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GRAZING MANAGEMENT: Summer Grazing Strategies following Early-Season Grazing of Big Bluestem

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ABSTRACT

Big bluestem (*Andropogon gerardii* Vitman) has a rapid growth phase that begins in early to mid-June in eastern Nebraska. During this rapid growth phase, rate of biomass accumulation exceeds intake rate of grazing livestock, resulting in low levels of harvest efficiency. To delay the rapid growth phase, big bluestem pasture can be grazed in mid- to late May without affecting herbage yields for the remainder of the growing season. A pasture experiment was conducted in 1999, 2000, and 2001 near Mead, NE. The objective was to determine the effect of timing and frequency of grazing big bluestem pasture, following a May grazing period, on cumulative pregrazing yields, cumulative herbage disappearance, resulting harvest efficiency, leaf/stem ratio, and stand persistence. Yield and morphological characteristics were obtained immediately before and after each grazing period, and basal cover of big bluestem was estimated annually. May grazing had no effect ($P < 0.1$) on cumulative pregrazing yields and resulted in an increase of cumulative herbage disappearance (3638 vs. 2673 kg ha^{-1}) and leaf/stem ratio (2.02 vs. 2.83) compared with paddocks with no May grazing. Grazing at the vegetative stage in June compared with the elongation stage resulted in an increase in cumulative pregrazing yields (10774 vs. 9510 kg ha^{-1}), cumulative herbage disappearance (4116 vs. 3194 kg ha^{-1}), and leaf/stem ratios (2.57 vs. 1.98). Grazing at the elongation stage in June followed by a grazing period in early August is not an advisable management strategy.

Warm-season grasses can be used as alternative forage resources to cool-season pastures in the summer (Forwood and Magai, 1992). In the eastern Great Plains, warm-season grasses begin growing and providing pasture about the time cool-season pastures begin to lose forage quality and productivity, which results in an overlap in production during May and June (Gerrish and Roberts, 1999). Producers may be sacrificing forage yield and quality on the warm-season pasture component of the total grazing system if they wait to graze warm-season pastures until mid-June to early July when cool-season pastures have been mostly utilized and are much less productive (George et al., 1996). Forage yield can be more evenly distributed and forage quality better maintained through the growing season if warm-season pastures are grazed at the vegetative stage in May (Gerrish and Roberts, 1999). Grazing in mid- to late May in eastern Nebraska delays stand development of warm-season pastures until later in the growing season (Wilkinson et al., unpublished data, 1997).

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Following grazing big bluestem in mid-May, animals can be returned to the cool-season pasture to make full use of the cool-season forage before returning to the big bluestem pasture in mid- to late June. Even without cool-season pasture, grazing big bluestem in May can be used to extend the length of the grazing season.

The objective of this study was to determine the effect of timing and frequency of grazing big bluestem pasture following a May grazing period on (i) herbage availability and herbage disappearance for the remainder of the grazing season and (ii) stand persistence. Results of this study should guide the development of an effective summer grazing strategy for big bluestem pasture following early-season grazing.

MATERIALS AND METHODS

Study Site

The study was conducted in 1999, 2000, and 2001 at the University of Nebraska Agricultural Research and Development Center near Mead, NE (41°11′ N, 96°33′ W; 315 m elevation). The continental climate of the area is characterized by wide seasonal variations. Average maximum daily temperatures range from 0.1°C in January to 31.5°C in July. Average minimum daily temperatures range from −11.4°C in January to 18.9°C in July. The long-term (1960–2000) average annual precipitation is 41 mm, and about 75% of this falls during the growing season (April through September) (HPRCC, 2001). The topography varies from level terrain to slopes of less than 3%. The prominent soil at the study site is a Sharpsburg silty clay loam (fine, montmorillonitic, mesic, Typic Argiudoll), and most of the parent material is loess of Peorian age (Elder et al., 1965).

Vegetation

Vegetation at the study site was a uniform, vigorous stand of 'Pawnee' big bluestem established on a 4-ha field in 1995. The stand was not fertilized during establishment or in subsequent years. Broadleaf weeds were controlled during establishment by applications of 2,4-D (2,4-dichlorophenoxy acetic acid) at the rate of 2.1 L ha^{-1}. The stand was not harvested in 1996 and established well, accumulating considerable plant biomass. The site was burned in late April 1999, 2000, and 2001 to remove dead plant material and to create uniform conditions for the grazing trial.

Experimental Methods

The experimental design was a randomized complete block with repeated measures and four replications. Treatments were arranged in a 2 × 2 × 2 factorial with the following factors and levels: (i) May grazing or no May grazing, (ii) June grazing at a late vegetative stage or June grazing at an early elongation stage, and (iii) late-summer grazing in early August and early September or late-summer grazing in early September only. The various grazing date treatment combinations were allocated randomly to eight 0.05-ha paddocks (experimental units). Each grazing date treatment was applied in a 24-h grazing period. Each paddock had the same grazing treatment applied to it for the 3 yr of the study.

May grazing occurred when the big bluestem was at an early vegetative stage of growth when tillers were 15 to 20 cm in height and the paddocks provided about 50 kg of dry matter per animal unit day (1 animal unit day is equivalent to 10.5 kg of forage dry matter). The corresponding dates were 17 May 1999, 31 May 2000, and 21 May 2001. June grazing was designed to either remove a large portion of exposed tiller growing points by grazing at the elongation stage or not remove tiller growing points by grazing at the vegetative stage. The two summer grazing periods (early August and early September) were designed to determine the effect of grazing strategies on pregrazing yields and utilization of big bluestem in late summer, a time when forage availability and quality are typically low. Grazing periods are identified by the following notations: M = May grazing, NM = no May grazing, Jv = June grazing at the vegetative stage; Je = June grazing at the elongation stage, A = early-August grazing, and S = early-September grazing.

Each paddock was grazed at a cumulative stocking rate of 9.9 animal unit months (1 animal unit month is equivalent to 310 kg of forage dry matter) per hectare regardless of the number of grazing periods (two to four). This is the recommended stocking rate for big bluestem pasture in eastern Nebraska (Waller et al., 1986). After the initial mid-May grazing period, animal demand was distributed proportionally over the number of grazing periods in each treatment (Table 1). The stocking rate was reduced by 40% for the early-August and early-September 2001 grazing periods because of dry conditions and low pregrazing yields in mid- to late summer. The grazing animals were Holstein heifers (*Bos taurus* L.) weighing between 227 and 454 kg. The wide range of animal weights allowed for application of the designated stocking rate during each grazing period.

Measurements

Standing crop biomass was sampled in each paddock immediately before and after each grazing period to determine cumulative pregrazing yields and cumulative herbage disappearance. Before and after each grazing period, all live herbage was clipped at ground level within 20 randomly selected 0.25-m^2 rectangular quadrats in each paddock. Herbage samples were dried in a forced-air oven at 50°C to a constant weight, and weights were recorded. Live herbage clipped in the postgrazing sampling period included upright and trampled tillers that were still connected to the plant base. Because trampled tillers were included as part of the postgrazing herbage biomass, herbage disappearance during the grazing period was assumed to be a result of consumption only. Cumulative pregrazing yields were calculated to determine the total amount of herbage available to grazing animals over the entire grazing season. It was calculated for each paddock as the sum of total pregrazing standing crop biomass for all grazing periods in a year. Higher cumulative pregrazing yields potentially would allow animals to increase intake and select a higher quality diet.

A measure of seasonal herbage production could not be calculated by summing the pregraze yields of all grazing periods and subtracting the postgraze yields of all but the final grazing period. This method assumes that all postgraze herbage survives and is included in the pregraze yield of the next grazing period. Field observations, however, indicated that a majority of the growing points of the green, intact tillers at the end of the grazing period were senesced before the beginning of the next grazing period. Particularly following dry intervals, pregraze yields were around 50% of the postgraze yields of the previous grazing period. This problem was especially evident in the mid- and late grazing periods. For example, postgrazing herbage yield on 25 June was 4590 kg ha^{-1} for one of the paddocks grazed at the elongation stage. The pregrazing herbage yield from the same paddock on 2 August was only 2950 kg ha^{-1}. This means there was 1640 kg ha^{-1} less herbage on offer on 2 August despite the regrowth that occurred during the 5-wk period from 25 June to 2 August. Without accurate estimates of herbage carryover from one period to the next, yields of new growth at the beginning of a grazing period and seasonal herbage production could not be estimated.

Cumulative herbage disappearance was calculated for each paddock as the difference between the total pregrazing standing crop biomass and total postgrazing standing crop biomass for all grazing periods in a year. Pregrazing yields and herbage disappearance could not be analyzed for each grazing period because not all paddocks were grazed in each grazing period. Calculating pregrazing yields and herbage disappearance on a cumulative basis provided an accurate, season-long estimate of key herbage parameters.

Five big bluestem samples containing 50 tillers each were collected from each paddock immediately before each grazing period. Samples were dried in a forced-air oven at 50°C to a constant weight. After drying, leaves were separated from stems at the leaf collar and each component weighed to determine leaf/stem ratio. Cumulative leaf/stem ratio was calculated for each paddock as the ratio between the total leaf weight and total stem weight for all grazing periods in a year.

Percentage ground cover of trampled herbage was estimated in each paddock after each grazing period to determine cumulative trampled herbage. After each grazing period, at 20 randomly selected points, ground cover of trampled herbage was measured in each paddock within a 0.25-m^2 frame. Cover of all plants lying at <45° to the ground was recorded as trampled herbage. Cumulative trampled herbage was calculated to aid in determining the effect of each grazing treatment on cumulative herbage disappearance and harvest efficiency.

Basal cover of big bluestem and invading species were estimated in all paddocks in mid-July 1999, 2000, and 2001 using a line-intercept method (Dill et al., 1986). Percentage cover of plant bases and relative species composition were calculated

Table 1. Experiment treatment combinations and corresponding stocking rates by each grazing period.

	Stocking rate by grazing period				
Treatment†	May	June vegetative	June elongation	Early August	Early September
	AUM‡ ha^{-1}				
MJvAS	2.00	2.63		2.63	2.63
MJeAS	2.00		2.63	2.63	2.63
MJvS	2.00	3.95			3.95
MJeS	2.00		3.95		3.95
NMJvAS		3.30		3.30	3.30
NMJeAS			3.30	3.30	3.30
NMJvS		4.95			4.95
NMJeS			4.95		4.95

† Grazing treatment combinations: M = May; NM = No May; Jv = June (vegetative); Je = June (elongation); A = early August; S = early September.

‡ AUM, animal unit month (equivalent to 310 kg of forage dry matter).

to determine the effect of grazing treatments on stand persistence.

Statistical Analysis

Data were analyzed as a randomized complete block design with repeated measures. A 2 × 2 × 2 factorial treatment arrangement was used with paddocks as the experimental unit. Analysis of variance procedures (ANOVA) were conducted using the Statistical Analysis System with the mixed procedure (SAS Inst., 1995; Little et al., 1996). Least significant difference (LSD) was used to separate means when ANOVA showed significant ($P < 0.1$) treatment effects.

RESULTS AND DISCUSSION

Precipitation

Precipitation from 1 April through 30 June 1999 was 50% above average. Precipitation totals from 1 July through 30 Sept. 1999 were 45% less than average and 40% less than the April through June totals (Fig. 1; HPRCC, 2001). The growing season was relatively dry in 2000; however, rainfall amounts were relatively high in June and July. The majority of the precipitation in June came in the last few days of the month. Precipitation from 1 April through 30 June 2000 was 17% less than average and 43% less than for the same period in 1999. Amount of precipitation received from 1 August through 30 Sept. 2000 was 22% less than average and 15% more than the same period in 1999. Precipitation from 1 April through 30 June 2001 was 20% above average, largely due to a single, high-precipitation event in late May. Precipitation from 1 July through 30 Sept. 2001 was 52% below average. These differing rainfall patterns probably contributed to the significant ($P < 0.1$) year × treatment interactions for the measures of vegetation response.

Cumulative Pregrazing Yields

The May grazing period had no effect ($P > 0.1$) on cumulative pregrazing yields in any year. In 1999, cumulative pregrazing yields were higher ($P < 0.1$) for JvAS than for JvS paddocks regardless of May grazing treatment (Table 2). Pregrazing yields in the JvAS paddocks were still relatively high in the September grazing period even though they also had been grazed in August. There was no effect of level of late-summer grazing for paddocks grazed at the vegetative stage in June 2000, and level of late-summer grazing did not affect cumulative pregrazing yields in 1999 and 2000 for paddocks grazed at the elongation stage in June. Cumulative pregrazing yields were higher ($P < 0.1$) for JeAS paddocks than for JvAS paddocks in 2001 (Table 2). Early-summer precipitation apparently triggered a surge in plant growth in mid-June, resulting in high pregrazing yields in JeAS paddocks at the elongation stage in June. The

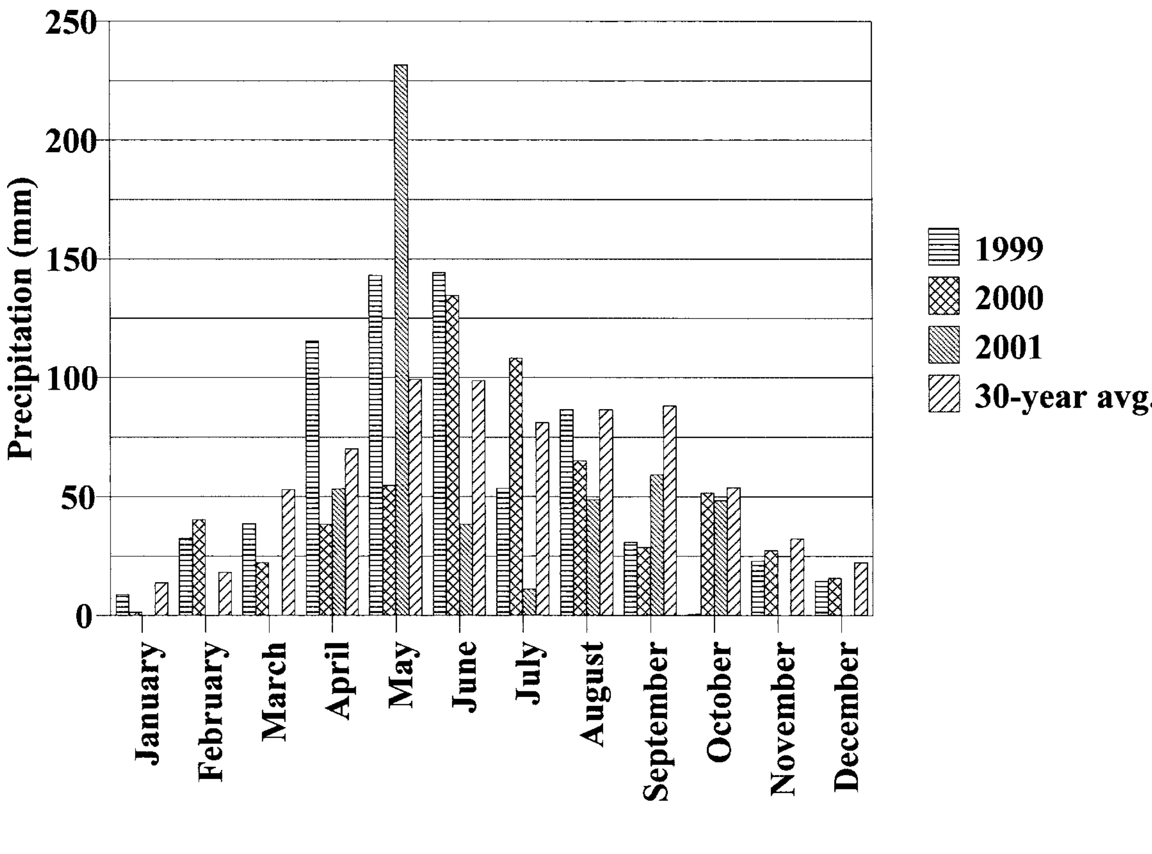

Fig. 1. Mean monthly precipitation for the Agricultural Research and Development Center near Mead, NE, for 1999, 2000, 2001, and the 30-yr average.

Table 2. Cumulative pregrazing yields for June and late-summer levels of grazing in 1999, 2000, and 2001.

Late summer	June Vegetative	June Elongation
	kg DM† ha^{-1}	
1999		
August, September	13 570^{aA}‡	12 030^{bA}
September	10 370^{aB}	11 920^{bA}
2000		
August, September	12 190^{aA}	11 200^{aA}
September	11 100^{aA}	10 380^{aA}
2001		
August, September	10 015^{aA}	11 490^{bA}
September	6 640^{aB}	7 440^{aB}

† DM, dry matter.
‡ Within row, means with same lowercase letter are not different ($p > 0.1$). Within column and year, means with same uppercase letter are not different ($p > 0.1$). Standard error of the estimates was 456.6 kg DM ha^{-1}.

precipitation likely came too late to result in any appreciable plant growth in JvAS paddocks before the vegetative stage grazing period in June.

In 1999, JvS paddocks had lower ($P < 0.1$) cumulative pregrazing yields than JeS paddocks (Table 2) regardless of May grazing treatment. The JeS paddocks had more time to accumulate herbage before being grazed in June than the JvS paddocks, resulting in high pregrazing yields in the JeS paddocks for the Je grazing period. The decline in precipitation in the latter half of the 1999 growing season (Fig. 1) may have also limited the regrowth of Jv paddocks before the early-September grazing period. Cumulative pregrazing yield for each year was highest for paddocks grazed in the sequence of June at the vegetative stage, early August, and September (data not shown). There was no effect of grazing strategy in June on cumulative pregrazing yields in late summer in 2000 (Table 2), possibly because of persistent dry conditions in late 1999 and early 2000. Cumulative pregrazing yields in 2001 were higher ($P < 0.1$) for JeAS- than JvAS-grazed paddocks (Table 2) because of the lack of early-spring precipitation and limited plant growth before the June grazing period at the vegetative stage. Overall, temporal distribution of rainfall appeared to be a key factor in the response of cumulative pregrazing yields to grazing treatments.

Cumulative Herbage Disappearance

Cumulative herbage disappearance over the season was higher ($P < 0.1$) for Jv paddocks than Je paddocks except for MJv-grazed paddocks in 1999 and NMJv in 2001 (Table 3). The low cumulative herbage disappearance for Je paddocks (Table 4) is likely a result of low herbage availabilities in August and September for the JeAS paddocks. Apparently, less than 40 d of rest between June elongation and August grazing periods was not adequate to provide sufficient herbage for grazing animals late in the growing season. The lower herbage availabilities may have limited intake of grazing animals, resulting in lower cumulative herbage disappearance. Higher cumulative herbage disappearance in Jv paddocks coincides with 11% less ($P < 0.1$) cover of trampled herbage in Jv paddocks (63%) than in Je paddocks (71%). Higher cumulative herbage disappearance and

Table 3. Cumulative herbage disappearance for May and June levels of grazing in 1999, 2000, and 2001.

May	June Vegetative	June Elongation
	kg DM† ha^{-1}	
1999		
Grazed	4840^{aA}‡	5040^{aA}
Not grazed	5640^{aA}	2650^{bB}
2000		
Grazed	4320^{aA}	2820^{bA}
Not grazed	4990^{aA}	3450^{bA}
2001		
Grazed	2630^{aA}	2180^{bA}
Not grazed	3030^{aA}	2280^{aA}

† DM, dry matter.
‡ Within row, means with same lowercase letter are not different ($p > 0.1$). Within column and year, means with same uppercase letter are not different ($p > 0.1$). Standard error of the estimates was 377.41 kg DM ha^{-1}.

lower cover of trampled herbage indicate that harvest efficiency was higher in the Jv paddocks. Herbage disappearance was not affected ($P > 0.1$) by level of grazing in May; however, cover of trampled herbage in M paddocks (56%) was 28% less ($P < 0.1$) than in NM paddocks (78%).

Cumulative herbage disappearance for paddocks grazed in September 1999 was inflated because of high levels of trampling in September. Dry conditions throughout July, August, and September 1999 (Fig. 1) apparently caused a high proportion of plants to cease growth by mid-August. Culms of fully elongated plants became brittle by late August and early September. The brittle culms dislodged from plant bases and were scattered about the paddock by grazing animals. Sampling procedures measured these culms as consumed by grazing animals, resulting in high estimates of herbage disappearance for early September 1999. The high herbage disappearance estimates in early September overwhelmed the effects of earlier grazing periods. Brittle culms were not observed in August and September 2000 and 2001, probably because of better moisture conditions. Although herbage disappearance estimates for late-summer–grazed paddocks are confounded because of excessive trampling, AS paddocks (64%) had less ($P < 0.1$) trampled

Table 4. Cumulative herbage disappearance for June and late-summer levels of grazing in 1999, 2000, and 2001.

Late summer	June Vegetative	June Elongation
	kg DM† ha^{-1}	
1999		
August, September	5540^{aA}‡	2900^{bA}
September	4930^{aA}	4780^{aB}
2000		
August, September	3930^{aA}	2390^{bA}
September	5380^{aB}	3880^{bB}
2001		
August, September	3010^{aA}	2860^{aA}
September	1900^{aB}	2350^{aA}

† DM, dry matter.
‡ Within row, means with same lowercase letter are not different ($p > 0.1$). Within column and year, means with same uppercase letter are not different ($p > 0.1$). Standard error of the estimates was 533.74 kg DM ha^{-1}.

Table 5. Cumulative leaf/stem ratios for June and late-summer levels of grazing in 1999, 2000, and 2001.

	June	
Late summer	Vegetative	Elongation
1999		
August, September	1.6[aA]†	1.0[bA]
September	1.3[aB]	1.3[aB]
2000		
August, September	1.0[aA]	0.9[aA]
September	0.9[aA]	0.9[aA]
2001		
August, September	6.2[aA]	4.9[bA]
September	4.5[aB]	4.5[aA]

† Means with same lowercase letter are not different ($p > 0.1$) within row. Means with same uppercase letter are not different ($p > 0.1$) within column and year. Standard error of the estimates was 0.15.

herbage than did paddocks grazed in early September only (70%).

Cumulative Leaf/Stem Ratio

Cumulative leaf/stem ratios for JvAS paddocks were higher ($P < 0.1$) than JvS and JeAS paddocks in 1999 and 2000 (Table 5). Grazing at the vegetative stage in June followed by a grazing period in August resulted in a more leafy, vegetative stand of grass for the grazing season. Grazing at the vegetative stage in June followed by a September grazing period resulted in a long rest period (75 d) and relatively low leaf/stem ratios in September.

Cumulative leaf/stem ratios were not affected by timing of grazing in June or late summer 2000 (Table 5). Leaf/stem ratios were relatively high early in the growing season and declined rapidly through the growing season for all treatments. Dry conditions in late 1999 and early 2000 delayed culm development, resulting in a higher proportion of leaves at the time of grazing in early 2000 across all paddocks. However, above-average rainfall in June and July (Fig. 1) and rapid accumulation of stem material late in the growing season lowered leaf/stem ratios.

High leaf/stem ratios in 2001 were likely a result of reduced culm development because of low rainfall during most of the summer. Other studies have shown reduced culm development as a result of water stress in switchgrass (*Panicum virgatum* L.) (George et al., 1989) and alfalfa (*Medicago sativa* L.) (Carter and Sheaffer, 1983).

Basal Cover

Basal cover of big bluestem grazed at the June elongation stage was 18 and 17% lower ($P < 0.1$) in 2000 and 2001, respectively, than in 1999 (Table 6). Basal cover of big bluestem in the Je paddocks was 32 and 30% lower ($P < 0.1$) in 2000 and 2001, respectively, than at the Jv stage in 2000 (Table 7). This data suggests that a grazing system with a rest period of 20 to 30 d during rapid growth and 30 to 40 d during slow growth would be necessary to maintain a viable big bluestem stand (Gerrish et al., 1994). As concluded earlier, grazing at the elongation stage in June followed by a grazing period in early August resulted in low cumulative pregrazing yields and cumulative herbage disappearances. This strategy also had a negative effect on basal cover of big bluestem, which may explain the low stand productivity in these paddocks.

Table 6. Basal cover of big bluestem for June levels of grazing in 1999, 2000, and 2001.

	June	
Year	Vegetative	Elongation
	Cover, %	
1999	4.20[aA]†	3.90[aA]
2000	4.65[aA]	3.20[bB]
2001	4.90[aB]	3.25[bB]

† Means with same lowercase letter are not different ($p > 0.1$) within row. Means with same uppercase letter are not different ($p > 0.1$) within column. Standard error for the estimates was 0.23.

Table 7. Basal cover of big bluestem for June and late-summer levels of grazing in 1999, 2000, and 2001.

	June	
Late summer	Vegetative	Elongation
	Cover, %	
1999		
August, September	4.0[aA]†	4.1[aA]
September	4.3[aA]	3.7[aA]
2000		
August, September	4.4[aA]	3.0[bA]
September	4.4[aA]	3.7[aB]
2001		
August, September	4.6[aA]	3.0[bA]
September	4.3[aA]	3.9[aB]

† Means with same lowercase letter are not different ($p > 0.1$) within row. Means with same uppercase letter are not different ($p > 0.1$) within column and year. Standard error of the estimates was 0.31.

In conclusion, a May grazing period followed by a recovery period of 30 d or more does not affect stand persistence and improves efficiency of use of standing forage for the remainder of the growing season. Grazing at the vegetative stage in June compared with grazing at the elongation stage in June results in higher seasonal leaf yields and harvest efficiency. Long recovery periods (75 d) in midsummer result in relatively low leaf/stem ratios for the season. Minimum regrowth time in the summer appears to be 40 d. Grazing at the elongation stage in June followed by a grazing period in early August results in low stand productivity and use. Managers should adopt grazing strategies that rotate grazing periods at the elongation stage in June among paddocks over years. They also should avoid August grazing periods after paddocks have been grazed in June at the elongation stage to prevent damage to the stand.

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