Nutritive Value of Crabgrass Harvested on Seven Dates in Northern Arkansas

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Story in Brief

Common crabgrass has been largely viewed as an unwanted weed because of its encroachment into field crops, gardens, and yards. It is undesirable in bermudagrass [*Cynodon dactylon* (L.) Pers.] hay fields because of slower drying which causes concerns about potential spontaneous heating and molding in hay. Visual observations and circumstantial evidence indicate that livestock prefer crabgrass to many other summer forages. Common crabgrass was harvested weekly between July 11 and August 22, 2001 to assess the nutritive value of leaf, stem and whole-plant tissue. The percentage of leaf decreased in linear ($P < 0.0001$), quadratic ($P = 0.0003$), and cubic ($P = 0.032$) patterns over sampling dates from 46.6% on July 11 to 28.4% on August 8. In general, concentrations of neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose, cellulose and lignin in whole-plant tissue increased linearly ($P \leq 0.013$) over sampling dates; a quadratic effect was observed for hemicellulose ($P = 0.006$), and a quartic effect ($P = 0.034$) was observed for lignin. Whole plant concentrations of N declined linearly ($P = 0.001$) from 3.36 to 2.55%. Crabgrass samples were evaluated for in situ disappearance of DM in five (843 ± 50 lb) ruminally cannulated steers. Crabgrass exhibited a more rapid ruminal disappearance rate than bermudagrass ($P < 0.0001$) and orchardgrass (*Dactylis glomerata* L.) hays ($P = 0.002$), but this rate was not as fast ($P < 0.0001$) as observed for alfalfa (*Medicago sativa* L.). The effective ruminal disappearance of DM was greater ($P < 0.0001$) for crabgrass than alfalfa, bermudagrass, and orchardgrass hays.

Introduction

Crabgrass evolved in Africa, but was inadvertently brought to the United States by Europeans. It is believed that the United States Patent Office imported crabgrass in 1894 as a way to provide forage for farm animals. Crabgrass has been viewed largely as an unwanted weed because of its encroachment into field crops, gardens, and yards (Dalrymple, 1999). It is undesirable in bermudagrass fields because it dries slower than bermudagrass; this causes concerns about potential spontaneous heating and molding in hay, and bales with significant amounts of crabgrass are unacceptable to the equine industry. However, visual observation and circumstantial evidence indicate that livestock prefer crabgrass to many other summer forages, and cattle often exhibit good summer performance when consuming this forage. Our objectives in this study were to determine the nutritive value and in situ disappearance kinetics of DM for common crabgrass harvested on weekly intervals throughout the summer.

Experimental Procedures

Collection of Experimental Forages. An existing stand of crabgrass was divided into four 12 x 24-ft field blocks and was fertilized with ammonium nitrate at a rate of 60 lb actual N/acre. In the summer of 2001, crabgrass was harvested by clipping two 0.25-m^2 frames per block to a 1-in stubble height with garden shears. For each frame, canopy height was measured at three random locations and three randomly selected plants were evaluated for growth stage. Forage samples were dried under forced air at 122°F and dry weights for each frame were converted to a per acre basis as an estimate of DM yield. Leaves were separated from the stem by separating each leaf at the collar. Crabgrass plots were clipped weekly beginning on July 11, 2001, and ending on August 22.

Laboratory Analysis. Dried crabgrass samples were ground through a 1 or 2-mm screen in a Wiley Mill (Arthur H. Thomas, Philadelphia, PA). Subsamples ground through the 1-mm screen were analyzed sequentially for neutral-detergent fiber (NDF), acid-detergent fiber (ADF), cellulose, acid detergent lignin, and ash by the batch procedures outlined by ANKOM Technology Corp. (Fairport, NY). Sodium sulfate and α-amylase were omitted from the neutral detergent solution. Concentrations of N were determined by rapid combustion (1574°F; LECO Model FP-428; LECO Corp., St. Joseph,MI); CP was calculated as the percentage of N in the sample x 6.25. Plant ash was determined by combustion of 2-g samples of each forage at 932°F for 8 h in a muffle furnace. The subsamples ground through a 2-mm screen were retained for in situ analysis.

In Situ Procedures in Confinement. Five (843 ± 50 lb) ruminally cannulated crossbred (Angus x Brangus x Gelbvieh) steers were used to determine in-situ DM disappearance kinetics of common crabgrass. The cannulations and care of the steers were approved by the University of Arkansas Animal Care and Use Committee. Each steer was housed in individual 11 x 16-ft pens with concrete floors that were cleaned regularly. Steers were offered a diet of alfalfa hay (16.1% CP, 51.9% NDF, and 38.7% ADF) and a corn-based supplement (94.7% cracked corn, 3% molasses, and 2.3% trace mineral salt). On a DM basis, the basal diet contained 85.7% alfalfa hay and 14.3% supplement, and was offered in equal portions (0630 and 1430 h) at 2.0% of BW daily. Fresh water was offered on an ad libitum basis. Steers were adapted to the basal diet for 10 days prior to initiating the trial. The alfalfa, bermudagrass, and orchardgrass controls were harvested as small square bales at the Forage Research Area in Fayetteville. All bales were made during the spring and summer of 2002 and exhibited no evidence of spontaneous heating or molding. Slices were taken from the center of each bale and ground through a 2-mm screen prior to in situ analysis. In general, the bermudagrass hay (62.1% NDF, 27.0% ADF, and 17.1% CP) had excellent nutritional value, but the alfalfa (51.9% NDF, 38.7% ADF, and 16.1% CP) and orchardgrass (67.2% NDF, 34.9% ADF, and

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12.3% CP) had moderate nutritional value. In situ procedures were consistent with the standardized technique described by Vanzant et al. (1998). Five-g samples of each forage were placed into dacron bags and pre-incubated in tepid water at 102°F for 20 min. Samples were then incubated in the rumen for 3, 6, 9, 12, 24, 36, 48, 72, or 96 h, and subsequently rinsed in a top-loading washing machine (Coblentz et al., 1997). A separate set of bags were pre-incubated and rinsed without ruminal incubation (0 h).

Data were fitted to the nonlinear regression model of Mertens and Loften (1980) using PROC NLIN of SAS (SAS Inst., Inc., Cary, NC). Dry matter was partitioned into three fractions based on relative susceptibility to ruminal disappearance. The A fraction was defined as the immediately soluble portion; the B fraction represented that portion of DM that disappeared at a measurable rate; and fraction C was defined as the portion of DM that was undegradable in the rumen. Fractions B and C, disappearance rate (k_d), and the discrete lag time were determined directly by the nonlinear regression model. For each forage, fraction A was calculated as 100 – (B + C); similarly, the potential extent of disappearance was calculated as 100 – C. For all forages, the degradability of DM was calculated as A + B x $[k_d/(k_d + k_p)]$, where k_p = passage rate (0.035/h).

Statistics. Agronomic characteristics and nutritive value of experimental forages were analyzed as a randomized block design with field blocks (n = 4) as replications and seven harvest dates as the treatment term. Harvest dates were evaluated by single degree of freedom orthogonal contrasts for linear, quadratic, cubic, and quartic effects of time. Disappearance kinetics of DM for crabgrass harvested on seven dates and alfalfa, orchardgrass, and bermudagrass hay controls were evaluated as a randomized complete block design with the five steers as blocks. Single degree of freedom contrasts were utilized to evaluate the effects of harvest date on the disappearance kinetics of crabgrass and to compare crabgrass with the control hays.

Results and Discussion

Agronomic Characteristics of Crabgrass. On July 11, stem elongation had reached the three-node stage with an associated DM yield of 3,079 lb/acre (Table 1). By July 25, the flag leaf sheath was swollen, and inflorescence was ready to emerge. At this time, the DM yield was 3,404 lb/acre. On the final harvest date, the average growth stage was the milk stage of seed development, and the associated DM yield was 3,752 lb/acre. Rainfall events in August triggered development of new tillers; therefore, the average growth stage on the final harvest date included fully mature tillers and other, less-developed tillers. Canopy height increased linearly ($P < 0.0001$) across harvest dates, ranging from a starting height of 11.2 inches to an ending height of 18.5 inches on August 22. The percentage of leaf decreased with significant linear ($P < 0.0001$), quadratic ($P = 0.0003$), and cubic ($P = 0.032$) trends over sampling dates from 46.6% on July 11 to 28.4% on August 8, but increased to 35.3% by August 22.

Nutritive Value of Crabgrass. In general, fiber contents (NDF, ADF, hemicellulose, cellulose and lignin) in whole-plant tissue increased linearly ($P \leq 0.013$) over sampling dates; a quadratic effect was observed for hemicellulose ($P = 0.006$), and a quartic effect ($P = 0.034$) was observed for lignin (Table 2). Leaf fiber contents (NDF, ADF, hemicellulose, cellulose and lignin) increased linearly ($P \leq 0.048$) over sampling dates; a quadratic effect was also observed for NDF, ADF, and cellulose ($P \leq 0.002$). In addition, a cubic effect was observed for NDF and hemicellulose ($P \leq 0.034$), and a quartic effect ($P = 0.002$) for hemicellulose. Concentrations of NDF, ADF, hemicellulose and lignin in the stem increased linearly ($P \leq 0.014$) over sampling dates; in addition, cubic effects ($P \leq 0.027$) were observed for NDF and ADF. Cubic and quadratic effects ($P = 0.049$) were observed for cellulose.

Leaf N (Table 2) declined linearly ($P < 0.0001$) throughout the harvest dates from 3.80 to 3.13%. On August 1, concentrations of N increased from 3.40 to 3.68%; this can probably be explained on the basis of new tiller development following a total of 1.3 in of rainfall that fell between July 25 and July 30. Concentrations of N in stem tissue declined linearly ($P = 0.002$) across the harvest dates, ranging from 3.31 to 2.42%. Whole plant concentrations of N declined linearly ($P = 0.001$) from 3.36 to 2.55% over the sampling dates.

Disappearance Kinetics. Fraction A declined in linear ($P = 0.001$), quadratic ($P = 0.001$) and quartic ($P = 0.012$) trends with harvest dates (Table 3). Fraction B decreased over harvest dates from 54.7 to 52.2% in linear, quadratic, and quartic ($P \leq 0.001$) trends. In contrast, fraction C increased from 12.2 to 16.2% over harvest dates in linear, quadratic, cubic, and quartic ($P \leq 0.043$) patterns. Crabgrass had a greater fraction A and B ($P < 0.0001$), and a smaller fraction C ($P < 0.0001$) than alfalfa. Alfalfa had a higher proportion of DM in fraction C which can potentially be explained on the basis of alfalfa having more lignin (7.6%), than crabgrass (overall range for whole plant = 1.89 to 2.90%; Table 2). Crabgrass had a more rapid disappearance rate than bermudagrass ($P < 0.0001$) and orchardgrass hays ($P = 0.002$); in contrast, alfalfa had a faster rate than crabgrass ($P < 0.0001$). The potential extent of disappearance was higher ($P < 0.0001$) for crabgrass than for alfalfa and orchardgrass hays, but there was no difference between crabgrass and bermudagrass ($P = 0.123$). The effective ruminal degradability of DM was greater ($P < 0.0001$) for crabgrass than for alfalfa, bermudagrass, and orchardgrass hays.

Implications

The effective ruminal degradability of DM for crabgrass was between 3.1 to 9.3 percentage units greater than the bermudagrass hay utilized in this study. This indicates that crabgrass offers improved ruminal digestibility over bermudagrass hay and should support greater animal performance. Crabgrass appears to have good nutritive value and offers considerable promise as a forage alternative during the summer months in the upper South.

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Table 1. Agronomic characteristics of crabgrass forages harvested during 2001 near Prairie Grove, AR.

Harvest date	Growth stage	DM yield	Canopy height	Leaf percentage
		lb/acre	Inch	%
July 11	stem elongation - 3 nodes	3079	11.2	46.6
July 18	Flag leaf emerging	2783	11.2	45.4
July 25	flag leaf sheath swollen	3404	12.3	37.5
August 1	< 50% inflorescence emerged	3463	14.3	38.0
August 8	< 50% inflorescence emerged	3183	13.1	28.4
August 15	milk stage	4138	17.8	35.0
August 22	milk stage	3752	18.5	35.3
SEM[1]		243	0.96	1.45
Effect[2]		L = 0.003	L < 0.0001	L < 0.0001
				Q = 0.0003
				C = 0.032

[1] Standard error of the mean.

[2] L, linear effect; Q, quadratic effect; C, cubic effect.

Table 2. Nitrogen and fiber characteristics of leaf, stem, and whole-plant fractions for crabgrass forages harvested during 2001 near Prairie Grove, AR.

Harvest date	N[1]	NDF	ADF	Hemicellulose	Cellulose	Lignin
	------------	------------	------------	% of DM	------------	------------
Leaf						
July 11	3.80	48.7	24.2	24.5	22.0	1.61
July 18	3.62	48.7	22.9	25.8	21.1	1.54
July 25	3.40	48.9	22.9	26.0	20.9	1.45
August 1	3.68	51.0	24.6	26.4	21.7	2.30
August 8	3.36	51.0	22.2	28.8	20.3	1.63
August 15	3.21	54.6	25.0	29.6	22.5	2.51
August 22	3.13	54.6	25.1	29.5	22.3	2.21
SEM[2]	0.110	0.37	0.30	0.28	0.29	0.197
Effect[3]	L < 0.0001	L < 0.0001	L = 0.002	L < 0.0001	L = 0.048	L = 0.002
		Q=0.002	Q = 0.0002	C = 0.031	Q = 0.001	
		C = 0.034		Qu = 0.002		
Stem						
July 11	3.31	59.5	31.7	27.8	29.2	2.15
July 18	2.98	57.0	28.4	28.6	26.4	1.75
July 25	2.61	60.1	30.4	29.7	27.4	2.62
August 1	3.10	62.2	32.3	29.9	28.8	2.98
August 8	2.81	61.3	30.0	31.3	27.1	2.60
August 15	2.53	64.2	33.1	31.1	29.2	3.39
August 22	2.42	63.7	32.0	31.7	28.7	3.02
SEM[2]	0.173	0.67	0.68	0.42	0.55	0.168
Effect[3]	L = 0.002	L < 0.0001	L = 0.014	L < 0.0001	Q = 0.049	L < 0.0001
		C = 0.026	C = 0.027		C = 0.049	
Whole plant						
July 11	3.36	55.5	29.4	26.1	26.4	2.35
July 18	3.07	55.6	27.5	28.1	25.2	1.89
July 25	2.74	57.4	28.8	28.6	25.9	2.44
August 1	3.05	60.8	31.2	29.6	27.4	2.89
August 8	2.85	58.8	28.9	29.9	26.0	2.60
August 15	2.68	61.9	31.3	30.6	27.2	2.90
August 22	2.55	61.2	30.9	30.3	27.7	2.81
SEM[2]	0.148	0.76	0.60	0.42	0.54	0.151
Effect[3]	L = 0.001	L < 0.0001	L = 0.001	L < 0.0001	L = 0.013	L = 0.0003
				Q = 0.006		Qu = 0.034

[1] Abbreviations: NDF, neutral detergent fiber; ADF, acid detergent fiber; lignin, acid detergent lignin.

[2] Standard error of the mean.

[3] L, linear effect; Q, quadratic effect; C, cubic effect; Qu, quartic effect

Table 3. In situ degradation kinetics of DM for common crabgrass harvested on weekly intervals near Prairie Grove, AR, and compared with alfalfa, bermudagrass, and orchardgrass hay controls.

Forage/harvest date	Fraction A[1]	Fraction B	Fraction C	Potential Extent	Lag time	K_d	Degradability[2]
	% of DM	% of DM	% of DM	% of DM	H	/h	% of DM
Crabgrass (CRAB)							
July 11	33.1	54.7	12.2	87.8	1.57	0.081	71.1
July 18	32.9	55.1	12.0	88.0	1.42	0.084	71.6
July 25	33.9	51.0	15.1	84.9	1.62	0.082	69.4
August 1	33.6	50.4	16.0	84.0	2.41	0.081	68.3
August 8	33.8	50.8	15.4	84.6	1.36	0.071	67.5
August 15	31.3	51.9	16.8	83.2	1.39	0.069	65.4
August 22	31.6	52.2	16.2	83.8	1.73	0.076	67.2
Alfalfa Hay (ALF)	29.4	37.6	33.0	67.0	1.41	0.143	59.3
Bermudagrass Hay (BER)	27.2	58.4	14.4	85.6	2.68	0.054	62.3
Orchardgrass Hay (OG)	21.0	62.1	16.9	83.1	4.00	0.060	60.1
SEM[3]	0.42	0.55	0.23	0.23	0.273	0.0049	0.41
Contrasts	P > F						
CRAB Linear[4]	0.001	< 0.0001	< 0.0001	< 0.0001	0.910	0.051	< 0.0001
CRAB Quadratic	0.001	< 0.0001	< 0.0001	< 0.0001	0.415	0.906	0.052
CRAB Cubic	0.772	0.510	0.043	0.043	0.492	0.088	0.0002
CRAB Quartic	0.012	0.001	0.001	0.001	0.030	0.530	0.562
CRAB vs. ALF	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.433	< 0.0001	< 0.0001
CRAB vs. BER	< 0.0001	< 0.0001	0.123	0.123	0.001	< 0.0001	< 0.0001
CRAB vs. OG	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.002	< 0.0001
ALF vs. BER	0.001	< 0.0001	< 0.0001	< 0.0001	0.002	< 0.0001	< 0.0001
OG vs. BER	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.002	0.350	0.001

[1] Abbreviations: A = immediately soluble fraction, B = fraction disappearing at a measurable rate, C = undegraded fraction, and K_d = disappearance rate.

[2] Calculated as $A + B[(K_d/(K_d + \text{passage rate})]$, where K_d = disappearance rate and the passage rate = 0.035/h.

[3] Standard error of the mean.

[4] Linear, quadratic, cubic, and quartic effects of harvest date on each response variable.