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Z. M. Duncan
Kansas State University, zmduncan@k-state.edu

A. J. Tajchman
Kansas State University, ajt2012@k-state.edu

M. P. Ramirez
Kansas State University, mickram@k-state.edu

See next page for additional authors
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Effects of Prescribed Fire Timing on Native Plant Composition, Forage Biomass Accumulation, and Root Carbohydrate Reserves in the Kansas Flint Hills: Year 2 of 6

Authors

Z. M. Duncan, A. J. Tajchman, M. P. Ramirez, J. Lemmon, W. R. Hollenbeck, D. A. Blasi, and K C. Olson

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*Z.M. Duncan, A.J. Tajchman, M.P. Ramirez, J. Lemmon, W.R. Hollenbeck,
D.A. Blasi, and KC Olson*

Abstract

Lespedeza cuneata (*Lespedeza cuneata*) is a highly-invasive forb that has degraded more than 960 square miles of Kansas rangeland. Recent research has demonstrated that mid-summer or early-fall prescribed fire can achieve comprehensive control of *sericea lespedeza*; however, ranchers have voiced concerns that fire later in the year (i.e., August-October) may negatively impact native warm-season plant populations. In year two of a six-year study, 18 pastures were grouped by watershed and assigned to one of three burn treatments: early spring (April 7 ± 2.1 days), mid-summer (August 21 ± 5.7 days), or early fall (October 2 ± 9.9 days). All fire treatments were applied prior to grazing by yearling stocker calves. Soil cover, botanical composition, forage biomass, and root carbohydrate reserves were evaluated over a three-year period. Total grass and forb basal cover did not differ ($P = 0.15$) between treatments. In addition, no differences ($P = 0.23$) were observed in total cool-season grass cover or warm-season grass cover between fire regimes; however, native-grass species were greatest ($P = 0.05$) in the summer fire treatment, intermediate in the spring fire treatment, and least in the fall fire treatment. Forage biomass, root starch, and total water-soluble carbohydrate levels in three key warm-season forage grasses and one key native legume did not differ ($P = 0.27$) between treatments. We interpreted these data to suggest that prescribed fire timing caused small changes in range-plant composition but did not reduce forage biomass or root carbohydrate reserves of key native plant species.

Introduction

The Kansas Flint Hills represent the largest intact remnant of the original tallgrass prairie on earth. Traditionally, ranchers apply annual spring-season prescribed fire to these native rangelands to improve stocker cattle growth performance, increase warm-season grass production, and limit the encroachment of woody and invasive plant species. On average, 2.1 million acres throughout the Flint Hills are burned annually from mid-March to early May. Burning during this time of year presents certain

challenges including low relative humidity, strong unpredictable winds, and elevated fuel loads. When combined, these factors increase the potential for uncontrolled fire. Another concern associated with spring prescribed fire is smoke management. Each spring, smoke produced from burning the Flint Hills travels to downwind municipalities, reduces air quality, and can negatively affect human health.

In addition, sericea lespedeza (*Lespedeza cuneata*) likely proliferates with annual spring prescribed fire. Sericea lespedeza was introduced to Kansas in the 1930s and has since invaded more than 960 square miles of Kansas grasslands. Recent research demonstrated that shifting the timing of prescribed fire from spring to mid or late summer provided comprehensive control of sericea lespedeza. Although control of sericea lespedeza can be achieved through late-summer burning (i.e., August-September), ranchers have voiced concerns that native warm-season grass populations or forage biomass may be affected negatively. The objective of our experiment was to document the effects of prescribed-fire timing on plant composition, forage biomass accumulation, and root carbohydrate concentrations of key tallgrass plant species over a six-year period.

Experimental Procedures

Our experiment was conducted at the Kansas State University Beef Stocker Unit. The Beef Stocker Unit is comprised of approximately 1,100 acres of native tallgrass prairie and is fenced into 18 pastures. Pastures were grouped by watershed and each watershed was assigned to one of three prescribed-fire treatments ($n = 6$ pastures per treatment): spring (April 7 ± 2.1 days), summer (August 21 ± 5.7 days), or fall (October 2 ± 9.9 days). A single, permanent 328-ft transect was established in each pasture. Pre-treatment botanical composition, basal cover, standing forage biomass, and root carbohydrate concentrations were determined in June 2018 and re-evaluated after fire application in 2019 and 2020. Prescribed fire treatments were applied prior to grazing in 2019 and 2020.

Botanical composition and soil cover were evaluated along each permanent 328-ft transect using a modified step-point method. Standing forage biomass was determined by clipping the vegetation within ten 0.82-ft² frames randomly placed at 33-ft intervals along each transect. Plant material was clipped at a height of 0.39-in above the soil and dried in a forced-air oven (122°F; 96 hours). Root-carbohydrate concentrations of three native C₄ grasses (i.e., big bluestem, little bluestem, and Indiangrass), and one leguminous, native forb (i.e., purple prairie clover) were also evaluated. Individual roots and rhizomes were collected from each pasture, washed with tap water, dried in a forced-air oven (122°F; 96 hours), and analyzed for both total starch and total water-soluble carbohydrate concentrations.

Results and Discussion

Following the second full cycle of prescribed fire application, bare soil cover was greater ($P \leq 0.01$; Table 1) in the spring burn treatment compared with the summer and fall burn treatments. Conversely, litter cover on the soil surface was greater ($P \leq 0.01$; Table 1) in pastures burned in the summer or fall compared with pastures burned in the spring. These trends can likely be attributed to the length of time since prescribed fire application. Soil cover was evaluated annually between late June and early July. As

the time since fire application increased, bare soil cover was reduced while litter cover on the soil surface increased. In contrast, basal vegetation cover did not differ ($P = 0.22$; Table 1) between prescribed fire treatments.

When botanical composition was evaluated, no differences ($P = 0.15$; Table 2) in total grass cover, cool-season grass cover, or warm-season grass cover were detected; however, differences within warm-season grass growth forms were apparent. Warm-season perennial tallgrass cover tended to be greater ($P = 0.07$; Table 2) in pastures burned in the summer or fall compared with those pastures burned in the spring. Warm-season perennial mid-grass cover was greater ($P = 0.05$; Table 2) in the spring-burn treatment compared with the fall-burn treatment, whereas summer-burned pastures were intermediate. Spring-season prescribed fire increased ($P = 0.01$; Table 2) warm-season perennial short grass cover compared with summer or fall prescribed fire. In addition, native grass species cover was greatest ($P = 0.05$; Table 2) in the summer-fire treatment, least in the fall-fire treatment, and intermediate in the spring-fire treatment. No differences ($P = 0.17$; Table 2) were observed between treatments when total forb cover and native forb cover were evaluated; however, nectar-producing forb cover was greater ($P = 0.02$; Table 2) in fall-burned pastures compared to spring- and summer-burned pastures. Similarly, annual forb cover was greater ($P = 0.03$; Table 2) in the fall treatment compared to the spring treatment, whereas the summer treatment was intermediate. Shrub cover was minimal (i.e., $\leq 1.5\%$) and not different ($P = 0.08$) between treatments.

No differences ($P = 0.91$; Table 1) in forage biomass were observed between prescribed-fire treatments. Furthermore, root starch and total water-soluble carbohydrate concentrations in big bluestem, little bluestem, Indiangrass, and purple prairie clover did not differ ($P = 0.27$; Table 3, Table 4) between the spring-, summer-, or fall-fire treatments. The lack of differences in forage biomass accumulation and root-carbohydrate concentrations were interpreted to suggest that prescribed fire timing may not affect the growth potential of key native tallgrass species.

Implications

We interpreted our data to suggest that prescribed fire timing is associated with small changes in range-plant composition; however, fire timing did not affect forage biomass accumulation or root carbohydrate reserves of key native tallgrass species. We will continue to evaluate these trends and modify our conclusions over the next five years.

Table 1. Effects of prescribed fire timing on tallgrass prairie soil cover and forage biomass in the Kansas Flint Hills

Item	Prescribed fire season			Standard error of the mean	P-value
	Spring	Summer	Fall		
Bare soil, % of total area	62 ^a	49 ^b	48 ^b	3.7	< 0.01
Litter cover, % of total area	21 ^b	36 ^a	35 ^a	4.8	< 0.01
Total basal vegetation cover, % of total area	17	15	17	1.6	0.22
Forage biomass, lb dry matter/acre	1796	1870	1897	252.1	0.91

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

Table 2. Effects of prescribed fire timing on basal cover (% of total basal plant 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	90	90	85	2.8	0.15
Native grass species	85 ^{ab}	87 ^a	79 ^b	3.2	0.05
Cool-season grass species	20.7	21.2	23.7	2.93	0.61
Warm-season grass species	68.9	69.1	61.4	4.90	0.23
C4 perennial tallgrasses	31.9	38.9	34.6	2.87	0.07
C4 perennial mid-grasses	33.0 ^a	29.0 ^{ab}	25.4 ^b	2.84	0.05
C4 perennial short grasses	3.7 ^a	1.2 ^b	1.3 ^b	0.83	0.01
Total forb cover	9.9	8.4	13.4	2.74	0.21
Native forb species	9.7	8.3	13.4	2.62	0.17
Annual forb species	0.3 ^b	1.0 ^{ab}	1.7 ^a	0.49	0.03
Nectar-producing forbs	1.8 ^b	1.9 ^b	3.8 ^a	0.68	0.02
Total shrub cover	0.5	1.2	1.5	0.98	0.08

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

Table 3. Effects of prescribed fire timing on root starch concentrations in key tallgrass species during summer

Item, % dry matter	Prescribed fire season			Standard error of the mean	P-value
	Spring	Summer	Fall		
Big bluestem	2.57	3.22	2.00	0.92	0.43
Little bluestem	1.53	1.57	1.28	0.57	0.86
Indiangrass	3.19	2.09	1.81	1.22	0.49
Purple prairie clover	4.92	3.39	3.59	1.23	0.41

Table 4. Effects of prescribed fire timing on root water-soluble carbohydrate concentrations in key tallgrass species during summer

Item, % dry matter	Prescribed fire season			Standard error of the mean	<i>P</i> -value
	Spring	Summer	Fall		
Big bluestem	3.31	4.57	4.02	0.78	0.27
Little bluestem	3.15	4.44	3.34	0.98	0.37
Indiangrass	5.11	3.47	3.95	1.29	0.42
Purple prairie clover	4.55	3.36	5.24	1.08	0.24