Effects of Nitrogen Fertilization Rate, Stockpiling Initiation Date, and Harvest Date on the Dry Matter Yield of Fall Stockpiled Bermudagrass

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Story in Brief

Well-established stands of ‘Common’ and ‘Tifton 44’ bermudagrass [*Cynodon dactylon* (L.) Pers.] located at Fayetteville and Batesville, AR, respectively, were chosen to evaluate the effects of stockpiling initiation date (August or September), and N fertilization rate (0, 33, 66, or 99 lb N/acre) on the dry matter (DM) yield potential of fall-stockpiled bermudagrass forage in 2000 and 2001. Harvest dates began in mid-October and continued at 3-wk intervals through late December. Soil types were a Captina silt loam at Fayetteville, and a Secesh silt loam at Batesville. Within year, DM yield increased linearly ($P \leq 0.008$) with N fertilization rate at Fayetteville in 2001, and in Batesville during both years. Stockpiling initiation date, harvest date, and their interaction affected ($P \leq 0.004$) DM yield. For August initiation dates, DM yield declined linearly ($P \leq 0.007$) with harvest date at both sites during both years; however, cubic responses ($P \leq 0.076$) also were observed in three of the four site-years. For September initiation dates, DM yield exhibited less consistent patterns over harvest dates. Yields of DM were greatest when stockpiling was initiated in early August, but overall yields, which ranged approximately from 90 to 4,200 lb/acre, were highly dependent on precipitation during August and early September.

Introduction

Beef cattle producers in Arkansas face many economic obstacles, including maintaining cows throughout winter months. Producers often rely on bermudagrass as the primary warm-season forage during the growing season because it has the potential to produce high forage yields in response to fertilization with N (Doss et al., 1966; Hill et al., 1993). This growth has traditionally been used to support grazing livestock, but large quantities are also harvested as hay that is fed during the late fall and early winter after bermudagrass is dormant. However, costs associated with hay production, and adverse weather conditions during spring and summer make extended grazing systems attractive to producers.

Recently, winter-feeding systems that involve stockpiling standing bermudagrass at the end of the growing season have received increased interest (Lalman et al., 2000; Scarbrough et al., 2001). Bermudagrass and other stockpiled forages can provide winter pasture for grazing livestock, thereby reducing the need for supplemental hay and its associated costs (Adams et al., 1994; Hitz and Russell, 1998). The objectives of this study were to evaluate the effects of N fertilization rate, stockpiling initiation date, and harvest date on the DM yield potential of stockpiled common and ‘Tifton 44’ bermudagrass forages throughout late fall and early winter.

Experimental Procedures

Forage Management. In August of 2000 and 2001, well-established stands of common and Tifton 44 bermudagrass were divided into four field blocks consisting of eight plots (12 x 20 ft) each at Fayetteville and Batesville, AR, respectively. Prior to initiating the study each year, the plot area at both locations was managed for hay production, and a final harvest was taken as close to the trial initiation date as possible. To initiate the trial, any additional forage in the plot area was clipped to a 2-in stubble height with a rotary mower equipped with a bagging attachment. Any mowed forage was removed from the site and discarded. Immediately thereafter, N fertilizer treatments (0, 33, 66, or 99 lb N/acre) were applied as ammonium nitrate (34-0-0) to half of the plots. Early initiation dates were on August 8, 2000 and August 7, 2001 at Fayetteville, and August 10, 2000 and August 9, 2001 at Batesville. A second (late) initiation date was also evaluated. These treatments were established on September 6, 2000 and September 4, 2001 at Fayetteville, and September 6, 2000 and September 6, 2001 at Batesville. Establishment techniques for the second initiation date were identical to those used in August. For treatments initiated in September, any bermudagrass growth that accumulated between the August and September initiation dates was clipped (2-in) as described previously and removed prior to fertilization.

Harvest Management. Forage growth was allowed to accumulate until mid-October, which coincides approximately with the expected first frost date for northern Arkansas. Plots were harvested by cutting a single swath across each plot with a self-propelled sickle-bar mower. Plots were harvested a total of four times at 3-wk intervals over a 9-wk period ending in December. During 2000, the fourth and final sampling date was delayed until early January due to poor weather conditions that included substantial snowfall and prolonged ground cover. Harvest dates in Fayetteville for 2000 were October 18, November 9, November 29, and January 8, while in Batesville the corresponding dates were October 19, November 10, November 30, and January 9. The January harvest dates at Fayetteville and Batesville were the first possible opportunity to harvest the plots after the snow cover melted. For 2001, harvest dates were on October 17, November 6, November 27, and December 18 at Fayetteville, and October 18, November 7, November 29, and December 19 at Batesville. A grab sample of each forage was dried to a constant weight in a forced-air oven (122°F) to determine the concentration of DM in the harvested forages. This value was used to calculate the total DM yield from each plot.

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Statistical Analysis. Because the growth characteristics of the bermudagrass varieties used in this study varied greatly (Burton and Monson, 1978), data for each location were analyzed independently. Data within each site-year were analyzed as a split-plot design (PROC GLM; SAS Inst., Inc., Cary, NC). Whole plots were arranged in a 2 x 4 factorial design that included two initiation dates (August or September) and four fertilization rates (0, 33, 66, or 99 lb N/acre). The subplot treatment factor was fall harvest date. Initially, the effects of year were included in the model, but there were numerous interactions ($P < 0.05$) of other treatment factors with year at both locations; therefore, each year was analyzed independently. Single degree of freedom orthogonal contrasts (PROC GLM; SAS Inst., Inc., Cary, NC) were used to describe the effects of N fertilization rate and harvest date on DM yield.

Results

Precipitation. Weather conditions were extremely dry in August 2000 at both locations; there was no measurable rainfall in Fayetteville, and only 0.13 in of precipitation fell at Batesville during this time period (Figures 1 and 2). Between July and December 2000, cumulative precipitation was only 89 and 63% of the 30-yr norm (National Oceanic and Atmospheric Administration, 2002) for the Fayetteville and Batesville sites, respectively. At Fayetteville in 2001, monthly precipitation exceeded the 30-yr norm during four of the six months between July and December. In August and November, months in which precipitation was less than the 30-yr norm, cumulative precipitation was at least 90% of expected levels. Similarly, precipitation at Batesville met or exceeded the 30-yr norm during five of the six months comprising this same time period. The lone exception to this trend was in August, when only 0.43 in of precipitation fell; this was only 14% of the 30-yr norm.

Batesville 2000. Fertilization rate tended to affect DM yield ($P = 0.057$; Table 1), but no interactions with fertilization rate were found ($P \geq 0.382$). Yield of DM increased linearly ($P = 0.008$; Table 2) with fertilization rate, but yields were low and the range was narrow (227 to 448 lb/acre). Main effects of initiation date and harvest date affected DM yield ($P < 0.001$; Table 1), as did their associated interaction ($P < 0.001$). For both initiation dates, DM yield declined in linear ($P \leq 0.013$) and cubic ($P \leq 0.024$) patterns over harvest dates, but plots initiated in September produced only 30 to 54% of the DM produced in companion plots initiated in August (Table 3). There was a 121 lb/acre increase in yield between the first and second harvest dates for plots initiated in September, but this was not observed for the other initiation date.

Fayetteville 2000. Yield of DM was not affected by N fertilization rate ($P = 0.559$; Table 1) or interactions of initiation date or harvest date with N fertilization rate ($P \geq 0.569$). Main effects of stockpiling initiation date and harvest date affected DM yield ($P < 0.001$), as did their associated interaction ($P < 0.001$). For the August initiation date, DM yield declined linearly ($P < 0.001$; Table 3) over harvest dates; a cubic effect ($P = 0.011$) was also detected, largely because DM yield increased by 123 lb/acre between the first and second harvest dates before declining sharply thereafter. Plots initiated in September yielded only 35 to 66% of the forage ($P < 0.001$) harvested from comparable plots that were initiated in August. Yield of DM from plots initiated in September increased by 102% between the first and second harvest dates. Overall, DM yield from September-initiated plots exhibited quadratic ($P < 0.001$) and cubic ($P < 0.001$) changes over harvest dates, and DM yield on the final harvest date exceeded that of the first harvest date by 127 lb/acre.

Batesville 2001. Fertilization rate strongly affected ($P < 0.001$) DM yield (Table 1); however, there also was a weak trend ($P = 0.084$) for an interaction between fertilization rate and initiation date. Yields of DM increased linearly ($P < 0.001$; Table 2) with fertilization rate; DM yield in plots fertilized at the highest rate accumulated more than three times as much DM as unfertilized checks, but all yields were poor, and the only treatment mean to exceed 1000 lb/acre was associated with the highest fertilization rate. Consistent with responses in other site-years, main effects of initiation and harvest dates ($P < 0.001$) and their interaction ($P = 0.003$) affected DM yield (Table 1). For treatments established in August, yield of DM declined linearly ($P = 0.007$; Table 3) from 1,190 to 734 lb/acre over the 9-wk sampling period. For plots initiated in September, a cubic response ($P = 0.053$) was observed where yield on the final harvest date was 139 lb/acre less than on the initial harvest date. However, yields for all treatments initiated in September were poor (312 to 464 lb/acre), and were, at best, only 50% of comparable treatments initiated in August.

Fayetteville 2001. Yield of DM was affected ($P = 0.007$; Table 1) by N fertilization rate, and there was a weak trend ($P = 0.092$) for a N fertilization rate by initiation date interaction. Yields increased linearly ($P = 0.002$), and were 25% greater in plots fertilized at the highest rate, compared to unfertilized controls (Table 2). A quadratic trend ($P = 0.060$) also was observed; this was likely because there was no yield response in plots fertilized with 33 lb N/acre relative to unfertilized checks. Main effects of initiation date and harvest date also affected yield ($P \leq 0.004$; Table 1), as did their associated interaction ($P < 0.001$). Regardless of initiation date, DM yield changed in linear ($P < 0.001$) and cubic patterns ($P \leq 0.076$) over harvest dates (Table 3). However, yields decreased over harvest dates in plots initiated in August, but increased in plots initiated in September because of contamination by winter-annual grasses and broadleaf weeds. These weed species were not observed in companion plots initiated in August, and suggest that the shading created with an August initiation date may have suppressed growth of winter-annual contaminants. As was observed at both sites in 2000, yields from plots initiated in September were only 16 to 55% of those from comparable treatments started in August.

Implications

These results suggest that acceptable accumulation of bermudagrass for use in grazing systems during the late fall and early winter is highly dependent on normal precipitation in August. Dry matter yields in excess of 4200 lb/acre were attained without drought stress in August-initiated plots grown at Fayetteville. In all cases, an August initiation date resulted in more DM yield than companion plots initiated in September. This system may be best adapted to less droughty sites, or where irrigation is available to insure adequate growth in dry years.

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Table 1. F-values and P > F for main effects and interactions of N fertilization rate (Nrate), stockpiling initiation date (I), and harvest date (H) for the DM yield of stockpiled bermudagrass harvested in Batesville and Fayetteville, AR in 2000 and 2001

	Fayetteville				Batesville			
	2000		2001		2000		2001	
Effect	F-value	P > F	F-value	P > F	F-value	P > F	F-value	P > F
Nrate[a]	0.7	0.559	5.4	0.007	2.9	0.057	23.0	< 0.001
I[b]	69.7	< 0.001	440.8	< 0.001	23.8	< 0.001	79.6	< 0.001
Nrate x I	0.5	0.717	2.5	0.092	0.8	0.546	2.5	0.084
H[c]	24.1	< 0.001	4.8	0.004	28.6	< 0.001	16.6	< 0.001
H x I	7.5	< 0.001	38.9	< 0.001	8.6	< 0.001	5.1	0.003
Nrate x H	0.9	0.569	0.8	0.614	1.1	0.382	1.4	0.222
Nrate x H x I	0.7	0.670	0.6	0.832	0.9	0.521	0.8	0.584

[a] Nitrogen fertilization rates were 0, 33, 66, and 99 lb/acre.

[b] Initiation dates were in early-August or early-September.

[c] Initial harvests were in mid-October, which approximately coincides with the expected first frost. Harvests were taken subsequently at three-week intervals through late December. The final harvest for 2000 was delayed at both sites until early January 2001 because of prolonged ice and snow cover.

Table 2. Orthogonal contrasts for the main effect of N fertilization rate on the DM yield of stockpiled bermudagrass

	Fayetteville		Batesville	
	2000	2001	2000	2001
N fertilization rate	DM yield	DM yield	DM yield	DM yield
Lb N/acre	lb/acre	lb/acre	lb/acre	lb/acre
0	924	2278	227	334
33	914	2253	298	580
66	996	2398	340	655
99	1032	2836	448	1018
SE	67.8	116.8	54.4	58.9
Effect[a]	NS	L = 0.002 Q = 0.060	L = 0.008	L < 0.001

[a] NS = nonsignificant ($P \geq 0.10$); L = linear; Q = quadratic.

Table 3. Orthogonal contrasts for DM yield as affected by the interaction of stockpiling initiation date and harvest date for stockpiled bermudagrass forage grown in Batesville and Fayetteville, AR in 2000 and 2001

	2000				2001			
	Aug		Sept		Aug		Sept	
Harvest date[a]	Bat[b]	Fay	Bat	Fay	Bat	Fay	Bat	Fay
	lb/acre	lb/acre	Lb/acre	lb/acre	lb/acre	lb/acre	lb/acre	lb/acre
1	662	1438	196	506	1190	4227	464	657
2	595	1561	317	1024	853	3571	312	911
3	276	1038	107	572	867	3682	431	1575
4	305	963	165	633	734	3170	325	1734
SE	58.0	92.7	26.8	38.3	107.9	172.1	56.2	79.4
Effect[c]	L < 0.001 C = 0.024	L < 0.001 C = 0.011	L = 0.013 C < 0.001	Q < 0.001 C < 0.001	L = 0.007	L < 0.001 C = 0.076	C = 0.053	L < 0.001 C = 0.013

[a] Initial harvests were October 19, 2000 and October 18, 2001 at Batesville and October 18, 2000 and October 17, 2001 at Fayetteville, which approximately coincides with the expected first frosts at each site. Harvests were taken subsequently at three-week intervals through late December. The final harvest for 2000 was delayed until January 9, 2001 because of prolonged ice and snow cover.

[b] Bat = Batesville; Fay = Fayetteville.

[c] L = linear; Q = quadratic; and C = cubic.