Changes in agricultural structure and globalization of production systems: the view of an agronomist

R. E. Blackshaw

Agriculture and Agri-Food Canada, Lethbridge, AB, Canada

***E-mail:* robert.blackshaw@agr.gc.ca**

Overall growth in global population, an increasing middle class (70 million people annually), and competing non-food uses (biofuels, bioproducts) 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 in order 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 evolving agricultural production systems. Global food products and global production practices driven by large multi-national companies may become the norm in many situations.

Overlaid on these considerable demand changes in agriculture are some very large 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 climate change. In terms of weed management, we can expect to see continued spread of weeds with global trade and a changing climate may allow new weed species to invade regions where they were previously not present. Additionally, weed resistance to herbicides will likely be an ever increasing problem as manual weeding declines and mechanization increases on a global basis.

The challenge for agricultural scientists and extension personnel will be to develop and foster adoption of more sustainable agricultural systems that address the above mentioned constraints in crop production. In my presentation I outline some of the changes that have occurred in western Canada during the past two decades that have resulted in a more sustainable crop production system. I realize that not all of these examples will be applicable to your region but hopefully there are some principles that are common to all. Additionally, I demonstrate that growers will change their farming practices when presented with sound and profitable alternatives.

Wind erosion is a serious issue in the semi-arid region of western Canada (400-500 mm of precipitation annually). Long-term research efforts were initiated in the 1960s to develop suitable conservation tillage practices. Major hurdles to overcome included development of a) seeding equipment capable of placing seed and fertilizer in undisturbed soil, b) straw spreaders/choppers integrated on harvest equipment to evenly distribute crop residues, and c) weed management programs that controlled weeds in the absence of tillage. It took 15-20 years of patient development before the agronomics and economics of such no-till systems came together to facilitate wide spread grower adoption. Currently, 75% of crops in western Canada are grown under no-till and wind erosion has been greatly reduced. A major additional benefit of no-till has been increased water use efficiency in this water limited region. Standing crop stubble facilitates greater snow trapping during winter and reduces evaporation during summer. This means that there is now more soil water for crop growth which has resulted in an 80% reduction in fallow (previously used to conserve soil water) and an overall increase in crop diversity. Drought-tolerant cereals used to be the dominant crops grown but now there is also considerable production of oilseed and pulse crops in this region. This is an important development because it not only reduces production risk and increases farm income but it is also a critical component of integrated weed management (IWM) and integrated crop management (ICM) systems. Diverse crop rotations are one of the most important methods of reducing insect, disease, and weed infestations as they limit the buildup of any one organism to very high levels and thus are a starting point for sustainable pest management.

Much research has been conducted to develop ICM practices in western Canada that are not only suitable in terms of agronomics but that are also economically viable for producers. Farmers have doubled crop seeding rates in recent years because of greater water use efficiency in no-till systems; resulting in greater weed suppression and higher crop yields. Initial research found that subsurface banded versus surface broadcast fertilizer reduced environmental losses and increased crop utilization. Subsequent research showed that weed growth and competition was markedly reduced in a no-till situation where most weed seed remains on the soil surface and fertilizer was subsurface banded 10 cm deep. Farmers liked the multiple benefits of this practice and 85% of fertilizer is now subsurface banded in a one pass operation during planting. Research has identified competitive cereal cultivars to suppress weeds and hybrid canola has been found to be more weed competitive than the previous open-pollinated cultivars. Hybrid canola was initially adopted for higher yield potential but growers state its weed suppressing ability was also a major reason to adopt the technology. Hybrid canola now represents 90% of canola production in western Canada. Cover crops have been demonstrated to provide numerous benefits (soil quality, weed suppression) and farmers are beginning to include them in their crop production systems.

These individual IWM/ICM practices can be efficacious on their own but the real benefits are only realized when they are combined and practiced in a multi-year approach. Studies conducted on the Great Plains of the United States concluded that a production system combining a minimum of three desirable agronomic practices was needed to see large reductions in weed growth and competition with crops. Research conducted in western Canada supports this conclusion. A new canola production system (competitive hybrid cultivar, high seeding rate, early in-crop herbicide application) was found to provide superior weed control and a 41% increase in yield compared with the traditional system (open-pollinated cultivar, low seeding rate, later in-crop herbicide application). Farmers rapidly adopted this new production system because it was more profitable. A five-year study examining the benefits of a competitive barley cultivar, higher seeding rate, and a diverse crop rotation (barley, canola, field pea) found that wild oat (*Avena fatua*) biomass could be reduced 70-fold while simultaneously attaining higher barley yields. Such cropping systems facilitate more targeted herbicide use and reduce overall selection pressure for weed resistance development.

In summary, highly productive but more sustainable crop production systems are required to meet the food demands of the future. Foremost 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. Diverse crop rotations, cover crops, intercropping, appropriate seeding rate, strategic fertilizer use, and targeted pesticide use are key components of such sustainable systems. Collectively, the agricultural community can meet these challenges but much cooperation and a dose of patience will be required to be successful.

References

Anderson, R.L. 2008. Diversity and no-till: keys for pest management in the U.S. Great Plains. Weed Science 56:141-145.

Blackshaw, R.E. 2005. Tillage intensity affects weed communities in agroecosystems. Pages 209-221 *in* Inderjit, ed. Invasive Plants: Ecological and Agricultural Aspects. Birkhauser Verlag, Switzerland.

Blackshaw, R.E. 2008. Agronomic merits of cereal cover crops in dry bean production systems in western Canada. Crop Protection 27:208-214.

Blackshaw, R.E., Beckie, H.J., Molnar, L.J., Entz, T., and Moyer, J.R. 2005. Combining agronomic practices and herbicides improves weed management in wheat-canola rotations within zero-tillage production systems. Weed Science 53:528-535.

Blackshaw, R.E., Harker, K.N., O'Donovan, J.T., Beckie, H.J., and Smith, E.G. 2008. Ongoing development of integrated weed management systems on the Canadian prairies. Weed Science 56:146-150.

Blackshaw, R.E. and Molnar, L.J. 2009. Phosphorus fertilizer application method affects weed growth and competition with wheat. Weed Science 57:311-318.

Blackshaw, R. E., Molnar, L.J. and Janzen, H.H. 2004. Nitrogen fertilizer timing and application method affect weed growth and competition with spring wheat. Weed Science 52:614-622.

Blackshaw, R.E., Molnar, L.J., and Moyer, J.R. 2010. Suitability of legume cover crop-winter wheat intercrops on the semi-arid Canadian prairies. Canadian Journal of Plant Science 90:479-488.

Harker, K.N. and Blackshaw, R.E. 2009. Integrated cropping systems for weed management. p. 67-76. Available at www.prairiesoilsandcrops.ca

Lindwall, C.W. and Sonntag, B., eds. 2010. Landscapes transformed: the history of conservation tillage and direct seeding. 219 p. Available at www.kis.usask.ca

Smith, E.G., Upadhyay, B.M., Blackshaw, R.E., Beckie, H.J., Harker, K.N., and Clayton, G.W. 2006. Economic benefits of integrated weed management systems in field crops of western Canada. Canadian Journal of Plant Science 86:1273-1279.

Changes in agricultural structure and globalization of production systems

An agronomist's view

Dr. Bob Blackshaw
Agriculture and Agri-Food Canada
Lethbridge, Alberta

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Canada

Increasing demand

- Growing world population
- Increasing middle class
  - 70 million people annually
- Changing diets
  - more meat, fruit, oils
- Estimated that a 70% increase in food production will be needed by 2050
- Competing demands for non-food materials
  - biofuels, bioproducts

Changing demand

- Societal demands will have a greater influence (environment, animal welfare, biodiversity)
- Large food retailers are demanding greater uniformity in food production -- but at a low cost of production
- Movement towards global food products (specified crop cultivars and production practices)
- Supply of ‘seasonal foods’ throughout the entire year

Agricultural structure

- Larger farm size to attain economies of scale
- Farm specialization to simplify operations
- Fewer farmers -- reduced political influence
  - only 2% of Canadians are farmers
- Fewer and larger multi-national companies with considerable vertical integration
  - seed, fertilizer, pesticides
  - food retailers

Agricultural structure

- Non-traditional entities becoming more involved in agriculture
  - corporate farms
  - sovereign wealth funds purchasing/leasing land in ‘land-rich’ regions
- Greater adoption of global technologies
  - genetically-engineered crops
  - precision agriculture
  - agricultural mechanization

Constraints

- Loss of productive agricultural soils
  - 1% of topsoil is lost annually to erosion
  - loss of land to urban or industrial development
- Declining water resources
  - agriculture accounts for ¾ of freshwater use
  - 50% of developing world's grains are grown on irrigated land
  - aquifers are being depleted

Constraints

- Energy will become more expensive
  - manufacture and operation of farm equipment
  - fertilizer production (especially N)
  - transportation costs in a global marketplace
- Climate change
  - hotter, drier climate in some regions
  - more extreme weather events (flash floods, hail storms, wind storms)
  - weed and pest problems could be more severe

Constraints

- Weed management
  - increased spread of weeds with global trade
  - climate change may allow certain weed species to invade new areas
  - herbicide resistance will be an ever increasing problem

Moving forward

- Develop and foster adoption of more sustainable agricultural systems
  - address soil loss, depleting water resources, and increasing energy costs
  - adopt IPM and ICM systems
  - mitigate effects of climate change
  - incorporate new technologies when and where appropriate



Conservation tillage research - Canada

- Research initiated in 1960s
- Early farmer adoption in 1980s
- Widespread farmer adoption in 1990s
- Revolutionized crop production
- Extended this technology to other countries -- but still much work to be done to enhance global adoption

46 years of continuous no-till at the Lethbridge Research Centre

Landscapes Transformed: The History of Conservation Tillage and Direct Seeding; 2010, www.kis.usask.ca

No-till in Canada

- 75% of crops are grown under no-till
- Soil erosion has been greatly reduced
- Standing crop stubble facilitates greater ‘snow trapping’ and reduces evaporation
- More soil water for crop growth
  - 80% reduction in fallow (no crop for 1 year)
  - can now grow crops requiring more soil water
- Crop diversification reduces production risk and increases farm income

No till and weed management

- Lower weed densities after 5-10 years
- Greater weed seed mortality when left on soil surface
- Crop residues suppress weed germination and growth
- Healthier and more competitive crops that suppress weeds
- Soil moisture conservation in this semi-arid region allows production of crops requiring more soil water – *result is greater crop diversity*

Crop production changes in western Canada

Farmers often grow 4-7 crops in any given year

		Million ha (2009)	Change from 1994 (%)
Cereals	Barley	3.0	- 35
	Corn	0.3	+ 20
	Oat	1.4	- 30
	Wheat	9.5	- 25
Oilseeds	Canola	6.5	+ 85
	Flax	0.8	+ 40
	Mustard	0.3	+ 5
	Soybean	0.3	+ 1000
	Sunflower	0.1	+ 150
Pulses	Dry bean	0.2	+ 120
	Field pea	1.9	+ 300
	Lentil	1.2	+ 200
	Forages	6.5	+ 20

Integrated crop management systems

- Diverse crop rotations
  - cereals, oilseeds, pulses, forages
- Higher crop seeding rates
- Competitive crop cultivars
- Strategic fertilizer use
- Green manure and cover crops
- Targeted use of pesticides

Upadhyaya, M.K. and Blackshaw, R.E. 2007. Non-Chemical Weed Management: Principles, Concepts and Technology. CAB Publishing, Wallingford, Oxfordshire, UK.

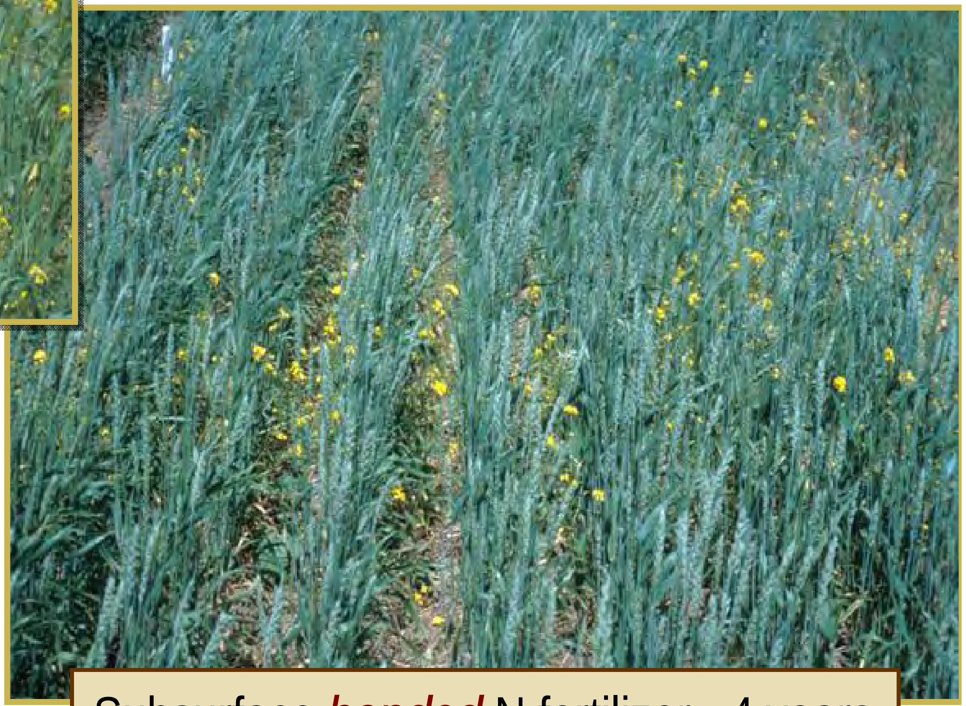
Crop rotation reduces weed and pest populations

	Continuous winter wheat	Winter wheat – spring canola
Year	*Bromus tectorum* m^{-2}	
1988	30	28
1989	54	25
1990	190	35
1991	400	70
1992	920	38
1993	740	40

Strategic fertilization reduces weed growth

Sinapis arvensis competing with
no-till spring wheat

Surface *broadcast* N fertilizer – 4 years



Subsurface *banded* N fertilizer - 4 years

Green manure and cover crops

- Reduce soil erosion
- Improve soil quality
- Suppress weeds through physical and/or allelopathic effects
- Legumes add nitrogen to cropping systems
- Cover crops reduce nitrogen leaching in wet environments

Hairy vetch (*Vicia villosa*)

Winter rye cover crop

Dry bean seeded into winter rye cover crop in mid-May

Dry bean in winter rye residue

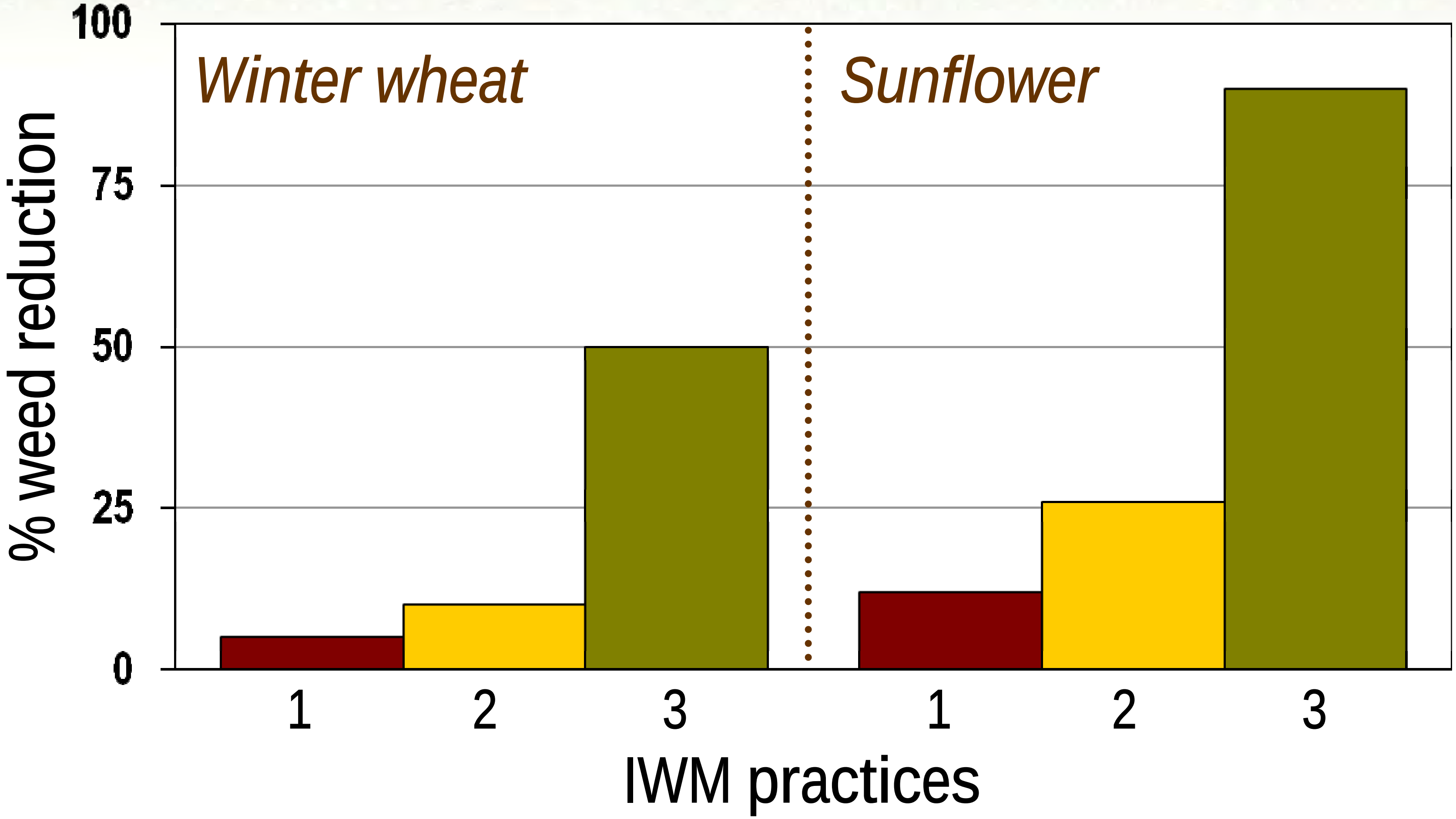
Putting together effective IWM and ICM systems

- Combining several desirable practices
  - 1 + 1 + 1 = 5
- Multi-year application of practices
  - 1 + 1 + 1 = 7

Study 1:
Combining IWM practices on US Great Plains

- Examined various combinations of:
  - competitive cultivar
  - higher seeding rate
  - narrower row spacing
  - subsurface banded fertilizer

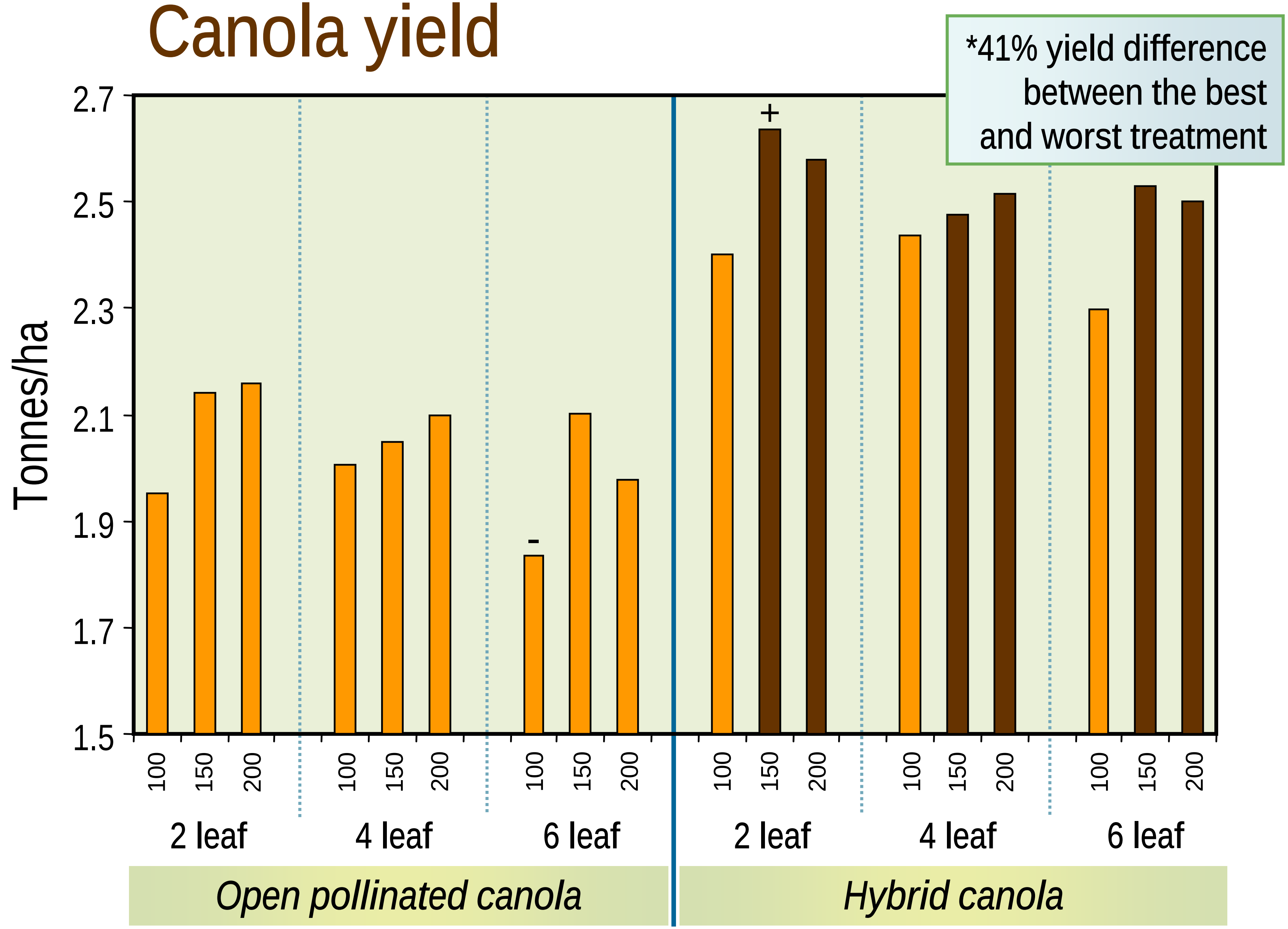
Weed suppression



Study 2: Combining ICM practices in canola

- Factorial arrangement of three agronomic practices
  - Hybrid or open-pollinated canola cultivar
  - Seeding rate (100, 150, 200 seeds/m^2)
  - Herbicide application (2-leaf, 4-leaf, 6-leaf of canola)

Canola yield

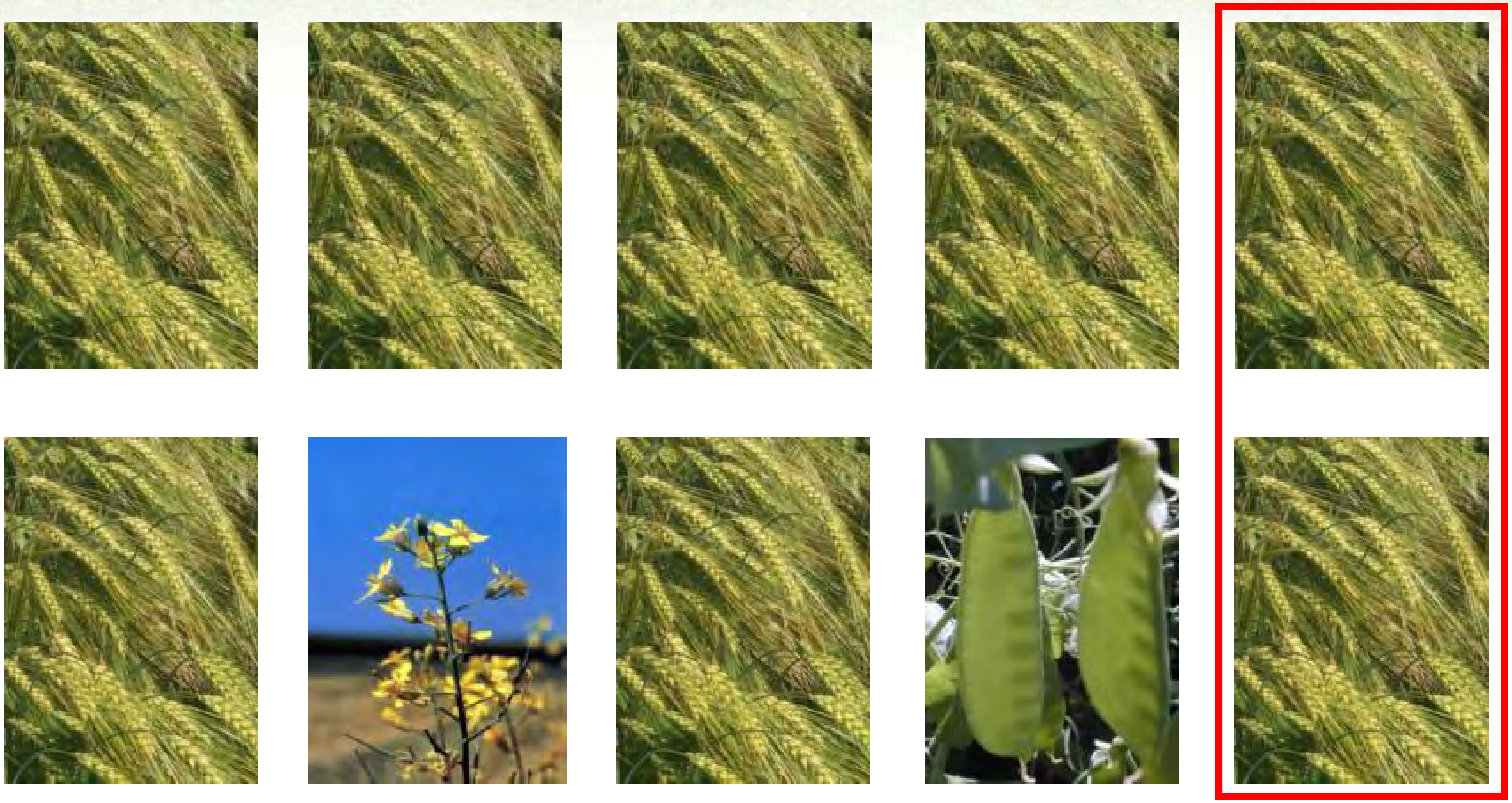


**ICM systems will be adopted if profitable!*

Study 3: Multi-year *Avena fatua* management

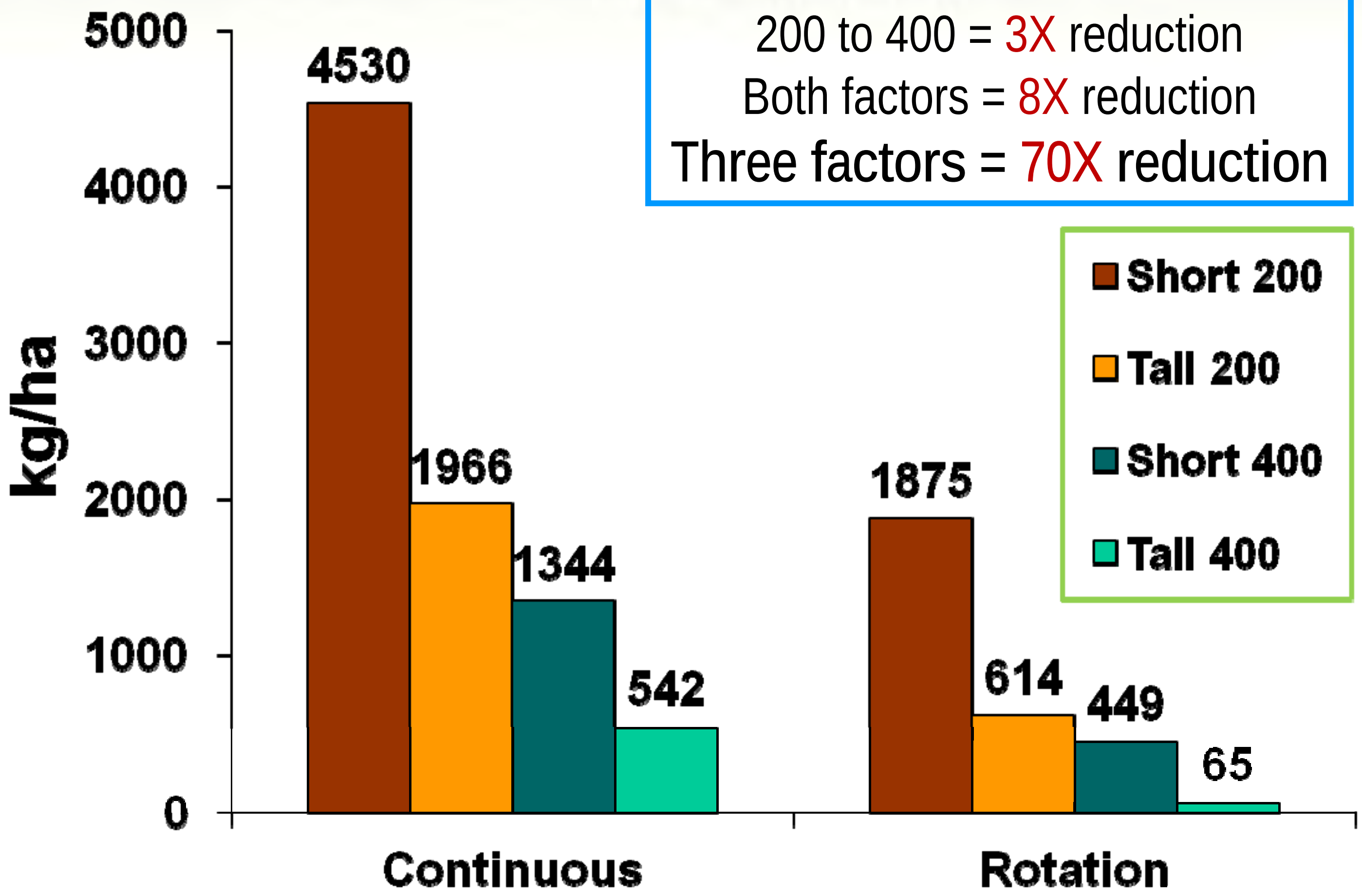
- Rotation – Continuous barley or
  Barley-Canola-Barley-Peas
- Barley cultivars
  - Semi-dwarf or tall
- Seeding rate – 1X or 2X (200 or 400 seeds/m^2)
- Herbicide rate – ¼, ½, or 1X
- Treatments applied to same plots year after year
  - examine cumulative treatment effects over time

Year 5 results

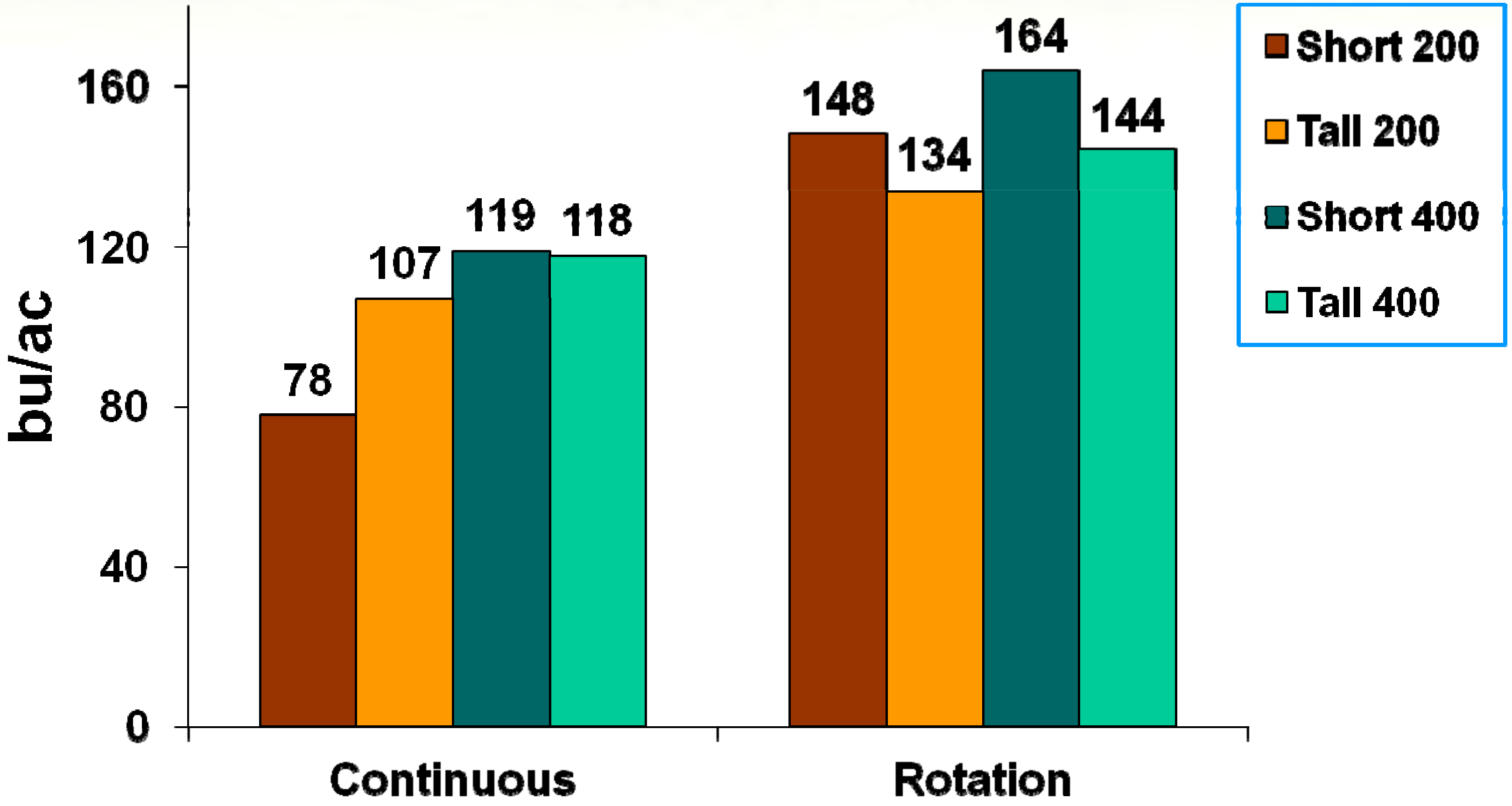


Avena fatua biomass – ¼ X herbicide rate – Year 5

Short to Tall = 2X reduction
200 to 400 = 3X reduction
Both factors = 8X reduction
Three factors = 70X reduction



Barley yield – ¼ X herbicide rate – Year 5



Summary

- Key agronomic practices required in the future
  - Global adoption of conservation tillage
  - Utilization of more diversified crop rotations
  - Greater inclusion of legumes (pulses, forages) in cropping systems
  - More targeted use of pesticides and fertilizer
  - Development of integrated cropping systems that are suitable for each region of the world

Summary

- Adoption strategies
  - Need to fully understand the <u>agronomics</u> and <u>economics</u> of more integrated systems
  - Greater emphasis needs to be placed on multi-year economics (5-10 years)
  - Demonstrations involving farmers can increase technology transfer
  - Patience is required to realize meaningful change

Canada