In Search of New Herbicide Chemistries for the Prairies

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Abstract

There are a limited of herbicide groups for use in Western Canada so there is a need introduce different modes of action to manage herbicide resistant weeds. In addition, many broadleaf crops such as chickpea have limited broadleaf weed control options. Sulfentrazone, a Group 14 PPO inhibitor has been screened in a number of broadleaf crops. Chickpea has exhibited excellent tolerance to sulfentrazone, while the tolerance of other broadleaf crops can be summarized as follows: sunflower and fababean (fair to good); field pea, and narrow-leaved lupin (fair); dry bean (poor) and lentil (very poor). Isoxaflutole is a Group 27 carotenoid biosynthesis inhibitor that may have potential for use in chickpea, tame buckwheat, and narrow-leaved lupin. Sulfentrazone effectively controls many broadleaf weeds but is weak on cruciferous weeds such as wild mustard. Isoxaflutole also controls a number of broadleaf weeds but does not control wild buckwheat. Both sulfentrazone and isoxaflutole are soil-applied herbicides with potential to carry-over and injure rotational crops. Preliminary results from field trials indicate that combined low rates of sulfentrazone and isoxaflutole can result in excellent broad spectrum weed control in chickpea. Carfentrazone-ethyl, a contact non-residual PPO inhibitor has been shown to be an effective pre-seed burndown partner for glyphosate. This would allow for the control of volunteer Roundup-ready canola prior to the seeding of broadleaf crops.

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 (Leeson, personal communication). This includes Group 1 (ACCase inhibitors); Group 2 (ALS inhibitors); Group 4 (synthetic auxins); Group 6 (photosynthetic inhibitors); and Group 9 (glycines). Weed resistance to herbicides is common in Canada; particularly to Groups 1 and 2. According to Heap (2006), there are three grass species in Canada with resistance to Group 1 herbicides including wild oat (*Avena fatua* L.), green foxtail (*Setaria viridis* L.), and Persian darnel (*Lolium persicum*). More importantly, there are approximately 17 grassy or broadleaf weed species with resistance to Group 2 herbicides (Heap, 2006)

Broadleaf control options in pulse crops such as chickpeas (*Cicer arietinum* L.) are very limited. Metribuzin is the only registered herbicide for control of broadleaf weeds in chickpea in Western Canada. Tolerance to the herbicide is fair and it does not provide adequate control of weeds such as kochia (*Kochia scoparia* L. Roth) and wild buckwheat (*Polygonum convolvulus* L.).

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. The screening has been supported by the Agriculture and Agri-Food Pesticide Risk Reduction Program and the Saskatchewan Provincial Minor Use Program.

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 marketed in the United States by FMC Corporation as Spartan herbicide. It is registered in the United States on soybean, tobacco and sunflower, and is also registered in North Dakota (Section 18) for control of wild buckwheat in chickpea and field pea (*Pisum sativum* L.). 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 tolerance to sulfentrazone is very good, field pea tolerance is fair, while lentil (*Lens culinaris* L.) and dry bean (*Phaseolus vulgaris*) tolerance is poor (Fig. 1).

Tolerance of flax (*Linum usitatissum* L.) has been fair to good depending on soil type and environment. In 2004, flax exhibited good tolerance to sulfentrazone at Scott; however, high rates resulted in unacceptable injury to flax with wetter conditions experienced in 2005 (Figure 2). Wet conditions were also prevalent in Indian Head in 2005; however, injury was acceptable (Figure 2). 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. The soil at Scott is a loam texture with lower organic matter and clay content than the Indian Head soil.

Sunflower (*Helianthus annus* L.) has exhibited fair to good tolerance to sulfentrazone, depending on rate and soil type (data not shown). Preliminary results at Scott indicate that narrow-leaved lupin (*Lupinus angustifolius* L.) and fababean (*Vicia faba* L.) exhibited fair and good tolerance, respectively to sulfentrazone (data not shown).

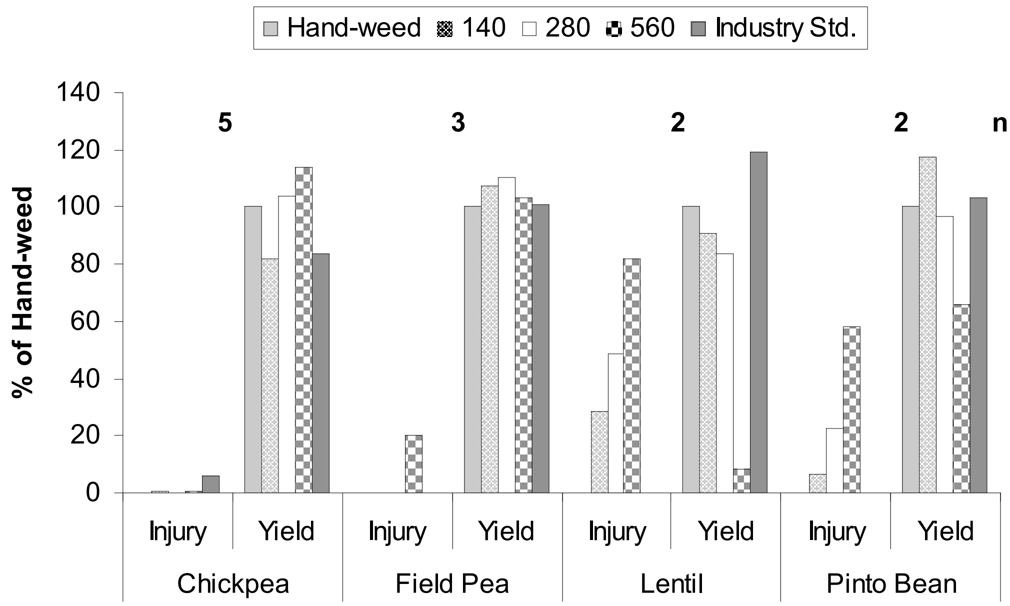

Fig. 1: Effect of sulfentrazone on % crop injury and yield (% of hand-weeded check) of pulse crops. Studies conducted in Saskatchewan and Alberta from 2002-2004. n = number of site-years of data. The proposed rate of sulfentrazone for Western Canadian registration in chickpea is 280 g ai ha^{-1}.

Sulfentrazone has provided good control of wild buckwheat, redroot pigweed (*Amaranthus retroflexus* L.) and excellent control of kochia and common lambsquarters (*Chenopodium album* L.) (Fig 3). Its major weakness is in the control of cruciferous weeds such as wild mustard (*Sinapis arvensis* L.) (Fig 3).

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 (*Zea mays* L.) in Eastern Canada. The only other crops that have exhibited tolerance are chickpea, tame buckwheat (*Fagopyrum esculentum*), and narrow-leaved lupin (data not shown). Chickpea tolerance has been excellent. The rate of isoxaflutole registered in field corn is 79 to 105 g ai ha^{-1}.

Isoxaflutole is a pro-herbicide which is also soil applied. Isoxaflutole has to undergo hydrolysis in the soil to be converted to diketonitrile, 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 provide excellent control of wild mustard, common lambsquarters, stinkweed (*Thlaspi arvense* L.), kochia, redroot pigweed, shepherd's purse (*Capsella bursa-pastoris*), wild tomato (*Solanum triflorum* Nutt.), and green foxtail (Fig. 4). It does not provide adequate control of wild buckwheat.

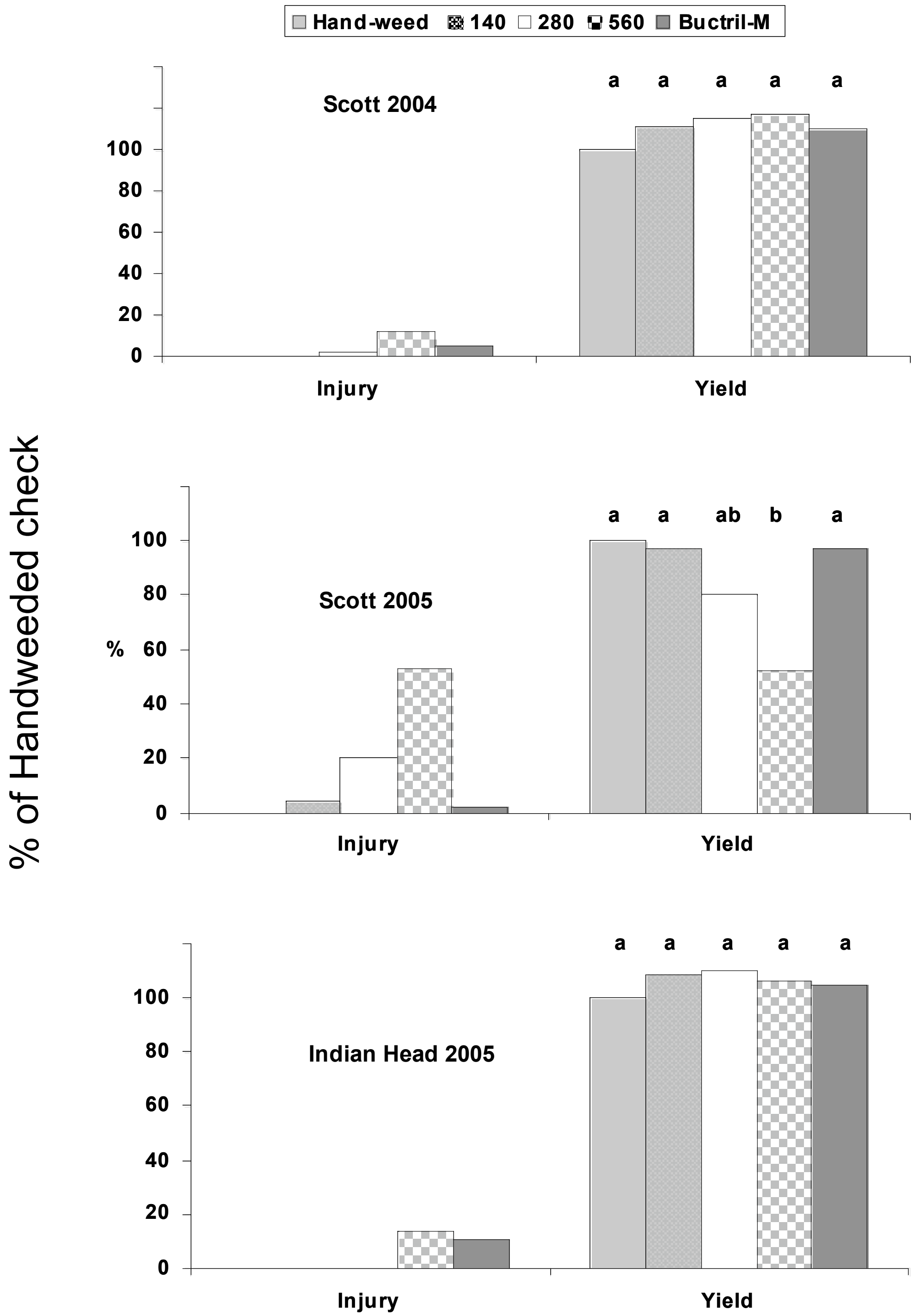

Fig. 2: Effect of sulfentrazone rate on % injury and yield of flax at Scott (2004 & 2005) and Indian Head 2005. Yield is expressed as a percent of the hand-weeded check.

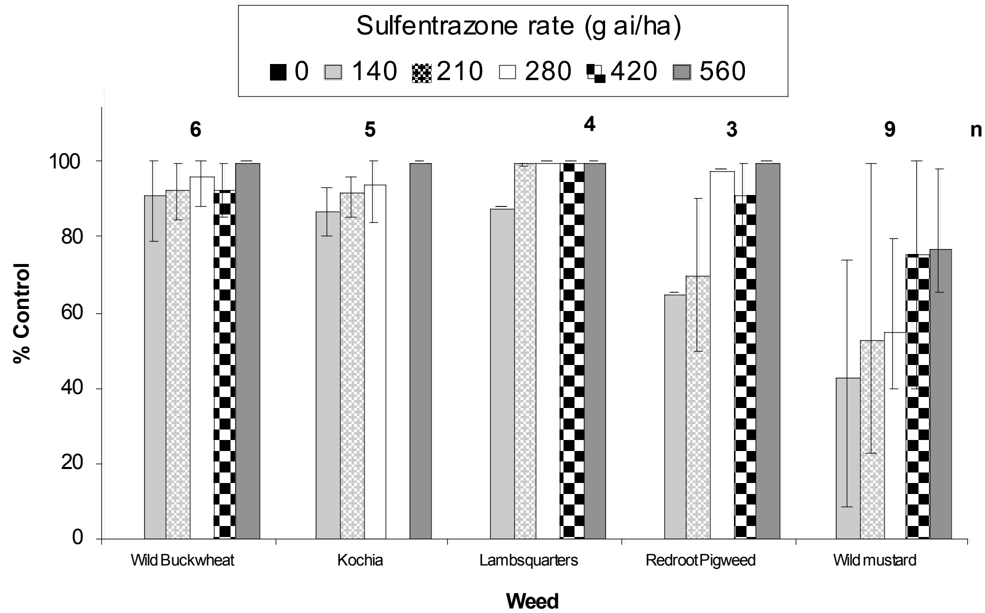

Fig. 3: Effect of sulfentrazone rate on control of broadleaf weed species in chickpea. Studies conducted in Saskatchewan and Alberta from 2002 to 2004. Error bars represent the range of control values. n = number of site-years.

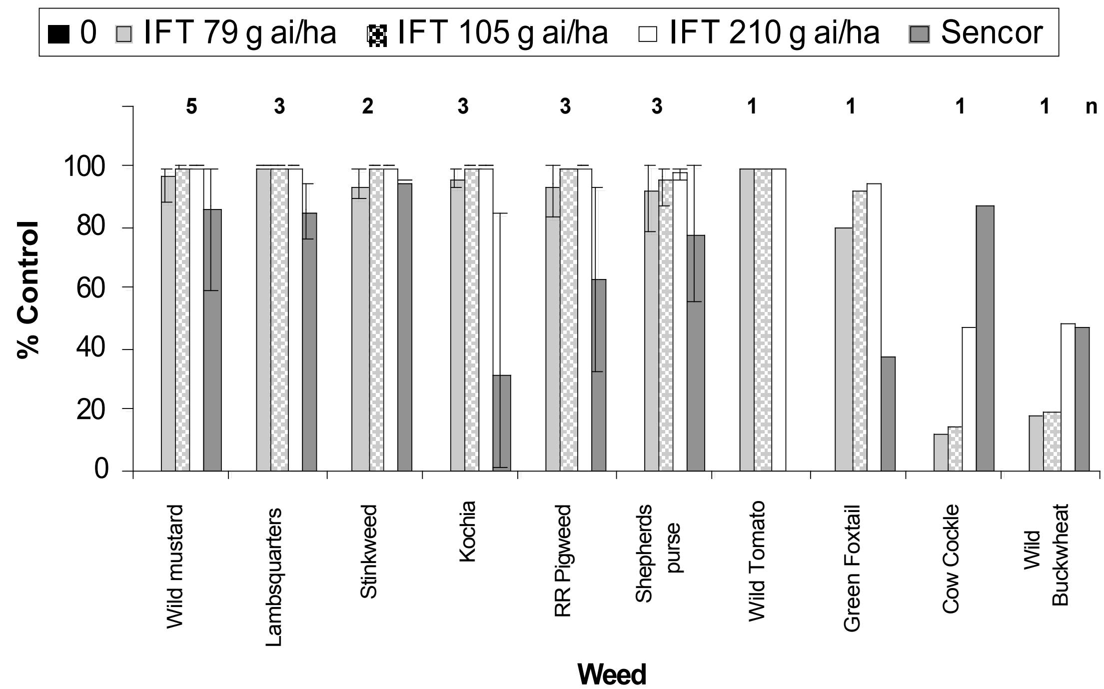

Fig. 4: Effect of isoxaflutole rate on control of broadleaf weed species in chickpea. Studies conducted in Saskatchewan and Alberta from 2002 to 2004. Error bars represent the range of control values. n = number of site-years.

Both sulfentrazone and isoxaflutole are pre-emergence soil applied. 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. As mentioned earlier, high rates of sulfentrazone are required to achieve adequate control of cruciferous weed species; while isoxaflutole does not control wild buckwheat. Therefore, field studies were conducted at two locations in Saskatchewan in 2005 with the objective of determining chickpea tolerance and weed control efficacy of isoxaflutole / sulfentrazone tank-mixes using various rate combinations.

Chickpea tolerance to the sulfentrazone / isoxaflutole tank-mix was excellent (data not shown). The tank-mix provided excellent control of wild buckwheat and wild mustard when combined at low rates (Fig. 5). In addition, combined low rates provided excellent control of kochia and wild tomato (data not shown). Re-cropping studies will be conducted in 2006 to see if these low rates reduce carryover injury to rotational crops.

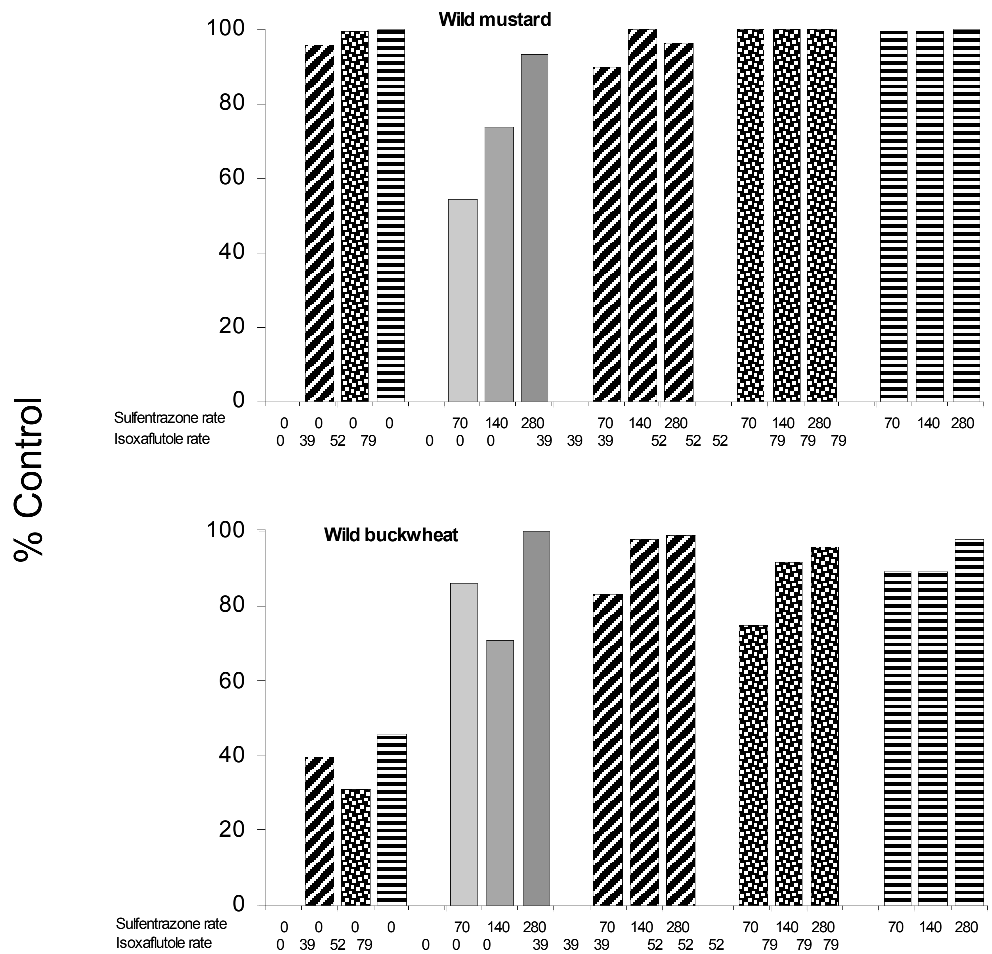

Fig. 5: Effect of sulfentrazone/isoxaflutole tank-mixes at various rate combinations on the control of wild mustard and wild buckwheat in chickpea. Mean of 2 sites: Scott, SK and Saskatoon, SK. 2005. Shaded / pattern combinations indicate combined rates of isoxaflutole and sulfentrazone.

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. 6). One-half of the recommended rate of 8.9 g ai ha^{-1} controlled RR canola when applied early.

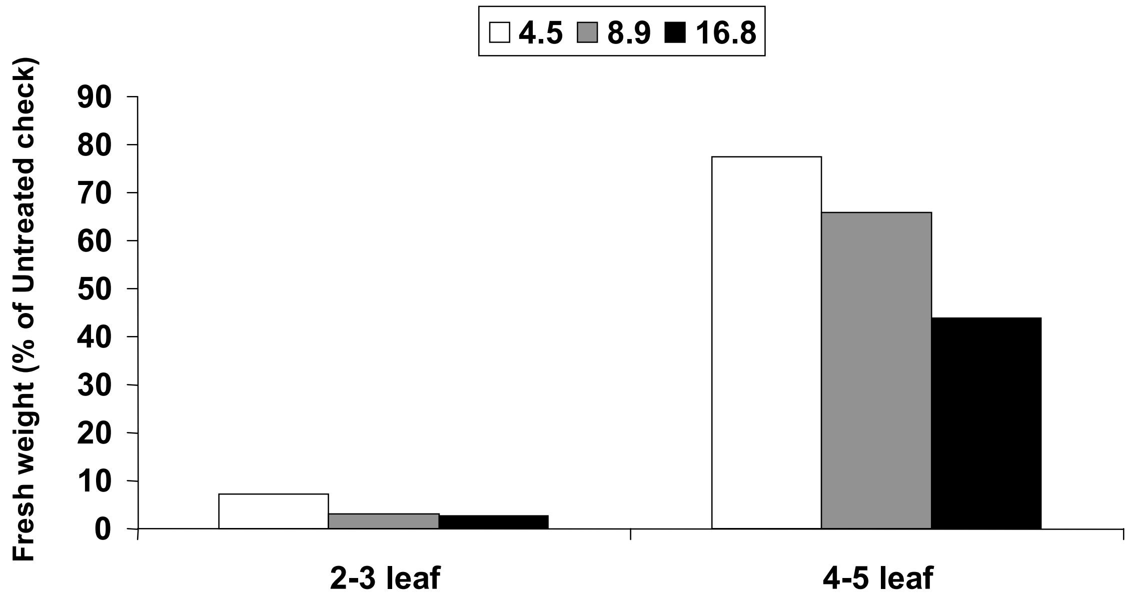

Fig. 6: Effect of carfentrazone-ethyl rate (g ai ha^{-1}) and timing on control of Roundup ready canola fresh weight (% of untreated check). Mean of 2 experiments. Scott, 2004.

To ensure that it was non-residual, a dose-response experiment was conducted at both Lethbridge and Scott prior to the seeding of lentil. Rates from 8.9 g ai ha^{-1} (low rate) to 67.2 g ai ha^{-1} (8X rate) were applied one day prior to seeding and five days after seeding. No injury was reported at any rate or application timing at Lethbridge (data not shown); however the 8X rate resulted in some initial injury to Scott when applied 5 days after seeding. The injury was transient and yields of lentil were equal to the glyphosate check (Fig 7). There appears to be a large margin of safety for the use of this product prior to the seeding or emergence of broadleaf crops.

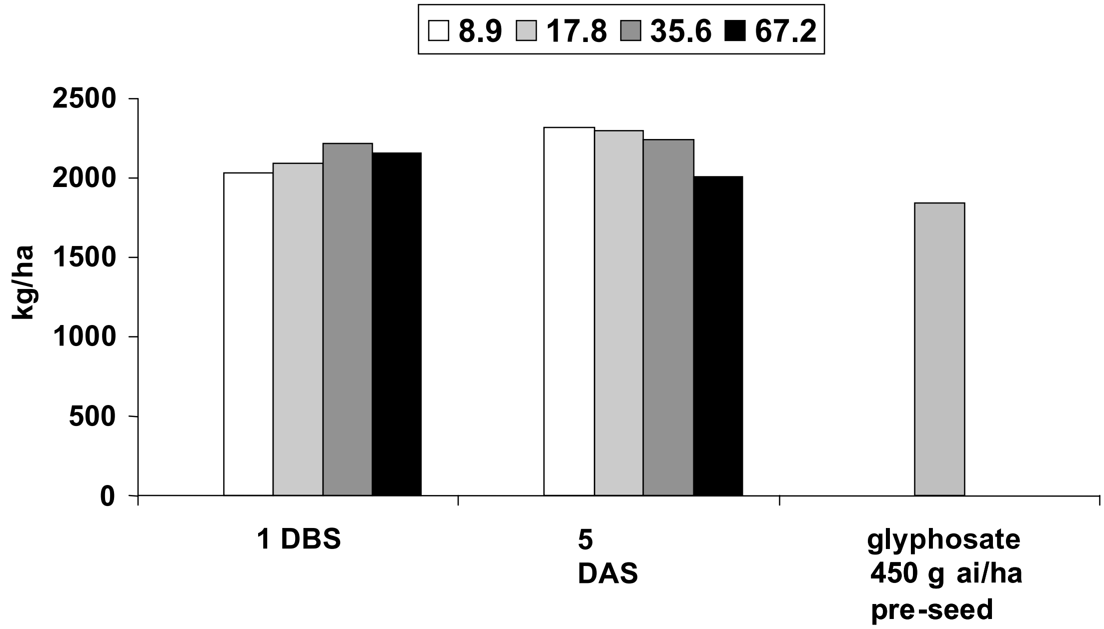

Fig. 7: Effect of carfentrazone-ethyl rate and timing on lentil yield. Scott, 2004. DBS = days before seeding; DAS = days after seeding.

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.

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