TILLAGE SYSTEM DIFFERENCES IN RE-CROPPING TO PURSUIT (IMAZATHAPYR) RESIDUES

D.A. Derksen
Agriculture and Agri-Food Canada
Box 760, Indian Head, SK, SOG 2K0

Abstract

Research was conducted from 1992 to 1994 at Indian Head, to determine the residual activity of imazethapyr on wheat and canola grown in zero- and conventional-tillage systems. Crop injury was evident one year after application, but not two. Canola was affected more than wheat and this was observed to a greater extent in conventional tillage. Further research is required to determine if this was due to greater herbicide decomposition or adsorption in the zero-tillage system, or to the physical separation of crop from herbicide residues.

Introduction

The adoption of conservation-tillage systems is occurring at a very rapid pace in western Canada. A recent poll has indicated that 70% of Saskatchewan farmers intend to switch to direct-seeding systems in the near future, with low-disturbance systems, such as zero tillage, being of the greatest interest (Lawton 1995). Coupled with the growth in conservation tillage has been an increase in the use of diversified crop rotations as a means in increasing net-returns, and controlling weeds and diseases (Hebblethwaite 1995). Given these trends, it is important to reassess agronomic factors, such as herbicide persistence, within conservation tillage.

Imazethapyr, trade named Pursuit, is an imidazolinone herbicide recently introduced by Cyanamid Canada Inc. for broadleaf and grassy weed control in alfalfa and field pea. The product is of considerable interest to field pea producers, because in controls a unique spectrum of difficult to control weeds. Currently, chickweed, stinkweed, volunteer canola, smartweed, wild mustard, green foxtail, wild oat, cleavers, redroot pigweed, and wild buckwheat are on the label. Activity on the following species has been observed: storks bill, flixweed, kochia, mallow, Russian thistle, and shepherds purse (Cyanamid 1991). Like other herbicides within this family, imazethapyr can persist into subsequent growing seasons.

Previous research has shown that microbial activity is the major method of imazethapyr breakdown, therefore, increasing soil moisture levels and soil temperature increases herbicide degradation (Cantwell et al. 1989). Furthermore, herbicide persistence increases as soil clay content increases and decreases as soil pH increases (Loux and Reese 1993). Research has shown that tillage has not influenced persistence (Walsh et al. 1993 and 1993); however, research comparing tillage systems has not been conducted. The objective of this research was to compare canola and wheat growth in zero- and conventional-tillage systems in years following imazethapyr application.

Materials and Methods

Field experimentation was conducted at Indian Head, SK from 1992 to 1994 on an Indian Head heavy clay soil (4%sand, 24% silt, 72%clay, 3%0M, pH 7.5-8.0). The 1992 growing season could generally be characterized as cooler and dryer than normal. Rainfall was 24 mm in April, 68 mm in May, 43 mm in June, 74 mm in July, 23 mm in August, and 47 mm in September. Mean monthly temperatures were 4.3°C in April, 12°C in May, 15°C in June, 16°C in July, 16°C in August, and 10°C in September. The 1993 growing season was cool and initially dry. Rainfall was 5.8 mm in April, 23.6 mm in May, 72.2 mm in June, 102 mm in July, 56.8 mm in August, and 57.6 mm in September. Mean monthly temperatures were 4.2°C in April, 11°C in May, 14°C in June, 16°C in July, 17°C in August, and 10°C in September. 1994 was generally warm and initially dry. Rainfall was 7.2 mm in April, 33.0 mm in May, 120.0 mm in June, 55.2 mm in July, 90.0 mm in August, and 3 1.2 mm in September. Mean monthly temperatures were 6.8°C in April, 12.2°C in May, 16°C in June, 18°C in July, 17°C in August, and 14°C in September.

The experiment was designed in a split plot configuration with tillage system as the main plot and rate of imazethapyr as the sub-plot with four replications. Sub-plots were 5.0m by 6.0m. The experiment was established in 1992 with imazethapyr applied to pinto beans. Since early fall frost prematurely ended crop growth, data from this year were not presented. The field had a 4 year history of zero tillage with the conventional plots cultivated in the spring of 1992 prior to seeding. Subsequently, conventional tillage plots were worked each fall and spring with a light duty cultivator. Each year zero tillage plots were treated with glyphosate (Roundup: 1.1 kg ai/ha) prior to seeding. Plots were over-sprayed to reduce the impact of weed growth on crop yield in 1992 and 1993. To control Canada and sow-thistle clopyralid (Lontrel: 300 g ai /ha) was applied to all plots each year. In 1993 diclofopmethyl (HoeGrass 0.8kg ai /ha) was applied to all plots and in 1994 wheat plots received tralkoxydim plus bromoxynil and MCPA (Achieve plus Buctril M: 250 + 280 + 280 g ai/ha) and the canola received clethodim (Select: 45.6 g ai/ha) plus ethametsulfuron-methyl (Muster: 22.5 g ai/ha). Herbicides were applied with a sprayer equipped to deliver 110 L/ha of final spray solution through 80015 fan-type nozzles at 275 kPA pressure.

In 1993 and 1994, the herbicide sub-plots were split and wheat and canola were seeded to determine residual imazethapyr activity. In 1994, wheat was seeded on canola stubble and canola on wheat stubble. "Katepwa" spring wheat was seeded at 108 kg/ha with 65 kg/ha of 12-51-O applied with the seed and 176 kg/ha of 46-O-O applied in a mid-row band between every other crop row. "Legend" canola was seeded at 8 kg/ha with 48 kg/ha of 12-5 1-O applied with the seed and 204 kg/ha of 46-O-O applied in the mid-row. Fertilizer rates were based on soil test recommendations. Seeding occurred on May 6th in 1993 and May 4th in 1994. Tan spot infestations were very high in wheat plots in 1994, particularly in the zero-tillage. This may have been due to the 3 year zero-tillage wheat stubble that surrounded the experiment.

Crop plants were counted in 2 metre row lengths 28 DAE. Visual crop tolerance was assessed on a scale of O-9 where 0 means complete crop kill, 7 means commercial acceptability, and 9 means no visual injury. Plots were machine harvested and dried to a common moisture level before weighing the samples.

An analysis of variance was conducted on the data. Since interactions occurred, the tillage systems were analyzed separately. Means were separated using contrasts ($p<0.05$).

Results and Discussion

In this study, imazethapyr persistence was evident one year after application, but not two (Tables 1,2,3 and 4). Canola was affected more than wheat and the effect was observed to a greater extent in conventional-tillage.

Imazethapyr did not affect the germination and emergence of canola (Table 1), but severally affected visual crop tolerance and reduced yield. Symptoms of injury were leaf and stem chlorosis, a purple discolouration and reduced plant growth. Injury was more evident in conventional tillage. For example, at 33.3 g ai/ha injury was rated as commercially acceptable in zero tillage while plants were severally injured in conventional tillage. At double the recommended rate (100gai/ha) canola yield was reduced by 46% in zero-tillage and 89% in conventional-tillage systems. These effects were not evident two years after application (Table 2). In fact, higher yields were evident in imazethapyr treated plots in conventional tillage, perhaps due to the residual impact of good weed control in previous years, from residual nitrogen that was not utilized by injured crop plants the year before, or from residual herbicidal effects into year two.

One year after the application of imazethapyr, no effect on spring wheat tolerance or stand was evident (Table 3); however, yields were lower in the zero-tillage plots treated with imazethapyr. The effect may have been masked in the conventional tillage plots, because the spring was very dry and the yield of wheat was lower in conventional tillage with or without imazethapyr residues. In the second year after application, no negative effects on the wheat crop were evident (Table 4). Similar to the canola yields, there was a trend in year two towards higher yields as the rate of imazethapyr increased.

These results concur with those in the US, in that, imazethapyr residues affected subsequent crop production one year after application; however, the reduced injury for canola in zero-tillage was a new finding. Several explanations exist. The crop may have been seeded below a herbicide treated layer in the zero-tillage system. Moreover, other research has found that microbial degradation of herbicides and adsorption to organic matter can be greater in zero tillage (Zablotowicz et al. 1995). Greer and Schaneau (1995) have found increased organic matter and nutrient cycling in long-term zero tillage fields in the Indian Head area. Conversely, past research at Indian Head has shown an increased persistence of chlorsulfuron (Glean) and triasulfuron (Amber) in zero tillage (Loeppky and Derksen 1992); however, research was conducted on a newly established zero tillage field.

This study should not be considered definitive (ie: more sites and years are required to confirm these findings). From 1992 to 1994 conditions were drier than normal in the spring of the second and third year, and the summers were cooler than normal in years one and two, therefore, the persistence of imazethapyr may have been at high levels. There are, however, a number of implications that arise. Firstly, imazethapyr residues can reduce subsequent crop yields of canola and wheat. Secondly, the affect was less for canola grown in zero tillage. If this is generally applicable, can imazethapyr be applied in the brown or dark brown soil zone if used in zero-tillage systems? Note that to reduce the risk of re-cropping injury to sensitive crops, the current label reconnnendations are for the black soil zone only. Thirdly, research is required to determine if tillage system differences in re-cropping injury were due to the physical separation of sensitive crops from herbicide treated layers in the soil, or to greater herbicide degradation by microbes and/or binding to organic matter in the unique zero-tillage environment. The characterization of soil chemistry, biology, and ecology is required to understand the affect that changing tillage systems on herbicide persistence.

Acknowledgements

The author would like to acknowledge the financial support of Cyanamid Canada Inc. and Agriculture and Agri-Food Canada and the technical assistance of S. Kopp and K. Schiffer.

References

Cantwell, J.R., R.A. Liebl, and F.W.Slife. 1989. Biogradation characteristics of imazaquin and imazethapyr. Weed Science. 37:8 15-8 19.

Curran, W.S., R.A. Liebl, and F.W. Simmons. 1992. Effects of tillage and application method on clomazone, and imazethapyr persistence. Weed Science. 40:482-489,

Cyanamid Canada Inc. Pursuit herbicide. American Cyanamid Company, Agricultural Research Centre, Box 400, Princeton, New Jersey. 30 pp.

Greer, K.J. and J.J. Schoenau. 1995. Short and long term changes with direct seeding. Proceedings: 1995 Direct Seeding Workshop. Lloydminster, SK. February 14 and 15, 1995. Saskatchewan Soil Conservation Association. pp 102-107.

Hebblethwaite, J. F. 1995. Conservation tillage: a global perspective. Proceedings: 1995 Direct Seeding Workshop. Lloydminster, SK. February 14 and 15, 1995. Saskatchewan Soil Conservation Association. pp 6- 11.

Johnson, D.H., D.H. Jordan, D.L. Lohnson, W.G. Talbert, and R.E. Talbert. 1993. Niclosulfuron, primisulfuron, imazethapyr, and DPX-PE350 injury to succeeding crops. Weed. Technology. 7:641-644.

Lawton, M. 1995. Conservation tillage. Lafond, G.P. and D.A. Derksen eds. Proceedings Sustainable Cropping: Implications of Crop Residue Management and Conservation Tillage. **Agricultural Institute** of Canada. Regina, SK. July 13 and 14, 1994. pp (in press).

Loeppky, H. A. and D. A. Derksen. 1992. Triasulfuron and chlorsulfuron persistence under zero and minimum tillage. Slinkard, A. E. and D. B. Fowler eds. Proceedings: Soils and Crops Workshop. University of Saskatchewan, Saskatoon Saskatchewan.

Loux, M.M. and K.D. Reese. 1993. Effect of soil pH on persistence an carryover of imidazolinone herbicides. Weed Technology. 7:452-458.

Monks, C.D. and P.A. Banks. 1993. Effect of straw, ash, and tillage on dissipation of imazaquin and imazethapyr. Weed Science. 41:133-137.

Walsh, J.D., M.S. Defelice, and B.D. Sims. 1993. Influence of tillage on soybean (Glycine max) herbicide carryover to grass and legume forage crops in Missouri. Weed Science. 41:144-149.

Walsh, J.D., M.S. Defelice, and B.D. Sims. 1993. Soybean (Glycine max) herbicide carryover to grain and fibre crops. Weed Technology. 7:625-632.

Zablotowicz, R.M., M.A. Locke, S.C. Wagner, K.R. Reedy, 1.A. Gaston, R.J. Smeda, and C.T. Bryson. 1995. Environmental aspects of the fate of herbicides in residue management cropping systems. WSSA Abstracts: 1995 Meeting of the Weed Science Society of America. Jan 30 - Feb 2,1995.

Table 1. Canola tolerance, crop stand, and yield one year after imazethapyr application.

Treatment	Rate	Crop Tolerance[a]		Crop Stand #/m row		Crop Yield g/m^2	
	g ai/ha	Zt[b]	Ct	Zt	ct	Zt	ct
check		9	8	35.0	31.4	330.7	277.9
imazethapyr	25.0		2	30.7	28.3	306.8	241.1
imazethapyr	33.3	8		38.8	36.3	278.1	136.0
imazethapyr	41.6	4	0	34.3	36.1	176.1	154.8
imazethapyr	50.0	3	0	31.5	38.5	221.1	69.7
irnazethapyr	100.0	3	0	33.5	29.9	178.5	28.6
ANOVA (F)							
tillage system				ns		co.01	
interaction				ns		<0.0001	
Contrast (p)							
Check vs imazethapyr (25.0 g/ha)				ns	ns	**ns**	**ns**
Check vs imazethapyr (33.3 g/ha)				ns	ns	**<0.05**	**<0.0001**
Check vs imazethapyr (41.6 g/ha)				ns	ns	<0.000 1	<0.000 1
Check vs imazethapyr (50.0 g/ha)				ns	ns	<0.0001	<0.000 1
Check vs imazethapyr (100 g/ha)				ns	ns	<0.0001	<0.000 1

[a]Visual crop tolerance on a O-9 scale where O=complete crop kill, 7=commercial acceptability, and 9=no visual injury.

[b]Zt=zero tillage and Ct=conventional tillage.

Table 2. Canola tolerance, crop stand, and yield two years after imazethapyr application.

Treatment	Rate	Crop Tolerance[a]		Crop Stand #/m row		Crop Yield g/m^2	
	g ai/ha	Zt[b]	Ct	Zt	ct	Zt	Ct
check		9	9	27.8	19.8	221.2	132.6
imazethapyr	25.0	9	9	28.6	19.8	208.8	171.6
imazethapyr	33.3	9	9	28.3	18.5	108.5	163.2
imazethapyr	41.6	9	9	29.1	18.3	221.1	158.3
imazethapyr	50.0	9	9	27.5	23.5	212.4	151.1
imazethapyr	100.0	9	9	27.1	18.9	227.7	187.7
ANOVA (F)							
tillage system				<0.05		co.05	
interaction				ns		ns	
Contrast (p)							
Check vs imazethapyr (25.0 g/ha)				ns	ns	**ns**	co.05
Check vs imazethapyr (33.3 g/ha)				ns	ns	**<0.05**	ns
Check vs imazethapyr (4 1.6 g/ha)				ns	ns	ns	ns
Check vs imazethapyr (50.0 g/ha)				ns	ns	ns	**ns**
Check vs imazethapyr (100 g/ha)				ns	ns	ns	**<0.05**

[a]Visual crop tolerance on a O-9 scale where 0=complete crop kill, 7=commercial acceptability, and 9=no visual injury.

[b]Zt=zero tillage and Ct=conventional tillage.

Table 3. Spring wheat tolerance, crop stand, and yield one year after imazethapyr application.

Treatment	Rate	Crop		Crop Stand #/m row		Crop Yield g/m^2	
	g ai/ha	ztb	Ct	Zt	ct	Zt	ct
check		9	9	44.6	47.0	357.5	280.5
imazethapyr	25.0	9	9	50.8	47.9	348.2	284.3
imazethapyr	33.3	9	9	47.5	45.8	330.5	282.6
imazethapyr	41.6	9	9	45.0	45.4	319.1	256.7
imazethapyr	50.0	9	9	45.1	46.5	3 14.3	286.0
imazethapyr	100.0	9	9	46.9	46.0	315.8	267.9
ANOVA (F)							
tillage system				ns		co.01	
interaction				ns		ns	
Contrast (p)							
Check vs imazethapyr (25.0 g/ha)				ns	ns	ns	ns
Check vs imazethapyr (33.3 g/ha)				ns	ns	ns	ns
Check vs imazethapyr (41.6 g/ha)				ns	ns	<0.05	ns
Check vs imazethapyr (50.0 g/ha)				ns	ns	co.05	ns
Check vs imazethapyr (100 g/ha)				ns	ns	co.05	ns

[a]Visual crop tolerance on a O-9 scale where 0=complete crop kill, 7=commercial acceptability, and 9=no visual injury.

[b]Zt=zero tillage and Ct=conventional tillage.

Table 4. Spring wheat tolerance, crop stand, and yield two years after imazethapyr application.

Treatment	Rate	Crop Tolerance[a]		Crop Stand #/m row		Crop Yield g/m^2	
	g ai/ha	Ztb	ct	Zt	ct	Zt	ct
check		9	9	31.6	29.9	202.3	210.2
imazethapyr	25.0	9	9	32.1	30.1	199.5	234.6
imazethapyr	33.3	9	9	31.3	32.0	225.0	245.0
imazethapyr	41.6	9	9	34.0	26.0	205.1	230.6
imazethapyr	50.0	9	9	30.6	25.4	207.9	220.8
imazethapyr	100.0	9	9	30.1	28.5	242.6	270.2
ANOVA (F)							
tillage system				co.05		co.05	
interaction				<0.05		ns	
Contrast (p)							
Check vs imazethapyr (25.0 g/ha)				ns	ns	ns	co.05
Check vs imazethapyr (33.3 g/ha)				ns	ns	ns	co.01
Check vs imazethapyr (41.6 g/ha)				ns	**ns**	ns	ns
Check vs imazethapyr (50.0 g/ha)				ns	**<0.05**	ns	**ns**
Check vs imazethapyr (100 g/ha)				ns	ns	co.05	**<0.0001**

[a]Visual crop tolerance on a O-9 scale where 0=complete crop kill, 7=commerical acceptability, and 9=no visual injury.

[b]Zt=zero and Ct=conventional