Effective Herbicide Options for Controlling Glyphosate-Resistant Palmer Amaranth in Roundup Ready 2 Xtend Soybean

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Abstract

Glyphosate-resistant (GR) Palmer amaranth has become a serious challenge for soybean producers in the mid-south and central United States, including Kansas. Field experiments were conducted at the Kansas State University Agricultural Research Center (KSU-ARC) near Hays, KS, and Kansas State University Ashland Bottoms (KSU-AB) research farm near Manhattan, KS, to determine the effectiveness of preemergence (PRE) and PRE followed by (*fb*) postemergence (POST) herbicide programs on GR Palmer amaranth control in Roundup Ready 2 Xtend soybean. The study site at Hays was infested with GR Palmer amaranth population prior to soybean planting; whereas, the Manhattan site had natural infestation of GR Palmer amaranth. Eleven treatments, including PRE alone and PRE *fb* POST-applied herbicides were investigated. All PRE treatments included Roundup PowerMax for control of other weed species, while POST treatments were mixtures of Roundup PowerMax and Engenia herbicides. A single PRE application of Fierce XLT and Panther PRO had ≥ 90% control of GR Palmer amaranth; whereas, control with Authority Elite and Zidua PRO did not exceed 83% at 6 weeks after POST (WAPOST). Combined over two locations, all PRE *fb* POST treatments had excellent control (≥ 96%) of GR Palmer amaranth at 6 WAPOST. No significant differences for soybean grain yield were observed among herbicide treatments at the Hays site; whereas, an approximate 10% increase in grain yield was observed with PRE *fb* POST vs. PRE alone programs at the Manhattan site. Based on these results, the two-pass programs (PRE *fb* POST) investigated in this research can be effectively used for season-long control of GR Palmer amaranth in Roundup Ready 2 Xtend soybean.

Keywords

dicamba-tolerant soybean, herbicide programs, glyphosate-resistant Palmer amaranth

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Summary

Glyphosate-resistant (GR) Palmer amaranth has become a serious challenge for soybean producers in the mid-south and central United States, including Kansas. Field experiments were conducted at the Kansas State University Agricultural Research Center (KSU-ARC) near Hays, KS, and Kansas State University Ashland Bottoms (KSU-AB) research farm near Manhattan, KS, to determine the effectiveness of preemergence (PRE) and PRE followed by (*fb*) postemergence (POST) herbicide programs on GR Palmer amaranth control in Roundup Ready 2 Xtend soybean. The study site at Hays was infested with GR Palmer amaranth population prior to soybean planting; whereas, the Manhattan site had natural infestation of GR Palmer amaranth. Eleven treatments, including PRE alone and PRE *fb* POST-applied herbicides were investigated. All PRE treatments included Roundup PowerMax for control of other weed species, while POST treatments were mixtures of Roundup PowerMax and Engenia herbicides. A single PRE application of Fierce XLT and Panther PRO had ≥ 90% control of GR Palmer amaranth; whereas, control with Authority Elite and Zidua PRO did not exceed 83% at 6 weeks after POST (WAPOST). Combined over two locations, all PRE *fb* POST treatments had excellent control (≥ 96%) of GR Palmer amaranth at 6 WAPOST. No significant differences for soybean grain yield were observed among herbicide treatments at the Hays site; whereas, an approximate 10% increase in grain yield was observed with PRE *fb* POST vs. PRE alone programs at the Manhattan site. Based on these results, the two-pass programs (PRE *fb* POST) investigated in this research can be effectively used for season-long control of GR Palmer amaranth in Roundup Ready 2 Xtend soybean.

Introduction

Palmer amaranth (*Amaranthus palmeri* S. Wats) has become a serious management concern for Kansas farmers. Palmer amaranth is commonly found in cropland and noncropland areas of the central and western parts of Kansas. It generally infests corn, sorghum, soybean, sunflower, fallow fields, and postharvest wheat stubble in this region. Palmer amaranth initiates its emergence during early summer (mid to late May) and manifests an extended period of emergence throughout the growing season. Palmer amaranth also grows rapidly and produces huge amounts of seeds (a single female plant can produce 0.6 million seeds) (Keeley et al., 1987). Season-long competition of Palmer

amaranth at 0.9 plants ft^{-2} has been found to reduce soybean grain yield by 68% (Klingaman and Oliver, 1994).

Glyphosate was an effective POST herbicide for Palmer amaranth control until the evolution of glyphosate-resistant (GR) populations across Kansas, which was discovered in 2011 (Heap, 2019). As per the recent survey, resistance to glyphosate has become fairly common among Palmer amaranth populations in Kansas. Furthermore, multiple herbicide-resistant (MHR) Palmer amaranth is also a serious management challenge to Kansas growers. Currently, Palmer amaranth populations are reported with resistance to one or more of the following herbicide site(s) of action, including sulfonylureas (ALS inhibitors), atrazine (PS II inhibitor), mesotrione (HPPD inhibitor), glyphosate (EPSPS inhibitor), and more recently to 2,4-D (synthetic auxins) in Kansas (Heap, 2019; Kumar et al., 2019).

The recent introduction of Roundup Ready 2 Xtend soybean will allow growers to use POST applications of low-volatile dicamba formulations (Xtendimax, Fexapan, and Engenia) for managing GR weed biotypes, including GR Palmer amaranth. However, increasing dicamba applications may possibly enhance the risk of evolving Palmer amaranth resistant to dicamba. Therefore, effective and alternative herbicide options (multiple sites of action) would be needed for controlling GR Palmer amaranth in Roundup Ready 2 Xtend soybean. The main objectives of this research were to evaluate and develop effective herbicide programs for GR Palmer amaranth control in Roundup Ready 2 Xtend soybean in Kansas.

Procedures

Two field experiments were established: at the Kansas State University Agricultural Research Center (KSU-ARC) near Hays, KS, and at the Kansas State University Ashland Bottoms (KSU-AB) research farm near Manhattan, KS. Soybean plots were established in no-till wheat stubble at the KSU-ARC; whereas, the study site at KSU-AB was under conventional tillage system. Experiments at both sites were established in randomized complete block designs, with 4 replications and a plot size of 10 × 30 ft. The study site at KSU-AB had a natural infestation of GR Palmer amaranth; whereas, a seedbank of GR Palmer amaranth was artificially established at KSU-ARC site. A Roundup Ready 2 Xtend soybean, Asgrow AG34X7 was planted at 156,900 seeds/a on May 22, 2018, at KSU-ARC. Similarly, a Roundup Ready 2 Xtend soybean variety Asgrow AG39X7 was planted at 130,000 seeds/a on June 4, 2018, at the KSU-AB site. Eleven different herbicide programs, including PRE alone, POST alone, and PRE followed by (*fb*) POST-applied herbicides were tested (Table 1). A nontreated control and hand-weeded check were also included. All PRE treatments were applied at their recommended field-use rates in combination with Roundup PowerMax at 32 fl oz/a. All POST treatments were a mixture of Roundup PowerMax at 32 fl oz/a and Engenia at 12.8 oz/a. The selected PRE herbicide programs were applied at each location immediately after soybean planting. POST treatments were applied on June 22, 2018, at KSU-ARC, and July 16 at KSU-AB. Treatments were applied with a CO_2-pressurized backpack sprayer equipped with Turbo Teejet Induction (TTI) nozzles (Spraying Systems Co., Wheaton, IL), calibrated to deliver 15 gallons per acre spray solution. Data on soybean injury and visual Palmer amaranth control on a scale of 0 to 100% (0 being no control and 100 being complete control)

were collected at biweekly intervals throughout the growing season after PRE herbicide treatments at both sites. Soybean grain yield was recorded by harvesting the middle two rows from each plot using a plot combine. Data on Palmer amaranth control (%), and soybean grain yield (bu/a) were subjected to ANOVA using PROC MIXED in SAS v. 9.3 (SAS Inst., Cary, NC) software. Means were separated using Fisher's protected least significant difference test at $P < 0.05$.

Results and Discussion

No visual soybean injury was observed with any PRE and/or POST herbicide programs tested (data not shown). Combined over two locations, a single PRE application of Fierce XLT at 5 oz/a and Panther PRO at 12 oz/a provided 90 to 100% control of GR Palmer amaranth throughout the season (Figure 1). In contrast, GR Palmer amaranth control with PRE-applied Authority Elite at 28 oz/a and Zidua PRO at 6 oz/a was moderate and did not exceed 83% at final rating. However, a sequential POST application of a tank-mixture of Roundup PowerMax and Engenia improved GR Palmer amaranth control of all PRE programs at both sites (Figure 1). Interestingly, GR Palmer amaranth control with a single POST application of Roundup (32 fl oz/a) plus Engenia (12.8 fl oz/a) did not differ from two applications of Roundup (32 fl oz/a) plus Engenia (12.8 fl oz/a) mixture (PRE *fb* POST or POST *fb* POST) at the final rating. Soybean grain yield from a majority of the herbicide programs did not differ and ranged from 18 to 22 bu/a at Hays; whereas, an approximate 10% increase in grain yield was observed with PRE *fb* POST vs. PRE alone programs at Manhattan (Figure 2).

Conclusions

Based on these results, growers should utilize two-pass herbicide programs, including PRE options such as Fierce XLT, Panther PRO, Authority Elite, or Zidua PRO followed by a sequential POST application of Roundup PowerMax + Engenia for effective and season-long control of GR Palmer amaranth in Roundup Ready 2 Xtend soybean.

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Table 1. List of selected herbicide programs tested for controlling glyphosate-resistant (GR) Palmer amaranth in Roundup Ready 2 Xtend soybean at the Kansas State University Agricultural Research Center near Hays, KS, and Ashland Bottoms research farm near Manhattan, KS, in 2018

Herbicide programs[a]	Treatments	Rate (oz/a)	Timing
Authority Elite	T1	28	PRE
Zidua PRO	T2	6	PRE
Fierce XLT	T3	5	PRE
Panther PRO	T4	12	PRE
Authority Elite *fb* Roundup PowerMax + Engenia	T5	28 *fb* 32 + 12.8	PRE *fb* POST
Zidua PRO *fb* Roundup PowerMax + Engenia	T6	6 *fb* 32 + 12.8	PRE *fb* POST
Fierce XLT *fb* Roundup PowerMax + Engenia	T7	5 *fb* 32 + 12.8	PRE *fb* POST
Panther PRO *fb* Roundup PowerMax + Engenia	T8	12 *fb* 32 + 12.8	PRE *fb* POST
Roundup PowerMax + Engenia *fb* Roundup PowerMax + Engenia	T9	32 + 12.8 *fb* 32 + 12.8	PRE *fb* POST
Roundup PowerMax + Engenia *fb* Roundup PowerMax + Engenia	T10	32 + 12.8 *fb* 32 + 12.8	POST *fb* POST
Roundup PowerMax + Engenia	T11	32 + 12.8	POST
Nontreated	T12	---	---
Hand-weeded	T13	---	---

[a]PRE = preemergence. POST= postemergence. *fb* = followed by.
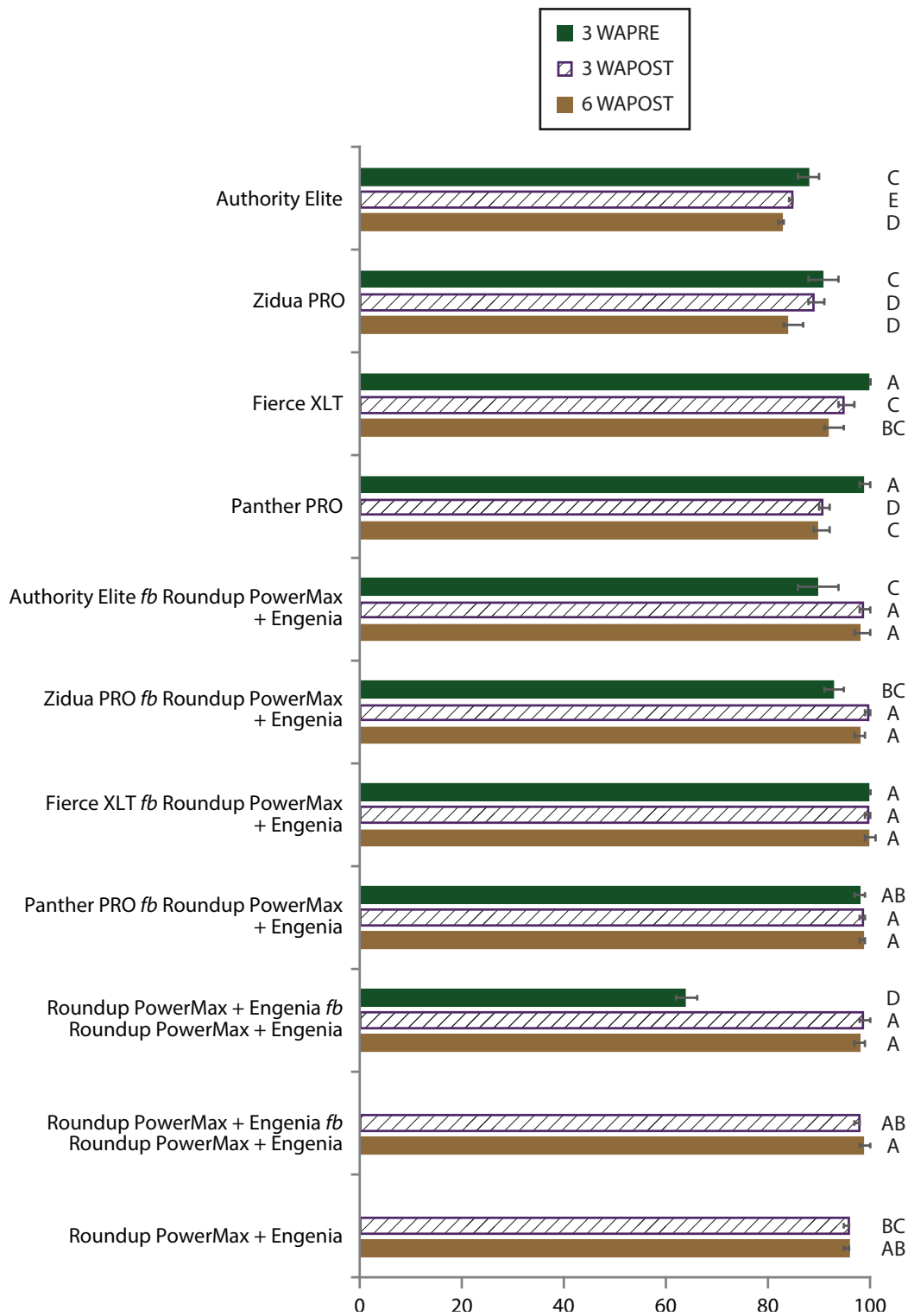
Figure 1. Effect of selected herbicide programs on visual control (%) of glyphosate-resistant Palmer amaranth in Roundup Ready 2 Xtend soybean combined over two locations. WAPRE = weeks after PRE. WAPOST = weeks after POST. Bars within each graph with similar letters are not different based on Fisher's protected LSD test at *P* < 0.05. Please see Table 1 for the full list of treatments.
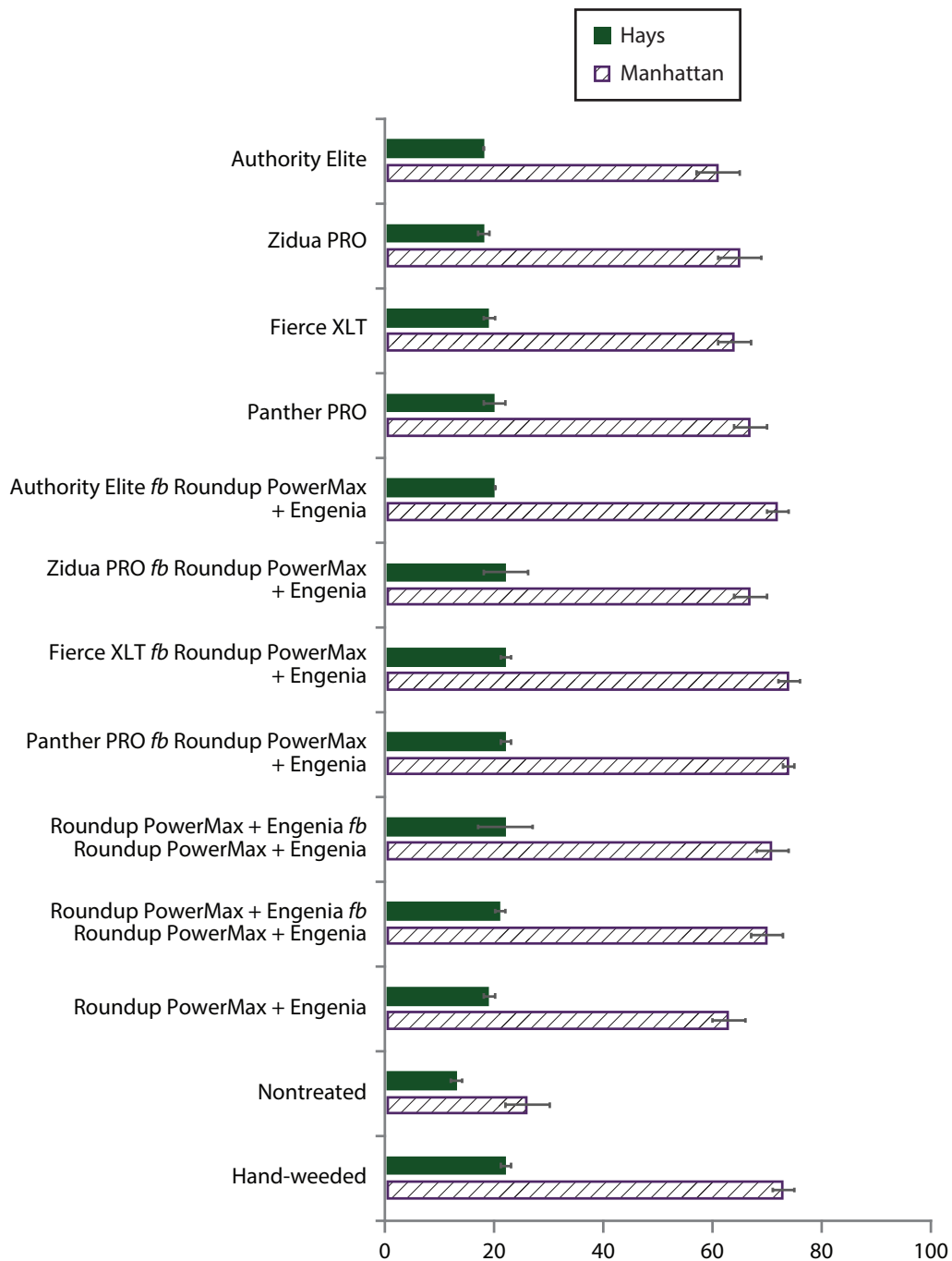
Figure 2. Effect of selected herbicide programs on soybean grain yields at the Kansas State University Agricultural Research Center near Hays, KS, and Ashland Bottoms research farm near Manhattan, KS, in 2018. Please see Table 1 for the full list of treatments.
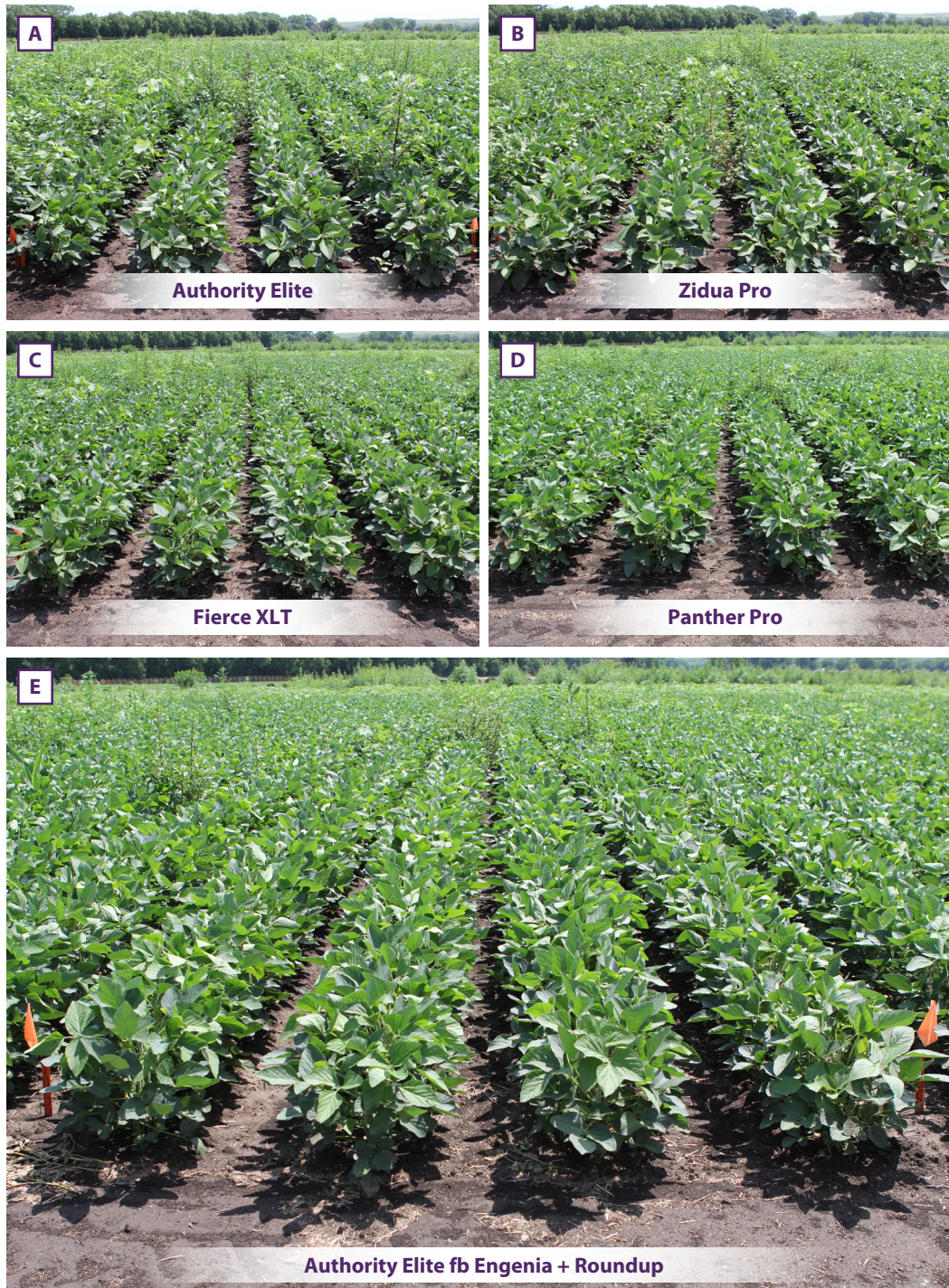
Figure 3. Visual response of glyphosate-resistant Palmer amaranth control in Roundup Ready 2 Xtend soybeans with PRE applied Authority Elite (A), Zidua Pro (B), Fierce XLT (C), Panther Pro (D), and Authority Elite PRE followed by Roundup PowerMax + Engenia POST (E) at 3 WAPOST in Manhattan, KS. WAPOST = weeks after POST.