

Control of Multiple Herbicide-Resistant Palmer Amaranth in Enlist Corn

R. Liu, V. Kumar, and T. Lambert

Summary

Recent evolution of multiple herbicide resistant (MHR) Palmer amaranth [resistant to 2,4-D, glyphosate (Roundup), chlorsulfuron (Glean), atrazine (Aatrex), and mesotrione (Callisto)] is a serious threat to newly developed stacked trait technologies, including Enlist crops (tolerant to 2,4-D, glyphosate, and glufosinate). Field experiments were conducted in 2019 at the Kansas State University Agricultural Research Center near Hays, KS, to determine the effectiveness of various preemergence (PRE) followed by (*fb*) postemergence (POST) herbicides (multiple modes of action) for controlling this MHR Palmer amaranth in Enlist corn. The study was established in no-till dryland wheat stubble where MHR Palmer amaranth seeds were uniformly infested. All PRE treatments included Roundup at 32 oz/a to control volunteer wheat seedlings at the time of corn planting. Treatments were arranged in a randomized complete block design, with four replications. Herbicides were applied using a handheld boom sprayer calibrated to deliver 15 GPA. Data on percent visual control of MHR Palmer amaranth were recorded biweekly throughout the season, and corn grain yield was recorded at harvest. All PRE *fb* POST herbicide programs—except PRE applied Armezon Pro plus Aatrex *fb* a POST treatment of Roundup + Enlist One + Liberty, and a sequential PRE *fb* POST treatment of Roundup + Enlist One + Liberty—provided excellent, season-long control (92-96%) of MHR Palmer amaranth. In contrast, end-season control of MHR Palmer amaranth did not exceed 85% with PRE applied Armezon Pro plus Aatrex *fb* a POST treatment of Roundup + Enlist One + Liberty, and a sequential PRE *fb* POST treatment of Roundup + Enlist One + Liberty. Corn grain yields were significantly improved among all the tested herbicide programs compared to the nontreated weedy check plots. These results indicate that the effective PRE *fb* POST (two pass) programs evaluated in this study can be utilized for effective management of MHR Palmer amaranth in Enlist corn.

Introduction

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is a dioecious (male and female flowers on separate plants) summer annual broadleaf weed that belongs to the pigweed family (Ward et al., 2013). It has several unique biological traits, including extended period of emergence, aggressive growth, and prolific seed production (Keeley et al., 1987; Steckel et al., 2004; Ward et al., 2013). It is also highly prone to develop herbicide resistance (Heap, 2020). Palmer amaranth has become the most problematic weed species in agronomic crops across western and central parts of Kansas (Thompson et al., 2018).

A Palmer amaranth biotype (MHR) from central Kansas has recently been confirmed with multiple resistance to 2,4-D (3.2-fold), glyphosate (11.8-fold), chlorsulfuron (5.0-fold), atrazine (14.4-fold), mesotrione (13.4-fold), and reduced sensitivity to fomesafen (Kumar et al., 2019). Evolution of multiple resistant Palmer amaranth biotypes poses a serious threat to newly developed stacked-trait technologies, including Enlist crops, which are tolerant to 2,4-D, glyphosate, and glufosinate. An increasing use of glyphosate, 2,4-D, and/or glufosinate with the recent commercialization of these Enlist crops may need greater attention.

Herbicides with multiple sites of action (premixes/tank-mixtures) are needed to manage MHR Palmer amaranth in Enlist crops. The main objective of this study was to evaluate the effectiveness of various PRE *fb* POST herbicide premixes and/or tank-mixtures for controlling MHR population in Enlist corn.

Procedures

A field study was conducted at the Kansas State University Agricultural Research Center near Hays, KS, in 2019. Enlist corn hybrid 'DKC62-53' was planted in no-till dryland wheat stubble on May 16 using 17,425 seeds per acre. Seeds of an MHR Palmer amaranth were uniformly infested at the site. Ten herbicide programs (Table 1), including PRE and POST were arranged in randomized complete block design with 4 replications. Herbicides were applied with a CO₂-pressurized backpack sprayer using Teejet AIXR110015 nozzles at 15 GPA. Plot size was 10 × 30 feet. PRE herbicides were applied on May 17, immediately after corn planting. POST herbicides were applied on June 13, at V6 to V8 corn growth stage. Data on percent corn injury and percent visual control of MHR Palmer amaranth were recorded at biweekly intervals, and corn yield was estimated by harvesting the middle two rows of each plot at maturity. All data were subjected to ANOVA using PROC MIXED in SAS v. 9.4 (SAS Inst. Inc., Cary, NC). Means were separated by Fisher's protected LSD test at $P < 0.05$.

Results

All PRE herbicide treatments were activated with enough moisture through rainfall events prior to and soon after corn planting. No corn injury was observed with any of the PRE and/or POST herbicide programs tested in this study (data not shown). PRE *fb* POST programs, including Roundup + SureStart II + Aatrex *fb* Roundup + Enlist One + Liberty + RealmQ; Roundup + Resicore + Aatrex *fb* Roundup + Enlist One + Liberty + Dual II Magnum; Roundup + FulTime NXT *fb* Roundup + Enlist One + Liberty + Corvus; Roundup + Anthem Maxx + Aatrex *fb* Roundup + Enlist One + Liberty plus Warrant; Roundup + Acuron *fb* Roundup + Enlist One + Liberty; Roundup + Harness Max *fb* Roundup + Enlist One + Liberty; Roundup + Keystone NXT *fb* Roundup + Enlist One + Liberty had an excellent season-long control (92 to 96%) of MHR Palmer amaranth (Table 1). End-of-season control of MHR population was 85% with PRE applied Roundup + Armezon Pro + Aatrex *fb* a POST treatment of Roundup + Enlist One + Liberty, and a sequential PRE *fb* POST treatment of Roundup + Enlist One + Liberty (Figure 1). There were no significant differences in corn grain yields among all PRE *fb* POST herbicide programs and yields ranged between 2.7 to 2.9 tons/a (Figure 2).

Conclusions

Results from this study indicate that two-pass herbicide programs (PRE *fb* POST) containing multiple herbicide sites of action are needed for season-long control of five-way resistant Palmer amaranth population. Effective PRE *fb* POST programs evaluated in this study can serve as important component of integrated strategies for managing MHR Palmer amaranth in Enlist corn.

References

- Heap I (2020) The International Survey of Herbicide Resistant Weeds. <http://www.weedscience.org>. Accessed: Mar 19, 2020.
- Keeley PE, Carter CH, Thullen RJ (1987) Influence of planting date on growth of Palmer amaranth (*Amaranthus palmeri*). *Weed Sci* 35:199–204.
- Kumar V, Liu R, Boyer G, Stahlman PW (2019) Confirmation of 2,4-D resistance and identification of multiple resistance in a Kansas Palmer amaranth (*Amaranthus palmeri*) population. *Pest Manage Sci* doi.org/10.1002/ps. 5400.
- Steckel LE, Sprague CL, Stoller EW and Wax LM (2004) Temperature effects on germination of nine *Amaranthus* species. *Weed Sci* 52:217–221.
- Thompson CR, Peterson DE, Fick WH, Currie RS, Kumar V, Slocombe JW (2018) Chemical weed control for field crops, pastures, rangeland, and noncropland. Manhattan, KS: Kansas State University Agricultural Experiment Station and Cooperative Extension Service Report of Progress 1139.
- Ward SM, Webster TM, Steckel LE (2013) Palmer amaranth (*Amaranthus palmeri*): a review. *Weed Technol* 27:12–27.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. List of herbicide programs and rates evaluated in Enlist corn at the Kansas State University Agricultural Research Center near Hays, KS

Treatment number	Herbicide Programs ^{a,b}	Rate (fl oz/a)	Timing
T1	Nontreated weedy check	---	---
T2	SureStart II + Aatrex <i>fb</i> Enlist One + RealmQ + Liberty	40 + 32 <i>fb</i> 32 + 16 + 32	PRE <i>fb</i> POST
T3	Resicore + Aatrex <i>fb</i> Enlist One + Dual II Magnum + Liberty	40 + 32 <i>fb</i> 32 + 16 + 32	PRE <i>fb</i> POST
T4	FulTime NXT <i>fb</i> Enlist One + Corvus + Liberty	80 <i>fb</i> 32 + 5.6 + 32	PRE <i>fb</i> POST
T5	Anthem Maxx + Aatrex <i>fb</i> Enlist One + Warrant + Liberty	4 + 32 <i>fb</i> 32 + 64 + 32	PRE <i>fb</i> POST
T6	Acuron <i>fb</i> Enlist One + Liberty	80 <i>fb</i> 32 + 32	PRE <i>fb</i> POST
T7	Harness Max <i>fb</i> Enlist One + Liberty	40 <i>fb</i> 32 + 32	PRE <i>fb</i> POST
T8	Keystone NXT <i>fb</i> Enlist One + Liberty	56 <i>fb</i> 32 + 32	PRE <i>fb</i> POST
T9	Armezon Pro + Aatrex <i>fb</i> Enlist One + Liberty	20 + 32 <i>fb</i> 32 + 32	PRE <i>fb</i> POST
T10	Enlist One + Liberty <i>fb</i> Enlist One + Liberty	32 + 32 <i>fb</i> 32 + 32	PRE <i>fb</i> POST

^a All PRE and POST programs were applied with Roundup PowerMax at 32 fl oz/a.

^b PRE programs included ammonium sulfate (AMS) at 2% v/v and POST included Class Act Ridion at 2% v/v. PRE = preemergence. POST = postemergence. *fb* = followed by.

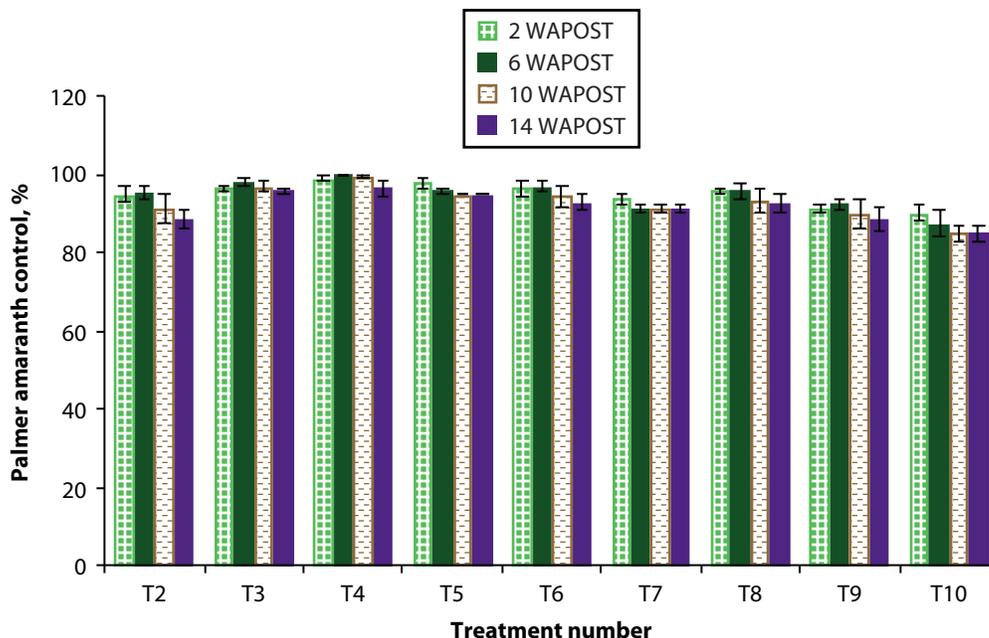


Figure 1. Percent control of five-way resistant Palmer amaranth with PRE *fb* POST herbicide programs in Enlist corn. The top bars represent the standard error of means. Palmer amaranth control in treatment 1 (nontreated weedy check) was 0% throughout the season; therefore, not shown in this figure.

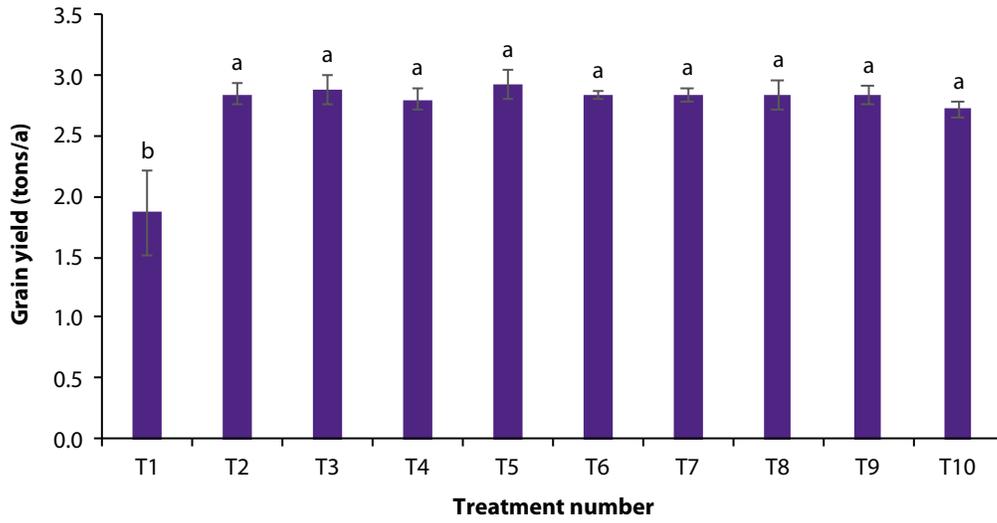


Figure 2. Effect of PRE *fb* POST herbicide programs on Enlist corn grain yield. Vertical bars represent the standard error of means.