

US grower perceptions and experiences with glyphosate-resistant weeds

Chuck Foresman* and Les Glasgow

Syngenta Crop Protection, Inc., Greensboro, NC 27419, USA

Abstract

BACKGROUND: A survey of 400 growers of maize, soybeans and cotton was made in the United States to determine perceptions, experiences and management practices with glyphosate-resistant weeds. The survey included growers in the north (corn belt) and south (cotton belt) of the USA in spring 2006.

RESULTS: Interestingly, 24 and 39% of northern and southern growers, respectively, assumed they had glyphosate weed resistance on their farm. Of the 200 southern growers interviewed, 67% had planted continuous glyphosate-resistant (GR) crops for a period of 3–5 years. According to the survey respondents, the key method for managing glyphosate-resistant weeds was to rotate to other herbicides.

CONCLUSION: Growers do value GR crop technology but are adopting measures to manage resistance only as needed.

© 2008 Society of Chemical Industry

Keywords: glyphosate; glyphosate-resistant crops; resistance management

1 INTRODUCTION

Glyphosate weed resistance is a growing problem for glyphosate-resistant (GR) soybean and cotton growers. Since the 1996 introduction and rapid adoption of GR crops, seven weeds have been confirmed resistant and reported to the International Survey of Resistant Weeds.¹ They include: rigid ryegrass (*Lolium rigidum* Gaudin), Italian ryegrass (*Lolium multiflorum* Lam.), common ragweed (*Ambrosia artemisiifolia* L.), horseweed [*Conyza canadensis* (L.) Cronq.], Palmer pigweed (*Amaranthus palmerii* S. Wats), tall waterhemp [*Amaranthus tuberculatus* (Moq.) JD Sauer.] and giant ragweed (*Ambrosia trifida* L.). Over 1.2 million ha of row crop land was estimated to be infested with one or more glyphosate-resistant weeds in the state of Tennessee in 2005 (Mueller T, private communication). Of these weeds, *C. canadensis* is the most prevalent, primarily owing to its propensity for widespread seed dispersal in the environment. A seed movement study conducted on *C. canadensis* in southern Delaware showed that seeds entering the planetary boundary layer of the lower atmosphere can move in excess of 500 km.²

GR crops have been adopted at an unprecedented pace in American agriculture; 94, 79 and 40% of all soybeans, cotton and maize area, respectively, was GR in 2006.³ Inevitably, year-on-year planting of GR crops on the same hectare allows multiple applications of glyphosate to the same weed populations, imposing heavy selection pressure for weeds that can resist

glyphosate. Glyphosate use labels are flexible and allow two in-crop, in-season applications for weed control. Current glyphosate registrations allow maximum single in-crop application rates of 1.3, 1.75 and 0.87 kg AE ha⁻¹ for maize, soybeans and cotton respectively.

Glyphosate use has grown approximately 9% per annum over the last 5 years in maize, cotton and soybeans. Average glyphosate use rate is growing slowly over the same time period, ranging from 0.8 to 0.89 kg AE ha⁻¹. The average number of glyphosate applications per hectare per year was 1.36 for soybeans, 1.29 for maize and 2.20 for cotton. Glyphosate treatment area for maize, cotton and soybeans in 2006 was approximately 67 million ha (Dmrkynetec, PO Box 46904, St Louis, MO, 2006).

With labels allowing more flexible use and with its broad-spectrum weed control characteristics, more intensive as well as more widespread use of glyphosate is certainly anticipated.

In order to determine how growers use GR systems and their awareness, perceptions, attitudes and experience of glyphosate-resistant weeds, in April 2006, Syngenta commissioned a telephone survey.

2 METHODOLOGY

Random calls were made until interviews were completed with 400 growers, of which 200 were in the northern corn belt region and 200 in the cotton belt of the south. The randomly selected interviewees were

* Correspondence to: Chuck Foresman, Syngenta Crop Protection, Inc., 410 Swing Road, Greensboro, NC 27419, USA

E-mail: chuck.foresman@Syngenta.com

(Received 22 March 2007; revised version received 7 November 2007; accepted 7 November 2007)

Published online 4 February 2008; DOI: 10.1002/ps.1535

located throughout both of these regions (Table 1). Minimum crop areas required to become a part of the survey were maize 100 ha and cotton 200 ha. In each case, the person interviewed was the primary decision-maker for the herbicide program on the property. The survey included questions on GR crop and glyphosate usage and glyphosate-resistant weeds – their presence, impact, management and cost to manage. Data were included from all who met the interview criteria, and were collected, collated and analyzed by Directions Research, Mason City, IA. Means were compared using Student's *t*-test at $P < 0.05$.

3 RESULTS AND DISCUSSION

3.1 GR crop use

Interviewees confirmed high adoption of GR technology on their farms, with more than 90% planting GR crops in 2006 (Table 2). Average per-farm, continuous-planted GR area for northern growers was 112 ha, and for southern growers 750 ha, demonstrating the very high adoption of GR technology in the south. In addition, 27% and 67% of northern and southern growers, respectively, said they had used GR technology year on year for a period of 3–5 years. There was a significant difference between northern (55%) and southern (20%) growers in their rotation from a GR crop to a non-GR crop in consecutive years. Similar results were obtained in a recent comprehensive survey in five states (Iowa, Indiana, Mississippi, Nebraska and North Carolina) in which 14, 25 and 54% of growers planted continuous GR corn, soybeans and cotton respectively.³

3.2 Glyphosate use

Glyphosate was used alone on approximately half of their area. In the north and south, 70 and 75% respectively made 2–3 glyphosate applications each year.

When considering GR soybeans, 56% northern and 42% southern growers indicated that glyphosate was used alone on at least some of their crop area (Table 3). Growers who responded that they used glyphosate alone were asked, 'On what proportion of your crop area was glyphosate used alone?' The

Table 1. Location of interviewees

North	Number of interviewees	South	Number of interviewees
Iowa	48	Alabama	19
Illinois	45	Arkansas	34
Indiana	22	Georgia	32
Kansas	12	Louisiana	18
Kentucky	5	Mississippi	37
Missouri	11	North Carolina	33
Nebraska	32	South Carolina	8
Ohio	12	Tennessee	19
South Dakota	13		

Table 2. Number of growers and proportion of area planted with GR crops^a

	North <i>n</i> = 200	South <i>n</i> = 200
Number of growers using GR technology	184a	194b
% of total area planted with GR crops	53a	83b
Average area (ha) per farm planted with GR crops	244a	797b
% of area with GR crop followed by GR crop in 2005 and 2006	22a	56b

^a Means followed by the same letter in a row are not significantly different by Student's *t*-test at $P < 0.05$.

result was a very high 91% of all crop area for northern growers and 89% for southern growers. Similarly, for cotton, 21% of growers said they used glyphosate alone on a portion of their crop area. The growers within this segment reported 81% of their area received only glyphosate for weed control. As for maize growers, 24% indicated glyphosate was used alone on a portion of their hectares, and growers within this segment reported using nothing but glyphosate on 61% of their hectares. In addition, approximately half the growers used a pre-emergence-applied herbicide in cotton and maize (Table 3).

However, in a recent survey in Delaware, a majority of maize growers (84%) reported that they were likely to use soil-applied herbicides followed by glyphosate as needed.⁴

3.3 Glyphosate weed resistance incidence

There was a significant difference in the proportion of northern (25%) and southern (39%) growers who believe they have glyphosate-resistant weeds on their farm. The glyphosate-resistant weeds most frequently mentioned by northern growers were *C. canadensis*, *C. album* L. and *A. tuberculatus*. For the south, *C. canadensis*, *A. palmerii*, *Ipomoea*

Table 3. Herbicide programs and the proportion (%) of grower use^a

Herbicide program	Crop/region			
	Maize north <i>n</i> = 110	Cotton south <i>n</i> = 190	Soybean north <i>n</i> = 176	Soybean south <i>n</i> = 104
Glyphosate alone	24	21	56a	42b
Glyphosate tank mixed	20 ^b	21	11a	22b
Pre-emergence herbicide followed by glyphosate	49	52	33a	34a
Other herbicide	7	6	–	2

^a Means followed by the same letter in a row for soybean columns are not significantly different by Student's *t*-test at $P < 0.05$.

^b Atrazine used by 15% of growers.

Table 4. Grower perception of crop area with glyphosate weed resistance – north

State	Proportion of crop area infested with resistant weeds (%)			
	0	1–49	50–99	100
	Number of growers			
Iowa	1	6	1	0
Illinois	1	11	1	1
Indiana	0	5	2	0
Kansas	1	2	1	0
Kentucky	0	1	1	1
Missouri	0	3	0	0
Nebraska	0	4	2	0
Ohio	1	0	0	1
South Dakota	0	0	0	1
Total	4	32	8	4
	Proportion of total respondents (%)			
	8	67	17	8

Table 5. Grower perception of crop area with glyphosate weed resistance – south

State	Proportion of crop area infested with resistant weeds (%)			
	0	1–49	50–99	100
	Number of growers			
Alabama	1	8	0	2
Arkansas	1	9	3	5
Georgia	0	7	0	2
Louisiana	0	2	0	1
Mississippi	0	6	3	0
North Carolina	2	6	0	1
South Carolina	0	0	0	1
Tennessee	0	7	2	5
Total	4	45	8	17
	Proportion of total respondents (%)			
	5	61	11	23

spp. and *Sorghum halepense* L. were identified as resistant. A significantly larger proportion of southern growers (23%) compared with northern growers (8%) reported they had glyphosate-resistant weeds on 100% of their farm (Tables 4 and 5). Growers who are not currently experiencing glyphosate resistance perceived that the added cost of resistance would range from \$34.35 in the north to \$40.28 per hectare in the south for additional herbicides, with an 8 and 7% reduction in yield in the north and south respectively. The higher numbers in the south probably reflect the widespread incidence of, as well as the awareness of, resistance to *C. canadensis* in cotton in that region. However, Mueller *et al.*⁵ estimated a net increase of \$62.97 per hectare as a result of the development of GR horseweed. Four in ten growers believed the glyphosate resistance problem is getting worse.

Conversely, one in four believed the situation is improving.

3.4 Remedies considered for glyphosate resistance

If resistance occurred, growers in the north and south said they would rotate herbicides, use tillage or tank-mix other herbicides with glyphosate to manage the problem. Of northern growers, 19% are more likely to rotate to a non-GR crop. Only 9% of southern growers said they would limit GR technology. In a recent survey, 27% of cotton growers reported that crop rotation or chemical rotation would be specific actions taken to minimize resistance to glyphosate.⁶

Growers are more likely to drop the GR technology in maize than in soybeans or cotton if resistant weeds become a problem. In addition, most growers (92%) are either very confident or somewhat confident that the industry will deliver new technologies or products in the next 3–5 years to manage glyphosate resistance problems.

4 CONCLUSIONS

The survey demonstrated that a large number of growers are aware that weeds can develop resistance to glyphosate. Grower perception of glyphosate resistance is more acute in the south than in the north. The growers are knowledgeable about which weeds to monitor for resistance, and many realize that glyphosate weed resistance will mean added herbicide cost and crop yield reductions. Many growers have identified weed management practices to utilize if weeds become resistant to glyphosate, including rotating to a non-GR crop or changing herbicides. Most growers believe new technologies will be discovered and commercialized to manage glyphosate weed resistance effectively in the next 3–5 years. Glyphosate herbicide will remain a key part of most maize, cotton and soybean growers' weed control programs, because it remains effective on a large number of weed species, is cost effective and is gentle to the crop. Undoubtedly, more glyphosate-resistant weeds will be identified and growers will look to industry and university for advice on developing agronomically sound management practices.

REFERENCES

- 1 Heap IM, *International Survey of Herbicide-resistant Weeds*. [Online]. Available: www.weedscience.com [12 January 2008].
- 2 Shields E, Dauer J, VanGessel MJ and Neumann G, Horseweed (*Conyza canadensis*) seed collected in the planetary boundary layer. *Weed Sci* 54:1063–1067 (2006).
- 3 Young BG, Farno LA, Shaw DR, Owen MDK, Weller SC, Wilcut JW, *et al.*, Grower utilization of Roundup Ready crops and perceived performance of glyphosate-based weed management systems. *Proc North Central Weed Sci Soc* 61:224 (2006).

- 4 Scott BA and VanGessel MJ, Delaware soybean grower survey on glyphosate-resistant horseweed (*Conyza canadensis*). *Weed Technol* 21:270–274 (2007).
- 5 Mueller TC, Mitchell PD, Young BG and Culpepper AS, Proactive versus reactive management of glyphosate-resistant or -tolerant weeds. *Weed Technol* 19:924–933 (2005).
- 6 Clewis SB, Everman WJ, Jordan DL, Wilcut JW, Farno LA, Givens WA, *et al.*, Grower assessments of long-term viability of Roundup Ready technology as a foundation for cotton production. *Proc Weed Sci Soc Am* 47:320 (2007).