Open-Pollinated Transfer of Glyphosate Resistance in Horseweed (*Conyza canadensis*) in Greenhouse Isolation

Ryan S. Henry, Vince M. Davis, William G. Johnson
Department of Botany and Plant Pathology, Purdue University

Introduction

Horseweed (*Conyza canadensis*) has become a problematic weed in crop production fields across the United States. The fraction of the population that is resistant to the herbicide glyphosate continues to increase each year. In Indiana, farmers have ranked horseweed as a top-five problematic weed, and a field survey found 38% of the population of horseweed to be glyphosate-resistant (GR) in southeastern Indiana. A single-locus, nuclear encoded gene confers glyphosate resistance (Zelaya et al. 2004). Horseweed primarily self pollinates, but nuclear encoded paraquat resistance out-crosses at approximately 4% under field conditions (Smisek 1995). The transfer of glyphosate resistance via pollen as a mechanism of gene flow, in addition to long distance seed movement, is troubling because it could aid in the evolution of multiple resistance.

Objective

The objective of this experiment was to quantify the potential for GR horseweed to outcross in open-pollinated populations with co-mingling glyphosate-resistant and susceptible biotypes.

Materials and Methods

Known GR field populations were purified with 0.42 kg ae ha^{-1} glyphosate and a known glyphosate-susceptible (GS) field population was used for parental plants (F_0).

GR survivors and GS F_0 plants were grown under normal greenhouse conditions and arranged in six, 8:1 GR:GS clusters at 10-25% open flowers.

Three clusters of 572 x 502 were placed in one greenhouse, and three clusters of 572 x 524 were in another greenhouse with an additional pair for manual cross pollinations. Clusters were spaced 3-m apart, and plants were spaced 13-cm apart within a cluster.

F_1 seeds were collected from the seven GS parents, propagated, and sprayed with 0.84 kg ae ha^{-1} glyphosate at 3 to 5-cm rosette width. Surviving F_1 plants were self-pollinated, and F_2 seeds were collected.

F_2 generation were then propagated and sprayed with 0.84 kg ae ha^{-1} glyphosate at 3 to 5-cm rosette width. Digital images were taken at 28 DAT with a Nikon Coolpix E5700 digital camera. Data were combined over three experimental runs.

F_2 segregation ratios were determined by visual GR or GS assessment and images were analyzed for green pixel counts using digital imaging software, ImageJ. ImageJ is available at http://rsbweb.nih.gov/ij/. GR:GS ratios were subjected to chi-square goodness-of-fit analyses.

Results

Figure 1. GR and GS F_1 horseweed progeny 35 DAT with 0.84 kg ae ha^{-1} glyphosate.

Figure 2. GR and GS F_2 horseweed progeny 28 DAT with 0.84 kg ae ha^{-1} glyphosate, and example of green value analysis with ImageJ software.

Table 1 Response of first (F_1) and second (F_2) generation horseweed progeny to 0.84 kg ae ha^{-1} glyphosate for open and manually cross pollinated horseweed. Green pixel value was determined by digital image analysis program.

Horseweed Biotypes		Glyphosate-resistant			Glyphosate-susceptible				
GS x GR	Cross pollination method	#	Green pixel value	Std. Dev.	#	Green pixel value	Std. Dev.	% GR	Chi-square P-value[1]
Checks									
GR		87	86	23	—	—	—	100	—
GS (572)		—	—	—	82	66	18	0	—
F_1									
572 x 502	open	2	185	4	182	121	14	1.1	—
572 x 524	open	11	167	13	276	106	18	4.0	—
572 x 524	manual	42	140	7	98	118	11	43	—
F_2									
572 x 502	open	59	89	16	19	67	15	76	1
572 x 524	open	92	91	12	22	65	9	81	0.20
572 x 524	manual	42	91	13	23	69	11	65	0.07

[1]Chi-square goodness-of-fit values for an expected 3:1 GR:GS ratio

Conclusions

Outcrossing for the 8:1 GR:GS clusters ranged from 1.1% to 4% and segregation for F_2 plants fit expected 3:1 R:S ratios according to chi-square goodness-of-fit analyses. Our results confirmed that glyphosate resistance in horseweed can transfer to a closely located, putative GS biotype at low frequencies under open-pollinated greenhouse conditions.

Literature cited

Smisek, A. 1995. Resistance to Paraquat in *Erigeron canadensis* L. M.S. Thesis, University of Western Ontario, London, ON N6A 5B8. Pp.82-84.

Zelaya, I. A., M. D. K. Owen, and M. J. VanGessel. 2004. Inheritance of evolved glyphosate resistance in *Conyza canadensis* (L.) Cronq. Theor. Appl. Genet. 110:58-70.