A brief history of herbicide use in western Canada

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Summary For the past 60 years, herbicides have played a vital role in crop production in western Canada. Their use has allowed for significant diversification in crop types and has triggered a major shift towards more soil- and water-conserving and energy-efficient farming systems. Many new herbicides were discovered and developed in the 1960s and 1970s, but the herbicide 'golden era' appears to be over. In recent years, dramatically fewer new herbicide registrations and ever-increasing numbers of herbicide-resistant weeds make the herbicide tools we already have increasingly valuable. All players (herbicide manufacturers, researchers, farm advisors and farmers) will need to work together closely to develop integrated strategies to ensure that effective weed control can be achieved on a sustainable basis for the future.

Keywords Herbicides, western Canada, history.

INTRODUCTION

In recent years, herbicide sales in western Canada have accounted for approximately 80% of total pesticide sales. Thus, in 2008, farmers in western Canada spent approximately Cdn $900 million on herbicides (R. Hurst, CropLife Canada, personal communication,). The intensive use of herbicides over the past six decades has resulted in the evolution of a significant number of cases of herbicide resistance in weeds (Heap 2010). While this has not yet resulted in a decline in herbicide use, it has certainly reduced the efficacy of some herbicides on many farms. Herbicide resistant weeds are a good reminder of the weakness inherent in the over-reliance on one weed control method and this problem is spurring renewed interest in the development of cost-effective integrated weed management systems.

DISCUSSION

Early 20th century attempts at chemical weed control in western Canada consisted of using various soil residual salts at extremely high rates for non-selective control of persistent perennial weeds and various inorganic compounds for selective control of annual broadleaved weeds in cereals (McRostie *et al*. 1932). The widespread use of herbicides became a significant factor in crop production in the 1960s.

The modern 'Selective Herbicide Era' really began in 1945 (Table 1) with the introduction of 2,4-D, a phenoxy herbicide that controlled many annual broadleaved weeds in cereal crops that was adopted very rapidly. In 1949 and 1962 it was used on 3.2 and >10 million ha, respectively (Wood and Olson 1946, Friesen 1963).

Other significant milestones in chemical weed control in western Canada include the introduction of the dinitroaniline herbicides in the 1960s. It is generally held that the western Canadian canola crop, which currently generates about Cdn $2.5 billion in annual farm cash receipts, could not have been established without these herbicides. The introduction of the thiocarbamate herbicides, diallate and triallate, also in the 1960s, provided western Canadian farmers with the first truly effective control of wild oats (*Avena fatua* L.) in cereal and dicot crops. In the mid-1970s, the introduction of the first ACCase inhibiting herbicide, diclofop-methyl, marked the beginning of highly effective annual grass control in a wide variety of cereal and dicot crops.

Diclofop-methyl was followed rapidly by several other ACCase inhibitors (Table 2). These herbicides remain very popular with western Canadian farmers in spite of the fact that resistance in wild oat has evolved on many farms throughout the area (Heap 2010).

The mid-1970s also marked the introduction of glyphosate and this herbicide, more than any other, has transformed crop production in western Canada over the past two decades as it has facilitated the widespread adoption of minimum-till and zero-till farming systems. These have reduced fuel and labour costs and the need for summer fallow and have significantly increased soil and water conservation in the semi-arid Canadian prairies.

In the early 1980s, the first sulfonylurea herbicides were introduced and these quickly followed by a variety of other ALS inhibitors including the imidazolinones (Table 2). These products are widely used to control both grass and broadleaf weeds in cereals and dicot crops. They remain very popular in spite of widespread resistance to this mode of action in several key weed species throughout the area (Heap 20 10).

Table 1. Introduction, by decade, of herbicide mode of action groups currently used in western Canada.

		Herbicide mode of action according to:	
Decade[A]	Mode of action	HRAC[B]	WSSA[B]
1940–49	Synthetic auxin	O	(4)
1950–59	Fatty acid / lipid synthesis inhibitor	N	(8)
	Carotenoid biosynthesis inhibition	F3	(11)
1960–69	Mitosis inhibition	K1	(3)
	Photosystem II inhibition	C1	(5)
	Photosystem II inhibition	C3	(6)
	Photosystem II inhibition	C2	(7)
	Photosystem II inhibition	D	(22)
1970–79	ACCase inhibition	A	(1)
	EPSP synthase inhibition	G	(9)
	Cellulose inhibition	L	(20)
	Unknown		(25)
	Cellulose inhibition	Z	(27)
1980–89	ALS / AHAS inhibition	B	(2)
1990–99	Glutamine synthetase inhibition	H	(10)
	Protox inhibition	E	(14)
	Mitosis inhibition	K3	(15)
2000–2009	Carotenoid biosynthesis inhibition	F2	(28)

[A] Product registration dates obtained from Pest Management Regulatory Agency, Health Canada (2010).
[B] For mode of action abbreviations see Senseman (2007).

Table 2. Mode of Action groups, use patterns and date of introduction of various herbicides used in western Canadian crop production over the past 60 years.

Mode of action (Group)	Product(s)	Use	Date(s)[A]
Photosynthesis inhibition (5)	bromacil, hexazinone	soil sterilant	1963, 1977
	simazine, atrazine	corn, forages	1963, 1971
	cyanazine	broadleaf weeds in cereals	1970
	metribuzin	pulse, cereal, potato	1971
Photosynthesis inhibition (7)	diuron, tebuthiuron	soil sterilant	1965, 1973
	propanil	green foxtail – cereals	1977
	linuron	horticulture, shelterbelts	1979
Pigment inhibition (11)	amitrole	mono & dicot weeds	1959
Cell membrane disruption (14)	fomesafen	dry beans	1997
	carfentrazone	pre-seed burn-off	2006
	sulfentrazone	broadleaf weeds - chickpea	2008
Cell division inhibition (15)	metolachlor	corn, bean, potato, soy	1990
	dimethanamid	corn, bean	1994
Cellulose inhibition (20)	dichlobenil	soil sterilant	1973
Cell membrane disruption (22)	diquat	crop desiccant, aquatic weeds	1960
	paraquat	weed control in horticulture	1963
Cell division inhibition (23)	barban	wild oat control in field crops	1960
Unknown (cell elongation)(25)	benzoylprop, flamprop	wild oat control in wheat	1972, 1977
FA and lipid inhibition (26)	TCA, dalapon	grass control	1947, 1955

[A] Product registration dates obtained from Pest Management Regulatory Agency, Health Canada (2010).

In 1950, farmers in the province of Saskatchewan could choose from only three registered herbicides: 2,4-D, 2,4-D + 2,4,5-T, and TCA. The provincial herbicide extension booklet was a 15 × 22.5 cm booklet with 24 pages. In contrast, in 2010 western Canadian farmers can choose from amongst approximately 200 trade name products which are outlined in a 21 × 28 cm publication with 268 pages devoted to herbicides (Anon. 2010). Today they are faced with an ever increasing number of choices as an increasing number of generic and private label products come to the market and the number of pre-packaged herbicide mixes expands. This situation increases the 'confusion level' amongst farmers as they make their annual herbicide product decisions and it tends to mask the fact that the rate of introduction of new modes of action has slowed to a crawl (Table 1).

CONCLUSIONS

Herbicides have been used extensively in western Canada for more than half a century and have contributed substantially to increased and more stable crop yields, and improved crop quality. Their use has also resulted in a marked reduction in the amount of tillage required to produce annual crops. This has contributed to significant reductions in summer fallow acreage and soil erosion throughout the prairies and an increase in water conservation. However, early hopes that they would bring an end to weed problems on the prairies were dashed long ago.

In spite of the effectiveness of herbicides, and their widespread use, weeds continue to be a major threat to successful crop production. Weed populations have changed and evolve in response to herbicide use. Tolerant or resistant species are filling the void left by more susceptible species. The appearance of herbicide resistant biotypes of several weed species is a constant reminder that over reliance on any one weed control method is ultimately doomed to failure. While herbicides will remain an important component of weed management on the prairies for many decades to come, their on-going utility can only be assured if they are used judiciously within well-designed, integrated systems that utilise a wide variety of weed management techniques.

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