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## Herbicide Strategies for Managing Glyphosate- and Dicamba-Resistant Kochia in Roundup Ready 2 Xtend Soybean

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# Herbicide Strategies for Managing Glyphosate- and Dicamba-Resistant Kochia in Roundup Ready 2 Xtend Soybean

## Abstract

Kochia populations with multiple resistance to glyphosate and dicamba are an increasing concern for growers in the High Plains region, including Kansas. A field study was conducted at the Kansas State University Agricultural Research Center near Hays, KS, to evaluate and develop herbicide options for controlling glyphosate- and dicamba-resistant kochia in Roundup Ready 2 Xtend soybean. The study site was uniformly infested with a glyphosate- and dicamba-resistant kochia population prior to soybean planting. Fifteen herbicide treatments (programs), including PRE alone and PRE followed by (*fb*) POST-applied herbicides, were investigated in a randomized complete block design with four replications. All PRE treatments included Roundup PowerMax for control of other weed species. Results indicated that a single PRE application of Spartan alone or with Engenia, Panther PRO, and Zidua plus Valor SX provided season-long control of glyphosate- and dicamba-resistant kochia. A single PRE application of Engenia or Zidua alone only provided 70 to 78% kochia control at 6 weeks after POST (WAPOST) application. However, PRE-applied Zidua alone or with Engenia, Engenia alone, Spartan + Zidua, and Spartan + Sencor followed by a sequential POST application of a tank-mixture containing Engenia and Roundup PowerMax provided  $\geq 95\%$  kochia control at 6 WAPOST. Kochia biomass reduction was  $> 92\%$  with a majority of the treatments; exceptions were Zidua PRE alone (59% reduction), Engenia alone (76% reduction), and Zidua + Engenia (88% reduction) treatments. Soybean grain yield for a majority of the tested treatments did not differ, and ranged from 23 to 25 bu/a. These results suggest that effective PRE herbicide options are available for managing glyphosate- and dicamba-resistant kochia in Roundup Ready 2 Xtend soybean.

## Keywords

glyphosate, dicamba, multiple resistant kochia, dicamba-tolerant soybean

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# Herbicide Strategies for Managing Glyphosate- and Dicamba-Resistant Kochia in Roundup Ready 2 Xtend Soybean

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## Summary

Kochia populations with multiple resistance to glyphosate and dicamba are an increasing concern for growers in the High Plains region, including Kansas. A field study was conducted at the Kansas State University Agricultural Research Center near Hays, KS, to evaluate and develop herbicide options for controlling glyphosate- and dicamba-resistant kochia in Roundup Ready 2 Xtend soybean. The study site was uniformly infested with a glyphosate- and dicamba-resistant kochia population prior to soybean planting. Fifteen herbicide treatments (programs), including PRE alone and PRE followed by (*fb*) POST-applied herbicides, were investigated in a randomized complete block design with four replications. All PRE treatments included Roundup PowerMax for control of other weed species. Results indicated that a single PRE application of Spartan alone or with Engenia, Panther PRO, and Zidua plus Valor SX provided season-long control of glyphosate- and dicamba-resistant kochia. A single PRE application of Engenia or Zidua alone only provided 70 to 78% kochia control at 6 weeks after POST (WAPOST) application. However, PRE-applied Zidua alone or with Engenia, Engenia alone, Spartan + Zidua, and Spartan + Sencor followed by a sequential POST application of a tank-mixture containing Engenia and Roundup PowerMax provided  $\geq 95\%$  kochia control at 6 WAPOST. Kochia biomass reduction was  $> 92\%$  with a majority of the treatments; exceptions were Zidua PRE alone (59% reduction), Engenia alone (76% reduction), and Zidua + Engenia (88% reduction) treatments. Soybean grain yield for a majority of the tested treatments did not differ, and ranged from 23 to 25 bu/a. These results suggest that effective PRE herbicide options are available for managing glyphosate- and dicamba-resistant kochia in Roundup Ready 2 Xtend soybean.

## Introduction

Managing herbicide-resistant (HR) kochia (*Bassia scoparia* L.) is a significant challenge for growers in the High Plains region, including western Kansas. So far, several kochia populations have been reported with resistance to one or more of four herbicide sites of action, including sulfonylurea (ALS inhibitors), atrazine (photosystem II inhibitors), dicamba (synthetic auxins), and glyphosate (Heap, 2019). Since the discovery of glyphosate-resistant (GR) kochia in 2007, the use of dicamba, a synthetic auxin herbicide, has increased dramatically in kochia control programs. A significant decline in dicamba price over the last decade is another reason for this change in dicamba

use pattern. However, kochia populations with multiple resistance to glyphosate and dicamba have become more evident in the region during recent years (Kumar et al., 2019; Westra, 2016).

The recent commercialization of Roundup Ready 2 Xtend soybean will further allow growers to use postemergence (POST) applications of low-volatile dicamba formulations (Xtendimax, Fexapan, and Engenia) for managing difficult-to-control weed species, including GR kochia. This increasing selection pressure from dicamba applications may possibly enhance the risk of widespread evolution of kochia populations with multiple resistance to glyphosate and dicamba. To avoid this situation, effective and alternative herbicide strategies (multiple sites of action) will be needed. The main objectives of this research were to 1) evaluate and develop effective herbicide programs for managing glyphosate- and dicamba-resistant (multiple resistant) kochia in Roundup Ready 2 Xtend soybean, and 2) determine the ultimate impact of those herbicide programs on soybean grain yield in western Kansas.

## Procedures

A field study was conducted at the Kansas State University Agricultural Research Center near Hays, KS. The study site was under no-till dryland wheat stubble. A Roundup Ready 2 Xtend soybean variety AG34X7 was planted on May 22, 2018. The study site was uniformly infested with a kochia population with multiple resistance to glyphosate and dicamba prior to soybean planting. This kochia population had survived up to 64 fl oz/a rate of Clarity and 44 fl oz/a rate of Roundup PowerMax in a separate greenhouse study. Fifteen different herbicide treatments, including PRE alone and PRE *fb* POST-applied herbicides were evaluated (Table 1). A nontreated control was included for treatment comparison. All PRE treatments were applied at their recommended field 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. All PRE treatments were applied on May 23, 2018, and POST treatments were applied on June 26, 2018. Treatments were applied with CO<sub>2</sub>-pressurized backpack sprayer equipped with Turbo Teejet Induction nozzles (Spraying Systems Co., Wheaton, IL), calibrated to deliver 15 gallons per acre spray solution. Experiments were conducted in a randomized complete block design with four replications. The plot size was 10 × 30 ft. Percent kochia control was visually evaluated at 3 weeks after PRE (WAPRE), and again at 3 and 6 weeks after POST (WAPOST) treatments on a scale of 0 to 100% (0 being no control and 100 being complete control). Kochia biomass reduction (% of nontreated weedy check) was also determined by collecting shoot biomass using a square meter quadrat from the center of each plot prior to soybean harvest. Soybean grain yield was recorded by harvesting the middle two rows from each plot using a plot combine. Data on percent kochia control, shoot biomass reduction, and soybean grain yield were subjected to ANOVA using PROC MIXED in SAS v. 9.3 software (SAS Inst., Cary, NC). Means were separated using Fisher's protected least significant difference test at  $P < 0.05$ .

## Results and Discussion

No visible soybean injury was observed with any PRE or/and POST herbicide programs tested (data not shown). Results indicated that Spartan alone or with Engenia, Panther

PRO, and Zidua + Valor SX treatments provided complete, season-long control of glyphosate- and dicamba-resistant kochia (Figure 1). Furthermore, the addition of Engenia to Zidua PRE improved kochia control compared to the Zidua alone treatment (82 vs. 57% control) at final rating. Kochia control with the Prowl + Outlook treatment did not exceed 70% at 6 WAPOST. PRE-applied Engenia, Zidua alone or with Engenia *fb* POST application of Roundup PowerMax + Engenia provided 100% control at 6 WAPOST (Figure 1). Consistent with percent control, kochia biomass reduction (% of nontreated) was > 92% with a majority of the treatments; exceptions were PRE treatments of Zidua alone (59% reduction), Engenia alone (76% reduction), or Zidua + Engenia (88% reduction) (Figure 2). Soybean grain yield for a majority of the tested PRE and PRE *fb* POST herbicide treatments did not differ, and ranged from 23 to 25 bu/a (Figure 3). Soybean grain yield for PRE-applied Zidua, Engenia, and Prowl + Outlook treatments averaged approximately 18 bu/a.

### Conclusions

Based on these results, growers should utilize two-pass herbicide programs, including PRE herbicides such as Spartan alone or with Engenia, Panther PRO, Zidua + Valor SX, Zidua + Engenia followed by a sequential POST application of Roundup PowerMax + Engenia for effective and season-long control of glyphosate- and dicamba-resistant kochia in Roundup Ready 2 Xtend soybean.

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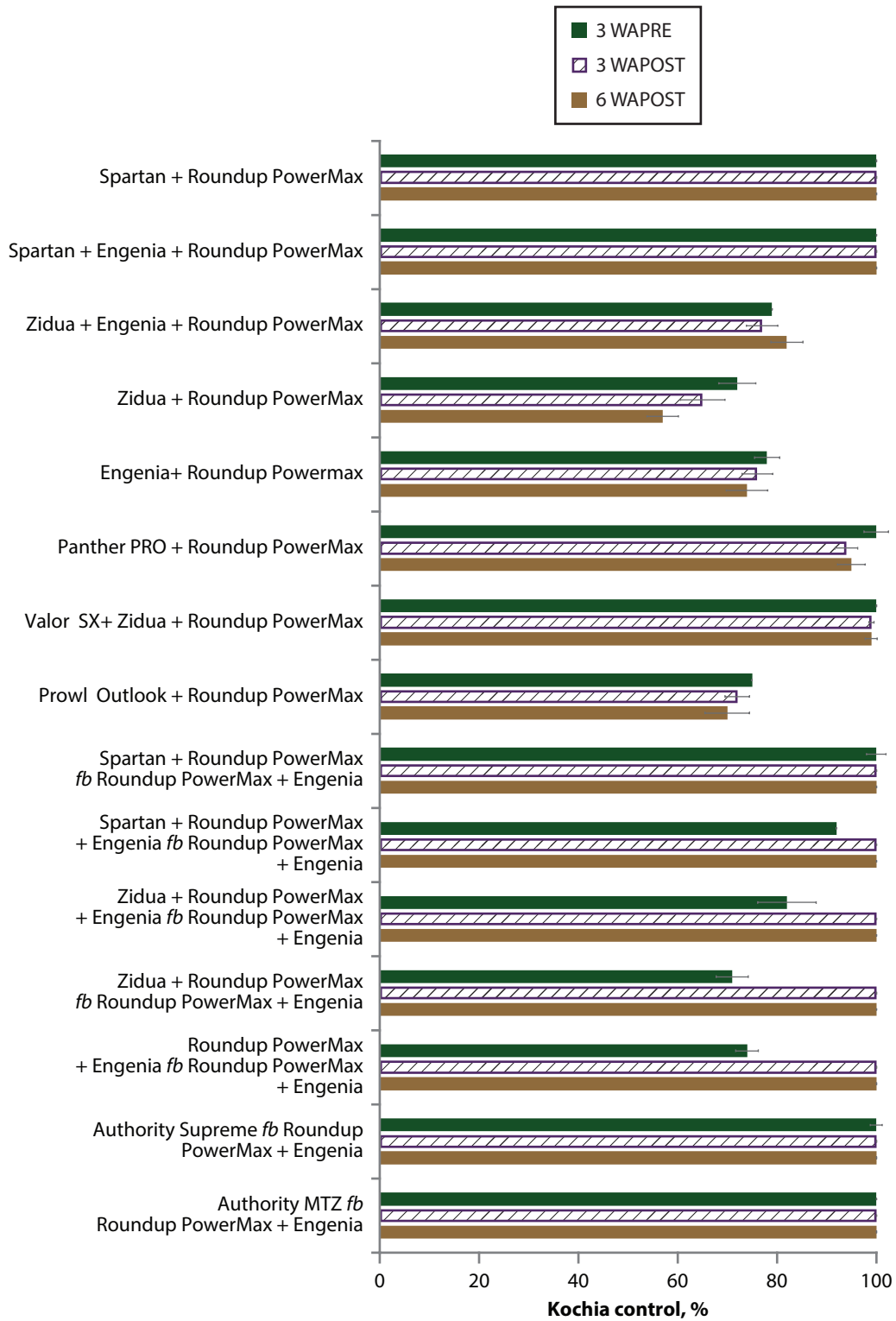
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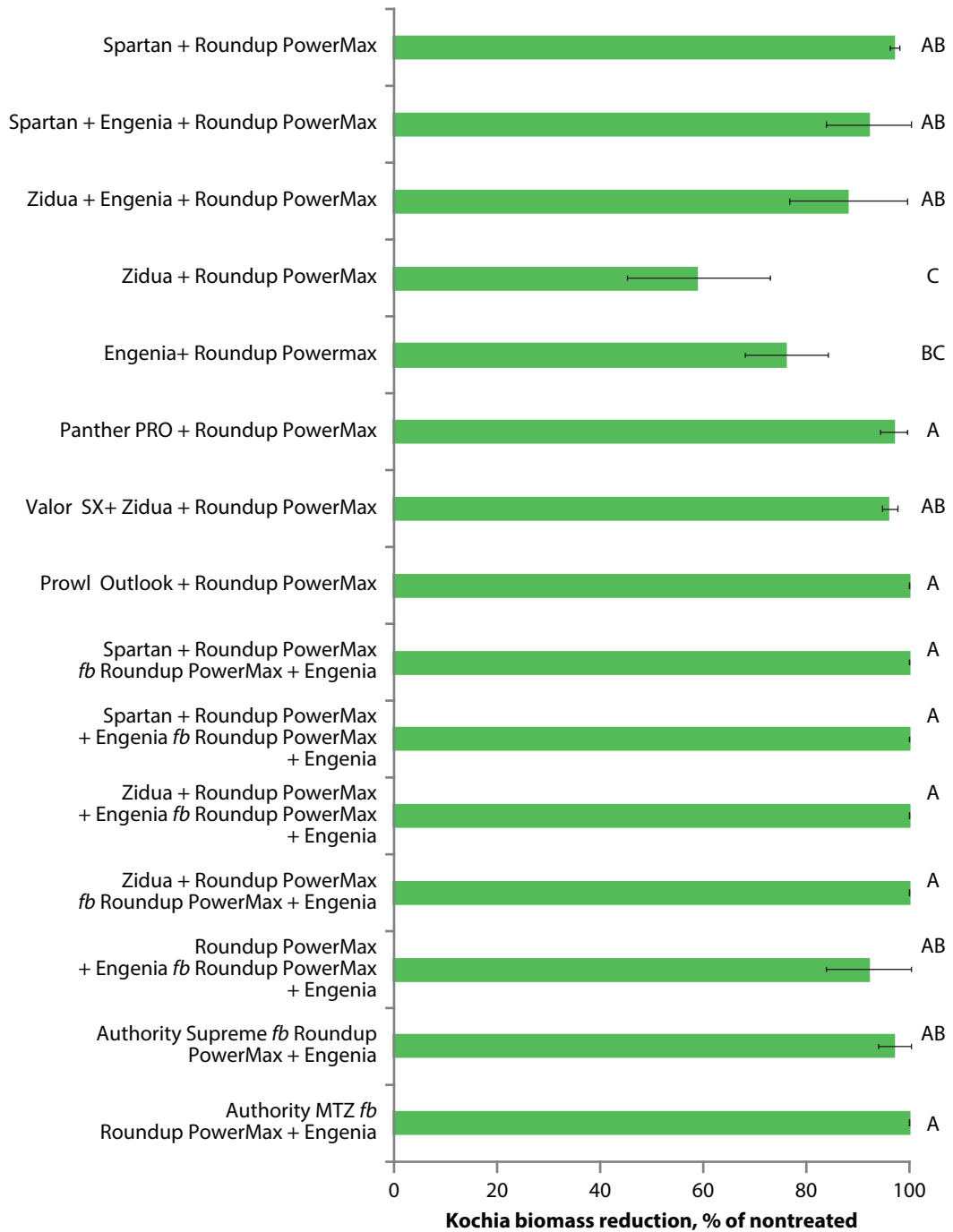
**Table 1. List of selected herbicide programs tested for managing glyphosate- and dicamba-resistant kochia in Roundup Ready 2 Xtend soybean at the Kansas State University Agricultural Research Center near Hays, KS, in 2018**

Herbicide programs <sup>a</sup>	Treatments	Rate (oz/a)	Timing
Nontreated	T1	---	---
Spartan + Roundup PowerMax	T2	6 + 32	PRE
Spartan + Engenia + Roundup PowerMax	T3	6 + 6.4 + 32	PRE
Zidua + Engenia + Roundup PowerMax	T4	1.3 + 6.4 + 32	PRE
Zidua + Roundup PowerMax	T5	1.3 + 32	PRE
Engenia + Roundup PowerMax	T6	32 + 12.8	PRE
Panther PRO + Roundup PowerMax	T7	12 + 32	PRE
Valor SX + Zidua + Roundup PowerMax	T8	2.3 + 1.75 + 32	PRE
Prowl + Outlook + Roundup PowerMax	T9	32 + 16 + 32	PRE
Spartan + Roundup PowerMax <i>fb</i> Roundup PowerMax + Engenia	T10	6 + 32 <i>fb</i> 32 + 12.8	PRE <i>fb</i> POST
Spartan + Roundup PowerMax + Engenia <i>fb</i> Roundup PowerMax + Engenia	T11	6 + 32 + 6.4 <i>fb</i> 32 + 12.8	PRE <i>fb</i> POST
Zidua + Roundup PowerMax + Engenia <i>fb</i> Roundup PowerMax + Engenia	T12	1.3 + 32 + 6.4 <i>fb</i> 32 + 12.8	PRE <i>fb</i> POST
Zidua + Roundup PowerMax <i>fb</i> Roundup PowerMax + Engenia	T13	1.3 + 32 <i>fb</i> 32 + 12.8	PRE <i>fb</i> POST
Roundup PowerMax + Engenia <i>fb</i> Roundup PowerMax + Engenia	T14	32 + 12.8 <i>fb</i> 32 + 12.8	PRE <i>fb</i> POST
Authority Supreme <i>fb</i> Roundup PowerMax + Engenia	T15	8 <i>fb</i> 32 + 12.8	PRE <i>fb</i> POST
Authority MTZ <i>fb</i> Roundup PowerMax + Engenia	T16	14 <i>fb</i> 32 + 12.8	PRE <i>fb</i> POST

<sup>a</sup>PRE = preemergence. POST = postemergence. *fb* = followed by.

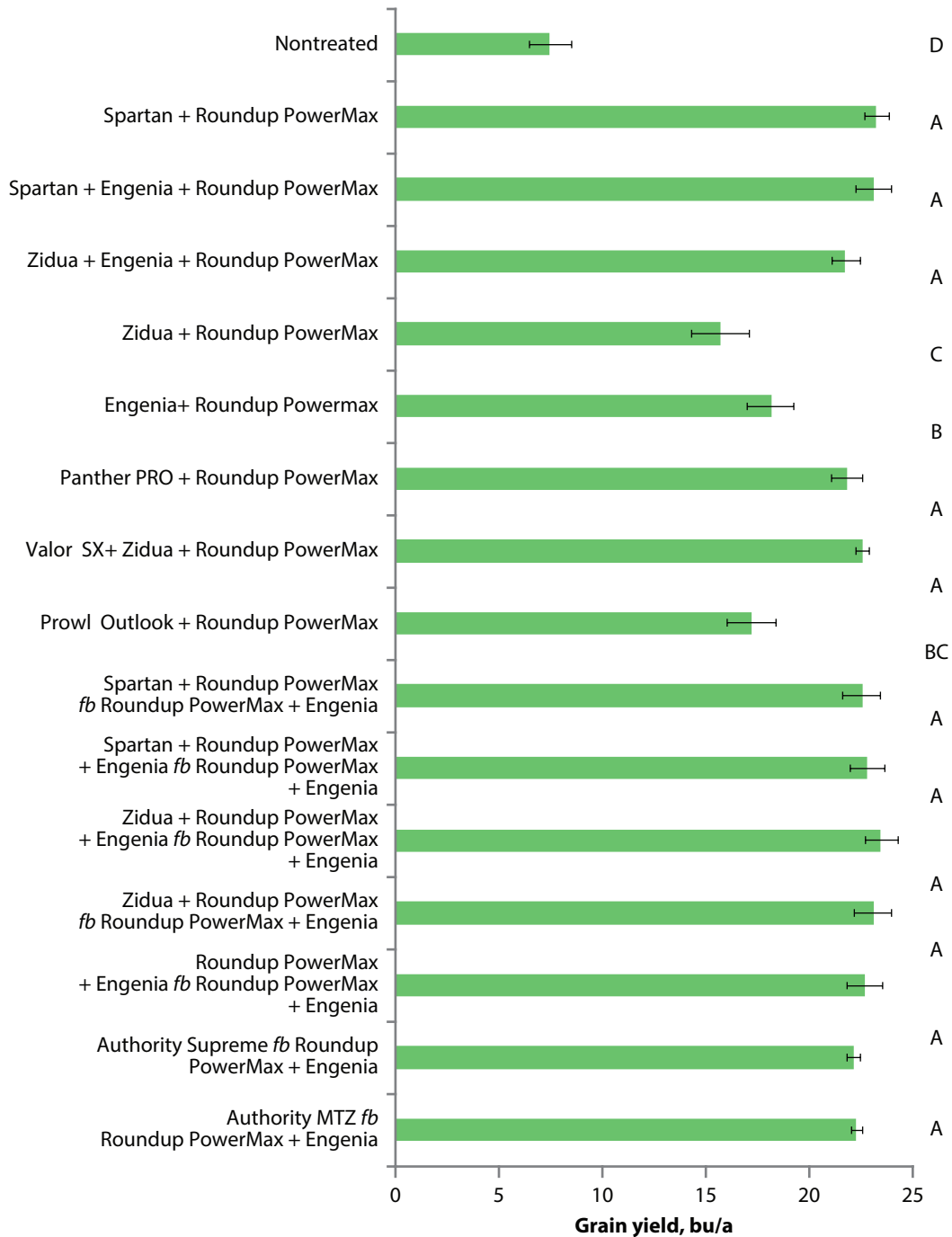


**Figure 1. Visual control (%) of glyphosate- and dicamba-resistant kochia with selected herbicide programs in Roundup Ready 2 Xtend soybean at the Kansas State University Agricultural Research Center near Hays, KS, in 2018. WAPOST = weeks after POST. WAPRE = weeks after PRE. Please see Table 1 for the full list of treatments.**

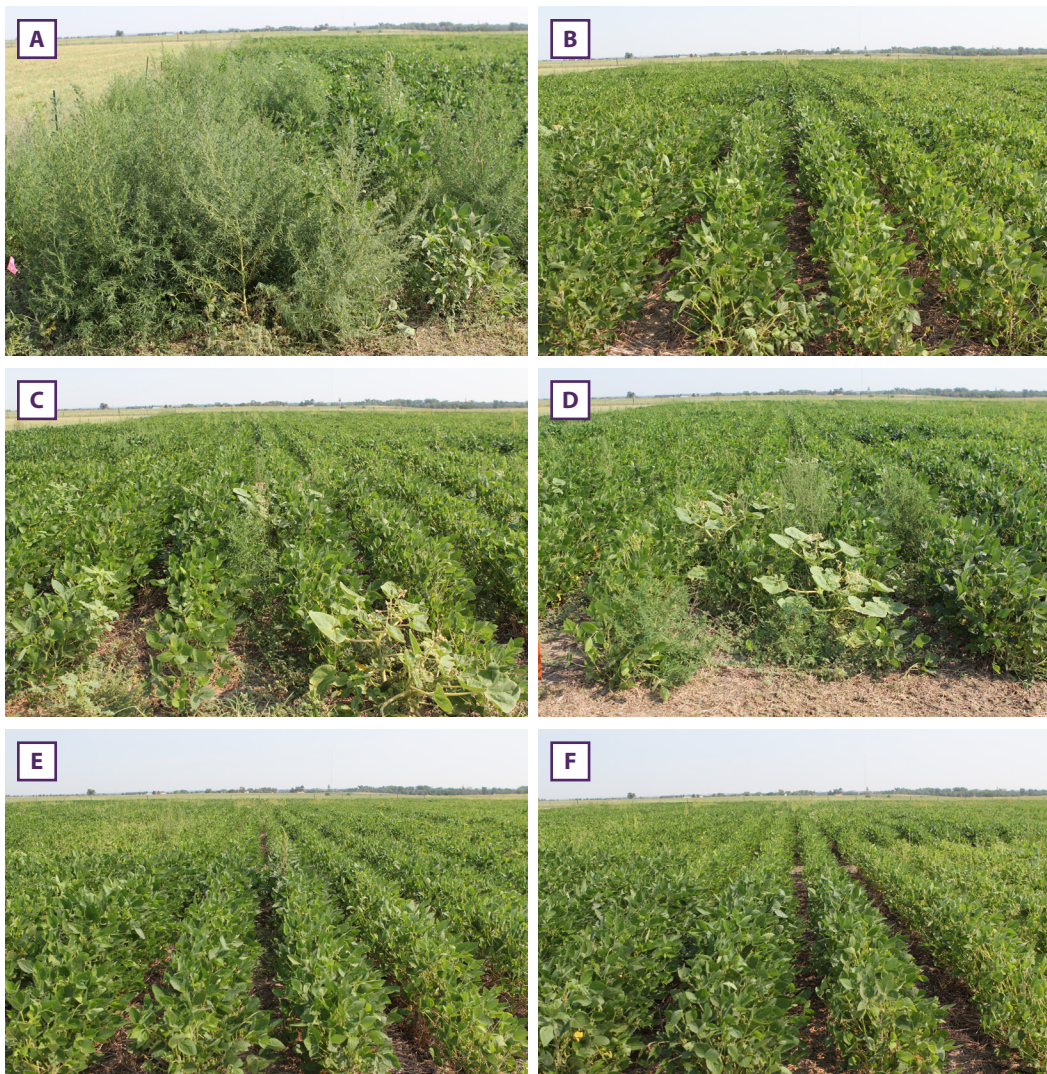


**Figure 2. Kochia biomass reduction (% of nontreated) with selected herbicide programs in Roundup Ready 2 Xtend soybean at the Kansas State University Agricultural Research Center near Hays, KS, in 2018. Bars with similar letters are not different based on Fisher’s protected LSD test at  $P < 0.05$ . Please see Table 1 for the full list of treatments.**





**Figure 3. Effect of selected herbicide programs on Roundup Ready 2 Xtend soybean grain yields at the Kansas State University Agricultural Research Center near Hays, KS, in 2018. Bars 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 4. Visual response of glyphosate- and dicamba-resistant kochia in nontreated weedy check (A), Spartan alone (B), Zidua + Engenia (C), Zidua alone (D), Panther PRO (E), and Authority Supreme followed by Roundup Powermax + Engenia (F) treatments at 6 weeks after POST.**