

Response of Kansas Feral Rye Populations to Aggressor Herbicide and Management in CoAXium Wheat Production System

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Summary

Feral rye (*Secale cereale* L.), also commonly known as cereal or volunteer rye, is a troublesome winter annual grass weed species in wheat producing regions of the United States, including Kansas. Lack of effective herbicide options complicates the selective control of feral rye in winter wheat. The main objectives of this research were (1) to determine the response of 10 feral rye populations collected from central Kansas wheat fields to Aggressor herbicide in dose-response assays, and (2) to evaluate the effectiveness of Aggressor herbicide for feral rye control in CoAXium winter wheat in Kansas. Dose-response assays indicated that all tested feral rye populations from Kansas wheat fields were highly sensitive to Aggressor herbicide with GR_{90} values (doses of Aggressor herbicide needed for 90% reductions in shoot biomass at 3 weeks after treatment) ranging from 4.2 to 9.3 fl oz/a. A field study conducted near Great Bend, KS, indicated that Aggressor herbicide applied at ≥ 10 fl oz/a in fall or spring timings provided an excellent end-season control ($\geq 94\%$) of feral rye in CoAXium winter wheat. Overall, these results suggest that effective feral rye control could be achieved with Aggressor herbicide in a CoAXium wheat production system in Kansas.

Introduction

Feral rye (*Secale cereale* L.) is a troublesome winter annual grass weed species in wheat producing regions of the United States, including Kansas. Feral rye seeds can germinate in fall or early spring with optimum soil temperatures ranging from 55 to 60°F. A single feral rye plant can produce up to 600 seeds of which only a small percentage can remain dormant and viable in soil seedbank for > 5 years. Season-long interference of feral rye has been reported to reduce wheat grain yield by >50% in Colorado, Kansas, Montana, Nebraska, and Wyoming (Cobel and Fay, 1985; Westra and D'Amato, 1989). The contamination of feral rye seeds can cause wheat dockage, losses in wheat quality, and grade reduction. Due to its winter annual life cycle, selective control of feral rye is difficult in winter wheat (Young et al., 1984).

The CoAXium wheat production system is a new non-GMO herbicide-resistant wheat technology that combines the use of Aggressor (quizalofop-p-ethyl, Group 1) herbicide with wheat varieties containing genes that confer tolerance to this herbicide – AXigen trait. Three CoAXium hard red winter wheat varieties (LCS Fusion AX, Crescent AX, and Incline AX) that contain the AXigen trait (resistance to the ACCase class of herbi-

cides) are now commercially available for use. The Aggressor herbicide has good foliar activity on grass weed species, so the CoAXium wheat production system may provide an opportunity for postemergence (POST) control of feral rye in wheat. However, to our knowledge, there is currently no published information on the effectiveness of Aggressor for feral rye control in CoAXium winter wheat in Kansas. In addition, the response of feral rye populations infesting Kansas wheat fields to Aggressor herbicide is also unknown.

The main objectives of this research were to (1) determine the response of feral rye populations collected from winter wheat fields in central Kansas to Aggressor, and (2) evaluate the effectiveness of Aggressor herbicide for feral rye control in CoAXium winter wheat in Kansas.

Procedures

Feral Rye Populations Collection

Fully matured seeds of 10 feral rye populations (one population per field site) were collected from winter wheat fields in central Kansas in 2018 (Table 1). The sampling field sites were randomly chosen depending upon feral rye infestation prior to wheat harvest. For each population, fifty to sixty seed heads were collected from each field site and composited together in a paper bag. The collected feral rye seed heads were air dried and then manually threshed and cleaned.

Dose Response Study

Seeds of each feral rye population were separately sown in square plastic pots (4 by 4 inch) containing a commercial potting mixture (Miracle-Gro Moisture Control Potting Mix, Miracle-Gro Lawn Products, Inc., Marysville, OH) in a greenhouse at the Kansas State University Agricultural Research Center (KSU-ARC) near Hays, KS. Growth conditions in the greenhouse were set at $77/73 \pm 4^\circ\text{F}$ day/night temperatures and 16/8 h day/night photoperiods. At 3- to 4-leaf stage, feral rye seedlings were separately treated with Aggressor at 0, 1, 2, 4, 8, and 16 fl oz/a using a stationary cabinet spray chamber. All Aggressor treatments included 1% (v/v) methylated seed oil (MSO). Greenhouse experiments were conducted in a randomized complete block (blocked by population) design with 12 replications (one plant/pot comprised a replication) per Aggressor dose, and repeated. All feral rye plants from each population were cut at the soil surface and the aboveground shoot biomass samples were determined at 3 weeks after treatment (WAT). Shoot biomass reduction (% of nontreated) of each feral rye population was regressed against Aggressor doses by using a three-parameter log-logistic model (Equation 1) (Ritz et al., 2015):

$$y = \{d/1 + \exp[b(\log x - \log e)]\}^{-1} \quad [1]$$

where y refers to shoot biomass (% of nontreated), d is the upper limit, b is the slope of each curve, e is the Aggressor dose needed for 50% reduction in shoot biomass referred as GR_{50} , and x is the Aggressor dose. All nonlinear regression parameter estimates and their standard errors and GR_{90} value (Aggressor dose needed for 90% reduction in shoot biomass) for each population were estimated using the *drc* package in *R* software (Ritz et al. 2015).

Field Study

An on-farm field study near Great Bend, KS, was conducted to evaluate Aggressor herbicide for feral rye control in winter wheat during the 2018/2019 growing season. The study utilized a CoAXium winter wheat variety “LCS Fusion AX” planted on November 19, 2018 using seeding rate of 60 lb/a. The field site had a natural infestation of feral rye population. The three POST treatments of Aggressor herbicide in fall (10 fl oz/a), spring (10 and 12 fl oz/a), and fall followed by (*fb*) spring (8 *fb* 8 fl oz/a) were arranged in a randomized complete block design with 4 replications. All treatments were applied with a CO₂-pressurized backpack sprayer using Teejet AIXR110015 nozzles, at 15 GPA. Fall applications were made on December 19, 2018, (3- to 4-leaf stage of wheat), and spring applications were made on April 4, 2019 (3- to 4-tillers stage of wheat). Percent feral rye control was visually assessed at biweekly intervals after spring applications. Data were subjected to ANOVA using PROC MIXED in SAS (SAS Inst. Inc., Cary, NC). Means were separated by Fisher’s protected LSD test at $P < 0.05$.

Results

Dose-Response Study

Based on a fitted model, the estimated GR₉₀ values (Aggressor doses needed for 90% shoot biomass reduction at 3 WAT) indicated a variable response to Aggressor herbicide among all tested feral rye populations. The estimated GR₉₀ values of FR01, FR04, FR05, FR06, FR09, and FR10 feral rye populations were significantly lower (ranged from 4.2 to 6.2 fl oz/a) compared to FR02, FR03, FR07, and FR08 populations (ranged from 7.1 to 9.3 fl oz/a) according to approximate t-test (Table 2 and Figure 1). Nevertheless, the GR₉₀ values of all 10 feral rye populations were lower than the Aggressor field-recommended rate (10 to 12 fl oz/a) for feral rye control in CoAXium winter wheat (Anonymous, 2017).

Field Study

No visual injury on winter wheat was observed with any Aggressor treatment tested (data not shown). Results indicated that all Aggressor treatments at ≥ 10 fl oz/a provided excellent end-of-season feral rye control ($\geq 94\%$) compared to non-treated weedy check, irrespective of application timing (Table 3 and Figure 2).

Conclusions

Results from greenhouse study indicated that feral rye populations collected from Kansas winter wheat fields were highly sensitive to Aggressor herbicide. The field study also showed an excellent feral rye control with Aggressor herbicide irrespective of rate or application timing. Altogether, these results suggest that CoAXium winter wheat technology can provide an alternative option for effective feral rye control in Kansas wheat production systems.

References

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Table 1. Winter wheat field sites in central Kansas from where the seeds of feral rye were randomly collected in 2018

Population	County	GPS coordinates	
		Longitude	Latitude
FR01	Stafford	-98.75	38.24
FR02	Stafford	-98.73	38.23
FR03	Stafford	-98.74	38.17
FR04	Russell	-98.53	38.95
FR05	Russell	-98.53	38.95
FR06	Reno	-98.20	38.15
FR07	Rice	-98.33	38.34
FR08	Barton	-98.73	38.33
FR09	Pratt	-98.61	37.81
FR10	Pratt	-98.53	37.76

Table 2. Regression parameter estimates from the whole plant dose response study based on shoot biomass (% of nontreated) at 3 weeks after treatment (WAT) of 10 feral rye populations treated with increasing doses of Aggressor herbicide in a greenhouse at Kansas State University Agricultural Research Center in Hays, KS

Population	Regression parameters estimates ^{1,2,3}			
	$d (\pm SE)$	$b (\pm SE)$	GR ₅₀ values	GR ₉₀ values
FR01	99 (2.5)	0.6 (0.1)	0.13	4.9
FR02	100 (2.6)	1.0 (0.1)	0.52	7.4*
FR03	100 (2.6)	0.8 (0.1)	1.04	9.3*
FR04	100 (2.4)	1.1 (0.4)	0.26	5.4
FR05	99 (2.5)	0.5 (0.1)	0.26	6.2
FR06	100 (2.6)	0.4 (0.1)	0.13	4.5
FR07	99 (2.4)	0.9 (0.1)	0.65	8.3*
FR08	99 (2.1)	1.1 (0.1)	1.04	9.2*
FR09	99 (2.7)	0.7 (0.1)	0.13	5.2
FR10	99 (2.5)	0.6 (0.2)	0.13	4.2

¹Abbreviations: FR01 through FR10 were feral rye populations collected from winter wheat fields in central Kansas. SE = standard error of mean.

² d is the upper limit, b is the slope of each curve, and GR₅₀ and GR₉₀ are the effective doses (fl oz/a) of Aggressor herbicide needed for 50% and 90% shoot biomass reduction (% of nontreated) for each feral rye population.

³An asterisk (*) denotes a significant difference of the GR₉₀ values between FR02, FR03, FR07, FR08 and FR01, FR04, FR05, FR06, FR09, FR10 feral rye populations according to approximate t -test (Ritz et al., 2015).

Table 3. Feral rye control with fall/spring-applied Aggressor herbicide in LCS Fusion AX winter wheat at a grower's field near Great Bend, KS, in 2019

Herbicide	Rate	Timing ^c	Feral rye ^d		
			4/18/2019	5/2/2019	6/6/2019
	fl oz/a		----- % control -----		
Aggressor + NIS ^a	10	FP	89 ab	94 ab	96 a
Aggressor + MSO ^b	10	FP	89 ab	94 ab	96 a
Aggressor + MSO ^b	10	SP	75 c	94 ab	96 a
Aggressor + MSO ^b	12	SP	80 bc	93 ab	94 a
Aggressor + NIS ^a / Aggressor + MSO ^b	8 (Fall)/ 8 (Spring)	FP/SP	93 a	96 a	98 a

^aNonionic surfactant (NIS) at 0.25% v/v was included.

^bMethylated seed oil (MSO) at 1% v/v was included.

^cFall POST (FP) was applied on December 19, 2018, Spring POST (SP) was applied on April 4, 2019.

^dMeans within each column followed by same alphabet letters are not different based on Fisher's protected LSD test at $P < 0.05$.

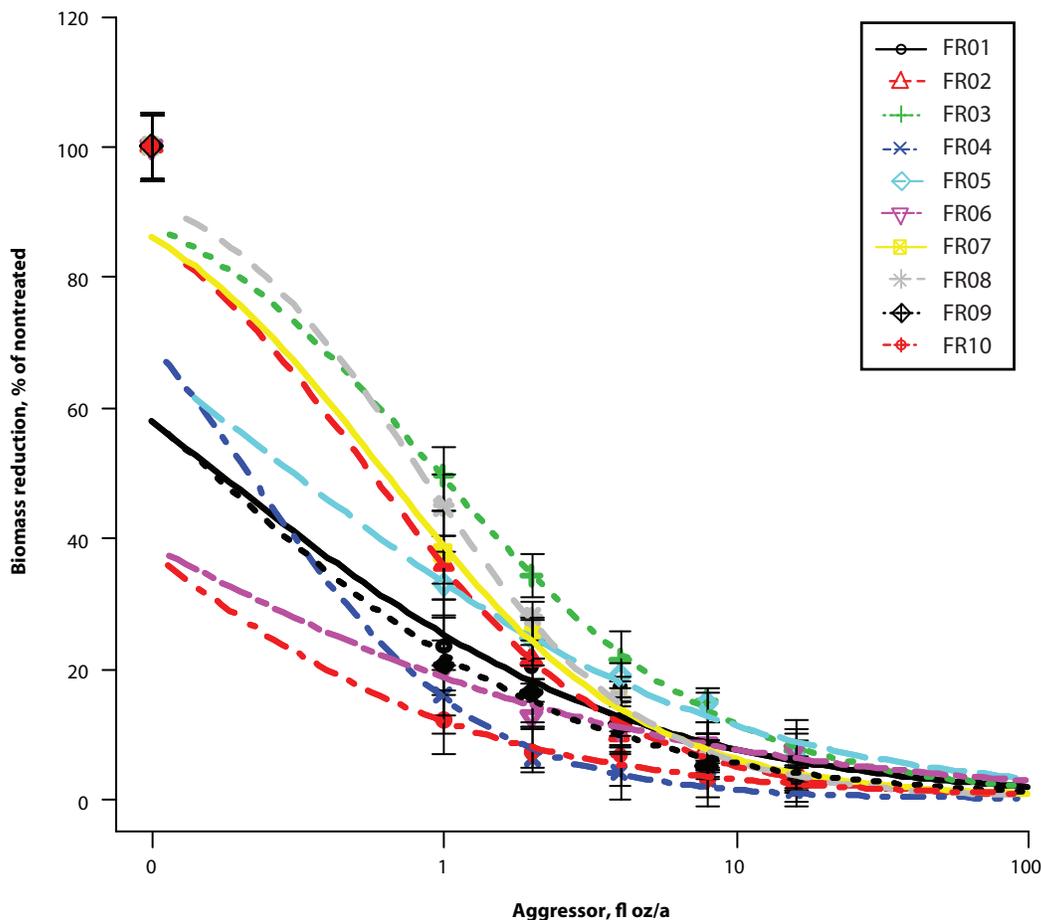


Figure 1. Shoot biomass reduction (% of nontreated) response of 10 feral rye populations from Kansas wheat fields treated with Aggressor at 3 weeks after treatment (WAT) in dose-response studies conducted at the Kansas State University Agricultural Research Center near Hays, KS.

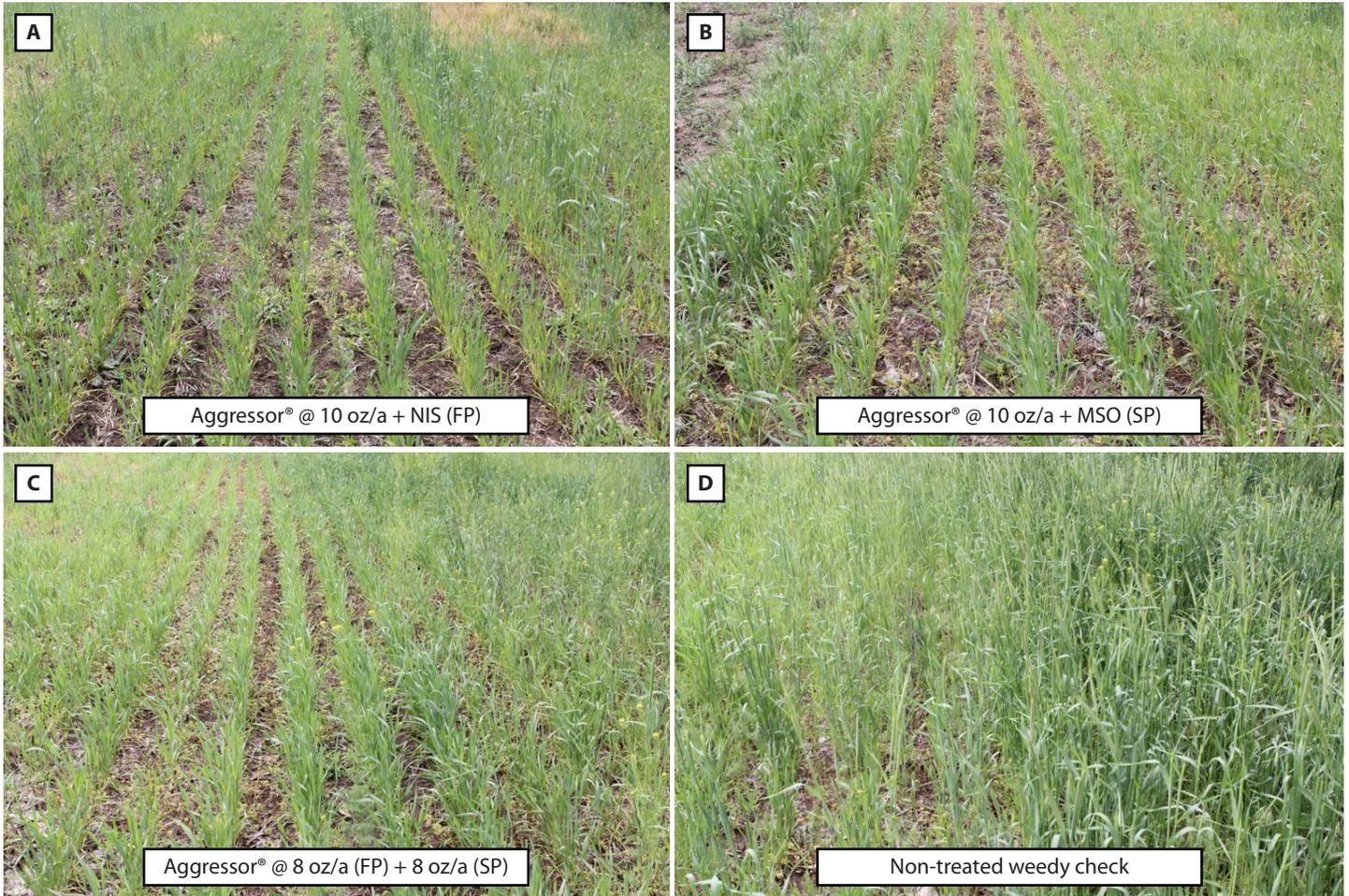


Figure 2. Visual control of feral rye in CoAXium wheat plots treated with Aggressor herbicide in fall (A), spring (B), fall followed by spring (C), and non-treated weedy check (D). Pictures taken on May 2, 2019.