activities to Brassica campestris L. Compounds 3h, 3i, 3j, 3k, 3p, and 3q also caused strong bleaching activities to Digitaria sanguinalis L. at a reduced concentration of 50 mg L^{-1}, whereas, compounds 3i, 3j, 3k, and 3q didn't exhibit a bleaching effect to Brassica campestris L. The results suggest that good selective toxicity between Digitaria sanguinalis L. and Brassica campestris L. could be found using compounds 3i, 3j, 3k, and 3q. These compounds led to decrease chlorophyll and carotenoid levels in the seedlings of Digitaria sanguinalis L. and Brassica campestris L. and showed progressive bleaching phytotoxicity. Among these compounds, 3j showed the strongest inhibitory activity against chlorophyll and carotenoid of .Digitaria sanguinalis L. The IC50 values of compound 3j to chlorophyll and carotenoid of Digitaria sanguinalis L. reached 2.74 mg L^{-1} and 3.47 mg L^{-1}, respectively. Meanwhile, the IC50 values to chlorophyll and carotenoid of Brassica campestris L. were 24.00 mg L^{-1} and 18.04 mg L^{-1}, respectively.
Keywords: pyrazolyl pyrimidine; chlorophyll;carotenoid; bleaching herbicidal activity;

Partners for Clio in corn for broad spectrum weed control.

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Clio (Topramezone) is a new, highly selective herbicide of pyrazole structure for post-emergence control of broadleaf and grass weeds in corn. Using HPPD, within 2-5 days after treatment, topramezone will cause observable strong photobleaching effects on the shoot, followed by plant death of weeds. The most common weeds in corn are Echinochloa colonum, Dinebra retroflexa, Dactylotenium Aegyptium,Trianthema sp., Eurphorbia hirta, Digera muricata, Commelina benghalensis,Physalis sp., and Cyperus rotundus. Topramezone at various rates and in combination with atrazine was tested by application at pre emergence and 12 days after planting of corn. 14 days after second application, Topramezone at 13.4gAI/ Ha in combination with Atrazine 335gAI/Ha provide excellent control of Echinochloa colonum and Eleusine indica compared to Atrazine solo at high rate of 750gAI/Ha. Clio partnering with Atrazine provides excellent control for all major weeds for corn
Keywords: topramezone; clio; corn; Atrazine;

Preliminary research of phytotoxicity to winter-planting potato caused by herbicide residues in Guangdong province.

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In recent years, succeeding winter-planting potato seedlings, in some paddy fields in Guangdong province, showed symptoms such as growth stagnation， light yellow and narrow leaves ， which caused great losses to farmers. Phytotoxic effects of quinclorac， MCPA-Na, and bensulfuron-methyl on potato seedlings were studied as potential instigators of these symptoms, for these herbicides were widely applied to control the weeds in rice production. Fei wu rui series potatoes, 50% quinclorac WP, 56% MCPA-Na WP,

10% bensulfuron-methyl WP. A pot experiment was conducted, and the herbicides were added to pot soil at different doses. The pots were placed in a greenhouse， the temperature and humidity were 5.0℃~22.3℃ and 40%~60%, respectively. 15 days after treatment, young seedlings began to emerge, and there were no significant differences between treatments. However, 40 days after treatment, compare to the control, quinclorac caused obvious phytotoxic effects to potato seedlings at concentration range of 56.25~225 g a.i./hm2 , which showed growth stagnation， narrow , crimp, fragile and light yellow leaves. this was similar to the field production symptoms. however, MCPA-Na, and bensulfuron-methyl did not cause clear phytotoxic effects. It was demonstrated that potato is sensitive to quinclorac, even at concentration of 56.25 g a.i./hm2 , which is only one fourth of lowest recommended concentration limit in field application.
Keywords: Herbicide Residues; Phytotoxicity; Winter-planting Potato ;

Modelled determination of the herbicide efficacy evaluation using the sap flow method.

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Changes in transpiration rate can be used to examine the effects of herbicides on plants, but also to determine the duration of the competition between crops and weeds for water after a herbicide application. By default, the effects of herbicides on weeds are evaluated by gas-exchange methods. However, the sap flow method can also be used to determine the plant transpiration demands. The aim of this study was to verify the sap flow method for determining the effect of herbicides on the basis of continuous measurements of the transpiration flow, and to demonstrate the effects of different active ingredients on the plant transpiration demands. The sap flow system was used to determine the impact of active ingredients on plants´ transpiration demands under laboratory and field conditions. Helianthus annuus L. was used as a model species. The effectiveness of three active ingredients, bromoxynil (dose 337.5 g/ha, PSII inhibitor), clopyralid (120 g/ha, synthetic auxin) and glyphosate (1350 g/ha, EPSPS inhibitor), was investigated and compared with untreated control. The influence of active ingredients on the water flow decline was proved by computing correlation coefficients which compared the measured transpiration average daily values (Q, kg/day) with the calculated values of sap flow (Qcal, kg/day). Qcal values were calculated from the regression dependency between the measured Q and global radiation, and vapour pressure deficit before herbicides application. The results proved a significant effect of herbicides on plant transpiration demands, determined by the sap flow method. The treatment by bromoxynil significantly eliminated transpiration from the second day and by glyphosate from the fifth day after the application. This study was supported by project TA02010669.
Keywords: sap flow; herbicide efficacy; transpiration;

Use of herbicides saflufenacil+glyphosate in management of weeds for plantation of corn(*Zea mays* L.) the system of direct plantation.

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This paper aims to evaluate the efficiency and selectivity of the herbicides saflufenacil + glyphosate in the pre-plantation stage. The experiment was conducted in the city of Bariri – SP, coordinates: Lat. 22□02’43”S, Long. 48□43’43”w Gr. All treatments were applied at three different times, seven days before the plantation, after total emergence and in pre-plantation.. Fertilization was 508 Kg/ha, using 06.24.16 formula. The experimental design was random blocks at with six treatments (saflufenacil+glyphosate 24.5+1188; 35.0+1188; 49.0+1188; carfentrazone+glyphosate 20.0+1188; flumioxazin+glyphosate 40+1188, all of them in i.a g; witness)and 4 repetitions.. The evaluations of agronomic efficiency were made to 14 and 28 DAT. In the 28 DAT evaluation, it was evaluated the development of the culture by measuring its height. The result of control was total for all the treatments with herbicide for the weeds Cenchrus echinatus, Digitaria horizontalis and Bidens pilosa. For Acanthospermum hispidum the results showed that all the treatments present the control, however, they are 100%. O result of the control Amaranthus hibridus had an excellent effect for all the treatments saflufenacil+glyphosate. At 28 DAT it may be verify that signs of fitotoxicity were not observed. The conclusion of the experiment allows to recommend saflufenacil+glyphosate whose results were positive, in application post-emergency and in pre-plantation, having in mind the efficiency demonstrated in the control.
Keywords: corn; saflufenacil; fitotoxity; glyphosate;no-till;

Influence of organosilicone adjuvant on the physical properties and efficacy of bentazone.

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This paper reports research on the influence of organosilicone adjuvant on the surface tension, viscosity，spreading diameter, drying time, maximum retention on the weed leaf blade surface and biological activity of bentazone. The result showed that the surface tension of liquid reduced from 31mN/m to 20mN/m, viscosity 2.6mPa•s gradually increased to 3.2 mPa•s; spreading diameter of droplet increased to 9.4 mm with the addition of organosilicone adjuvant. The liquid drying time on the Solanum nigrum and Amaranthus reduced from 17.3 min and 12.7 min; maximum retention on weeds blade surface on Solanum nigrum and Amaranthus was largest when surface tension was 27mN/m maximum, respectively 22.4mg cm-2 and 29.2mg cm-2. The control of Solanum nigrum and Amaranthus achieved with bentazone could be increased 37.6% and 39.0% in fresh weight terms by the addition of organosilicone adjuvant. Bentazone formulations added the Organosilicones additives could increase the biological activity of bentazone.
Keywords: Bentazone ;Surface tension ;Viscosity;Spreading diameter ;Maximum retention;

Future challenges to agriculture and its impacts on weed science

Oral presentations

Changes in agricultural structure and globalization of production systems: the view of an agronomist.

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Growth in global population, changing dietary preferences, and competing non-food uses all indicate that large increases in agricultural production will be required in the coming decades. This will drive the pace of change in agriculture at an ever increasing rate. The ongoing trend towards fewer farmers, larger farm size, and more specialized farming operations will likely continue to attain economies of scale needed to generate sufficient profit margins. Societal demands and large food retailers will have a greater influence on how food is produced; animal welfare, biodiversity and the environment will need to be considered to an even greater extent in our evolving agricultural production systems. Global food products and global productions practices driven by large multi-national companies may become the norm in many situations. Overlaid on these already considerable changes in agriculture are some very real constraints on future food production. These include loss of productive soils to erosion and urbanization, declining water resources, more expensive energy, and the effects of a changing climate. The challenge for agricultural scientists and extension personnel will be to develop and foster adoption of more sustainable agricultural systems. Foremost in crop production should be more widespread adoption of conservation tillage systems to reduce soil erosion, build soil quality, conserve soil water, and improve irrigation efficiencies. Secondly, implementation of integrated crop management systems is required for the various crops and regions of the world to attain more sustainable agricultural systems. Diverse crop rotations, cover crops, intercropping, targeted pesticide programs, and strategic fertilizer use are key components of such sustainable systems.
Keywords: global agricultural changes; specialized farms; increased food demand; conservation tillage; integrated cropping systems;

The future of agriculture and requirements for the food industry.

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Future agriculture will require an integrated production based on international quality standards along the food chain to create more value for all involved. Clear traceability with transparency and sustainability are key components for the future of a trusted production of feed and food, both for the local as well as the global markets. Effective quality control needs to be implemented at each step of the whole supply chain, from the agricultural production, including cultivar selection, crop protection with pest and residue management to food processing aspects. Training, communication and on-site guidance of growers are key to a sustainable production meeting international standards and regulations as well as the retailer´s and by that the market requirements.
Keywords: Food chain; traceability; transparency; sustainability

The role of ICT for future agriculture and the role of agriculture for future ICT.

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At the start of the 21st Century we are faced with the emerging problem of global food demand and exceeding the Earth's carrying capacity with the current way of agricultural production. Moreover, the issues of safety, health, quality and sustainability, underpinned by the concept of transparency, have become increasingly important. In many global discussion forums it has been acknowledged that ICT can and will play an important role in meeting these challenges. Over the past thirty years, ICT technologies have been introduced in the agri-food sectors. However, the uptake of these solutions has been slow due to a number of important yet unresolved issues. So there's still a large potential in stimulating adoption of current ICT, but future ICT technologies even promise more potential gains. At the same time, it is believed that the agri-food sector itself can also play an important role in the development of future ICT. The objective of this paper is to present this interactive future development of ICT for the agri-food sector. This will be based on several studies and user panel discussions that were carried out in several EU-projects such as SmartAgriFood, agriXchange, ICT-agri and FutureFarm, including a global view. The following issues will be covered:
• specific characteristics of the agri-food sector, relevant for ICT development.
• future ICT needs from agri-food users' perspective.
• future capabilities of ICT to meet future long and short term needs.
• organization of future ICT development in the agri-food sector through private-public cooperation.
The results will be concluded by setting the agenda points for future ICT development for the agri-food sector and an how these can be achieved.
Keywords: Future Internet; Smart Farming; Private-Public Partnerships;

Sustainability and weed management.

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The introduction of glyphosate tolerant cropping systems has revolutionized the agronomics of weed management. The significant benefits of conservation tillage, increased productivity and flexibility of crop management over the last 16 years have driven herbicide tolerant crops to 94 million hectares or 59% of the total biotech trait hectares.(James, ISAAA, 2011) The challenge of glyphosate resistant weeds make it clear that new and sustainable strategies must be implemented to maintain the agronomic gains of this technology. The incorporation of herbicide tolerant traits into the highest yielding germplasm for each region is a challenging task and one that Monsanto has made successful by using advancements in conventional and molecular plant breeding. For the next generation's crops to be most successful in this changing environment, they will need to grow with less water, less added nutrients. The next gen crops ability to tolerate higher planting densities will be a major tool in the weed management system. Combined with the most convenient herbicide tolerant trait systems the crops of the future will create a sustainable high yielding production of food, fiber and renewable energy. Every technology man has developed will be necessary to feed, clothe and sustain the 8.2 billion people predicted to exist in 2030. The presentation will summarize the view of Monsanto as a global seed company on the future of agriculture and weed management.
Keywords: herbicide; resistant; glyphosate; sustainability; weed;