The Quest for New Herbicide Chemistries

E.N. Johnson[1], R.E. Blackshaw[2], W.E. May[3], K.L. Sapsford[4], F.A. Holm[4]

[1]Scott Research Farm, Agriculture and Agri-Food Canada, Box 10, Scott, SK. S0K 4A0. [2]Lethbridge Research Center, Agriculture and Agri-Food Canada, Box 3000, Lethbridge, AB. T1J 4B1. [3]Indian Head Research Farm, Agriculture and Agri-Food Canada, Box 760, Indian Head, SK S0G 2K0. [4]Crop Development, University of Saskatchewan, Saskatoon, SK. S7N 5A8

Introduction

There are approximately 45 herbicide active ingredients registered in Western Canada belonging to 14 different herbicide groups (Saskatchewan Agriculture and Food, 2006). However, weed survey data indicates that the majority of herbicide use is limited to 5 herbicide groups (Groups 1, 2, 4, 6, and 9) (Leeson, personal communication). Weed resistance to herbicides is common in Canada; particularly to Groups 1 and 2. There are approximately 17 grassy or broadleaf weed species with resistance to Group 2 herbicides in Canada (Heap, 2006)

Herbicides belonging to Group 14 (protoporphyrinogen oxidase inhibitors) or Group 27 (carotenoid biosynthesis inhibitors) are not commonly used in Western Canada. However, these unique modes of action may have a fit so screening of herbicides from these two groups has been undertaken in a number of broadleaf crops.

Screening of Sulfentrazone and Isoxaflutole for Use in Broadleaf Crops

Sulfentrazone is a Group 14 herbicide that inhibits the protoporphyrinogen oxidase (PPO) enzyme, which is important in the synthesis of chlorophyll (Vencil 2002). It is registered in the United States on soybean, tobacco and sunflower. It also has Section 18 registrations in North Dakota for wild buckwheat control in chickpea and field pea and kochia control in flax. Sulfentrazone is a soil-applied herbicide that requires soil moisture for activation and root uptake (Dirks et al. 2000).

Research conducted in Saskatchewan and Alberta indicates that chickpea and fababean tolerance to sulfentrazone is excellent, flax, sunflower, lupin and field pea tolerance is fair to good, while pinto bean and lentil tolerance is poor and very poor, repsectively. Tolerance is dependent on soil type and environment. For example, flax exhibited good tolerance to sulfentrazone at Scott in 2004; however, high rates resulted in unacceptable injury to flax with wetter conditions experienced in 2005 (Figure 1). Wet conditions were also prevalent in Indian Head in 2005; however, injury was acceptable (Figure 1). The soil at Scott is a loam texture with lower organic matter and clay content than the Indian Head soil. Soil activity of sulfentrazone is dependent on soil pH and cation exchange capacity (Kerr et al. 2004). Of the two factors, cation exchange capacity is the most important with sulfentrazone being more active in soils with low soil cation exchange capacity (coarse textured, low organic matter).

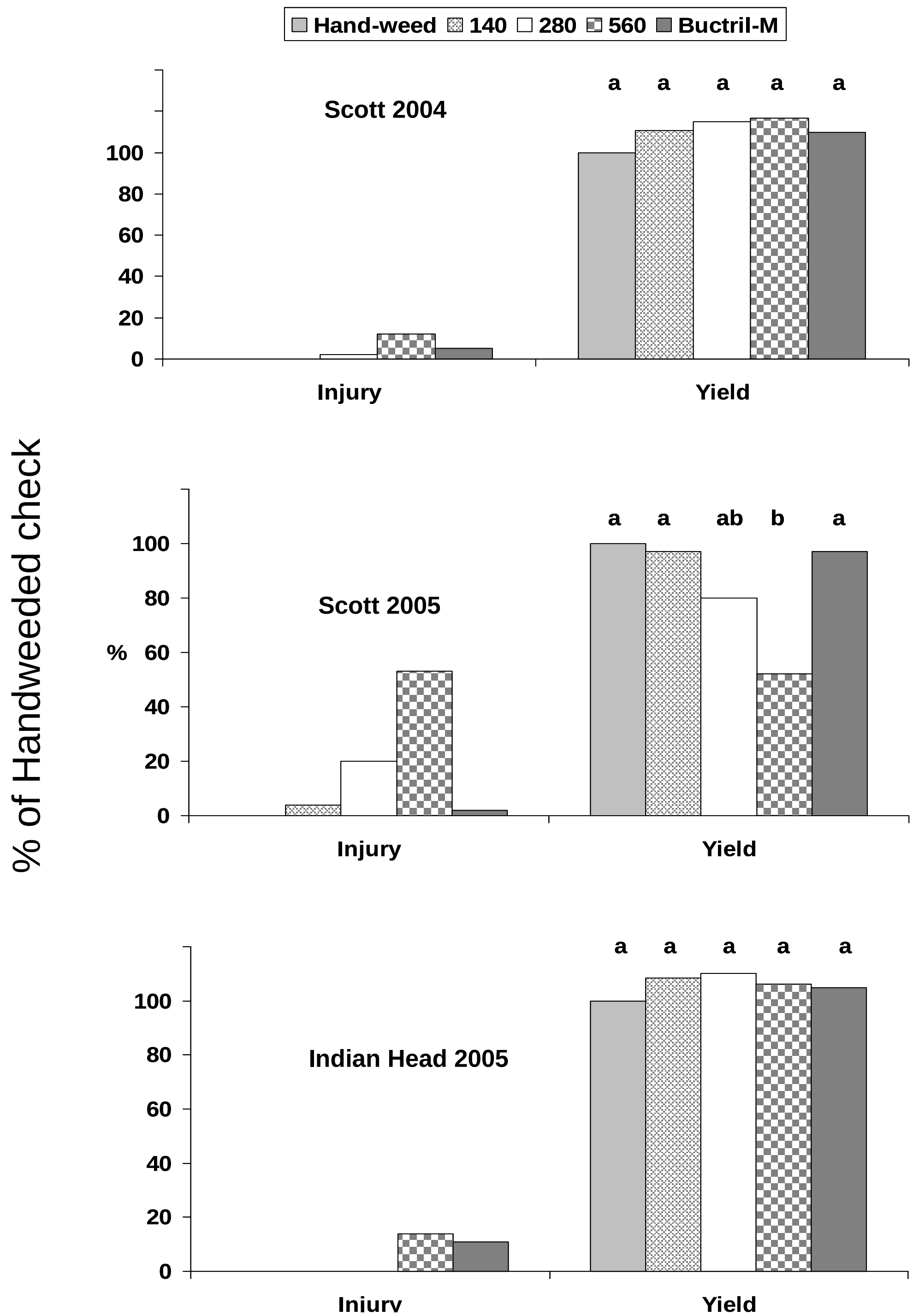

Fig. 1: Effect of sulfentrazone rate on % injury and yield of flax at Scott (2004 & 2005) and Indian Head 2005. Yield is expressed as a percent of the hand-weeded check.

Sulfentrazone has provided good control of wild buckwheat, redroot pigweed and excellent control of kochia and common lambsquarters. (Fig 2). Its major weakness is in the control of cruciferous weeds such as wild mustard (Fig 2).

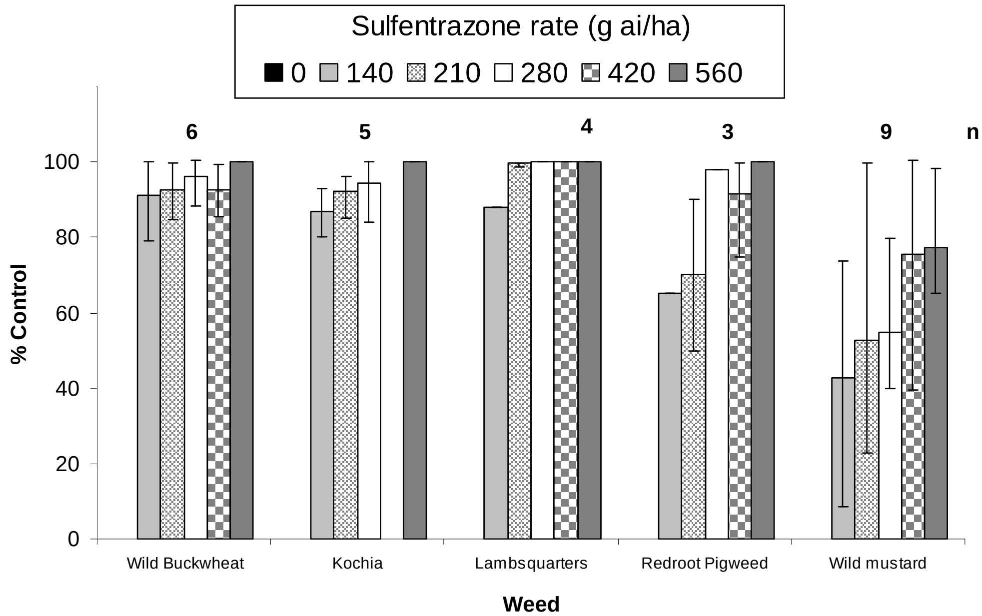

Fig. 2: Effect of sulfentrazone rate on control of broadleaf weed species in chickpea. Studies conducted in Saskatchewan and Alberta from 2002 to 2004. Error bars represent the range of control values. n = number of site-years.

Isoxaflutole is a Group 27 herbicide which inhibits carotenoid biosynethis (Vencil 2002). Carotenoids are pigments that protect chlorophyll from photo-oxidation. If carotenoid synthesis is inhibited, photo-oxidation of chlorophyll will occur leaving the plant with a bleached appearance, ultimately resulting in plant death. Isoxaflutole is registered in field corn in Eastern Canada. The only other crops that have exhibited tolerance to isoxaflutole are chickpea and tame buckwheat.

Isoxaflutole has to undergo hydrolysis in the soil to be converted to its active form (Rice et al. 2004). Soil moisture is required for hydrolysis to occur; therefore, under dry soil conditions weed control can be dramatically reduced. Isoxaflutole has been shown to control wild mustard, common lambsquarters, stinkweed, kochia, redroot pigweed, shepherd’s purse, wild tomato, and green foxtail (Fig. 3). It does not control wild buckwheat or cow cockle.

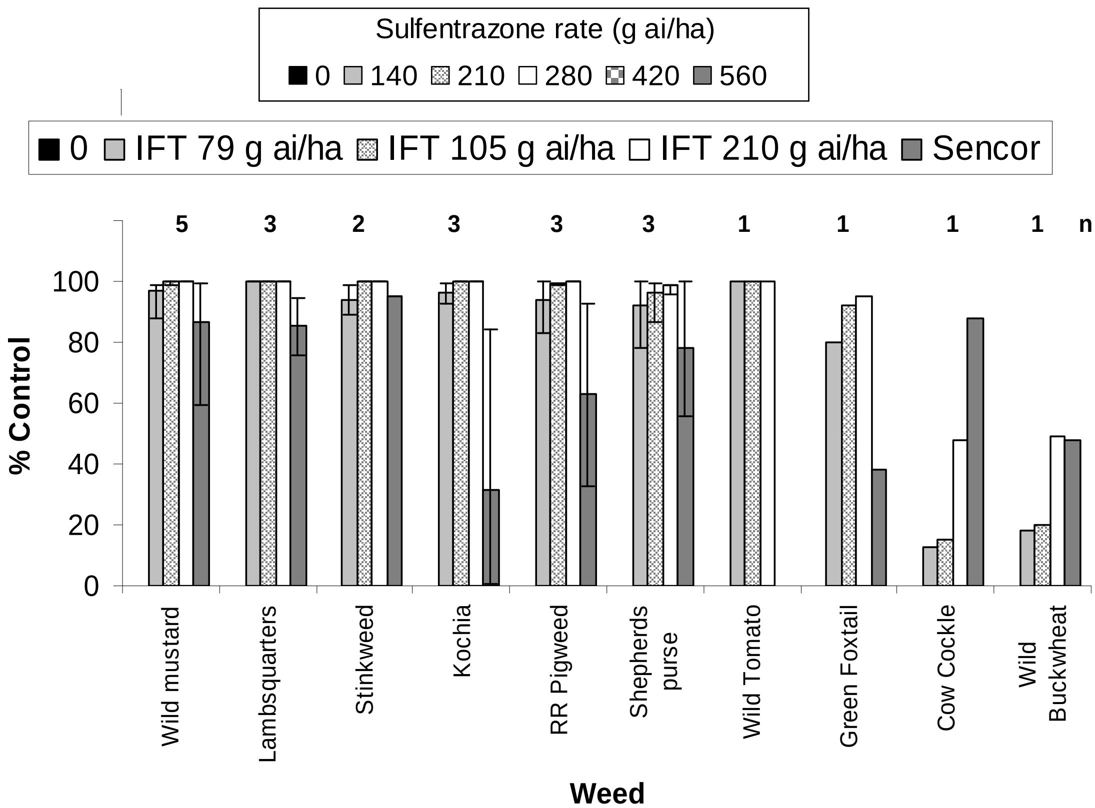

Fig. 3: Effect of isoxaflutole rate on control of broadleaf weed species in chickpea. Studies conducted in Saskatchewan and Alberta from 2002 to 2004. Error bars represent the range of control values. n = number of site-years.

Both sulfentrazone and isoxaflutole are pre-emergence soil applied herbicides. Re-cropping studies conducted in Saskatchewan show that there is potential for residues to carry over and result in unacceptable phytotoxicity to rotational crops such as lentil with both these products. Due to the complimentary weed control spectrum of each product, it was thought that combined low rates of and isoxaflutole and sulfentrazone could control a wide spectrum of broadleaf weeds in chickpea. To test this hypothesis, field studies have been conducted in 2005-06 to determine chickpea tolerance and weed control efficacy of isoxaflutole / sulfentrazone tank-mixes at various rate combinations.

Chickpea tolerance to the sulfentrazone / isoxaflutole tank-mix was excellent (data not shown). The tank-mix provided good control of wild mustard at reduced rates of both products. In addition, combined low rates provided excellent control of wild buckwheat, and kochia (data not shown). Re-cropping studies are underway to see if these low rates reduce carryover injury to rotational crops.

Carfentrazone-ethyl

Carfentrazone-ethyl is a Group 14 post-emergence herbicide (PPO inhibitor) marketed in the United States by FMC Corporation (Vencil 2002). It is a contact non-residual herbicide for control and suppression of a wide spectrum of broadleaved weeds in fallow / preplant burndown systems and as a tank-mix partner in a number of cereal crops. Since it is non-residual, studies were initiated in Saskatchewan and Alberta to investigate its use as a pre-seed or pre-emergence burndown treatment for the control of volunteer Roundup ready canola prior to the seeding of broadleaf crops.

A carfentrazone-ethyl / glyphosate tank-mix provided excellent control of volunteer Roundup ready canola when applied at the 2-3 leaf stage (Fig. 4). One-half of the recommended rate of 8.9 g ai ha^{-1} controlled RR canola when applied early. Studies have shown that cartentrazone-ethyl is not residual; therefore, it would be safe to apply prior to broadleaf crops.

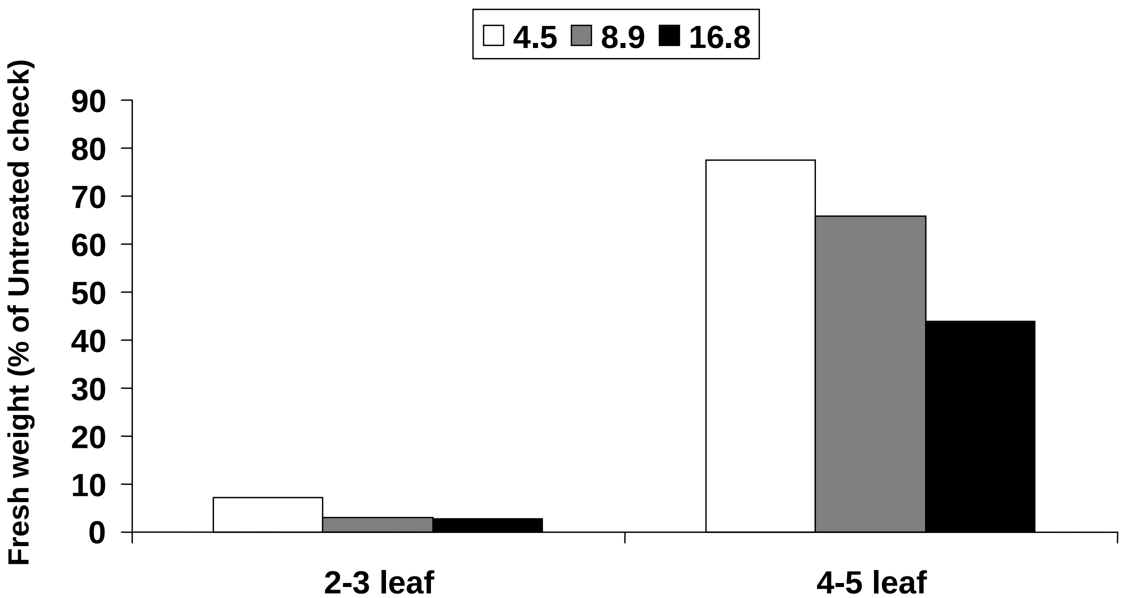

Fig. 4: Effect of carfentrazone-ethyl rate (g ai ha^{-1}) and timing on control of Roundup ready canola fresh weight (% of untreated check). Mean of 2 experiments. Scott, 2004.

Conclusions

There are opportunities to introduce herbicides with different modes of action such as Groups 14 and 27 to Western Canada. The major beneficiary may be low acreage broadleaf crops. These different modes of action will provide alternatives to manage the growing number of herbicide resistant weeds such as Group 2 resistant kochia.

References

Dirks, J.T., W.G. Johnson, R.J. Smeda, and R.E. Massey. 2002. Use of pre-plant sulfentrazone in no-till, narrow-row, glyphosate resistant *Glycine max*. Weed Sci. 48: 628-639.

Kerr, G.W., P.W. Stahlman, and J.A. Dille. 2004. Soil pH and cation exchange capacity affects sunflower tolerance to sulfentrazone. Weed Technol. 18: 243-247.

Saskatchewan Agriculture and Food. 2006. 2006 Guide to Crop Production. Saskatchewan Agriculture and Food, Regina, SK. 366 pp.

Heap, I. 2006. The International Survey of Herbicide Resistant Weeds. Online. Internet. Available www.weedscience.com. Accessed: March 11, 2006.

Rice, P.J., W.C. Koskinen, and M.J. Carrizosa. 2004. Effect of soil properties on the degradation of isoxaflutole and the sorption-desorption of isoxaflutole and its diketonitrile degradate. J. Agric. Food Chem 52: 7621-7627.

Vencil, W.K. 2002. Herbicide Handbook 8th Edition. Weed Science Society of America, Lawrence, KS. 493 pp.

Acknowledgements

The technical support of Brett Hrynewich, Herb Schell, Cindy Gampe, Gerry Stuber, Teri Ife, Randall Brandt, Louis Molnar, Roger Geremia, and Orla Willoughby is much appreciated. Funding support has been provided by the Agriculture and Agri-Food Canada Pesticide Risk Reduction Program and the Saskatchewan Provincial Minor Use Program.