Weed shifts in glyphosate tolerant crops – a regional perspective

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Abstract

The commercialization of numerous glyphosate tolerant crop varieties could potentially allow farmers in the Central High Plains to grow a three, four or five – crop rotation utilizing only glyphosate as the sole weed management tactic. Plots were established under irrigation at Torrington, Wyoming; Scottsbluff, Nebraska; and Ft. Collins, Colorado in 1998 to determine if glyphosate use pattern in glyphosate tolerant crops influences weed control by placing selection pressure on weed species, alters weed population dynamics, or leads to development of glyphosate resistant weeds. After six years there was no evidence that any species has developed resistance to glyphosate. However, at all three sites common lambsquarters (*Chenopodium album*) populations have increased in the treatments receiving 0.4 kg/ha of glyphosate. Rotating glyphosate with conventional herbicides was no more effective in slowing this population increase than the use of glyphosate at 0.8 kg/ha.

Media summary

Reducing the glyphosate rate allows weeds with a slightly higher natural tolerance to survive and become the dominant species.

Key Words

Glyphosate rate, conventional herbicides, dominant species, weed shifts, herbicide resistance.

Introduction

Glyphosate has been used to control unwanted vegetation for over thirty years. The commercialisation of glyphosate tolerant crops in 1996 has allowed growers to treat their fields with this herbicide without fear from damage to crops. Glyphosate tolerant varieties of maize (*Zea mays*), soybean (*Glycine max*), and canola (*Brassica napas*) have been commercially available to growers for seven to eight years. Glyphosate tolerant varieties of sugarbeet (*Beta vulgaris*), spring wheat (*Triticum aestivum*), and lucerne (*Medicago sativa*) have been developed and will likely be released in the near future. Farmers in the Central High Plains will potentially be able to grow a three, four or five-crop rotation utilising glyphosate as the main weed management tactic.

It is difficult to predict what effect a continuous glyphosate tolerant cropping system will have on the weed species composition of fields. Studies were initiated in the Central High Plains to determine if glyphosate use pattern in glyphosate tolerant crops influences weed control by placing selection pressure on weed species, alters weed population dynamics, or leads to the development of glyphosate resistant weeds.

Methods

Trials were established under irrigated conditions in 1998 at Research and Extension Centers near Torrington, WY; Scottsbluff, NE; and Ft. Collins, CO under conservation tillage techniques to evaluate the impact of herbicide treatment and crop rotation on weed population dynamics in glyphosate tolerant crops. The experimental design at all sites was a two factorial split plot set in a randomised complete block design with four replications. Main plots were crop rotation and sub-plots herbicide treatments. Sub-plot size was 9.1 by 30.5 m (12 crop rows wide). Treatments and crop rotations are described in Table 1.

Table 1. Description of herbicide treatments used in continuous corn and rotational plots from 1998 to 2003.

Designation	Year	Crop	Herbicide	Rate (kg/ha)	Applications
LG-C	1998	maize	glyphosate	0.4	twice
	1999	maize	glyphosate	0.4	twice
	2000	maize	glyphosate	0.4	twice
	2001	maize	glyphosate	0.4	twice
	2002	maize	glyphosate	0.4	twice
	2003	maize	glyphosate	0.4	twice
LG-R	1998	maize	glyphosate	0.4	twice
	1999	sugarbeet	glyphosate	0.4	twice
	2000	maize	glyphosate	0.4	twice
	2001	sugarbeet	glyphosate	0.4	twice
	2002	wheat	glyphosate	0.4	twice
	2003	maize	glyphosate	0.4	twice
HG-C	1998	maize	glyphosate	0.8	twice
	1999	maize	glyphosate	0.8	twice
	2000	maize	glyphosate	0.8	twice

	2001	maize	glyphosate	0.8	twice
	2002	maize	glyphosate	0.8	twice
	2003	maize	glyphosate	0.8	twice
HG-R	1998	maize	glyphosate	0.8	twice
	1999	sugarbeet	glyphosate	0.8	twice
	2000	maize	glyphosate	0.8	twice
	2001	sugarbeet	glyphosate	0.8	twice
	2002	wheat	glyphosate	0.8	twice
	2003	maize	glyphosate	0.8	twice
RG-C	1998	maize	glyphosate	0.8	twice
	1999	maize	acetachlor + isoxaflutole	1.7 + 0.05	once
	2000	maize	glyphosate	0.8	twice
	2001	maize	acetachlor + isoxaflutole dicamba + dilfufenzapyr	1.7 + 0.05 0.2	once once
	2002	maize	glyphosate	0.8	twice
	2003	maize	acetachlor + isoxaflutole	1.7 + 0.05	once
RG-R	1998	maize	glyphosate	0.8	twice
	1999	sugarbeet	phenmidipham + desmedipham + triflusulfuron + clopyralid + clethodim	0.18 + 0.18 + 0.02 + 0.1 + 0.1	3 times
	2000	maize	glyphosate	0.8	twice
	2001	sugarbeet	phenmidipham + desmedipham +	0.18 + 0.18 +	3 times

			triflusulfuron + clopyralid + clethodim	0.02 + 0.1 + 0.1	
	2002	wheat	glyphosate	0.8	twice
	2003	maize	acetachlor + isoxaflutole	1.7 + 0.05	once
NG-C	1998	maize	rimsulfuron + thifensulfuron + dicamba	0.011 + 0.006 +0.14	once once
	1999	maize	acetachlor + isoxaflutole	1.7 + 0.05	once
	2000	maize	acetachlor + isoxaflutole	1.7 + 0.05	once
	2001	maize	acetachlor + isoxaflutole dicamba + diflufenzapyr	1.7 + 0.05 0.2	once once
	2002	maize	acetachlor + isoxaflutole dicamba + diflufenzapyr	1.7 + 0.05 0.2	once once
	2003	maize	acetachlor + isoxaflutole	1.7 + 0.05	once
NG-R	1998	maize	rimsulfuron + thifensulfuron + dicamba	0.011 + 0.006 +0.14	once once
	1999	sugarbeet	phenmidipham + desmedipham + triflusulfuron + clopyralid + clethodim	0.18 + 0.18 + 0.02 + 0.1 + 0.1	3 times
	2000	maize	acetachlor + isoxaflutole	1.7 + 0.05	once
	2001	sugarbeet	phenmidipham + desmedipham + triflusulfuron + clopyralid + clethodim	0.18 + 0.18 + 0.02 + 0.1 + 0.1	3 times
	2002	wheat	bromoxynil + MCPA + fluroxypyr	0.42 + 0.42 + 0.21	once
	2003	maize	acetachlor + isoxaflutole	1.7 + 0.05	once

Nine soil cores were pulled from each plot in the spring prior to field preparation for weed seed bank analysis. The soil cores were bulked, weed seed extracted with a semi-automatic elutriator and weed seed counted by species. Weed density counts were made on three 3 m sections of row before herbicide treatment, two weeks after the last herbicide treatment, and again near crop harvest. Crop density and yield were determined from the same area where the soil cores were pulled and from which the weed density counts were made. Data were collected from the same site each year at all locations and the plot sampling arrangement is shown in Figure 1.

Results

After six seasons (1998 to 2003) there was no evidence that any weed species had developed resistance to glyphosate. However, at all three irrigated locations common lambsquarters populations have increased in the treatments receiving the low rate of glyphosate when compared to the other treatments (Table 2). This effect was most pronounced at Scottsbluff and was similar in both, rotational (RC) or continuous maize (CC) plots. Rotation also had no effect at Ft. Collins, but at Torrington common lambsquarters populations were less in continuous maize compared to rotation plots.

Wild buckwheat (*Polygonum convolvulus*) which was not present in detectable quantities at Torrington in 1998 increased to over 4 plants/m^2 in 2003 in the CC plots treated with the low rate of glyphosate (Table 3).

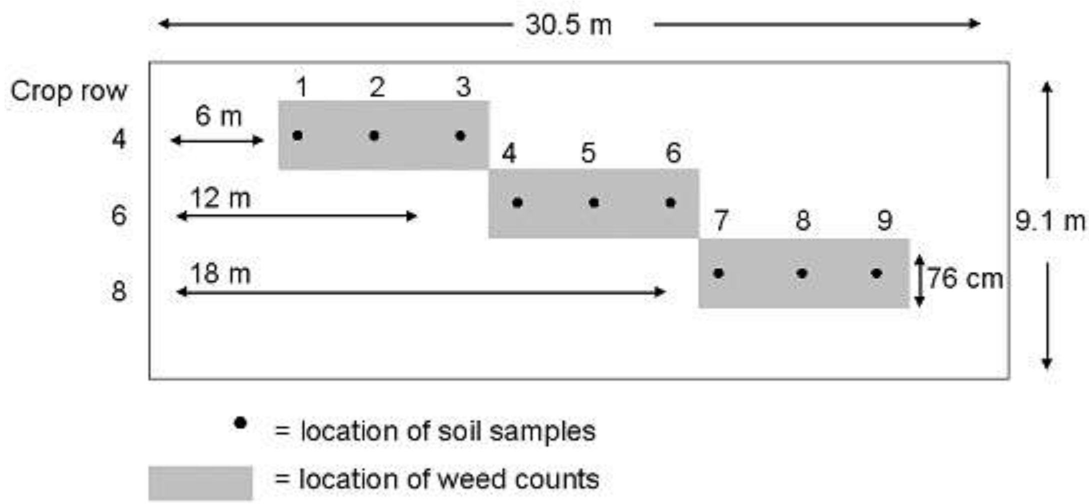

Figure 1. Plot sampling arrangement used at all experimental sites from 1998 to 2003.

Table 2. Influence of herbicide treatment and rotation on common lambsquarters populations in 2003.

	Scottsbluff, NE	Torrington, WY		Ft. Collins
Treatment	Avg. Rotations	CC	RC	Avg. Rotations
		plants/m^2		
LG	44 a	3.5 b	5.1 a	6 a
HG	14 b	0.5 c	1 c	2 b
RG	12 b	0 c	0 c	1.5 b
NG	8 b	0 c	0 c	0.5 b

Table 3. Influence of herbicide treatment and rotation on wild buckwheat populations at Torrington, WY in 2003.

	Torrington, WY	
Treatment	CC	RC
	plants/m^2	
LG	4 a	0.1 b
HG	0.2 b	0 b
RG	0 b	0 b
NG	0 b	0 b

Conclusion

The data indicate if the rate of glyphosate is reduced species that possess a slightly higher natural tolerance and survive the application are allowed to reproduce. Over time, these increase in numbers and become the dominant weed. For this study rotating glyphosate with conventional herbicides as in the alternating glyphosate treatment was no more effective on common lambsquarters than the high glyphosate rate at all three sites.