Efficacy of Spring Herbicide Applications for Fescue Control: A Comparison of Three Products

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Abstract: The Conservation Reserve Program (CRP) was designed to remove highly erodible cropland from production. Although wildlife habitat benefits are an important component of CRP, millions of hectares of CRP do not produce optimal wildlife benefit because of poor cover crop choice. Kentucky-31 tall fescue (*Festuca arundinacea*; hereafter, fescue) was one of the most commonly planted grasses on CRP fields but provides relatively poor habitat for grassland birds such as northern bobwhites (*Colinus virginianus*). Control of fescue and release of a latent native plant community may enhance habitat value of CRP fields for northern bobwhite and other grassland birds. During 1999–2000, we evaluated effects of various spring herbicide applications, both singular and in combination, on vegetation structure and composition in fescue-dominated CRP fields. Glyphosate produced the poorest fescue control, released an undesirable johnsongrass (*Sorghum halepense*) stand, and suppressed legumes. Imazapyr controlled fescue in both the first and second growing seasons post-treatment and did not reduce abundance of legumes, but provided little residual johnsongrass control. Imazapic controlled fescue, did not reduce legumes, and provided residual control of johnsongrass. Imazapic in combination with glyphosate also reduced fescue and controlled johnsongrass but suppressed legume establishment. Our results suggest that all the herbicide treatments we tested can reduce fescue; however, they have different effects on johnsongrass and legumes. We recommend managers use imazapic when attempting to control tall fescue and johnsongrass and promote legume restoration. Imazapyr also is an effective herbicide if johnsongrass control is not a conservation concern.

Key words: agriculture, CRP, Conservation Reserve Program, fescue, herbicide, Mississippi, northern bobwhite, succession, vegetation

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U.S. Department of Agriculture (USDA) land retirement programs (e.g., Conservation Reserve Program [CRP]) offer an opportunity to influence management on privately owned lands and provide quality grassland communities within agricultural ecosystems (Kurzejeski et al. 1992). The CRP provision of the 1985 Food Security Act was designed to remove highly erodible cropland (HEL) from production. Under CRP, landowners receive an annual payment to remove HEL from production for 10 years and plant a permanent cover crop (i.e., grasses, legumes, or trees; Berner 1988). Wildlife habitat enhancement was promoted as a secondary benefit of CRP in 1985 but was elevated to a programmatic objective under the 1996 and subsequent farm bills.

Throughout the Midwest and southeastern United States, Kentucky-31 tall fescue (*Festuca arundinacea*) was one of the most commonly planted grasses on CRP fields. The establishment of coarse-stemmed, sod-forming grasses like fescue on cropland diversion program lands produces low-quality habitat for grassland bird species such as northern bobwhite (*Colinus virginianus;* Roseberry and Klimstra 1984, Barnes et al. 1995). Vegetation structure and composition in CRP fields are not static over the life of the contract but vary in relation to time since establishment (McCoy et al. 2001). As plantings age, vegetation composition changes from a diverse annual community with an abundance of bareground to a perennial grass and forb community with dense litter accumulation and little bare ground (Burger et al. 1990, McCoy et al. 2001). Some type of disturbance is required to maintain CRP fields in early successional plant communities, and herbicidal conversion of fescue-dominated CRP fields might improve bobwhite habitat quality by promoting more desirable native early successional plants (Madison et al. 1995; Burger 2000, 2005; McCoy et al. 2001; Greenfield et al. 2001, 2002, 2003).

On fescue dominated sites, disking and prescribed fire have been shown to produce only short-term (i.e., one-year) enhancements in habitat quality because fescue quickly recolonizes and outcompetes more desirable plant species (Madison et al. 1995, 2001; Greenfield et al. 2002, 2003). Herbicides (Madison et al. 2001) or herbicide in combination with fire (Greenfield et al. 2001) have been shown to produce greater long-term enhancements in bobwhite habitat quality. Glyphosate and imazapic, either singly or used in combination, have been shown to satisfactorily control fescue (Washburn and Barnes 2000*a*, *b*; Washburn et al. 2000; Greenfield et al. 2001; Barnes 2004). Methodology for fescue control and planting of native warm-season prairie grasses is well developed (Washburn and Barnes 2000*a*, Washburn et al. 2000, Barnes 2004, Harper et al. 2005) and has been shown to enhance habitat value for bobwhite and other grassland wildlife.

Planting of native grasses is not always necessary. On former prairie sites, a latent native grass community often exist that can be released simply by control of the competing exotic grasses (Barnes 2004). However, previous research (Greenfield et al. 2001, Hamrick et al. 2004) and practical experience has shown that control of one exotic may simply release another exotic laying latent in the seed bank. Prior studies on Mississippi Blackland Prairie sites have reported that johnsongrass (*Sorghum halepense*) responds positively to fescue control (Greenfield et al. 2001, 2003). Herbicide applications that simultaneously control fescue, seedling johnsongrass, and release latent *Andropogon* species would be desirable. Our objective was to investigate fescue, johnsongrass, broomsedge (*Andropogon* spp.), legume, and forb response to six spring herbicide treatments, including singular and combination treatments of glyphosate, imazapic, and imazapyr, on a former prairie site enrolled in CRP in east-central Mississippi.

Study Area

We conducted research on the Blackland Prairie Wildlife Management Area (BPWMA) located in Lowndes County, Mississippi. The BPWMA was located within the Blackland Prairie of Mississippi (33.3372869014, –88.561523299) and elevation ranged from 62–92 m. Soils were chalks, calcareous clays, acid clays, and sediments overlying calcareous materials with an alkaline pH and low magnesium. Annual precipitation ranged from 127–140 cm (Pettry 1977) and average temperatures in Lowndes County were 27 and 8 C during summer and winter, respectively. The fields we used were enrolled in CRP under Conservation Practice 1 (CP-1) and planted to tall fescue in 1987. Other dominant vegetation included broomsedge, johnsongrass, and goldenrod (*Solidago* spp.). Prior to enrollment, the area was used for agricultural purposes. Much of the area was previously in crop production for soybeans, corn, cotton, and livestock forage. These fields were historically Blackland prairie communities (Barone 2005).

Methods

We designed our experiment to evaluate effects of various herbicide treatments on vegetation structure in fescue-dominated CRP fields with an emphasis on fescue control, johnsongrass control, and broomsedge release. Two fields at BPWMA were established with a split-plot arrangement of treatments in a randomized complete block design where fields were the blocking variable. Fields contained four hillslope positions (i.e., whole plot effect) with seven 25 × 25 m plots (i.e., split-plot effect) per position, thus $n = 8$ replicates per treatment (4 positions × 2 fields). We randomly assigned treatments to split-plots within each hillslope position. Whole plots and split plots were separated by a 5-m mowed buffer that was maintained annually for experimental independence.

Prior to herbicide application, both fields were burned during the third week in April 1999 to provide uniformity within plots before treatment application. We burned fields with a backing fire until an approximate 1 m backline was created along the downwind side, then finished with a head fire. To improve herbicide efficacy, the fescue was allowed to recover following the burn to a height of 15–20 cm when inflorescences were produced. Fescue met these guidelines approximately three weeks following the burns; thus, we applied herbicide treatments during the second week of May 1999. Herbicide treatments consisted of application of imazapic (Plateau) at 8 and 12 oz/acre (0.585 L/ha and 0.877 L/ha; hereafter imazapic8 and 12, respectively), imazapic + glyphosate (Roundup Ultra) at 8 and 48 oz/acre (0.585L/ha imazapic, 3.508 L/ha glyphosate; hereafter imazapic8/glyphosate48), imazapic + glyphosate at 12 and 48 oz/acre (0.877 L/ha imazapic, 3.508 L/ha glyphosate, hereafter imazapic12 /glyphosate48), glyphosate at 48 oz/acre (3.508L/ha, hereafter glyphosate48), imazapyr (Arsenal AC, BASF Corporation, Research Triangle Park, North Carolina) at 8 oz/acre (0.585 L/ha, hereafter imazapyr8), and a control with no herbicide. All herbicide treatments were applied along with water at 20 gallons spray solution/acre (185 L/ha), 30 psi, and at 3 ft (0.91 m) above foliage. Imazapic solutions contained 1 pint (0.473 L) Sunet methylated seed oil and imazapyr8 contained 0.5% nonionic surfactant. We applied herbicide treatments using a utility tractor with a 110 gallon (416 L), PTO-driven sprayer with flat fan nozzles mounted on a 12 ft (3.6 m) boom width. Effects of herbicide application (i.e., dead fescue plants) were apparent within seven days.

We recorded vegetation measurements during the first and second growing seasons post-treatment on 28–29 July 1999 and 14 July 2000. We used a 0.1-m^2 frame to ocularly estimate vegetation structure (Daubenmire 1959). We estimated percent horizontal cover of various plant life forms to the nearest 5.0% within the frame. Life forms measured included grass canopy (excluding fescue), fescue grass canopy, legume canopy, woody canopy, bareground, litter cover, and litter depth. To provide an assessment of species-specific plant response to herbicide treatments, we identified plant species or genera within each frame, and quantified the percent cover by those taxa. We used a Robel pole to obtain visual obstruction readings (VOR), which indexed vegetation height and vertical density (Robel et al. 1970). We also measured maximum and average canopy height at each Robel pole location. We conducted vegetation sampling systematically within each split-plot by sampling 10 points equidistantly spaced along the diagonal of each 25 × 25 m plot. At each sampling point, we oriented the 0.1-m^2 frame relative to hill slope position. The frame at the first sampling point was placed directly up slope from the point, whereas at the second sampling point we placed it across the slope directly to the left of the point. Likewise, we placed it directly down slope from the third sampling point and across the slope directly to the right at the fourth point. This sequence was repeated from sampling points 5–10. A VOR was recorded in the same direction at each point 4 m from the point at a height of 1 m.

Statistical Analysis

We used analysis-of-variance (ANOVA) in a split-plot, randomized complete block design to test for differences in vegetation responses among herbicide treatments. We blocked on field, treated hill-slope positions as whole-plot effects, and treatments as split-plot effects (Petersen 1985, Milliken and Johnson 1992). We constructed annual models as we were specifically interested in evaluating treatment effects during the first and second years following treatment application. When no interactions were observed between hill-slope position and treatment effects, treatment main effects were discussed. When interactions were observed, we did not interpret them because interactions implied spatial variability in plant response. Following a significant F-test ($P \leq 0.05$) for treatment main effects, we used Tukey's Multiple Comparison (HSD) test to compare among treatments (Milliken and Johnson 1992). We tested homogeneity of variance and normality using Levene's test (Milliken and Johnson 1992) and the Shapiro-Wilk test (Conover 1980), respectively. Variables that violated assumptions were appropriately transformed (Steel and Torrie 1980).

Results

During the first growing season post-treatment, we detected a hill-slope position by treatment interaction in canopy cover of foxtail (*Setaria* spp.; $F_{6,18} = 4.02$, $P = 0.015$), therefore no additional analyses were conducted on that genera. We observed treatment effects for average canopy height ($F_{6,18} = 7.05$, $P < 0.001$), percent fescue canopy ($F_{6,18} = 9.94$, $P < 0.001$), percent grass canopy ($F_{6,18} = 11.65$, $P < 0.001$), percent legume canopy ($F_{6,18} = 4.58$, $P = 0.003$), maximum vegetation height ($F_{6,18} = 8.65$, $P < 0.001$), and VOR ($F_{6,18} = 7.53$, $P < 0.001$). Furthermore, we detected treatment effects in canopy cover of *Desmanthes illinoensis* ($F_{6,18} = 6.40$, $P < 0.001$) and johnsongrass ($F_{6,18} = 7.03$, $P < 0.001$; Table 1). Canopy cover of broomsedge did not differ among treatments ($F_{6,18} = 0.90$, $P = 0.512$).

During the second growing season post-treatment, we detected no hill-slope position by treatment interactions in canopy cover of plant classes or individual plant species ($P \geq 0.05$). We observed treatment effects for percent bareground ($F_{6,18} = 4.97$, $P = 0.002$), percent fescue canopy ($F_{6,18} = 10.18$, $P < 0.001$), percent grass canopy ($F_{6,18} = 3.22$, $P = 0.018$), percent litter cover ($F_{6,18} = 4.82$, $P = 0.002$), and percent legume canopy ($F_{6,18} = 2.85$, $P = 0.031$). Similarly, we detected treatment effects in canopy cover

Table 1. Mean structural characteristics (with associated standard errors) of vegetative variables that differed among treatments in tall fescue (*Festuca arundinacea*) Conservation Reserve Program fields in Mississippi one (1999) and two (2000) years post application.

	Treatments[a]						
Variable (year)	**Imazapyr8**	**Control**	**Imazapic8**	**Imazapic8/ Glyphosate48**	**Imazapic12**	**Imazapic12/ Glyphosate48**	**Glyphosate48**
AVECAN (cm; 1)[b]	27 abc[c] (1.7)	45a (2.7)	26abc (1.9)	17c (1.4)	25bc (1.5)	15c (1.1)	42ab (3.0)
% Fescue canopy (1)	5b (0.8)	29a (3.0)	5b (0.9)	2b (0.5)	5b (1.0)	4b (1.0)	13b (2.2)
% Grass canopy (1)	10c (1.4)	34a (2.6)	15bc (1.7)	12c (1.6)	11c (1.2)	10c (1.2)	26ab (2.6)
% Legume canopy (1)	18ab (3.4)	13ab (2.2)	18ab (2.4)	5ab (1.1)	20a (2.9)	3b (0.5)	4b (1.0)
MAXVEG (cm; 1)[b]	64abc (4.3)	91a (3.7)	54bc (3.1)	37c (2.7)	50bc (2.5)	39c (3.0)	79ab (3.5)
VERTOBS (cm; 1)[b]	15ab (1.3)	28a (2.3)	13b (1.3)	9b (1.0)	14b (1.2)	8b (1.1)	28a (2.3)
% DESMAN (1)[b]	14ab (3.0)	11abc (2.2)	13abc (2.4)	3bc (1.0)	20a (3.0)	1bc (0.3)	0.3c (0.1)
% JOHN (1)[b]	15abc (2.4)	23ab (2.1)	19ab (1.7)	9bc (1.4)	12bc (1.8)	4c (0.7)	29a (2.4)
% Bareground (2)	47a (3.2)	24b (2.2)	42ab (3.0)	52a (2.7)	42ab (2.6)	53a (2.9)	32ab (2.2)
% Fescue canopy (2)	8cd (2.2)	49a (3.8)	27abc (3.2)	11bcd (2.4)	17bcd (2.6)	3d (1.2)	32ab (3.3)
% Grass canopy (2)	28b (3.0)	57a (3.4)	37ab (3.6)	30b (3.2)	39ab (3.6)	29b (3.7)	40ab (3.4)
% Litter cover (2)	45abc (2.9)	67a (2.5)	45abc (3.1)	33c (2.4)	42bc (2.5)	39bc (2.6)	58ab (2.5)
% Legume canopy (2)	14ab (2.4)	8ab (1.5)	10ab (1.6)	8ab (1.8)	15a (2.0)	6ab (1.6)	1b (0.8)
% DESMAN(2)[b]	13ab (2.4)	8ab (1.6)	7ab (1.5)	6ab (1.6)	14a (2.0)	3ab (1.3)	1.3b (0.8)
% JOHN (2)[b]	10ab (1.7)	11ab (1.2)	7ab (1.1)	4b (1.1)	4b (0.8)	5ab (1.1)	13a (1.7)

a. Herbicide applications occurred in May 1999; vegetation measurements conducted during July 1999–2000

b. AVECAN = average canopy height; MAXVEG = maximum vegetation height; VERTOBS = vertical obstruction; DESMAN = % coverage by *Desmanthes illinoensis;* JOHN = % coverage by johnsongrass

c. Means within rows followed by identical letters are not different, Tukey's HSD ($P > 0.05$)

of *Desmanthes illinoensis* ($F_{6,18} = 3.35$, $P = 0.015$) and johnsongrass ($F_{6,18} = 3.45$, $P = 0.013$; Table 1). Canopy cover of broomsedge did not differ among treatments ($F_{6,18} = 1.57$, $P = 0.198$).

Discussion

During the first growing season post-treatment, herbicides reduced fescue cover by 55%–93%. Residual canopy cover of fescue on herbicide treated plots varied from 2% on plots treated with imazapic8/glyphosate48 to 13% on plots treated with glyphosate48. Fescue control into the second growing season was best achieved with imazapic12/glyphosate48 (3% residual fescue cover), imazapyr8 (8% residual fescue cover), imazapic8/glyphosate48 (11 % residual fescue cover), and imazapic12 (17% residual fescue cover). These observations were consistent with studies in Kentucky (Washburn et al. 2000, Barnes 2004). Washburn and Barnes (2000*b*) reported that spring application of 2.2 kg/ha glyphosate (~2 lb/ac) reduced fescue cover (average 91% pretreatment) to less than 12% on average. In the same study, 12 oz/ac imazapic alone or in combination with 0.5 or 1 qt glyphosate/ac reduced fescue cover to less than 3% (Washburn and Barnes 2000*b*). During the second growing season following treatment, fescue increased but was <15% coverage for most treatments. They attributed the fescue recovery to incomplete kill instead of seed germination. In another study in Kentucky, applying 12 oz/ac imazapic controlled fescue better than glyphosate, and native grass establishment was more successful following imazapic applications (Washburn et al. 2002).

Previous research (Greenfield et al. 2001, 2003; Hamrick et al. 2004) on Blackland Prairie sites had indicated that herbicidal control of fescue was likely to release johnsongrass. During the first growing season following treatments, johnsongrass coverage was greatest in plots treated with glyphosate48 (29%), and least in plots treated with imazapic12/glyphosate48. Treatments containing imazapic tended to produce better residual control of johnsongrass and response was somewhat dose-dependent with better control at the higher (12 oz/ac vs. 8 oz/ac) rate.

Although planting of native grasses is often a component of grassland restoration, under some circumstances a latent native grass community exists that can be released simply by controlling competing exotic grasses (Barnes 2004). Imazapic has been used for fescue control in existing native warm season grasses plantings and remnant native grassland communities (Washburn et al. 2002). Washburn et al. (2002) reported that prescribed fire followed by application of 4–12 oz/ac imazapic reduced fescue cover to less than 25% and increased native grass cover by 18%–25% in remnant native barrens communities in Kentucky. Release of broomsedge was an objective of our study, but despite substantive reduction in fescue cover and residual control of johnsongrass, broomsedge cover remained between 5%–13% and was not different among treatments in either year. Treatments did, however, affect response of other native species. Treatments that contained glyphosate consistently diminished coverage of *Desmanthes illinoensis* and legumes collectively, whereas imazapic and imazapyr treatments produced *Desmanthes illinoensis* and legume coverage equal to untreated plots. Washburn and Barnes (2000*a*) similarly reported that 4–12 oz/ac of imazapic did not negatively affect the density of *Desmanthes illinoensis* in Kentucky. Masters et al. (1996) reported that in Nebraska, 4 oz/ac of imazapic enhanced establishment of *Desmanthes illinoensis*.

Management Implications

Spring application of all herbicides provided fescue control during the first growing season following treatment. However, we encourage managers to recognize that controlling fescue and restoring grasslands will likely require an aggressive management approach through time. We recommend managers consider using imazapic and imazapyr, as both controlled fescue without reducing legumes. However, imazapyr may not be appropriate if johnsongrass control is a concern. None of the herbicides used in our study increased remnant broomsedge on these sites during the first two growing seasons following application. Optimal herbicide prescriptions for grassland renovation will depend on the specific exotic weed complex present and selectivity toward desirable extant native species. On Blackland Prairie sites with a long history of intensive agricultural use, planting of native warm season grasses and site appropriate forbs may be a necessary component of grassland restoration.

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