Herbicide-Use Trends in Prairie Canola Production Systems

Julia Y. Leeson[1], A. Gordon Thomas[1], Hugh J. Beckie[1], Clark A. Brenzil[2], Linda M. Hall[3], Todd Andrews[4], Kim R. Brown[4], Rene C. Van Acker[5]

[1]Agriculture and Agri-Food Canada, 107 Science Place, Saskatoon, SK, S7N 0X2; [2]Saskatchewan Agriculture and Food, 3085 Albert Street, Regina, SK, S4S 0B1; [3]Alberta Agriculture, Food and Rural Development / University of Alberta, 410 Ag/Forestry, University of Alberta, Edmonton, AB, T6G 2P5; [4]Manitoba Agriculture, Food and Rural Initiatives, Box 1149, Carman, MB, R0G 0J0; [5]Department of Plant Science, University of Manitoba, Winnipeg, MB, R3T 2N2

Key Words: herbicide-tolerant canola systems, herbicide use, environmental impact quotient

Introduction

Since the introduction of herbicide-tolerant (HT) canola in the mid-1990s, acreage has increased dramatically in the Canadian Prairie Provinces. In 2005, 96% of the canola acreage was planted to herbicide-tolerant varieties (H. Beckie, unpubl. data). Glyphosate-tolerant (RR) varieties were most common accounting for 50% of the acreage, followed by glufosinate-tolerant (LL) and imidazolinone-tolerant (CL) varieties accounting for 32% and 14% of the acreage, respectively.

Recent studies have estimated that the use of HT canola has reduced the environmental impact of the crop by 20% (Brookes and Barfoot 2005) or 37% (Brimner et al. 2005) based on Environmental Impact Quotients (Kovach et al. 1992); however, both studies used incomplete data sets. Brookes and Barfoot's (2005) estimate was based on a single representative treatment for RR, LL and NT (non-tolerant); the CL system was not included. The estimate by Brimner et al. (2005) was based on the total canola acreage to which each herbicide product was applied. Without information on rates and treatments, their report assumed all herbicides were applied at the lowest recommended rates and only HT herbicide partners were applied to HT crops.

Management data including crop variety, herbicide products, application rates and application area have been collected for fields on farm management practices surveys in conjunction with weed surveys in Alberta, Saskatchewan and Manitoba in the 1990s and 2000s (Leeson et al. 2005). The objective of this paper is to determine the herbicide use intensity and environmental impact of canola production systems based on herbicide treatments reported by producers in prairie farm management practices surveys.

Methodology

In the 1990s, data for 235 NT fields are obtained from questionnaires associated with prairie weed surveys conducted in 1995 in Saskatchewan and 1997 in Alberta and Manitoba. In the 2000s, surveys were conducted in 2001 in Alberta, 2002 in Manitoba and 2003 in Saskatchewan.

The more recent surveys included management information for 161 RR, 63 LL, 63 CL and 42 NT fields.

Herbicide use intensity is calculated by multiplying the area to which an active ingredient was applied by the application rate. Application area was based on the percentage of fields using the active ingredient and the percentage of the field treated. Herbicide application rates were based on actual use reported for the field when available. Mean rates reported for herbicide products in the survey were used when actual rates were not specified by a producer. In the 1997 Alberta management questionnaire, the in-crop product rates were reported as recommended, higher than recommended or lower than recommended. In this case, the average rates of products used in the other provinces in the 1990s were calculated for each category and substituted into the calculations for Alberta.

Herbicide treatments were defined based on the active ingredients (ai) applied, the number of applications, and the time of application. The herbicide use intensity (kg ai/ ha) associated with each treatment was calculated based on the average rates of the active ingredients applied within the treatment.

Environmental Impact Quotient (EIQ) was multiplied by the herbicide use intensity to assess environmental impact (Kovach et al. 1992). EIQ is the mean risk to producers, consumers and ecology:

$$EIQ = \{C[(DT*5)+(DT*P)] + [(C*((S+P)/2)*SY)+(L)] + [(F*R)+(D*((S+P)/2)*3)+(Z*P*3)+(B*P*5)]\}/3$$

where:

C = chronic toxicity	F = fish toxicity
DT = dermal toxicity	R = surface loss potential
P = plant surface half-life	D = bird toxicity
S = soil half-life	Z = bee toxicity
SY = systemicity	B = beneficial arthropod toxicity
L = leaching potential	

The EIQ values for each active ingredient used in this report are from Kovach et al. (2004) (Table 1).

Table 1. Environmental Impact Quotient (EIQ) of Common Herbicide Active Ingredients in Canola (from Kovach et al. 2004)

Active Ingredient	EIQ
clethodim	17.00
clopyralid	18.10
ethalfluralin	23.30
ethametsulfuron	28.67
fluazifop	44.00
glufosinate	28.25
glyphosate	15.30
imazamox	19.50
imazethapyr	27.30
quizalofop	51.70
sethoxydim	27.50
trifluralin	18.80

Data for each production system in the 2000s are multiplied by the portion of the total area represented by that system in 2005 to estimate the current total use in canola.

Results

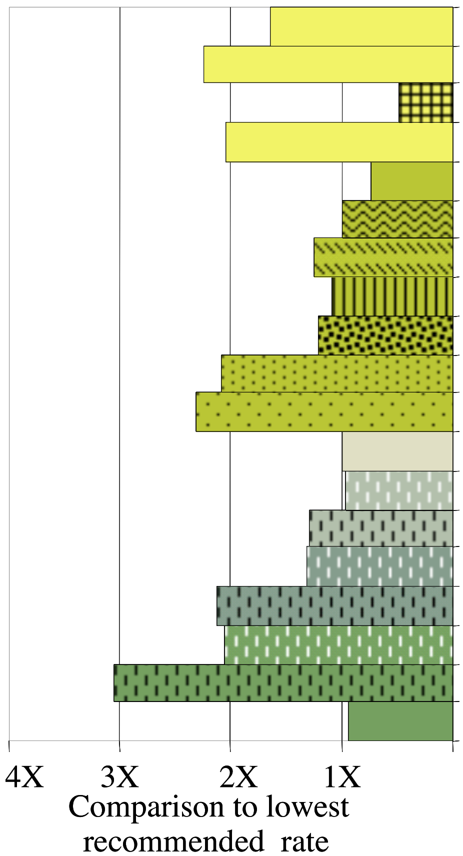
Producers used a large variety of different herbicide treatments in each of the canola production systems (Table 2). In the 1990s, the most common treatments used in NT systems were a single application of trifluralin (19.6% of area) or ethalfluralin (10.2% of area). The majority of the acreage received other combinations of herbicide active ingredients. In the 2000s NT systems, a single application of ethalfluralin was the most common treatment in NT canola systems (14.3% of area). In the RR system the most commonly used treatment, two in-crop applications of glyphosate, accounted for 43.5% of the area. In the LL and CL systems, the most common treatment accounted for only 23.8% of the area. In these systems and the 2000s NT system the second most common treatment included a pre-seed application of glyphosate, either in the fall or spring.

In general, the most common treatment did not reflect the amount of active ingredient applied to most of the acreage in the system (Table 2). The most common NT treatments had higher use intensities than the 79 other treatments used on a majority of the acreage, while the most common LL and CL treatments had lower herbicide use intensities than the other treatments.

Table 2. Common Herbicide Treatments in Canola Production Systems

System	Treatment	% Area	kg ai/ha
1990s NT	trifluralin	19.6	1.15
	ethalfluralin	10.2	1.11
	other (79 different treatments)	70.2	0.96
2000s NT	ethalfluralin	14.3	0.90
	glyphosate, ethametsulfuron, quizalofop	9.5	0.72
	other (25 different treatments)	76.2	0.75
2000s RR	glyphosate (2X in-crop)	43.5	0.92
	glyphosate (1X in-crop)	26.7	0.56
	other (11 different treatments)	29.8	1.33
2000s LL	glufosinate	23.8	0.47
	glyphosate, glufosinate	23.8	1.18
	other (22 different treatments)	52.4	1.12
2000s CL	imazamox, imazethapyr	23.8	0.03
	glyphosate, imazamox, imazethapyr	20.6	0.68
	other (28 different treatments)	55.6	0.55

Most active ingredients are applied at higher than the lowest recommended rate (Fig. 1). Post-harvest glyphosate is applied at approximately three times the lowest recommended rate; pre-seed glyphosate, fall-applied trifluralin, ethametsulfuron, quizalofop, imazamox, glufosinate, and in-crop glyphosate are applied at more than twice the lowest recommended rate. Actual rates of active ingredients (kg ai/ha) are highest for fall, spring and pre-harvest herbicides followed by glyphosate (in-crop) and glufosinate. Most active ingredients with high EIQs (Table 1) are applied at low rates (e.g. fluazifop and quizalofop); ethalfluralin and trifluralin are exceptions.



Active Ingredient	kg ai/ha
glyphosate (RR in-crop)	0.48
glufosinate (LL)	0.46
imazethapyr (CL)	0.025
imazamox (CL)	0.021
other in-crop	0.051
fluazifop	0.074
clopyralid	0.19
clethodim	0.033
sethoxydim	0.18
quizalofop	0.075
ethametsulfuron	0.035
other fall or spring	1.1
ethalfluralin (spring)	1.1
ethalfluralin (fall)	1.1
trifluralin (spring)	1.1
trifluralin (fall)	1.2
glyphosate (spring)	0.55
glyphosate (fall)	0.82
glyphosate (pre-harvest)	0.84

Figure 1. Average rate of application of herbicide active ingredients across all systems. Actual rates listed on the right are averaged across products containing the active ingredient. Rates are also compared to the recommended rate for each product.

The area treated with trifluralin and ethalfluralin use has declined since the 1990s, even in NT canola (Fig. 2). The area treated with glyphosate (all application times) has increased since the 1990s, but use differs by system. Glyphosate is often applied prior to planting canola; on 29%, 38%, 56% and 67% of the acreage in the RR, NT, CL and LL canola systems, respectively. In all systems, the area treated with in-crop herbicides has increased since the 1990s. In-crop herbicides other than herbicide partners are used on 35% and 55% of the LL and CL acreage, respectively, but are rarely used in RR systems. A second in-crop application of glyphosate is used on 54% of the acres in RR systems.

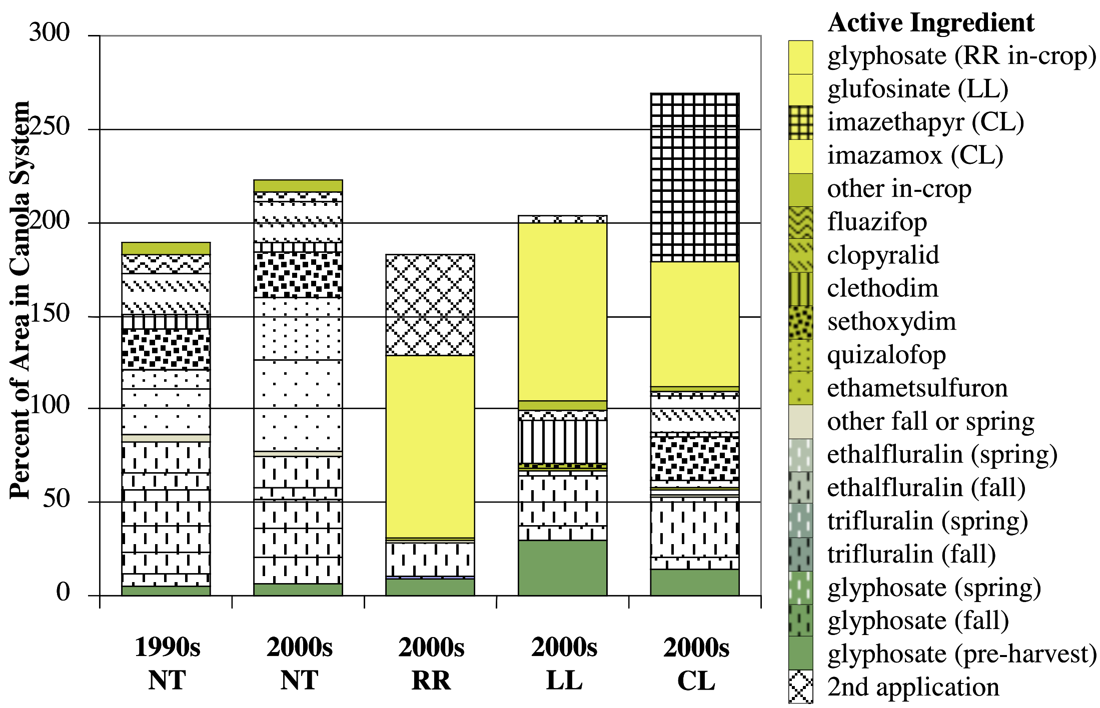


Figure 2. Application of area for herbicide active ingredients in each canola system. The total area adds to more than 100% as more than one active ingredient may be applied.

An average herbicide use intensity of 1.0 kg ai/ha in 1990s NT canola is largely attributable to use of trifluralin and ethalfluralin (Fig. 3). Total herbicide use intensity in RR and LL canola systems is similar to 1990s NT canola, due to high rates of glyphosate and glufosinate, respectively (Fig. 1). Total herbicide use intensity in CL canola is approximately 50% of the other systems due to the low amount of in-crop active ingredients.

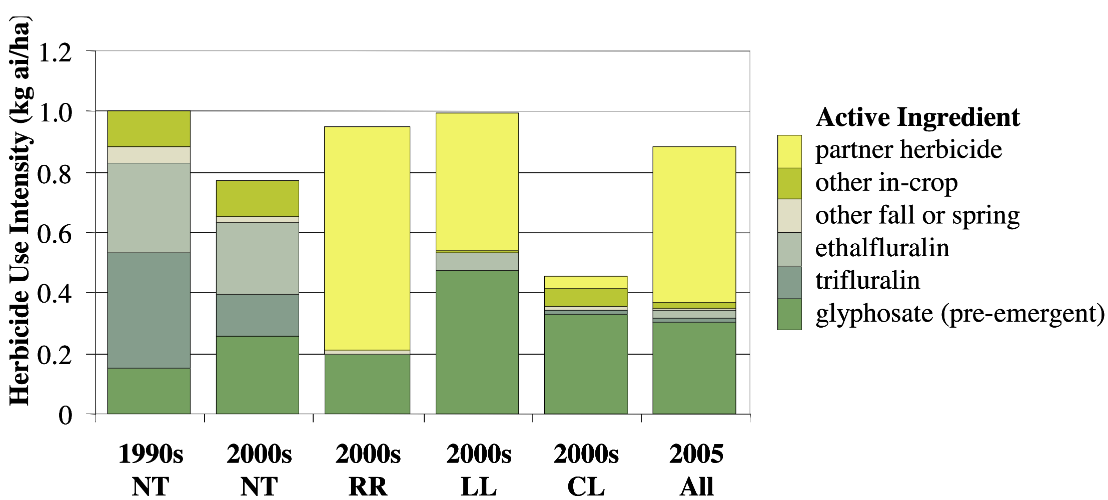


Figure 3. Contribution of herbicide active ingredients to herbicide use intensity in each canola system.

LL canola has the highest environmental impact, slightly higher than 1990s NT canola (106%) Fig. 4). Although the herbicide use intensity in the LL and RR systems was similar, the relatively low EIQ of glyphosate, reduced the environmental impact of the RR system relative to the LL system. 2000s NT, RR and CL canola have lower environmental impact than 1990s NT canola (77, 71 and 38%, respectively). Based on the proportions of each system planted in 2005, the environmental impact of canola in 2005 was 88% of the 1990s.

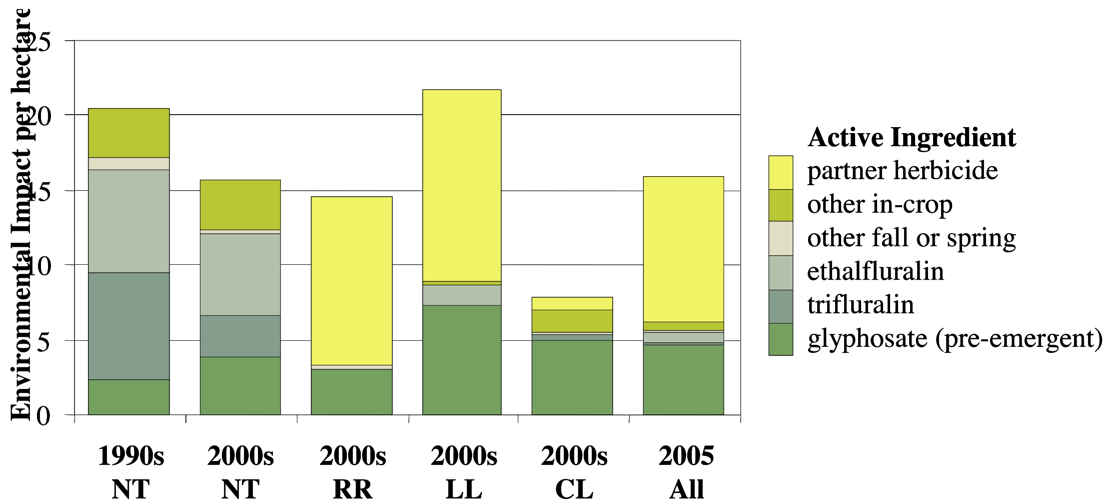


Figure 4. Contribution of herbicide active ingredients to environmental impact of each canola system.

Discussion

The introduction of HT canola production systems has resulted in an 11.6% drop in herbicide use intensity and a 22.0% drop in environmental impact per hectare from 1990s to 2005. Our data set indicates a smaller decrease in environmental impact than reported by Brimner et al. (2005). Their report assumed all herbicides were applied at the lowest recommended rates and only HT herbicide partners were applied to HT crops. Neither assumption was true in our data set. The change in environmental impact in our data set is similar to that of Brookes and Barfoot (2005); however, they compared a single representative treatment for RR and LL systems to NT (CL was excluded). Our data indicate that a single treatment does not represent the majority of fields.

The environmental benefit of HT canola is dependant on the area planted to each production system. Our data indicate large differences in the impact among systems; therefore, any future change in the relative area of systems will change the overall impact.

Acknowledgements

We would like to thank the over 500 producers who took the time to fill out the management questionnaires. Special thanks to the many provincial and federal staff who helped with surveys. The 2000s surveys were funded in part by Arvesta Canada, Aventis CropScience, BASF Canada, Bayer CropScience, Dow AgroSciences, DuPont Canada, Monsanto Canada, Nufarm

Agriculture, and Westco; by the Matching Investment Initiative (MII) of Agriculture and Agri-Food Canada; and by Alberta Agriculture, Food and Rural Development Farming for the Future Program. Significant in-kind contributions were provided by Alberta Agriculture, Food and Rural Development; Saskatchewan Agriculture and Food; Manitoba Agriculture, Food and Rural Initiatives; and Agriculture and Agri-Food Canada.

References

Brimner, T. A., G. J. Gallivan and G. R. Stephenson. 2005. Influence of herbicide resistant-canola on the environmental impact of weed management. Pest Management Science 61:47-52.

Brookes, G. and P. Barfoot. 2005. GM crops: the global economic and environmental impact - the first nine years 1996-2004. AgBioForum 8:187-196.

Kovach, J., C. Petzoldt, J. Degni and J. Tette. 1992. A method to measure the environmental impact of pesticides. New York's Food and Life Sciences Bulletin 139:139-146.

Kovach, J., C. Petzoldt, J. Degni and J. Tette. 2004. A method to measure the environmental impact of pesticides, Table 2, List of pesticides. [Online] Available: www.nysipm.cornell.edu/publications/eiq/default.aspnysipm.cornell.edu/publications/Eiq [19 October 2005]

Leeson, J. Y., A. G. Thomas, L. M. Hall, C. A. Brenzil, T. Andrews, K. R. Brown and R. C. Van Acker. 2005. Prairie weed surveys of cereal, oilseed and pulse crops from the 1970s to the 2000s. Weed Survey Series Publication 05-1. Agriculture and Agri-Food Canada, Saskatoon Research Centre, Saskatoon, Saskatchewan. 395 pp.