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Carostan Flaccidgrass:

Nutrititive Value Responses to Nitrogen Fertilization and Cutting Management

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Carostan Flaccidgrass: Yield and Nutritive Value Responses to Nitrogen Fertilization and Cutting Management

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Contents

Abstract

Carostan flaccidgrass, an introduced, perennial, warm-season grass, was evaluated for its response to nitrogen fertilization at three maturity stages. Flaccidgrass responded to nitrogen applications up to 100 lbs/acre, when cut in the vegetative stage, and up to 300 lbs/acre, when cut in the boot or anthesis stages of maturity. Nutritive value of the forage, in terms of increased crude protein (CP) and decreased neutral detergent fiber (NDF), was improved by nitrogen application. Increasing maturity at cutting, however, decreased nutritive value—as evidenced by reduced in vitro true organic matter disappearance (IVTOD) and CP and increased NDF and its constituent fiber fractions—but still averaged 60.4% IVTOD at anthesis. Flaccidgrass has potential to provide forage of greater nutritive value in animal production systems that will promote greater daily animal responses.

Introduction

Animal production systems of the upper South are favored by productive, warm-season grasses that maintain acceptable nutritive value during the growing season. Maintenance of nutritive value becomes critically important when greater daily productive responses are desired. Generally, hybrid bermudagrass has served this role when grown as a component of a pasture system. Although productive and responsive to nitrogen fertilization, forage of bermudagrasses adapted to the region is only moderate in nutritive value. The availability of a productive, perennial, warm-season grass with greater nutritive value would be an asset as a component of an animal production system.

Flaccidgrass (*Pennisetun flaccidum* Griseb.), an introduced, perennial, subtropical (C4) grass that is widely adapted to the eastern United States, has been shown to be productive and to maintain greater nutritive value than bermudagrass (Burns et al., 1998a,b). Our objectives in this experiment were to: (1) determine the dry matter yield response of flaccidgrass over a range of nitrogen applications for several defoliation frequencies, and (2) evaluate the subsequent associated changes in nutritive value.

Materials and Methods

Two long-term, well established stands of 'Carostan' flaccidgrass served as the experimental sites. One site was located west of Raleigh at the Reedy Creek Road Field Laboratory, and the other site was located south of Raleigh at the Lake Wheeler Road Field Laboratory. Both sites had a Cecil clay loam soil. The summer prior to initiation of this two-year experiment, the areas were uniformly fertilized and harvested. The following late winter, the areas were burned off in mid-February, clipped to remove all carry-over growth, and the experiment was laid out in a split-plot design with four replicates. Whole plots (each 15 feet wide by 20 feet long) consisted of nitrogen rates, and subplots (5 feet wide by 20 feet long) consisted of maturity stages. Six nitrogen rates were evaluated, consisting of 0, 100, 200, 300, 400, and 500 lbs/acre of actual nitrogen, and assigned at random to a whole plot. Ammonium nitrate was the source of nitrogen, the quantity of actual nitrogen to be applied on each treatment was divided by four, and equal applications occurred within each treatment. Applications occurred each year on approximately April 1, May 17, July 1, and August 15. The three subplots were randomly assigned one of three maturity stages consisting of a vegetative stage (VS, cut when 20 inches back to a 2-inch stubble), a boot stage (BS, cut at boot to a 3-inch stubble), and an anthesis stage (AS, cut at anthesis, [i.e., pollen shedding] to a 3-inch stubble). Six feet separated each whole plot within a replicate to avoid potential cross-nitrogen contamination, and each replicate was laid out based on land slope with a 5-foot alley between replicates. The experiment was conducted over two years followed by a third year to assess residual (carryover) soil nitrogen status. In the third year, no nitrogen was applied to the experimental areas, and the plot area at each location was uniformly cut three times to a 3-inch stubble. This occurred on May 28, July 14, and September 2 at location 1 and on June 1, July 16 and September 3 at location 2. Otherwise, the same cutting and sampling procedures were maintained.

All treatments were cut with a 24-inch sickle mower set to the appropriate stubble height. The forage was raked up, weighed, and subsamples were taken for dry matter and nutritive value determinations. The sample for dry matter determination was placed in a cloth bag, oven dried at 170°F, and used to determine dry matter per plot. A second subsample was quick frozen in liquid nitrogen in the field, freeze dried, ground to pass through a 1mm screen, and stored in a freezer (-16°F) until analyzed for nutritive value in the laboratory. Nutritive value estimates included in vitro true organic dry matter disappearance (IVTOD) and total nitrogen and nitrate nitrogen (NO3-N)—both expressed on an organic matter basis—and neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose (CELL), and lignin. Crude protein (CP) was determined by multiplying total nitrogen by 6.25, and CELL was determined by difference. Wet chemistry was used to estimate NO3-N, whereas wet chemistry was used for the other constituents only to develop calibration equations in association with their prediction using near-infrared spectroscopy (NIRS).

Data were statistically analyzed as a split-plot design over locations and years for the two-year experiment and over locations only for the third year when estimating residual nitrogen influences. Least square means are presented from the application of mixed model methodology. Means for all variables were compared for nitrogen rate, using trend analysis, and for maturity stage by a set of orthogonal contrasts within the analysis of variance.

Results and Discussion

Dry Matter Yield

As expected, and well documented in existing literature, both nitrogen application and maturity stage at harvest are very influential factors in altering forage dry matter yield and its nutritive value. This is also evident for flaccidgrass, as dry matter yield in this study increased from 5,218 pounds per acre at zero nitrogen application to 10,080 pounds per acre when topdressed at 300 lbs/acre, with some slight reduction at or above 400 lbs/acre of nitrogen, resulting in a significant cubic response (Table 1). Also, delayed cutting significantly increased dry matter yield from 6,813 pounds per acre at the vegetative stage to 10,804 pounds per acre at anthesis. A nitrogen rate × maturity stage interaction was noted for yield and is attributed to the lack of parallel changes among maturity stages within each nitrogen rate (Appendix Table 1). The noted exception was at the 100 lbs/acre nitrogen rate, where yield at the boot stage declined compared with the vegetative stage.

Not surprisingly, height at cutting generally reflected dry matter yields increasing some from about 33 inches at zero nitrogen to about 37 inches at the 500 lbs/acre rate (Table 1). As expected, the greatest height differences were noted for maturity stage, averaging 26.2 inches at vegetative and 45 inches by anthesis. The significant nitrogen rate × maturity stage interaction is attributed to a lack of parallel changes among maturity stages from one nitrogen rate to another but with no crossovers occurring (Appendix Table 1).

Nutritive Value

All estimates of nutritive value for flaccidgrass were altered by both nitrogen rate and maturity stage (Table 1). The most important observed changes included the substantial increases in CP and NO3 –N concentrations with increasing nitrogen application. Both variables showed a significant quadratic response increasing from the zero to the 300 or 400 lbs/acre nitrogen application, with subsequent modifications in the increases thereafter. Estimates of IVTOD and NDF, and its constituent fiber fractions, were more variable, giving cubic responses to increasing nitrogen applications with changes being rather meager.

Table 1. Dry matter yield (Yield), height (Ht), and nutritive value of Carostan flaccidgrass for a range of nitrogen application rates at three maturity stages (dry matter basis).

Treatment	Plant		Forage Nutritive Value[1]						
	Yield	Ht	IVTOD	CP	NO_3-N	NDF	ADF	CELL	Lignin
	lbs/acre	inches	------------------------------ % ------------------------------						
Nitrogen Rate (lbs/acre):									
0	5,218[2]	32.7	69.6	7.6	0.010	67.9	37.0	32.6	3.97
100	8,540	36.8	67.4	9.4	0.019	67.5	37.5	32.6	4.47
200	9,682	37.4	67.0	12.0	0.039	66.5	37.1	32.0	4.63
300	10,080	37.0	67.8	13.8	0.070	65.3	36.4	31.1	4.64
400	9,880	36.7	67.9	15.5	0.104	64.3	35.7	30.6	4.64
500	9,929	36.8	68.2	16.2	0.134	64.0	35.7	30.5	4.67
Maturity Stage:									
Vegetative (VS)	6,813[3]	26.2	77.1	16.0	0.087	61.7	32.9	29.0	3.41
Boot (BS)	9,048	37.4	66.5	12.0	0.066	66.8	37.4	32.2	4.56
Anthesis (AS)	10,804	45.0	60.4	9.4	0.035	69.2	39.4	33.5	5.54
Significance (*P*):									
Nitrogen Rate (NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Linear	<0.01	<0.01	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Quadratic	<0.01	<0.01	<0.01	<0.01	<0.01	0.92	0.05	0.92	<0.01
Cubic	0.03	0.01	0.01	0.06	0.14	0.01	<0.01	<0.01	0.01
Quartic	0.79	0.47	0.45	0.63	0.74	0.87	0.93	0.83	0.61
Maturity Stage (MS)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
VS vs. (BS + AS)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
BS vs. AS	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NR x MS	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

[1] IVTOD = in vitro true organic matter disappearance; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; CELL = cellulose.
[2] Each value is the mean of three maturity stages, two years, two locations, and four replicates (n = 48).
[3] Each value is the mean of six nitrogen rates, two years, two locations, and four replicates (n = 96).

Maturity stage at harvest also altered all nutritive value concentrations and is consistent with reduced nutritive value with increasing plant maturity (Table 1). Concentrations of IVTOD, CP, and NO3 –N decreased from the vegetative to the anthesis stage, whereas NDF and its constituent fiber fractions increased. As noted above for dry matter yield, the nitrogen rate × maturity stage interaction was consistently significant. This was again attributed to a lack in parallel changes among the maturity stages from one nitrogen rate to another (Appendix Table 1).

Assessment of Residual Soil Nitrogen

The potential of nitrogen remaining in the soil after the growing season, especially at the greater nitrogen rates, was assessed the year following this two-year experiment. In the third year, dry matter yield and the associated estimates of nutritive value of the forage were obtained from each plot as done during the two-year experiment but without nitrogen application and under three uniform cuts. The residual nitrogen effect is evident as yields increased by some 4,186 pounds per acre from an average of 6,830 pounds per acre at the zero nitrogen application up to the 500 lbs/acre rate (Table 2). Delaying maturity at cutting under these residual conditions from the vegetative stage to the boot stage did not increase dry matter yield, whereas delaying until anthesis did.

Although uniform cuts were taken, heights of the forage increased linearly from the residual zero to the 500 lbs/acre nitrogen rate, but the range (41 to 44 inches) was small (Table 2). Height differences at cutting among the maturity stages were significant, but again, the range (42 to 44 inches) was small and of little importance.

The nutritive value of the growth from the residual nitrogen was generally altered for IVTOD, CP, and NO3 –N, with the former declining in response to increased yield and the latter two increasing in response to increasing residual nitrogen (Table 2). The NDF and its fiber constituents showed little response. The maturity effect of growth from the residual nitrogen on nutritive value was evident only for IVTOD and lignin concentrations with IVTOD decreasing and lignin concentrations increasing from the vegetative to the anthesis stage.

Table 2. Residual nitrogen influence on dry matter yield (Yield), height (Ht), and associated nutritive value of Carostan flaccidgrass following two years of nitrogen application and cut at three maturity stages (dry matter basis).

Treatment[2]	Plant		Forage Nutritive Value[1]						
	Yield	Ht	IVTOD	CP	NO_3-N	NDF	ADF	CELL	Lignin
	lbs/acre	inches	%						
Nitrogen Rate (lbs/acre):									
0 (0)	6,830[3]	41.6	72.3	9.2	0.040	67.6	37.6	35.3	4.01
0 (100)	6,894	40.9	70.9	9.8	0.061	67.9	37.6	33.0	4.14
0 (200)	7,487	43.2	70.8	10.1	0.045	67.7	37.6	33.0	4.23
0 (300)	8,709	43.2	70.0	10.0	0.049	67.8	37.8	33.2	4.25
0 (400)	9,553	43.8	68.3	10.8	0.079	67.9	37.9	33.2	4.42
0 (500)	11,013	44.4	67.1	11.4	0.095	67.7	38.1	33.2	4.62
Maturity Stage (MS):									
Vegetative (VS)	8,199[4]	41.9	70.4	10.1	0.067	67.6	37.6	33.0	4.16
Boot (BS)	8,209	43.0	69.8	10.3	0.059	67.8	37.8	33.2	4.30
Anthesis (AS)	8,834	43.7	69.4	10.3	0.059	67.9	38.0	33.3	4.38
Significance (P):									
Nitrogen Rate (NR)	<0.01	0.02	<0.01	<0.01	0.06	0.96	0.55	0.93	<0.01
Linear	<0.01	<0.01	<0.01	<0.01	0.01	0.99	0.07	0.88	<0.01
Quadratic	0.05	0.96	0.25	0.38	0.23	0.55	0.44	0.53	0.27
Cubic	0.65	0.57	0.51	0.29	0.49	0.86	0.84	0.45	0.25
Quartic	0.69	0.24	0.19	0.57	0.19	0.47	0.91	0.75	0.75
Maturity Stage (MS)	0.01	<0.01	0.03	0.42	0.37	0.48	0.10	0.32	<0.01
VS vs. (BS + AS)	0.12	<0.01	0.01	0.19	0.16	0.24	0.07	0.16	<0.01
BS vs. AS	0.01	0.01	0.35	0.94	0.98	0.78	0.23	0.60	0.15
NR x MS	0.07	0.01	0.22	0.64	0.04	0.14	0.13	0.32	0.05

[1] IVTOD = in vitro true organic matter disappearance; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; CELL = cellulose.
[2] 0 (100) indicates no nitrogen was applied in this residual year to the 100 lbs/acre nitrogen rate treatment during the previous two-year experimental period.
[3] Each value is the mean of three maturity stages, two locations, and four replicates (n = 24).
[4] Each value is the mean of six nitrogen rates, two locations, and four replicates (n = 48).

Summary

- Carostan flaccidgrass was responsive to nitrogen fertilization up to about 100 lbs/acre of nitrogen when cut at the vegetative stage (20 inches of growth) and up to about 300 lbs/acre at the boot and anthesis stages.
- Nitrogen fertilization increased CP and NO3 –N, changed IVTOD little, and reduced NDF.
- Forage cut in the vegetative stage yielded least but was greatest in nutritive value.
- Sufficient residual soil nitrogen was present in the year following the previous two-year experiment to increase dry matter yield some 4,183 pounds per acre from the zero nitrogen rate to the previous 500 lbs/acre nitrogen rate.
- Carostan flaccidgrass is a desirable, perennial, warm-season grass that, if properly managed, has potential for use in an animal production enterprise that requires a productive forage of greater nutritive value.

Appendix

Appendix Table 1. Dry matter yield (Yield), height (Ht), and nutritive value for the nitrogen rate (Nitrogen) × maturity stage (Stage) interaction (dry matter basis).

Treatment		Plant		Forage Nutritive Value[1]						
Nitrogen	**Stage[2]**	**Yield**	**Ht**	**IVTOD**	**CP**	**NO_3-N**	**NDF**	**ADF**	**CELL**	**Lignin**
(lbs/acre)		lbs/acre	inches	------------------------------ % ------------------------------						
0	VS	4,066[3]	24.3	77.7	9.7	0.011	64.8	34.6	30.9	3.05
	BS	5,164	33.9	67.7	7.2	0.010	68.9	37.8	33.2	4.14
	AS	6,425	39.7	63.5	6.0	0.008	70.1	38.7	33.7	4.71
100	VS	8,499	30.3	75.0	12.1	0.027	64.1	34.5	30.5	3.59
	BS	7,830	37.4	67.4	9.4	0.021	68.1	38.0	33.1	4.34
	AS	9,291	42.7	59.8	6.7	0.010	70.4	40.0	34.2	5.48
200	VS	7,201	25.5	75.8	15.2	0.051	62.3	33.4	29.3	3.54
	BS	9,511	39.3	65.5	12.1	0.049	67.3	37.8	32.4	4.73
	AS	12,332	47.4	60.0	8.8	0.019	70.0	40.1	34.2	5.60
300	VS	7,126	26.0	77.5	18.0	0.104	60.6	32.3	28.2	3.47
	BS	10,336	38.3	66.4	13.0	0.069	66.4	37.2	31.9	4.59
	AS	12,780	46.8	59.5	10.5	0.037	69.0	40.0	33.4	5.86
400	VS	6,880	25.6	78.3	19.9	0.148	59.5	31.5	27.6	3.39
	BS	10,483	37.0	66.0	15.0	0.110	65.1	36.6	31.1	4.75
	AS	12,277	47.5	59.5	11.7	0.054	68.2	39.0	33.1	5.77
500	VS	7,104	25.6	78.4	20.9	0.182	59.2	31.4	27.5	3.43
	BS	10,965	38.5	66.2	15.1	0.136	65.3	36.9	31.4	4.79
	AS	11,717	46.1	60.1	12.7	0.083	67.4	38.8	32.6	5.79

[1] IVTOD = in vitro true organic matter disappearance; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; CELL = cellulose.
[2] Stage (S) = vegetative (VS), boot (BS), and anthesis (AS).
[3] Values are the mean of two locations, two years, and four replicates (n = 16).

References

Burns, J.C., D.S. Fisher, R.D. Mochrie, K.R. Pond, and D. H. Timothy. 1998a. Daily animal gains and acre productivity of flaccidgrass compared with tall fescue, bermudagrass, and switchgrass. p. 39-44. In Carostan Flaccidgrass: establishment, adaptation, production, forage quality, and utilization. Tech. Bull. 313. North Carolina Agricultural Research Service, North Carolina State University, Raleigh, NC

Burns, J.C., R.D. Mochrie, and D. H. Timothy. 1998b. Dry-matter intake and digestibility of flaccidgrass hay compared with bermudagrass and switchgrass hays. p. 44-46. In Carostan Flaccidgrass: establishment, adaptation, production, forage quality, and utilization. Tech. Bull. 313. North Carolina Agricultural Research Service, North Carolina State University, Raleigh, NC.

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