WEED MANAGEMENT IN CANADIAN POTATOES

J A Ivany
Agriculture and Agri-Food Canada, Crops and Livestock Research Centre, 440 University Ave, Charlottetown, PEI, C1A 4N6, Canada
E-mail: IvanyJ@agr.gc.ca

Summary: Potatoes are produced on 175,300 ha in Canada with production concentrated in Prince Edward Island (25%), Manitoba (22%), New Brunswick (14%), and Alberta (13%). The number of herbicides available for weed management has decreased due to deregistration and development of weed resistance. Interest in non-chemical and organic techniques to provide weed management has increased. Aggressive mechanical methods between potato rows coupled with banded, in-row herbicide or thermal treatments gave effective weed control and high potato yield. Corn gluten gave limited control of broad-leaved weed species. Acetic acid injured emerged potato foliage and reduced marketable yield. A concentration of 20% acetic acid was needed to reduce weed biomass to acceptable levels. The new herbicides sulfentrazone and flumioxazin controlled weeds, but caused potato injury if applied near emergence or post-emergence and reduced marketable yield.

INTRODUCTION

Potatoes are produced in all provinces of Canada with over 74% of the 175,300 ha in 2004 found in Prince Edward Island, Manitoba, New Brunswick and Alberta (Statistics Canada 2005). The construction of large French fry processing plants has doubled production in the past 20 years. The cultivar Russet Burbank makes up 60 to 65% of the production in Prince Edward Island and New Brunswick and 80 to 90% in Manitoba and Alberta. The second cultivar is Shepody, but due to shorter storage capability, is used mainly early in the processing season.

Potato growers in Canada have lost several herbicides over recent years and no new herbicides have become available. Metribuzin is the backbone of weed control programs in potatoes but resistant *Chenopodium album* is common in fields in Prince Edward Island and growers must use linuron to control this species. Unfortunately, linuron-resistant *Amaranthus retroflexus* is present in Ontario and some other provinces. Several herbicides are effective on the predominant annual grass species *Echinochloa crus-galli, Setaria spp* and perennial species *Elytrigia repens*. The other primary annual broad-leaved weed species in Canadian potatoes are *Ambrosia artimisiifolia*, and *Raphanus raphanistrum*. Problem perennial broad-leaved weed species in local areas include *Mentha arvensis, Cirsium arvense* and *Asclepias syriaca*, the latter in Ontario.

The new herbicides sulfentrazone (Bailey *et al.*, 2002; Grichar *et al.*, 2003; Wilson *et al.*, 2002) and flumioxazin (Hutchinson *et al.*, 2005; Wilson *et al.*, 2002) are available in the United States for the control of several problem weed species in potatoes but have not been registered in Canada.

Research efforts aimed at obtaining weed control in organic systems without the use of herbicides have been intensified. Weed control with mechanical cultivation and/or with thermal devices (propane), give varied results depending on equipment used, time and frequency of cultivation, weed population and species. In Iran, a portable gasoil flamer controlled weeds better, produced higher potato yields and was the least costly method of weed control (Shimi, 2000). Eberlein *et al.* (1997), found that cultivation was effective at low weed densities but at high weed densities control was less effective and yields and net returns were reduced below that for a standard herbicide treatment. Kilpatrick (1993) found that cultivating several times was as effective as herbicide programs in giving weed control and potato yields were comparable.

The objective of the studies reported here was to evaluate several methods and new herbicides that could provide effective weed control in potato production. This paper will report on cultivation combined with in-row banded treatments (herbicide, thermal, corn gluten), the use of acetic acid, and the potential of two new herbicides to manage weeds in potatoes.

MATERIALS AND METHODS

General: Field experiments were conducted from 2002 to 2004 at Charlottetown, Prince Edward Island on a fine sandy loam soil with a pH and organic matter from 5.8 to 6.0 and 2.6% to 3.0%, respectively. Plots were 4 rows, 8 m long, in randomised complete block with four replications. Fertiliser was applied as 15-15-15 (N-P-K) at 950 kg/ha at planting. Seed pieces of Russet Burbank were machine planted between May 18 and 30 with 45 cm in-row spacing and 0.9 m between rows. Treatment effects on grass and broadleaved weeds were assessed by measurement of weed fresh biomass /M^2. Crop injury and weed control were visually assessed using a linear scale from 0 to 100 where 0 = no injury or control and 100 = kill or complete control. Yields were obtained from two plot rows and graded into marketable and total tubers. Data collected was subjected to the analysis of variance using Genstat (Anonymous, 1987).

Cultivation with banded treatments: Herbicide (Metribuzin at 0.5 kg ai/ha)), corn gluten at 1000 kg ai/ha, or thermal (propane flamer) applied in a 30 cm band over the potato row was evaluated in combination with physical methods between the rows (basket weeder, finger weeder, and power tiller) and compared to a herbicide applied broadcast. The herbicide and corn gluten were applied the day after planting and the thermal treatment was applied when the first flush of weeds was in the cotyledon to 2 true leaf stage, but before potato emergence. The mechanical treatments with the basket weeder and the finger weeder were applied twice, when the first flush of weeds was at cotyledon stage and again when the second flush was at the cotyledon stage. The power tiller treatments were applied 2 to 4 days after the thermal treatment and before potato emergence.

Acetic acid: Glacial acetic acid was evaluated in 2004 diluted to concentrations of 10, 20 and 30 % by volume in 300 L /ha and applied in a 30 cm band over the row when weeds had emerged to the cotyledon stage. A single application on the first flush of weeds was compared to two applications; once at the first flush and again at the second flush of weeds. Potatoes were not emerged at the first flush and had less than 50% of sets emerged 1-3 cm at the second flush. Weeds between the rows were removed using the multi-head power tiller noted above.

New Herbicides: The herbicides sulfentrazone and flumioxazin were assessed in three experiments applied pre-emergence in 2001 and 2003 and pre-emergence, at potato emergence and post-emergence to potatoes in 2004 compared to the standard herbicides metribuzin and linuron. Weeds were at the 2 to 4 leaf stage at the at emergence timing with potatoes just at emergence and at the 4 to 6 leaf stage in the post-emergence timing with potatoes 2 to 6 cm tall.

RESULTS

Cultivation with banded treatments: Aggressive mechanical tillage between potato rows and coupled with in-row systems reduced weed biomass and gave high potato yield (Table 1). There was no significant difference between the tillage treatments applied between the rows, with all giving good control (data not presented). Thermal and herbicide treatments gave comparable weed biomass reduction when applied over the row. Corn gluten did not control weeds (Table 1) and yields were lower in 2004.

Acetic acid: Acetic acid at 20 and 30% injured potatoes severely and reduced marketable yield compared to the broadcast metribuzin treatment (Table 2). Acetic acid applied twice was no more effective in reducing weed biomass. Acetic acid at 10% caused minor, short lived injury on potatoes and was not effective in reducing weed biomass. All acetic acid treatments reduced potato marketable yield slightly compared to broadcast herbicide treatment.

New herbicides: In 2001, sulfentrazone pre-emergence caused only slight, short lived injury on potatoes and gave excellent control of *Chenopodium album* but not *Raphanus raphanistrum* (Table 3). When sulfentrazone was used alone, potato yield was reduced, most likely due to the poor control of *Raphanus raphanistrum* as the addition of metribuzin gave weed control and yields were comparable to metribuzin used alone. In 2003, flumioxazin controlled *Chenopodium album* and, even though visual injury to potatoes was severe shortly after application, yields were not affected. In 2004, sulfentrazone pre-emergence, at-emergence and post-emergence controlled *Chenopodium album* but not *Raphanus raphanistrum*. Flumioxazin pre-emergence, at-emergence and post-emergence controlled *Chenopodium album* but did not control *Raphanus raphanistrum* when used post-emergence. Both herbicides at-emergence or post-emergence caused severe injury and reduced yield compared to metribuzin and linuron.

Table 1. Weed biomass and marketable potato yield with herbicide, thermal, or corn gluten treatments applied in a 30 cm band over the row to control weeds in the row and with cultivation between the rows.

Weed Control Method	Weed Biomass (g/m^2)		Marketable Yield (t/ha)	
	2002	2004	2002	2004
Herbicide	8.0	52.0	40.1	42.8
Thermal	20.0	56.0	38.0	42.2
Corn gluten	533.0	1153.0	36.3	34.1
Herbicide broadcast	0	65.0	40.0	41.6
SE (24df)	47.6	79.3	1.2	2.6

Table 2. Effect of application at weed cotyledon (cot) or 2-4 leaf stage and concentrations of acetic acid on % potato injury, weed biomass and marketable yield evaluated on cultivar Russet Burbank.

Treatment	Time Applied	Kg/ha applied	% potato injury		Weed Biomass (g/m^2),	Yield (t/ha)
			1 week	3 weeks		
Untreated	-	-	0	0	847.6	34.5
Metribuzin	pre	0.50	0	0	41.2	47.1
Acetic acid	cot	30%	68	18	48.2	40.2
Acetic acid	cot + 2-4 leaf	30%	65	21	0	36.3
Acetic acid	cot	20%	53	14	159.2	38.2
Acetic acid	cot + 2-4 leaf	20%	53	11	72.7	36.5
Acetic acid	cotyledon	10%	4	0	705.7	33.3
Acetic acid	cot + 2-4 leaf	10%	3	1	541.3	31.5
SE (21df)					150	2.55

DISCUSSION

Cultivation with banded treatments

Weed control can be achieved with physical methods and the addition of effective methods to control weeds that arise in the potato row as cultivation alone is not effective in removing or burying weeds in the row. Use of herbicide or thermal treatment in a band over the row markedly reduced weed biomass and provided potato yields comparable to broadcast herbicide supporting findings of other authors (Belinder *et al.*, 2000; Ivany, 2002). The thermal treatment would be useful in organic production and banding over the row would reduce cost of propane. Corn gluten was not effective in controlling weeds common in potato production.

Acetic acid

Acetic acid at concentrations of 20 and 30% were effective when used in a band to remove weeds but there was no advantage to using the higher rate of application. Injury on potatoes was severe at these concentrations and yields were reduced even with the single application to the first flush of weeds. A concentration of 10% acetic acid was not effective in weed control and crop response.

Table 3. Potato injury, control of *Chenopodium album* and *Raphanus raphanistrum* and potato marketable yield with several new herbicides applied pre-emergence (pre), at emergence (at emerg) , or post-emergence (post) to cultivar Russet Burbank.

Herbicide and year	Time Applied	Kg/ha applied	% Injury	% Control		Yield (t/ha)
				C.album	*R.raphanistrum*	
2001						
Metribuzin	pre	0.550	0	100	100	26.6
Sulfentrazone	pre	0.206	3	100	23	16.4
Metribuzin +	pre	0.550	6	100	100	26.5
Sulfentrazone	pre	0.206				
Metribuzin +	pre	0.550	4	100	100	31.1
Sulfentrazone	pre	0.206				
Control	-	-	0	0	0	10.3
SE (14df)						1.97
2003						
Flumioxazin	pre	0.05	10	100		
Flumioxazin	pre	0.10	21	100		
Flumioxazin	post	0.05	50	100		
Control	-	-	0	0		22.6
SE (9df)						1.95
2004						
Metribuzin	pre	0.550	0	78	100	38.5
Linuron	pre	1.000	0	97	98	36.7
Sulfentrazone	pre	0.140	0	100	60	29.4
Sulfentrazone	at emerg	0.140	58	100	33	26.7
Sulfentrazone	post	0.140	75	100	13	24.7
Flumioxazin	pre	0.100	0	100	98	36.3
Flumioxazin	at emerg	0.100	75	98	91	34.0
Flumioxazin	post	0.100	76	99	64	27.3
Control	-	-	0	0	0	18.8
SE(24df)			-	-	-	2.94

New herbicides

Both sulfentrazone and flumioxazin showed promise when applied pre-emergence for control of *Chenopodium album* but in 2004 potato yield was reduced with sulfentrazone at this timing. Crop injury and yield reduction with both sulfentrazone and flumioxazin applied at potato emergence and post-emergence were comparable to that found by other authors (Bailey *et al.*, 2002; Grichar *et al.*, 2003; Hutchinson *et al.*, 2005; Wilson *et al.*, 2002). In 2001, 6 mm of rain fell two days after treatment, in 2003 16 mm of rain fell the day after treatment and in 2004 13 of rain fell two days after pre-emergence treatment. Crop injury occurred with flumioxazin in 2003 when applied pre-emergence. This injury with rainfall raises the concern that rainfall soon after application could cause severe injury and yield loss, especially if pre-emergence

treatments are delayed after planting. Therefore, it is unlikely these herbicides will be registered for use in eastern Canada where crops are mainly rain-fed.

The loss of effective herbicides, due to resistance or deregistration, without any new herbicides being made available is a serious concern for Canadian potato producers. Growers who use cultivation could still cope, but it is anticipated that yields will be reduced and costs increased due to more frequent cultivations and higher energy costs. Combinations of cultivation with thermal or acetic acid applied in bands could give control in conventional and organic systems but are probably less useful where growers use hill shaper systems of production. The two new herbicides sulfentrazone and flumioxazin showed potential for use pre-emergence but concerns about possible injury and yield loss need to be addressed. The search for new herbicides must continue, but as potatoes have a high production risk and the returns to agrochemical companies that register new herbicides are potentially low, the immediate future does not look bright in Canada.

ACKNOWLEDGEMENTS

The assistance of Mr. David Main, Weed Management Technician, in the completion of these experiments is gratefully acknowledged.

REFERENCES

Anonymous, 1987. Genstat 5 Reference Manual. Oxford University Press, New York, NY.

Anonymous, 2005. Canadian potato production. Statistics Canada, Agriculture Division. Statistical bulletin 22-008-XIE, Vol. 2, No 3. January 2005. 8p.

Bailey WA, Wilson HP, Hines TE, 2002. Response of potato (*Solanum tuberosum*) and selected weeds to sulfentrazone. Weed Technology 16, 651 – 658.

Belinder RR, Kikrwyland JJ, Wallace RW, Colquhoun, 2000. Weed control and potato (*Solanum tuberosum*) yield with banded herbicides and cultivation. Weed Technology 14,30-35.

Eberlein CV, Patterson PE, Gutieri MJ, Stark JC, 1997. Efficacy and economics of cultivation for weed control in potato (*Solanum tuberosum*). Weed Technology 11, 257-264.

Grichar WJ, Besler BA, Brewer KD, 2003. Purple nutsedge control and potato (*Solanum tuberosum*) tolerance to sulfentrazone and halosulfuron. Weed Technology 17, 485-490.

Hutchinson PJS, Boydston RA, Ransom CV, Tonks DJ, Beutler BR, 2005. Potato variety tolerance to flumioxazin and sulfentrazone. Weed Technology. 19: 683 – 696.

Ivany JA, 2002. Banded herbicides and cultivation for weed control in potatoes (*Solanum tuberosum*). Canadian Journal of Plant Science 82, 617-620.

Shimi P, 2000. Use of flamer as a herbicide replacement in potato fields. Turkish Journal of Field Crops 5, 41-44.

Wilson DE, Nissen SJ, Thompson A, 2002. Potato (*Solanum tuberosum*) variety and weed response to sulfentrazone and flumioxazin. Weed Technology 16, 567-574.