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Abstract

Prescribed fire is required to maintain the native tallgrass prairie ecosystem. Typically, ranchers apply annual spring fire from mid-March through late April to suppress woody vegetation and to stimulate cattle performance. It has been recently documented that shifting prescribed fire from spring to late summer or early fall provides comprehensive control of the noxious weed sericea lespedeza (*Lespedeza cuneata*). In spite of those findings, Flint Hills ranchers have voiced reluctance to consider using late-summer or early-fall prescribed burning as a routine sericea lespedeza control measure on grazing lands because of concerns about unintended harm to beef cattle growth performance or a perceived protracted weakening of native warm-season grass populations. In year one of a six-year study, 18 pastures were grouped by watershed and assigned to one of three burn treatments: spring (April), mid-summer (August), or early fall (October). All fire treatments were applied before grazing began. Yearling heifers ($n = 360$) were grazed for 90 days beginning May 1. Plant composition, forage biomass, and root carbohydrate concentration in key native plants in the tallgrass prairie were evaluated during late June and early July. Heifers grazing spring-burned pastures had greater total body weight gain and greater average daily gain ($P = 0.02$) than heifers grazing summer- or fall-burned pastures. Pre-treatment forage biomass was not different ($P = 0.12$) between treatments. One year following fire application, forage biomass was greatest ($P \leq 0.01$) in the summer-burn treatment, intermediate in the spring-burn treatment, and least in the fall-burn treatment. Total grass and forb basal cover did not differ ($P \geq 0.13$) between treatments. Conversely, spring and summer fires were associated with greater ($P = 0.03$) native grass basal cover compared with fall fire. Furthermore, summer fire resulted in lesser ($P = 0.02$) basal cover of introduced grass species compared to the fall fire. Root starch and water-soluble carbohydrate levels in three key warm-season forage grasses and one key native legume did not differ ($P \geq 0.32$) among treatments. These preliminary findings were interpreted to indicate that prescribed fire timing influenced stocker cattle performance, plant composition, and forage biomass accumulation. In

contrast, root carbohydrate reserves were not affected by season of fire. Beef producers are encouraged to compare potential revenue loss associated with the declines in yearling growth performance reported here with the cost of alternative methods of sericea lespedeza control.

Introduction

The tallgrass prairie once extended from Indiana in the east, Kansas in the west, Canada in the north, and Texas in the south. Settlement of the prairie resulted in the conversion of native grasslands into farmland. Of the 170 million acres of tallgrass prairie that once existed, less than 4% of those acres remains today. The Kansas Flint Hills make up the largest contiguous portion of the remaining tallgrass prairie; this area is used primarily for cattle production. One of the challenges facing Flint Hills ranchers is the rapid degradation of native pastures by the noxious weed, sericea lespedeza (*Lespedeza cuneata*). Sericea lespedeza was introduced to southeastern Kansas in the 1930s because of its perceived soil conservation properties. Since that time, the highly prolific plant has moved westward and invaded more than 960 square miles of grasslands in Kansas, most of which is located in the Flint Hills.

Traditionally, ranchers have applied annual spring-season prescribed fires to native tallgrass rangelands because of their ability to limit encroachment of trees and shrubs while subsequently boosting cattle performance. Unfortunately, this practice has resulted in numerous air-quality issues in downwind municipalities and has not limited the proliferation of sericea lespedeza. Recent research has indicated that shifting the timing of prescribed fire from spring to late summer or early fall provided comprehensive control of sericea lespedeza, and a significant motive for ranchers to evaluate alternative seasons for prescribed fire application. Although late-summer or early fall fires have been shown to successfully and affordably control sericea lespedeza, some ranchers remain hesitant to apply these techniques out of concerns over sacrificing cattle performance or negatively impacting native plant populations. At this time, no direct comparisons of stocker cattle performance are available for these prescribed fire regimes. The objective of our experiment was to document the effects of prescribed fire timing on stocker cattle performance, plant composition, and forage biomass annually over a six-year period. This manuscript reports the first complete year of our work. It is our hope that this project will generate the data necessary for ranchers to make well-informed management decisions about noxious weed control.

Experimental Procedures

Our study was conducted at the Kansas State University Beef Stocker Unit located northwest of Manhattan, KS. The Beef Stocker Unit is fenced into 18 pastures ranging from 30 to 75 acres in size. Pastures were grouped by watershed and each watershed assigned to one of three prescribed burning times ($n = 6$ pastures per treatment): early spring (April), mid-summer (August), or early fall (October). A permanent 328-foot transect was established in each pasture. Transects were marked with orange survey stakes and GPS coordinates were recorded. Botanical composition and basal cover were estimated utilizing the modified step-point method. Plant sampling began in June 2018 and burn treatments were applied prior to grazing in summer of 2019.

In year one of a six-year trial, yearling heifers ($n = 360$) were stocked at 250-lb live weight/acre and grazed from May 1 to August 1. Heifers were individually weighed on day 0 and randomly assigned to pastures. On day 90, cattle were individually weighed.

Pre-treatment standing forage biomass was measured using 2.7 square foot clipping frames placed at 32.8-foot intervals along each transect. Plant material was clipped to a height of 0.39 in and dried to a constant weight. A visual obstruction technique was used to estimate forage biomass before and after fire treatments were applied. These observations were collected at 3.28-foot intervals along each 328-foot transect. Root-carbohydrate flux was evaluated in three native warm season (C_4) grasses (i.e., big blue-stem, little bluestem, and Indian grass), and one leguminous, native forb (i.e., purple prairie clover). Individual roots and rhizomes were collected, washed, separated from parent plants, and dried. Root samples were analyzed for both total starch and total water-soluble carbohydrate concentrations.

Results and Discussion

Following fire-treatment applications (i.e., August of 2018, October of 2018, and April of 2019), total body weight gain during the summer of 2019 was slightly improved ($P = 0.02$; Table 1) in the spring-burn treatment compared to summer- and fall-burn treatments. Heifers that grazed spring-burned pastures gained 29 and 21 lb more body weight than heifers that grazed summer- and fall-burned pastures, respectively. No difference ($P = 0.37$; Table 1) in total body weight gain was observed between summer and fall treatments. In addition, the average daily gain was greater ($P = 0.02$; Table 1) for heifers that grazed the spring treatment compared to those that grazed summer and fall treatments.

Initial forage biomass did not differ ($P = 0.12$; Table 1) between treatments; however, after fire-treatment applications, standing forage biomass was greater ($P < 0.01$; Table 1) in the summer-burn treatment compared with the spring- and fall-burn treatments. Pastures burned in the summer produced 493 and 300 more pounds of dry biomass per acre compared with pastures burned in fall and spring, respectively. The elevated forage biomass observed in the summer treatment may have been due to the presence of standing dead plant material. When fire was applied in the summer treatment, regrowth occurred before the first frost and standing dead plant material was present at the beginning of the following grazing season. Forage biomass was measured using a visual obstruction technique, which included standing dead plant material in the biomass estimate. Consumption of this material may have contributed to the reduction in cattle growth performance observed in the summer fire treatment. Heifers grazing summer-burned pastures had an increased opportunity to consume standing dead plant material, which is known to have poor nutritive value relative to actively-growing plants.

Litter cover on the soil surface was greater ($P = 0.04$; Table 2) in the summer-burn treatment compared with the spring-burn treatment, whereas pastures burned in the fall were intermediate. Conversely, bare soil tended to be less ($P = 0.08$; Table 2) in the summer burn treatment compared to spring, and fall burned pastures were intermediate. Increased bare soil has been associated with increased soil temperature and earlier plant growth but can lead also to increased water runoff and soil moisture loss.

When basal vegetation cover was evaluated, no differences ($P = 0.42$; Table 2) were detected between treatments; however, differences in plant composition were apparent. Spring- and summer-burned pastures had a greater ($P = 0.03$; Table 3) native grass cover compared with fall-burned pastures. In addition, summer fire was associated with less ($P = 0.05$; Table 3) introduced grass species cover than fall fire, whereas spring fire was intermediate. Cover attributable to warm- and cool-season grasses did not differ ($P \geq 0.12$) between fire treatments. Total forb cover, native forb cover, introduced forb cover, and perennial forb cover, likewise, did not differ ($P \geq 0.24$; Table 3) between treatments. Conversely, annual forb cover was greatest ($P = 0.04$; Table 3) in the fall fire treatment, least in the spring fire treatment and intermediate in the summer fire treatment.

Root starch and total water-soluble carbohydrate concentrations in big bluestem, little bluestem, Indian grass, and purple prairie clover did not differ ($P \geq 0.23$; Table 4, Table 5) between treatments. The lack of difference in root carbohydrate reserves between treatments was likely an indication that the timing of burning had little impact on growth potential of native plants.

Implications

The first year of data from our six-year study was interpreted to indicate that prescribed fire timing influenced stocker cattle performance and was associated with small changes in range-plant composition; however, fire timing did not affect root carbohydrate reserves of key native forage plants. Beef producers are encouraged to compare potential revenue shortfalls resulting from the declines in yearling growth performance reported here with the cost of chemical methods for sericea lespedeza control.

Table 1. Effects of prescribed fire timing on stocker cattle performance and forage biomass accumulation in the Kansas Flint Hills

Item	Prescribed fire season			Standard error of the mean	P-value
	Spring	Summer	Fall		
Initial body weight, lb	619	625	622	13.1	0.92
Final body weight, lb	856	831	837	12.5	0.14
Total body weight gain, lb	236 ^a	207 ^b	215 ^b	9.5	0.02
Average daily gain, lb/day	2.6 ^a	2.3 ^b	2.4 ^b	0.11	0.02
Initial forage biomass (2018), lb dry matter/acre	1528	1754	1645	109.8	0.12
Final forage biomass (2019), lb dry matter/acre	852 ^b	1120 ^a	680 ^c	27.8	< 0.01

^{a,b,c}Within rows, means with unlike superscripts differ ($P \leq 0.05$).

Table 2. Effects of prescribed fire timing on tallgrass prairie soil cover in the Kansas Flint Hills

Item, % of total area	Prescribed fire season			Standard error of the mean	P-value
	Spring	Summer	Fall		
Bare soil	58	47	49	4.8	0.08
Litter cover	23 ^b	36 ^a	32 ^{ab}	4.8	0.04
Total basal vegetation cover	19	17	19	1.6	0.42

^{ab}Within rows, means with unlike superscripts differ ($P \leq 0.05$).

Table 3. Effects of prescribed fire timing on basal cover of grasses and forbs on tallgrass prairie in the Kansas Flint Hills

Item, % of total basal plant cover	Prescribed fire season			Standard error of the mean	P-value
	Spring	Summer	Fall		
Total grass cover	91	92	87	2.5	0.13
Native grass species	89 ^a	90 ^a	82 ^b	2.9	0.03
Introduced grass species	2.3 ^{ab}	1.6 ^b	5.0 ^a	1.41	0.05
Cool-season grass species	20.3	19.5	23.3	2.80	0.37
Warm-season grass species	70.8	72.2	64.1	4.09	0.12
Total forb cover	8.4	7.1	11.0	2.39	0.28
Native forb species	8.3	7.1	11.0	2.34	0.25
Introduced forb species	0.1	0	0	2.34	0.24
Annual forb species	0.3 ^b	0.7 ^{ab}	1.9 ^a	0.69	0.05
Perennial forb species	8.1	6.5	9.1	2.10	0.45

^{ab}Within rows, means with unlike superscripts differ ($P \leq 0.05$).

Table 4. Effects of prescribed fire timing on root starch reserves of key tallgrass prairie species during July

Item, % dry matter	Prescribed fire season			Standard error of the mean	P-value
	Spring	Summer	Fall		
Big bluestem	2.02	4.06	2.55	1.26	0.23
Little bluestem	1.96	2.11	1.59	0.86	0.83
Indian grass	4.55	2.94	2.33	1.86	0.46
Purple prairie clover	5.09	3.98	3.95	1.65	0.72

Table 5. Effects of prescribed fire timing on root water-soluble carbohydrate reserves of key tallgrass prairie species during July

Item, % dry matter	Prescribed fire season			Standard error of the mean	<i>P</i> -value
	Spring	Summer	Fall		
Big bluestem	3.89	5.27	4.35	1.20	0.48
Little bluestem	3.51	5.50	3.72	1.49	0.32
Indian grass	6.14	3.87	4.02	1.98	0.42
Purple prairie clover	5.07	3.63	5.84	1.67	0.40