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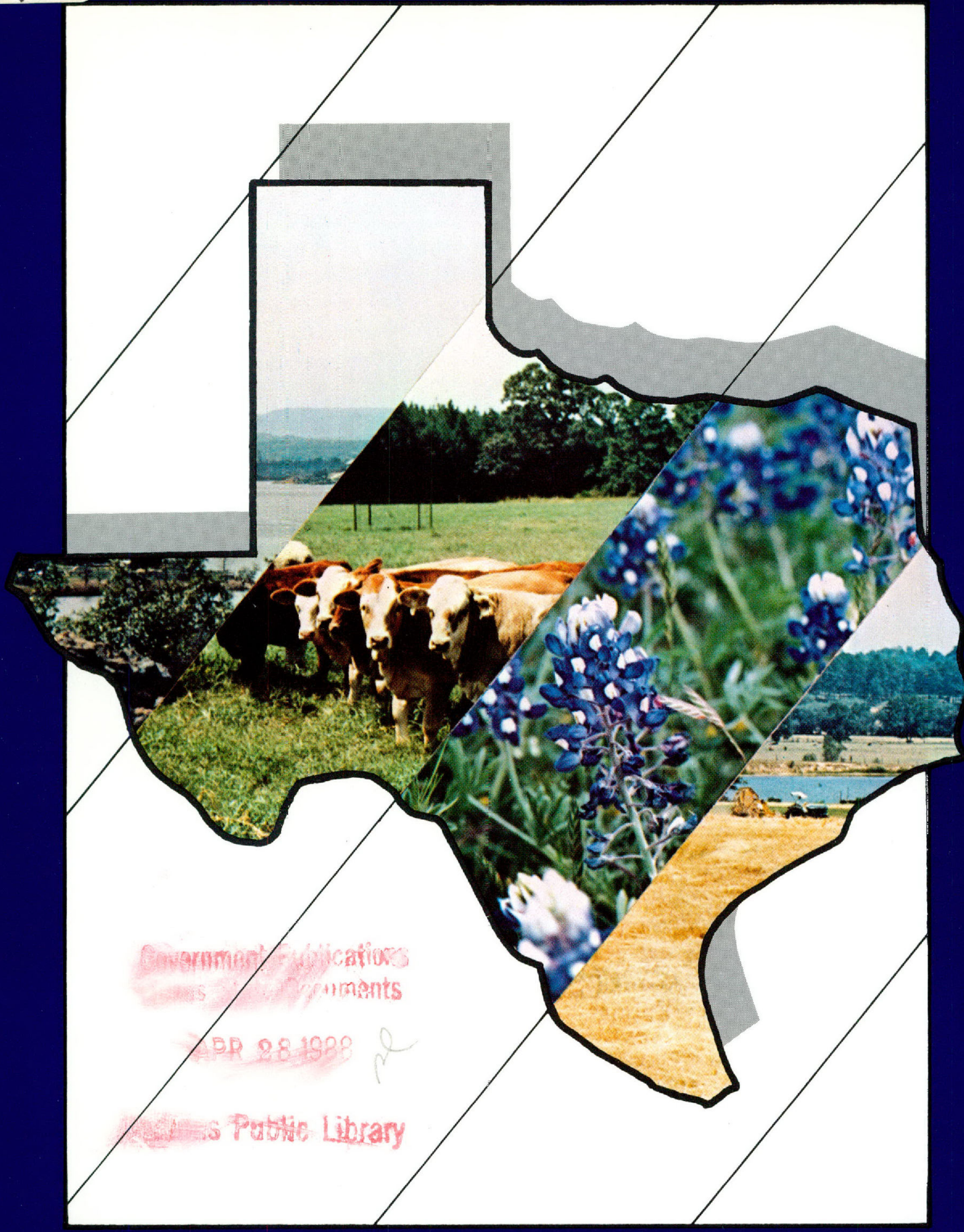

Forage Research In Texas, 1987

THE TEXAS AGRICULTURAL EXPERIMENT STATION / Neville P. Clarke, Director / The Texas A&M University System / College Station, Texas

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Foreword

"Forage Research in Texas" is published annually with the intention of keeping interested producers, researchers, and extension personnel abreast with current forage research in Texas. The publication includes works from the major land resource areas of Texas. Many multi-disciplinary research efforts are enclosed.

Scientists with agricultural expertise from a wide range of disciplines meet annually to discuss and plan research. The primary objective of these studies is to provide information that may help the producer in reducing the risks involved in management decisions related to the soil-plant-animal interactions. An attempt is made to include summaries of research that may be of greatest interest to producers, professional agricultural workers, and other scientists.

On behalf of the Texas Agricultural Experiment Station, let me express my appreciation to the contributors of this cooperative effort.

Neville P. Clarke, Director
Texas Agricultural Experiment Station

Texas Agricultural Experiment Station

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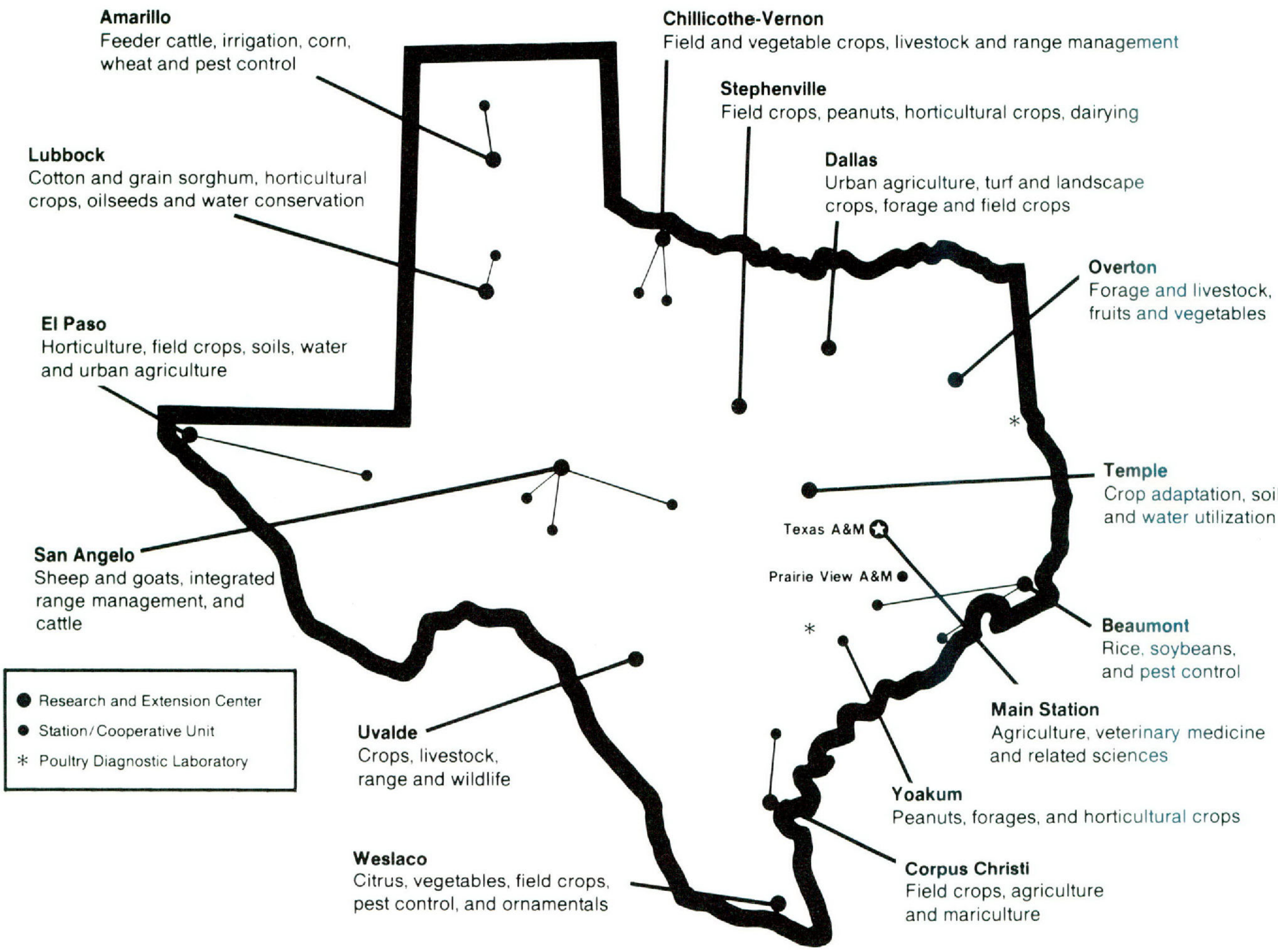

Forage Research In Texas, 1987

Intakes and Digestibilities of Bermudagrass and Sorghum Silages

H. LIPPKE

Summary

Silages from common bermudagrass and a forage sorghum hybrid were fed to yearling steers in intake and digestion trails to determine relative intakes of indigestible neutral detergent fiber (INDF). Average dry matter intakes and digestibilities were similar for the forage portion of the diets. However, INDF intake was 35 percent greater for bermudagrass than for sorghum, indicating a higher ruminal rate of passage of undigested residues for bermudagrass-fed animals.

Introduction

In a series of stall feeding experiments with sorghum silage and fresh or ensiled rygrass conducted at Angleton, yearling cattle were able to consume no more INDF than .4 percent of body weight (Lippke, 1986). As a consequence, dry matter intakes of diets with more than 15 percent INDF content were proportionally less than maximum. The objective of the experiment described here was to determine the relative intake capacity of yearling cattle for INDF from bermudagrass, which commonly has a much higher INDF content than sorghum or ryegrass.

Procedure

A hybrid forage sorghum was harvested in the soft-dough stage of maturity and ensiled in a 6- X 16-ft fiberglass tank. Common bermudagrass with less than 20 percent dallisgrass was harvested in mid-summer, 7 weeks after the previous cutting, and ensiled in two plastic-lined, 5- X 12-ft steel tanks. In each case samples were taken at harvest for determination of dry matter.

Nine-month-old Hereford x Brahman steers that had been weaned for 6 weeks and treated for internal parasites were weighed after a 16-hour fast and placed in individual pens. Five steers (548 lbs) were randomly assigned to receive ad libitum amounts of bermudagrass silage and six steers (523 lbs) were assigned to sorghum silage diets. Data from only the last 10 days of the 16-day intake trial were used to measure intake. Cottonseed meal was fed separately in amounts to bring diet protein content up to 8 percent. Following the intake trial, four steers on each forage were continued in a 7-day digestion trial in which each animal was offered 90 percent of the average amount consumed voluntarily during the intake trial. Details of experimental procedures have been described previously (Lippke, 1980).

Results and Discussion

Both forages were at optimum dry matter content (33 percent) for proper ensiling. Protein content of the sor-

KEYWORDS: Silages/Angleton/intakes/digestibilities.

ghum was very low (Table 1) and required considerable cottonseed meal supplementation to raise diet protein content to 8 percent. This was considered a minimum to prevent protein level from having a major influence on intake.

TABLE 1. COMPOSTION, INTAKE, AND DIGESTIBILITY OF BERMUDAGRASS AND SORGHUM SILAGES

	Forage	
Item	Bermuda	Sorghum
Composition, %		
Protein	7.3	2.8
NDF	67.7	56.9
ADF	34.7	34.7
Cellulose	26.5	26.5
INDF	29.4	21.9
Intake, % of body weight		
Forage dry matter	1.79	1.69
Total dry matter	1.81[a]	1.95[b]
INDF	.58[a]	.43[b]
Digestible dry matter, %	51.6[a]	56.6[b]

Values in the same line with different superscripts are significantly (P<.05) different.

The content of INDF in bermudagrass was typically higher than in sorghum. However, the cattle in this experiment were able to consume significantly greater amounts of INDF from bermudagrass than from sorghum (Table 1). Consequently, average dry matter intakes of the silage portions of the diets were almost the same, although total dry matter intake was significantly higher for sorghum silage. Dry matter digestiblity, though significantly higher for sorghum-containing diets, was reduced three percentage units when the contribution of cottonseed meal was discounted mathematically.

The higher intake of INDF by cattle-fed bermudagrass silage in this experiment is consistent with the conclusion drawn previously (Lippke, 1980) that a higher proportion of hemicellulose (NDF minus ADF) in the cell wall constituents results in more rapid ruminal degradation of cell structure, increased rate of passage from the rumen, and greater fiber intake. Correlations of INDF intake with changes in hemicellulose:cellulose ratio within forage species should be further explored.

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Relationship of Grazing Time To Forage-On-Offer

G. Kanyama-Phiri and B. E. Conrad

Summary

A study on the relationship of time spent grazing by cattle to forage-on-offer was conducted in summer 1986.

Average forage-on-offer differed significantly (P<0.001) between July [152 lbs dm/(cow-calf day^{-1})], and September [123 lbs dm/(cow-calf day^{1}). Conversely, grazing time increased significantly (P<0.001) from 535 minutes,/day^{-1} in July to 778 minutes/day^{-1} in September. Grazing time also increased significantly (P<0.001) as forage-on-offer decreased by days, but not by stocking rates. In general, cattle grazed more actively during the day than during the night. These results suggest an indirect relationship between grazing time and forage-on-offer.

Introduction

Numerous investigations have reported a general tendency for animals to adjust their grazing time in response to changes in forage-on-offer. As forage-on-offer decreases, time spent grazing increases as the animal attempts to meet its forage intake (Allden and Whittaker, 1970; Hein, 1935; Scarnecchia et al, 1985; Jamieson and Hodgson, 1979). Other investigations have further demonstrated that as forage-on-offer becomes limiting, grazing animals will increase grazing time up to a point beyond which any further limitation results in a corresponding decline in grazing time (Chacon and Stobbs, 1976; Chacon et al. 1978; and Hendricksen and Minson, 1980) Thus, under critical shortages of forage-on-offer, animals may not compensate for small bite sizes, consequently, their daily forage intake will be reduced. Other researchers have reported increases in night grazing by dairy cattle under forage limiting conditions (Chacon and Stobbs, 1976; Cowan and O'Grady, 1976). However, Ebersohn et al. (1983), working with beef cattle reported that night grazing contributed only a small percentage to total grazing time.

Procedures

The study was conducted on Coastal bermudagrass [*Cynodon dactylon* (L.) Pers.] pastures at the Texas A&M University Research Farm in the Brazos River Bottom during summer 1986. The soil at the site is described as a ships clay—westwood silt loam intergrade (Udic chromustent-fluvertic ustochrept) (Hons pers. Comm.). Eight bermudagrass pastures were rotationally grazed (7 days grazing-21 days rest) at multiple stocking rates set at 2.7, 3.2, 3.8, and 5.0 cow-calf pairs per acre. The experiment was conducted as a repeated measure, randomized complete block design with two replications per stocking rate.

A double sampling technique described by Kanyama-Phiri and Conrad (1986) and separate regression equa-

KEYWORDS: Grazing time / stocking rates / bermudagrass / forage on offer.

tions were used on a weekly basis in order to predict forage-on-offer.

Three esophageal fistulated steers were fitted with Kienzle vibracorders to measure total time spent grazing each day and the time of day during which grazing occured (grazing time distribution). The time spent grazing as measured in this studv included time spent by the animal searching for forage. Record charts on the vibracorders were changed every 7 days. Interpretation of these charts was done using a 7-day chart analyzer. Grazing time distribution was then expressed in 6-hour increments (0-6, 6-12, 12-18, and 18-24 hours). Statistical analysis procedures were used to document the relationship of grazing time to forage-on-offer.

Similar information is lacking to document the relationship of grazing time to forage-on-offer of bermudagrass. Such information is critical for the proper stocking management for livestock production from bermudagrass pastures in Texas. The objective of this study was, therefore, to investigate the relationship of grazing time to forage-on-offer.

Results and Discussion

Forage-on-offer by days and by stocking rates for July and September are shown in Table 1. Forage-on-offer in September was 25 percent, 15 percent, and 10 percent less, respectively on days 1, 5, and 7 than in July. During both sampling dates there were similar declines in forage-on-offer with increasing stocking rates and time but the degree of utilization was less in September than in July. Grazing time on the other hand did not follow the same pattern (Table 2). The time spent searching for and consuming forage (grazing time) was much greater in September than in July. There were large decreases in the grazing time between day 4 and day 7 for the heavy stocked pastures. The July results appear to be in agreement with the findings of Chacon and Stobbs (1976), Chacon et al. (1978), and Hendricksen and Minson (1980). These authors attributed the decline in grazing time, towards the end of the grazing cycle, to lack of desire by the animals to eat stems. Other investigators have suggested that animals will decrease grazing time

TABLE 1. FORAGE-ON-OFFER BY STOCKING RATES AND DAYS

SR	Forage-on-offer (lbs DM/Cow/Calf) Day 1	Day 4	Day 7	Mean
Cow/Calf/A		July		
5.0	152	54	16	74
3.8	192	126	58	126
3.2	256	148	109	171
2.7	296	239	182	239
Mean	224	142	91	
		September		
5.0	104	67	30	67
3.8	129	76	54	86
3.2	204	155	112	157
2.7	233	188	129	183
Mean	168	121	82	

TABLE 2.GRAZING TIME BY SR AND BY DAYS, MINUTES PER DAY

Stocking rate (Cow/Calf/A)	Grazing Time Day 1	Day 4	Day 7	Means
		July		
5.0	515.5	649.0	408.5	524.3
3.8	533.0	541.5	466.5	513.7
3.2	545.0	595.5	552.0	564.2
2.7	593.0	476.0	640.5	569.8
Means	546.6	565.4	516.9	
		September		
5.0	735.5	781	591	702.50
3.8	833	741	877	817.00
3.2	628	766	777	723.83
2.7	844	841	882	869.00
Means	770.25	782.25	781.75	

towards the end of the grazing cycle in anticipation of being moved into new a pasture (Jamieson and Hodgson, 1979). These two reasons could possibly explain the grazing behavior of animals under the heavy stocking rates. The changes in the grazing behavior in Sepember did not follow this trend. Apparently with bermudagrasses the heavy stem load concept does not exist nor are the animals anticipating being rotated as depicted by the grazing times in September between days 4 and 7. It may be associated with an environmental condition variable that tends to restrict animal movement during hot dry weather. Visual observations indicated that some cows on heavily stocked pastures were forced to wean their calves early when forage-on-offer became limiting. It was also interesting to note that a significant ($P<0.05$) decrease in the average forage-on-offer from 152 lbs DM/(cow-calf day^{-1}) in July to 123 lbs DM/(cow-calf day^{-1}) in September resulted in a highly significant ($P<0.00$) increase in time spent grazing from 543 to 778 minutes/day^{-1}, respectively.

Results of percentage grazing time distribution by quarter of day are presented in Table 3. On the average, the time spent grazing between 0 and 6 a.m. was significantly less than the other quarters. These results appear to be in agreement with those of Ebersohn and Limpus (1983) who reported that steers spent between 12 and 15 percent of total grazing time between midnight and daybreak (0-6 hours). Other researchers have reported that night grazing may increase in dairy cattle because grazing is interrupted by milking schedules during the day.

These results appear to provide inconclusive evidence of a relationship between grazing time and forage-on-offer and that the period of grazing during the season appears to play a significant role in this relationship.

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Influence of Supplemental Protein or Energy on Performance of Calves Grazing Winter Pastures

K. N. Grigsby, F. M. Rouquette, Jr., W. C. Ellis, D. P. Hutcheson, and M. J. Florence

Summary

Forty spring-born Simmental crossbred calves were fall-weaned and placed on rye-ryegrass pastures in mid-February. Calves were blocked by sex and received pasture only (PAS), pasture plus a fishmeal supplement (FIS), pasture plus a corn supplement (CRN), or pasture plus a corn-rumen stable amino acid supplement (CAA). Calves receiving CRN and CAA had average daily gains (ADG) of 3.48 and 3.26, respectively. Both corn supplements produced greater calf ADG than PAS (2.23) and FIS (2.62) supplements. Average daily consumption of the monensin added supplements of FIS, CRN, and CAA was .74, 1.68, and1.60 lbs/hd, respectively. Results from this study indicated that calves were unable to consume sufficient quantities of energy from winter pasture to produce maximum genetic potential gains. The conversion ratio of supplement to increased gain ranged from 1.3 to 1.9 which has encouraging biological as well as economical implications.

KEYWORDS: Protein supplement/corn/amino acid/fishmeal/ryegrass/forage.

Introduction

The humid South is well adapted to producing high quality winter/spring pastures. Although these pastures contain high levels of crude protein (20 to 25 percent), grazing calves often gain at a rate less than their maximum genetic capability. This indicates a possible deficiency in dietary intake of protein and/or energy. Extensive ruminal protein degradation may produce a tissue level protein deficiency which may limit growth. It has also been suggested that the resulting microbial protein may be deficient in the indispensible amino acids, lysine and methionine, which may also be a growth limiting factor. Therefore, the objective of this trial was to determine the influence of supplemental energy and source of protein supplement on stocker calves grazing rye-ryegrass pastures.

Procedure

Forty spring-born, ½ Simmental x ¼ Hereford x ¼ Brahman steers (n = 20) and heifers (n = 20) were weaned on October 2 and grazed on bermudagrass pastures until November 19. On this date, they began receiving 4 lbs/hd/day ground corn, 1 lb/hd/day whole cottonseed, and ad libitum bermudagrass hay. Calves continued to receive this ration until February 13, at which time they were weighed (average 668 lbs), implanted with Ralgro, given a visual condition score (VCS) ranging from 1 to 10, and allotted by weight, and VCS to the following four treatments: (1) 'Elbon' rye-Marshall' ryegrass pasture only (PAS); (2) pasture + low-solubility fishmeal (FIS); (3) pasture + corn (CRN); and (4) pasture + corn and rumen-stable methionine and lysine (CAA).

Each treatment was replicated with five steers (Rep 1) and five heifers (Rep 2). Individual replicates of CRN and CAA were group fed, whereas, Rep 1 and Rep 2 of FIS were combined and fed via Pinpointer 4000 to determine individual daily supplement intake. Therefore, one 6-acre pasture and six 3-acre pastures were grazed in this trial. All groups were fed ad libitum except Rep 2 of CAA, which did not limit voluntary daily intake to the targeted 2 lbs/hd. The FIS, CRN, and CAA supplements contained 37.2, 8.3, and 10.5 percent crude protein, respectively, and monensin at 90 mg/lb (Table 1). Variation in ingredient composition for CAA was due to attempts to regulate voluntary daily intake of CAA by heifers in Rep 2. The FIS and CRN were pelleted; whereas, CAA was fed in a loose form to prevent disruption of the polymer coating on the rumen stable lysine and methionine during the pelleting process. The polymer coating is resistant to rumen pH but sensitive to the more acidic abomasal pH.

TABLE 1. COMPOSITION OF SUPPLEMENTS FED TO CALVES GRAZING RYE-RYEGRASS PASTURES

	Fishmeal	Corn	Corn + AA
		% of DM	
Rolled corn	—	70.00	67.96
Animal fat	—	.98	1.00-5.00
Cane molasses	2.88	2.88	3.00-10.00
Salt	2.94	2.94	0-3.00
Minerals	1.24	10.21	10.50
Rumensin 60	.15	.15	.15
Rumen-stable methionine	—	—	.90
Rumen-stable lysine	—	—	1.17
Fishmeal (Menhaden)	48.50	—	—
Cottonseed hulls	27.00	—	—
Wheat mill run	11.34	—	—
Formulated % Crude Protein	37.2	8.3	10.5
Formulated NEm (mCal/lb)	.59	.85	.84
Formulated NEg (mCal/lb)	.39	.56	.55

Test animals were given a 14-day adjustment period prior to initiation of the grazing trial to allow for adjustment to the high quality forage and the supplement. Calves were weighed on February 27, March 24, April 29, and May 28. The trial was terminated on May 28 (90 days). Each calf was given a final weight and VCS, and was measured for rump fat thickness via ultrasound.

Pastures were fertilized with 50 lbs N/A at 4- to 6-week intervals. Forage on-offer was monitored closely by visual observation and biweekly pasture samples. Pasture samples were taken by hand-clipping four, 1-ft square areas to ground level. Each sample was intended to represent one quarter of the pasture. The level of forage on-offer was equalized across treatments by the put-and-take method. Forage was maintained at a sufficient level to allow animals to graze selectively. Grazer animals were added to pastures on February 27, April 8, and April 29 at various rates and were removed when forage had been consumed to the desired level. The average level of forage on-offer at initiation and termination of the trial was 171 and 138 lbs DM/100 lbs live bodyweight, respectively (Table 2).

Forage samples for chemical analysis were taken biweekly by hand-picking portions of the sward which visually estimated those plant parts selected by the animals. Forage crude protein levels ranged from 20 to 30 percent during the grazing period (Table 3).

Results

The calf average daily gains (ADG) for CRN (3.48) and CAA (3.26) were significantly higher ($P < .01$) than PAS (2.23) and FIS (2.62), but were not different from each other (Table 4). Therefore, rumen-stable methionine and lysine did not increase ADG over that of the corn supplement in this trial. Although there was a .39 lb/day increase in gain due to FIS, FIS was not statistically different from PAS. All supplements were consumed ad libitum except Rep 2 of CAA, which was restricted-fed daily at 2 lbs/hd. Average daily consumption (ADC) for FIS, CRN, and CAA was .74, 1.68, and 1.60 lbs, respectively (Table 4). The magnitude of ADG tended to be related to level of supplement consumption. The increase in gain (IG) due to supplement was defined as the difference in level of ADG of a supplemented treatment and that of PAS. The IG for FIS, CRN, and CAA was .39, 1.25, and 1.03 lbs/hd/day, respectively (Table 4). The supplement:increased gain ratio (ADC:IG) describes the feed efficiency for each supplement, assuming the increase in ADG over PAS was due solely to the nutrient content of the supplement and that there was no effect on forage utilization. The ADC:IG ratio for FIS, CRN, and CAA was 1.89, 1.33, and 1.55, respectively (Table 4). The ADC:IG ratios were below the range considered to be normal for feedlot cattle, indicating an increased forage utilization (i.e., intake, digestibility, or both).

At the beginning of the adjustment period (February 13), VCS were not different for treatments. However, at termination of the 90-day grazing trial, CRN had a

TABLE 2. FORAGE AVAILABLE ON EACH PASTURE AND EXPRESSED AS POUNDS OF DRYMATTER (DM) AVAILABLE/100 POUNDS OF LIVEWEIGHT (BW) OF RYE-RYEGRASS PASTURES

Treatment	2/25	3/5	3/20	4/2	4/17	5/2	5/16	5/18	AVG.
	Date								
	lbs DM/100 lb BW								
PAS	154	155	102	195	147	68	146	189	145
FIS	146	139	82	135	97	77	75	104	107
CRN	146	136	113	177	103	229	107	116	141
CAA	238	229	153	262	155	127	100	144	176
AVG.	171	165	113	192	126	125	107	138	142

TABLE 3. PERCENT CRUDE PROTEIN OF RYE-RYEGRASS PASTURES

Treatment	2/25	3/5	3/20	4/2	4/17	5/2	5/16	5/28	AVG.
	Date								
	Percent								
PAS	24.0	20.2	18.7	30.8	27.0	24.1	24.2	22.9	24.0
FIS	27.0	19.3	19.6	27.6	26.1	21.1	23.0	23.4	23.4
CRN	22.9	21.8	21.6	29.8	26.9	20.1	26.3	24.5	24.2
CAA	23.7	21.0	18.5	29.8	26.6	24.8	25.9	25.0	24.4
AVG.	24.4	20.7	19.6	29.7	26.7	22.5	25.1	24.0	24.0

TABLE 4. AVERAGE DAILY GAIN, CONSUMPTION OF SUPPLEMENT, AND CONVERSION RATIOS OF PROTEIN SUPPLEMENTS FED TO CALVES GRAZING BERMUDAGRASS PASTURES

Average Treatment	Average Daily Gain	Average Daily Consumption	Increased Gain	Supplement: Increased Gain Ratio
	Pounds			lb:lb
PAS	1.03d	0	0	0
PDQ	1.22cd	.43	.19	2.26
FMB	1.20cd	.45	.17	2.65D
DPDQ	1.51b	1.92	.48	4.00
AA	1.40bc	2.21	.37	5.97
FM	1.92a	1.12	.89	1.25

TABLE 5. VISUAL CONDITION SCORE AND RUMP FAT THICKNESS OF CALVES GRAZING RYE-RYEGRASS PASTURES

Treatment	Visual Condition Score*		Rump Fat Thickness
	Initial (d=0)	Final (d=90)	Via Ultrasound inches
PAS	6.10a	6.80a	1.00a
FIS	5.75a	6.95a	1.09a
CRN	5.95a	7.85b	1.21b
CAA	5.85a	7.15a	1.08a

a,b = Means in same column differ, p<.05.
* Visual, 1-10 range with 10 being extreme fat condition.

significantly higher (P<.01) VCS (Table 5). Measurement of rump fat thickness via ultrasound confirmed the results of VCS, as CRN had a higher (P<.01) rump fat thickness than other treatments (Table 5).

Fishmeal was fed via Pinpointer 4000 to determine individual daily supplement intake. Results indicated that ADG was positively related (P<.01) to ADC (ADG = 0.82 + 0.6 ADC; r = .73) of the fishmeal supplement (Figure 1). Results of this trial indicated that calves grazing rye-ryegrass pastures may be deficient in energy or protein intake for maximum weight gain. Although supplemental dietary energy increased ADG, the increase in performance may have been due to an increased efficiency of microbial protein synthesis.

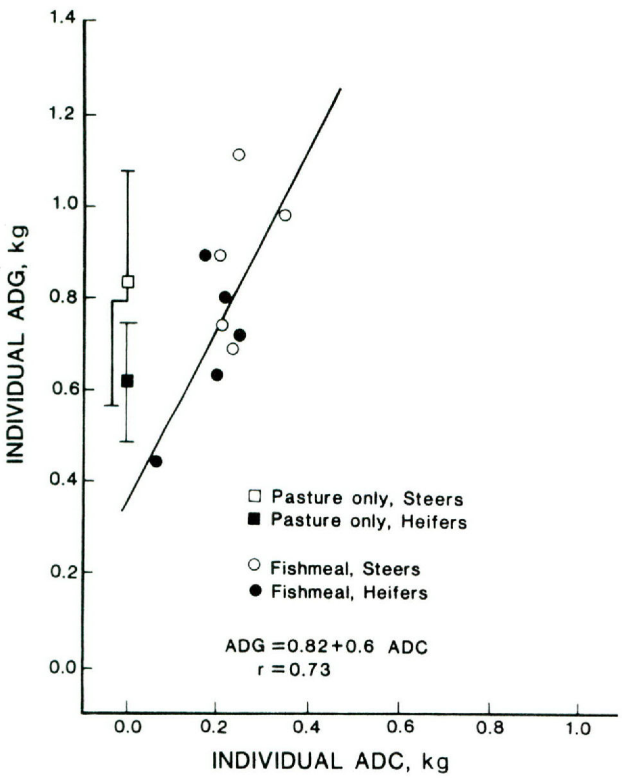

Figure 1. Influence of average daily consumption on average daily gain of steers and heifers.

Protein Supplements for Stocker Calves Grazing Coastal Bermudagrass Pastures

K. N. Grigsby, F. M. Rouquette, Jr., W. C. Ellis, D. P. Hutcheson, and M. J. Florence

Summary

Fall-born, Simmental crossbred calves were weaned in early June and grazed on bermudagrass pasture until early October. In addition to a pasture only treatment, calves received ad libitum access to each of five different protein supplements. Average daily gain (ADG) of calves receiving only pasture was 1.03 lbs and represents a near-normal gain for this fat-conditioned, fall-born calf. Two condensed molasses blocks produced nearly identical calf ADG of 1.2 lbs. A dry formulation of the molasses block produced ADG of 1.5 lbs; however, supplement consumption was increased more than 4-fold. A fishmeal pellet containing monensin and consumed at 1.12 lbs per day produced calf ADG of 1.92 lbs. Although forage protein values were above-normal for this grazing period, animal performance was significantly improved with relatively small amounts of daily protein supplement. Thus, biologically, protein supplements showed to be a positive stimulation of gain for stockers grazing bermudagrass during the mid- to late-summer period.

Introduction

Poor weight gains (< 1 lb/day) from beef calves grazing warm-season perennial grasses suggest a possible protein or energy deficiency. Forage protein has been reported to be degraded to a large extent in the rumen. Therefore, a supplement such as fishmeal which has been reported to be resistent to rumen degradation and essentially "by-passes" the rumen to the other stomach compartments, may increase daily gain of grazing calves. Lysine and methionine may also be limiting growth since microbial protein has been shown to below in these indispensible amino acids. There has long been interest in limiting daily intake of pasture supplements by incorporating them into condensed molasses blocks. The molasses block limits intake due to its physical and chemical form instead of using innutritious ingredients such as salt. The objectives of this grazing study were: 1) to determine the influence of source and level of supplemental protein on performance of growing beef calves grazing Coastal bermudagrass pastures, and 2) to evaluate the condensed molasses block as a method of limiting daily supplement intake.

Procedure

Seventy-two fall-born, ½ Simmental x ¼ Hereford x ¼ Brahman steers (n = 36) and heifers (n = 36) were weaned on June 11, 1986. Each calf was weighed and measured for rump fat thickness (RFT) via ultrasound

KEYWORDS: Protein supplement/bermudagrass/molasses block/fishmeal/by-pass protein.

device. They were blocked by sex and allotted by weight (average 650 lbs) and visual condition score (VCS) to the following six treatments: (1) Coastal bermudagrass pasture with free-choice mineral (PAS); (2) PAS plus a 31.6 percent crude protein (CP), commercially available condensed molasses block containing fish solubles, cottonseed meal, blood meal, meat scraps, and urea as protein sources (PDQ); (3) PAS plus a 32.5 percent CP condensed molasses block containing Menhaden fishmeal, fish solubles, and urea as sources of protein (FMB); (4) PAS plus a 34.2 percent CP dry supplement containing cottonseed meal, fish solubles, urea, and meat scraps as protein sources (DPDQ); (5) PAS plus a 30.7 percent CP dry protein supplement composed of DPDQ containing 1.3 percent rumen-stable methionine (RSmet) and 1.7 percent rumen-stable lysine (RSlys) (AA); and (6) PAS plus 37.2 percent CP dry supplement containing Menhaden fishmeal and monensin (FM).

Calves were allotted by treatment to six feedlot pens and fed ad libitum bermudagrass hay. Calves assigned to PDQ and FMB treatments were given ad libitum access to their respective supplements, while calves allotted to DPDQ, AA, and FM were given 1 lb/hd/day of their respective supplements for 7 days. Calves assigned to the PAS treatment were fed corn at 2 lbs/hd/day and cottonseed meal at one half lb/hd/day during this weaning, drylot period. On June 18, 1986, all calves were implanted with Ralgro, weighed, visually condition-scored (VCS), and placed on Coastal bermudagrass pasture to begin a 7-day pasture-treatment adjustment period to allow the calves to adjust to the forage and supplements. All calves were reweighed on June 25, 1986 to initiate the weight gain-protein supplement trial.

Each treatment was replicated with six steers (Rep 1) and six heifers (Rep 2). Individual replicates of PDQ, FMB, and FM were group fed; whereas, Rep 1 and Rep 2 of DPDQ and AA were combined and fed via Pinpointer 4000 and Pinpointer 5000, respectively, to determine individual daily supplement intake. The trial consisted of two 3.6-acre pastures (DPDQ and AA), six 1.8-acre pastures (PDQ, FMB, and PAS), and two 3.0-acre pastures (FM). All supplements were fed ad libitum. The ingredient composition of each supplement is presented in Table 1. The AA supplement contained RSmet and RSlys which has a polymer coating that is stable at rumen pH (5.4) but unstable at abomasal pH (2.9).

Calves were weighed on June 25 (d-1), July 23 (d-28), August 20 (d-56), September 17 (d-84), and October 13, 1986 (d-110) to detect changes in average daily gain (ADG) throughout the trial. On October 13, each calf was given a final weight, VCS, and rump fat thickness.

Pastures were fertilized with 66 lbs N/A at 4-week intervals. To equalize forage-on-offer across treatments at initiation of the trial, all pastures were shredded to an average height of 7 to 8 inches on June 24, 1986. Forage-on-offer was monitored closely by visual observation and monthly dry matter pasture samples. Pasture samples were taken by hand-clipping four, 1-ft square areas to ground level. Each sample was intended to represent one quarter of the pasture. The average level of forage-on-offer at initiation and termination of the trial was 205 and 170 lbs of dry matter per 100 lbs of live bodyweight, respectively (Table 2). Although FM tended to have more forage-on-offer throughout the grazing period, all treatments had more than adequate forage to allow selective grazing and ad libitum intake. These grazing pressures, or stocking rates, would be classified as light or very conservative for this region of the state.

Forage samples for chemical analysis were taken biweekly by hand-picking portions of the sward which visually represented similar portions selected by the animals. Crude protein levels of the forage ranged from approximately 11 to 20 percent during the grazing period (Table 3).

TABLE 1. FORMULATION OF PROTEIN SUPPLEMENTS USED WITH CALVES GRAZING BERMUDAGRASS PASTURES

	PDQ[1]	FMB[2]	DPDQ[3]	AA[4]	FM[5]
Cane molasses	66.98	67.05	4.26	4.26	—
Soy oil	.71	.71	—	—	—
Lecithin	1.36	1.36	—	—	—
Urea	6.49	6.50	2.13	2.13	—
Hydrated lime	.97	.97	—	—	—
Trace minerals	.97	.97	.21	.21	.25
Fish solubles	1.95	1.95	1.70	1.70	—
Vitamin A, D, & E	.28	.20	—	—	—
Dical phosphate	4.37	4.37	2.13	2.13	—
Cottonseed meal	11.92	—	34.04	34.04	—
Meat scraps	3.18	—	8.51	8.51	—
Blood meal	.80	—	—	—	—
Fishmeal (Menhaden)	—	15.90	—	—	48.50
Wheat midds	—	—	21.28	21.28	—
Milo meal	—	—	7.45	4.47	—
Calcium carbonate	—	—	2.13	2.13	—
Ammonium sulfate	—	—	.21	.21	.25
Vegetable fat	—	—	1.06	1.06	—
Salt	—	—	14.89	14.89	2.94
Rumen-stable methionine	—	—	—	1.28	—
Rumen-stable lysine	—	—	—	1.70	—
Cane molasses (dehyd)	—	—	—	—	2.88
Rumensin 60	—	—	—	—	.15
Magnesium oxide	—	—	—	—	.74
Cottonseed hulls	—	—	—	—	27.00
Wheat mill run	—	—	—	—	11.34
% Crude protein	31.6	32.5	34.2	30.7	37.2

[1]PDQ = Commercially available, condensed molasses block.
[2]FMB = Specially formulated condensed molasses block.
[3]DPDQ = Specially formulated dry protein supplement.
[4]AA = Specially formulated dry protein supplement with rumen-stable amino acids.
5FM = Specially formulated dry fishmeal pellet containing monensin.

TABLE 2. AVAILABLE FORAGE IN EACH TREATMENT PASTURE EXPRESSED AS POUNDS DRY MATTER (DM) PER 100 POUNDS BODY WEIGHT (BW)

	Date					
Treatment	6/27	7/25	8/25	9/19	10/11	Avg.
	Pounds DM/100 Pounds BW					
PAS	194	176	197	162	138	174
PDQ	191	218	189	252	197	209
FMB	188	220	152	194	125	176
DPDQ	130	139	220	170	139	160
AA	242	185	197	192	136	190
FM	280	333	263	309	287	294
AVG.	205	212	204	213	170	201

TABLE 3. PERCENT CRUDE PROTEIN OF BERMUDAGRASS PASTURES THROUGHOUT THE GRAZING PERIOD

	Date						
Treatment	6/27	7/11	7/25	8/12	8/25	9/19	10/11
	Percent						
PAS	15.4	16.0	12.4	20.9	18.0	18.7	18.1
PDQ	14.8	16.3	12.8	19.6	18.6	17.1	17.7
FMB	16.0	16.8	12.8	19.3	20.4	16.7	20.1
DPDQ	15.4	18.5	13.5	20.6	17.9	18.9	19.3
AA	15.5	14.6	11.3	19.3	17.6	17.7	18.9
FM	15.2	17.7	14.4	20.0	16.7	18.0	18.1

TABLE 4. AVERAGE DAILY GAIN, CONSUMPTION OF SUPPLEMENT, AND CONVERSION RATIOS OF PROTEIN SUPPLEMENTS FED TO CALVES GRAZING BERMUDAGRASS PASTURES

Average Treatment	Average Daily Gain	Average Daily Consumption	Increased Gain	Supplement: Increased Gain Ratio
	Pounds			lb:lb
PAS	1.03d	0	0	0
PDQ	1.22cd	.43	.19	2.26
FMB	1.20cd	.45	.17	2.65D
DPDQ	1.51b	1.92	.48	4.00
AA	1.40bc	2.21	.37	5.97
FM	1.92a	1.12	.89	1.25

TABLE 5. VISUAL CONDITION SCORE (VCS) AND RUMP FAT THICKNESS (RFT) MEASURED VIA ULTRASOUND OF CALVES GRAZING BERMUDAGRASS

Treatment	RFT (d-0)	RFT (d-110)	VCS (d-110)
	Inches		
PAS	.26	.12	5.5
PDQ	.31	.13	5.6
FMB	.33	.12	5.6
DPDQ	.31	.15	5.9
AA	.31	18	6.0
FM	.20	.14	5.8

Results

Calves assigned to FM had ADG of 1.92 lbs which was significantly higher ($P<.01$) than the ADG of PAS (1.03), PDQ (1.22), FMB (1.20), DPDQ (1.51), and AA (1.40) (Table 4). The ADG for calves on AA and DPDQ were not different ($P<.01$) from each other but were higher ($P<.01$) than PAS. There was an increase in gain due to the protein supplement but no effect due to the RSlys and RSmet (AA). At the level of consumption obtained in this trial, PDQ and FMB did not increase calf ADG over that of PAS. Forage protein content was above-normal for the summer period due to a reasonably well-distributed rainfall pattern and additions of nitrogen fertilizer at monthly intervals. Thus, the level of protein available in the forage may have restricted some of the potential gains anticipated from the supplements. The ad libitum, average daily consumption of PDQ, FMB, DPDQ, AA, and FM was .43, .45, 1.92, 2.21, and 1.12 lbs, respectively (Table 4). The condensed molasses blocks (PDQ and FMB) proved to be an effective method of limiting daily intake of protein supplements. Increased gain from a supplemented treatment is the increase in ADG obtained from a protein supplemented group over that of the PAS group. The increased gain for PDQ, FMB, DPDQ, AA, and FM was .19, .17, .48, .37, and .89 lbs, respectively (Table 4). Assuming the protein supplement did not influence forage utilization (intake or digestibility), the supplement:gain ratio describes the feed efficiency for each supplemented group. The supplement:increased gain ratio for PDQ, FMB, DPDQ, AA, and FM was 2.26, 2.65, 4.00, 5.97, and 1.25, respectively (Table 4). Except for AA, whose conversion ratio approached the range of values considered to be a normal feedlot efficiency for beef cattle, each supplemented group had an exceptionally low feed efficiency for increased gain which indicated an increased efficiency of forage utilization or an increased efficiency of protein utilization. Data collected by feeding DPDQ via Pinpointers did not produce significant correlations between consumption of supplement and ADG. Rump fat thickness and visual condition scores were not different ($P<.01$) at initiation or termination of the 110-day grazing period (Table 5).

Although results indicated that bermudagrass pastures were nutritionally deficient for maximum weight gain by growing beef calves, it cannot be determined from this trial if the increased ADG was directly due to the dietary protein being delivered to the small intestines for use at the tissue level, if the dietary protein was utilized as energy, or if the efficiency of microbial protein production was enhanced. Extremely low supplement:gain ratios usually indicate an increased forage utilization.

Influence of Pasture Supplementation on Fecal Particle Size of Yearling Horses and Calves Grazing Bermudagrass Pastures

K. N. Grigsby, D. K. Hansen, F. M. Rouquette, Jr., W. C. Ellis, and M. J. Florence

Summary

Fecal samples were collected from 12 yearling stock horses (770 lbs) and 24 yearling beef calves (650 lbs) to determine the distribution of fecal particle sizes attributable to livestock and pasture supplementation. After wet-sieving fecal samples collected from pasture supplemented and non-supplemented calves and horses, it was concluded that horses had a higher ($P<.01$) percent of their fecal particles retained by large and medium size mesh sieves than calves. Calves had a higher ($P<.01$) percentage of their fecal particles retained by the small sieves, as compared to horses. Although there was a numerical tendency for pasture supplement to increase the percent of particles retained by large sieves, there was not a significant effect on particle size due to supplementation.

Procedure

Fecal samples were collected, per rectum, from 24 yearling ½ Simmental x ¼ Hereford x ¼ Brahman calves (650 lbs) and 12 yearling stock horses (770 lbs). The calves and horses were on separate grazing trials of Coastal bermudagrass. Each grazing trial contained a pasture only treatment, replicated by sex, and a pasture-supplemental feed treatment, also replicated by sex. The treatments were: (1) n = 12 calves grazing Coastal bermudagrass pasture (CPAS); (2) n = 12 calves grazing Coastal bermudagrass pasture plus a 34.2 percent crude protein (CP) pasture supplement being fed on an ad libitum basis (CSUP); (3) n = 6 horses grazing Coastal bermudagrass pasture (HPAS); and (4) n = 6 horses grazing Coastal bermudagrass pastures plus a pasture supplement which provided 50 percent NRC (1978) requirements for energy and 60 percent of their NRC requirement for protein (HSUP). The HSUP and CSUP consumed 5 and 1.9 lbs of their respective supplements, daily.

Fecal samples from CPAS and CSUP were collected on August 12, 1986 while HPAS and HSUP samples were collected July 14, 1986. All samples were immediately frozen until wet-sieved. Each fecal sample was wet-sieved for 12 minutes, in duplicates, using a Fritsch wet-sieving apparatus. Sieves with mesh openings of 1.00, .400, .160, .100, .071, and 0.32 mm were used to analyze CPAS and CSUP. Fecal samples of HPAS and HSUP were wet-sieved in a similar manner with the exception of a 1.600 mm sieve being added to divide the large fraction of particles being retained by the 1.000 mm sieve. The 1.600 mm sieve was not used for CPAS and CSUP due to the extremely small quantity of particles that were large enough to be trapped by the 1.600 mm sieve. For analysis, the 1.600 and 1.000 mm sieves were combined and reported as the fraction retained on the 1.000 mm sieve. After wet-sieving, particles retained on individual sieves were washed from the mesh into a preweighed 100 ml beaker. Samples were then dried in a force-draft oven for 48 to 72 hours or until the sample was completely dry. Since mean particle size is strongly influenced by the sieve sizes used, data are reported for particles retained on each sieve as a percent of total particles retained.

The level of forage-on-offer and determination of CP and percent neutral detergent fiber (NDF) were obtained on the individual grazing trials in an identical manner. Forage-on-offer for HPAS, HSUP, CPAS, and CSUP were 205, 150, 185, and 180 lb dry matter forage/100 lbs liveweight, respectively. Although HSUP had less forage-on-offer, numerically, all levels of forages were in the range considered to be a low stocking rate and should not limit daily forage intake. The percent CP of forage which is similar to that selected by the animals in CPAS, CSUP, HPAS, and HSUP was approximately 20.9, 20.6, 17.0, and 17.5 percent, respectively, while percent NDF was approximately 70, 69, 76, and 75 percent. Forage quality samples were taken by hand picking portions of the sward representing selectivity by the animals.

Results and Discussion

Information obtained from the wet-sieving technique is reported for individual sieves as a percent of total fecal particles retained. A statistical analysis of the percent of total particles retained on each sieve is reported in Table 1. Excluding the .160 mm sieve, all significant differences ($P<.01$) are between livestock species. Calves tended to have a higher percent of their total fecal particles retained by the smaller sieves, while horses tended to have a higher percent retained by larger sieves. Significantly ($P<.01$) more particles were retained on the .160 mm sieve for HPAS than CPAS, CSUP, or HSUP suggesting that supplementation to grazing horses may slightly increase mean fecal particle size. There was no significant effect of protein supplementation to grazing calves, although there was a numerical tendency toward increasing particle size.

Fecal particle sizes were classified as large, medium, and small (Table 2). The large class is a combination of those particles retained on the 1.600 mm and 1.000 mm sieves. The medium class is formed by combining the .400 mm and .160 mm retained particles, while the small class is formed by combining the .100 mm, .071 mm, and .032 mm sieve particles. When fecal particles are classified and analyzed in this manner, significant differences are confined to species differences. The HPAS and HSUP had significantly more ($P<.01$) of their fecal particles in the medium and large classification, than CPAS and CSUP, while CSUP and CPAS had significantly more particles than HPAS and HSUP retained in the small classification.

Under the conditions of this trial, horses tended to have more large fecal particles than calves, and pasture supplementation had no significant effect on fecal particle size of calves or horses. Differences in fecal particle size between calves and horses was thought to be largely attributed to differences in regurgitation-rumination digestive processes. Although diet selection of ber-

TABLE 1. PERCENT OF FECAL PARTICLES FROM CALVES AND HORSES RETAINED ON EACH OF SIX DIFFERENT SIZED SIEVES

	Sieve Size (mm)					
Treatment	1.000	0.400	0.160	0.100	0.071	0.032
	Percent retained					
Calves						
Pasture Only	10.375 b*	17.131 b	30.210 b	20.0423 a	14.743 a	7.4993 a
Pasture + Supplement	14.093 b	17.156 b	26.117 b	19.1744 a	14.847 a	8.6130 a
Horses						
Pasture Only	18.720 a	21.813 a	34.742 a	15.6339 b	6.397 b	3.1811 b
Pasture + Supplement	21.252 a	23.776 a	29.709 b	14.5994 b	7.482 b	2.6937 b

*Numbers within the same column and followed by a different letter are statistically different (P<.01).

TABLE 2. PERCENT OF FECAL PARTICLES FROM CALVES AND HORSES RETAINED ON SIEVES GROUPED INTO THREE CATEGORIES

	Pasture Groups		
Treatments	Large[1]	Medium[2]	Small[3]
	Percent retained		
Calves			
Pasture Only	10.375 b*	47.341 b	42.284 a
Pasture + Supplement	14.093 b	43.273 b	42.634 a
Horses			
Pasture Only	18.720 a	56.555 a	24.725 b
Pasture + Supplement	21.252 a	53.486 a	25.262 b

[1]Large = particles from sieves sized 1.60 + 1.00 mm.
[2]Medium = particles from sieves sized .400 + .160 mm.
[3]Small = particles from sieves sized .100 + .071 + .032 mm.
*Numbers within the same column and followed by a different letter are statistically different (P<.01).

TABLE 3. AVERAGE DAILY GAIN (ADG) OF CALVES AND HORSES GRAZING BERMUDAGRASS PASTURES WITH OR WITHOUT SUPPLEMENTAL FEED

Treatments	ADG	ADC[1]	Increased Gain[2]	Supplement: Increased Gain
	lbs/hd		lbs	
Calves				
Pasture Only	1.03	—		
Pasture + Supplement	1.51	1.92	.48	4:1
Horses				
Pasture Only	1.03	—		
Pasture + Supplement	1.28	5.06	.25	20.2:1

[1]ADC = Average daily supplement consumption.
[2]Increased gain due to supplement.

mudagrass was not measured, this was thought to have a small, and possibly insignificant, impact on fecal particle size in this trial. In addition, since the rumination process resulted in greater quantities of small fecal particles, the efficiency of forage digestion by calves may exceed that of horses. Forage intake was not measured on these two groups of livestock; however, the liveweight gains on bermudagrass pastures (Table 3) showed performance on pasture only to be identical at 1.03 lbs/day and a sizable ADG advantage for calves receiving the protein supplement. The efficiency of converting supplemental protein to calf gain was greater than the efficiency of converting supplemental energy-protein to horse gain. Both groups of livestock had acceptable performance on the pasture or pasture supplement rations.

Grazing Behavior of Yearling Horses. I. Time Spent Grazing Different Forages

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Summary

The time budgeting of yearling horses grazing improved pastures at two different times of the year in East Texas was studied. Three yearling horses weighing 650 lbs each were grazed from March through September and from December through January. Time spent grazing and time involved in other behavior was measured using a Kienzle TFW time recorder device in September and December 1986. Time spent grazing averaged 16.3 hours or 67.8 percent of the time (24 hours) in September when bermudagrass was grazed, and 13.8 hours or 57.2 percent of the day in December during which time rye-ryegrass was grazed. A circadian pattern of grazing was seen in both times of the year, with a depression just before sunrise and after sunset. However, there was fairly sustained grazing activity during the dark hours. These results indicated that the Kienzle time recorder device can be used successfully with horses.

Introduction

There have been few reports in the literature of grazing behavior or time budgets (Arnold, 1984) for behavior in horses. Most reports have described behavior of feral horses (Feist, 1971) or horses grazing large areas (Tyler, 1972; Arnold, 1984), but there have been very few describing the behavior of horses grazing small pastures. Therefore, the grazing behavior or time budgeting of yearling horses grazing improved pastures at two different seasons in East Texas was studied.

Procedure

Three yearling horses averaging 650 lbs were grazed on bermudagrass pastures which were sod-seeded with rye-ryegrass from March through September 1986. Animals were removed from pastures in October and placed back on similar pastures in December for grazing of cool-season annual forage. Animals were stocked at slightly less than 3 AU/A throughout the experiment.

Time spent grazing and time spent in other behavior was measured using a Kienzle TFW time recorder device.[1] The device transfers the motion of the horse's head onto a recording chart by means of a pendulum motion and a stylus. The clock-like device is enclosed in a weather-proof bag attached around the animal's neck at the throat latch area and secured to a halter. When the horse lowered the head to graze, the movement of the head produced markings on the recording chart. The time recorders were placed on the horses for 3 to 4 days prior to the actual measurement to allow the horses to become accustomed to the device. Records were made for 7 consecutive days during September when horses were grazing bermudagrass and December when rye-ryegrass was grazed. The chart records were validated by observation of horses several times daily.

Results and Discussion

Time spent grazing was easily measured since distinctive marks were made when the horse's head was lowered. However, the distinction between other types of behavior (resting, walking, running, etc.) was not measurable with this device. All other behavior was grouped under time spent not grazing.

Examining Table 1, it can be seen that during September, yearlings grazed 68 percent of the day, or 16.3 hours per day. This is similar to the value of 16.9 hours found in mature thoroughbred horses grazing paddocks in August (Francis-Smith, 1977). In a study conducted in Australia, the time spent grazing ranged from 4 to 16 hours per day over a period of 2 years in mature horses (Arnold, 1984). Time spent not grazing, which included all other activities, constituted 32.2 percent of the day. During September, forage availability was approximately 4,900 lbs DM/A. The time spent grazing by yearlings during December was 57.2 percent or 13.8 hours per day. Time spent in other activities was 42.8 percent. Forage availability during this time was approximately 2,200 lbs DM/A. Grazing time was 2.5 hours less in December than during September, which could be due to the season or forage type since bermudagrass was grazed in September and rye-ryegrass was utilized in December. The most obvious difference between these types of forages was the greater moisture content of the rye-ryegrass, which may have caused more fill and sense of satiety to the horses with less forage; thereby, reducing grazing time.

A graphic representation of percent time spent grazing per hour in September and December is shown in Figures 1 and 2, respectively. Even though total time spent grazing was different between times of the year, a similar circadian trend was evident from both forage types. Percent time grazing was depressed just before

TABLE 1. TIME SPENT GRAZING AND NOT GRAZING BY YEARLING HORSES

Animal	Date	Pasture	Hours Grazing	Time Spent Grazing (%)	Time Not Grazing (%)
8	9-16	bermudagrass	17.9	74.4	25.6
3	9-16	bermudagrass	14.9	61.9	38.1
16	9-16	bermudagrass	16.1	67.0	33.0
Mean			16.3	67.8	32.2
7	12-3	rye-ryegrass	13.1	54.4	45.6
8	12-3	rye-ryegrass	14.2	59.2	40.8
17	12-3	rye-ryegrass	13.9	58.1	41.9
Mean			13.8	57.2	42.8

KEYWORDS: Horses/grazing behavior/forage/bermudagrass/ryegrass.

[1]Kienzle Apparate Villingen/Schwarzwald.

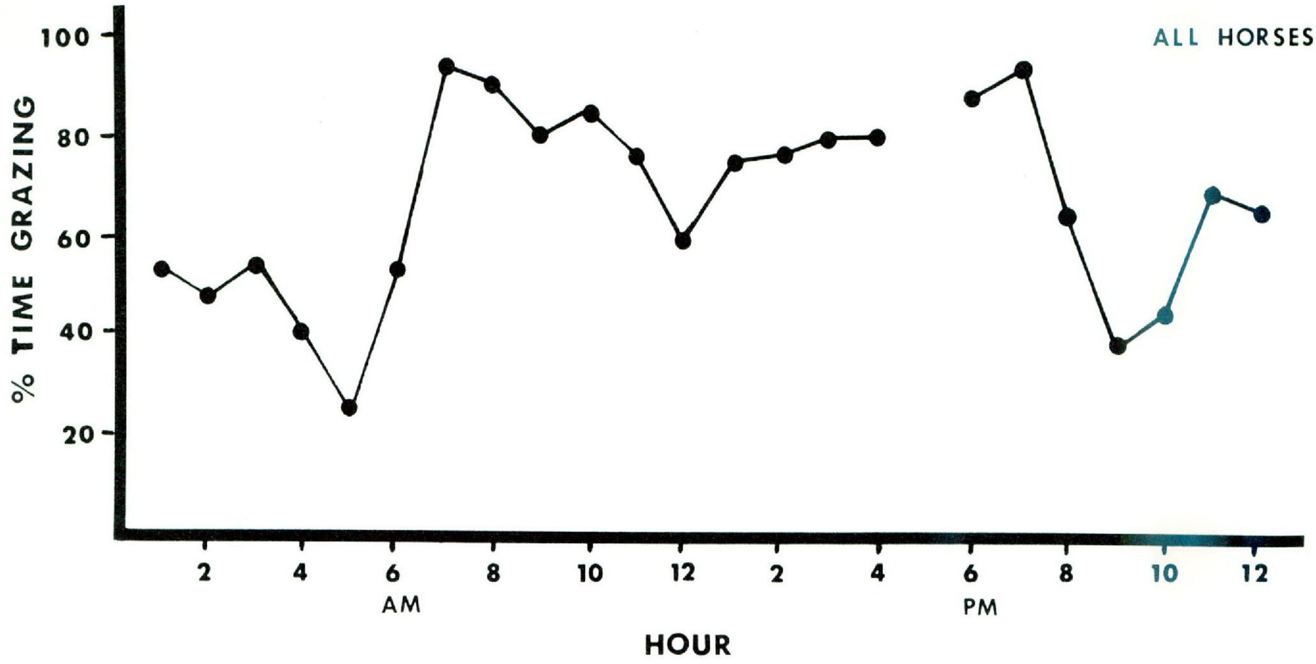

Figure 1. Percent time spent grazing per hour of yearling horses in September on bermudagrass.

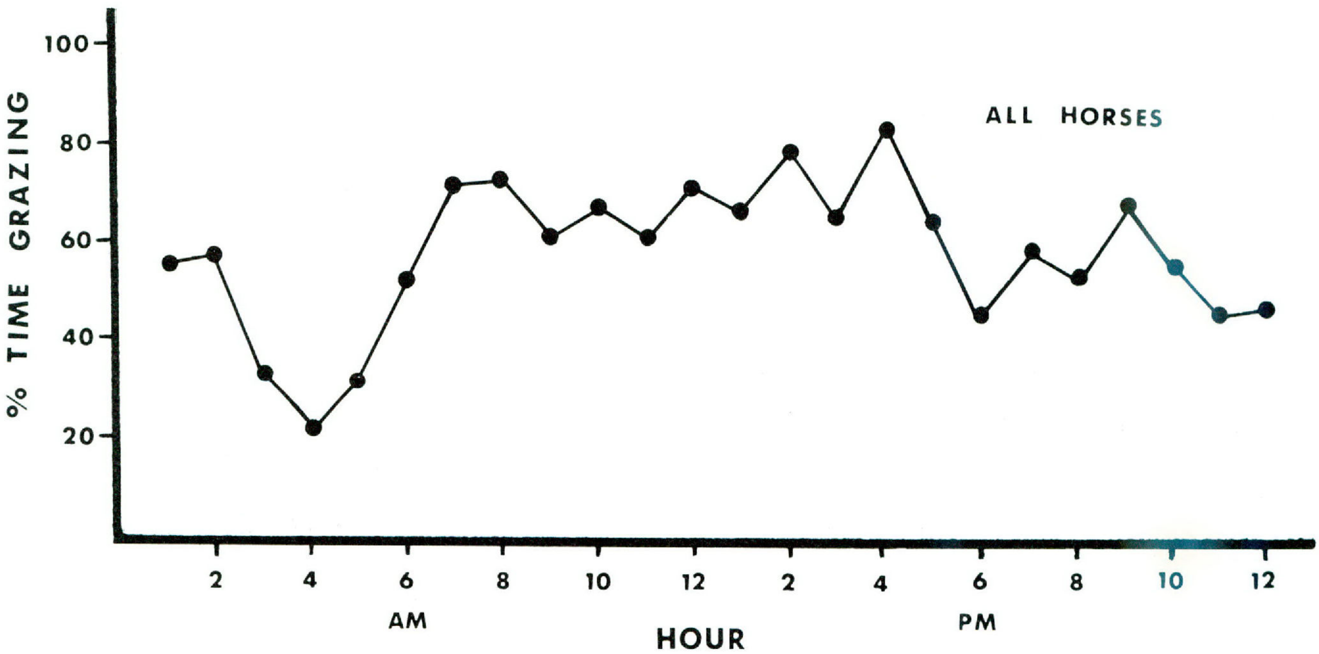

Figure 2. Percent time spent grazing per hour of yearling horses in December on rye-grass pastures.

sunrise on both forages (approximately 4 to 6 a.m.). Grazing was maintained at a fairly high level during the daylight hours, then was depressed again at approximately sunset (6 to 8 p.m.), and resumed thereafter. This was similar to a circadian pattern seen in horses grazing in Australia where grazing was most depressed between 2 and 6 a.m. (Arnold, 1984).

Results of these experiments indicated that the Kienzle time recorder device can be used successfully with horses. The adjustment period to the device should be at least 3 to 4 days before representative charts can be produced. The times spent grazing per day found in these experiments were similar to the few reports in the literature using mature horses in large paddocks. The time spent grazing per day of yearling horses on small, improved pastures ranged from 13.8 to 16.3 hours, and horses tended to graze throughout the night as well as during the daylight hours. With the increasing economic advantage of improved pastures for horses, more research needs to be conducted in the area of equine grazing behavior in these situations.

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Grazing Behavior of Yearling Horses. II. Selective or Spot Grazing of Bermudagrass

D. K. Hansen, F. M. Rouquette, Jr., M. J. Florence

Summary

Selective or spot grazing of pastures by yearling horses has long been observed but not quantitated to date. Six stock horse yearlings averaging 650 lbs were assigned to each of two 'Tifton 44' bermudagrass pastures from March through September 1986. Spot-grazed areas (<2 inches in height) in both pastures were measured in mid-September. Forage available to ground level and selection samples were taken at this time. Forage available was greater, as expected in the long, less grazed areas than in the spot-grazed areas and averaged 4,500 and 1,600 lbs DM/A, respectively. Crude protein content of longer bermudagrass was also lower (18.2 percent) than grass in the short, spot-grazed areas (20.6 percent). The total area of the pasture that was spot grazed was approximately 38 percent and was similar for both pastures.

KEYWORDS: Horses/grazing behavior/bermudagrass/selective grazing.

Introduction

Selective or spot grazing by yearling horses had been observed in a grazing trial conducted in Overton 1984. In 1986, the closely grazed areas in two pastures were distinct and sizeable enough to be measured. Therefore, a measurement of the area within a bermudagrass pasture which had been selectively grazed was quantified.

Procedures

Three stock horse yearlings averaging 650 lbs were assigned to each of two 'Tifton 44' bermudagrass pastures of approximately 1.4 acres from March through September 1986. From March through May, 'Elbon' rye and 'Marshall' ryegrass made up the major portion of the available diet, while from May through September, bermudagrass was grazed exclusively in this sod-seeded pasture system. Pastures were fertilized with 60-60-60 (N-P_2O_5-K_2O) in late November and 50 lbs/A N at approximate 6-week intervals throughout the grazing period. During mid-September, measurements of the largest selective grazing areas in each pasture were taken to determine the percentage of each pasture that was closely grazed. Forage available to ground level of the closely or frequently and the infrequently grazed areas were taken at this time. Forage samples were clipped adjacent to areas grazed by the horses to estimate the actual diet selected, and subsequently dried, ground, and stored for later chemical analysis.

Results and Discussion

Pastures were stocked at approximately two yearlings/A (1,400 lbs bodyweight per acre) since three yearlings occupied each of the 1.4 A bermudagrass pastures for the entire trial period. This is consistent with a light or conservative stocking rate of cattle in similar pastures as described by Rouquette et al., 1984, which allowed for selective grazing and hence *ad libitum* intake potential of bermudagrass by the yearling horses.

In Table 1, forage available to ground level (0-inch height) and crude protein content of bermudagrass pastures are presented for the frequently grazed (short) and infrequently grazed (tall) areas. Obviously, the forage available in the infrequently grazed areas was greater than the closely grazed areas. Also, crude protein percentage of the bermudagrass samples taken from the closely grazed areas was higher (20 percent) than the infrequently grazed areas (18 percent). This was most likely due to percent leaf and the immaturity of available forage. Thus, yearlings tended to select the young, im-

TABLE 1. FORAGE AVAILABILITY AND PROTEIN OF PASTURES GRAZED BY YEARLING HORSES

	PASTURE			
	1		2	
	Short Forage	Tall Forage	Short Forage	Tall Forage
Forage Availability (lb DM/A)	1,838	5,102	1,234	4,058
Crude Protein (%)	20.5	18.0	20.7	18.4

TABLE 2. CALCULATED AREAS IN BERMUDAGRASS PASTURES WHICH WERE SELECTIVELY GRAZED BY YEARLING HORSES

	Total Area	Short Forage			Tall Forage		
Pasture	ft^2	ft^2	acreage	%	ft^2	acreage	%
1	64,275	24,039	.55	37.4	40,236	.93	62.6
2	62,184	24,127	.55	38.8	38,057	.88	61.2

mature bermudagrass that tended to be much more uniform in height than the infrequently grazed areas (Table 2). Also, there were negligible defecation spots in the closely grazed areas, while there were fairly random, widespread defecation spots in the infrequently grazed areas. This behavior has been shown previously in thoroughbred horses grazing in paddocks (Francis-Smith, 1977).

After measurement of grazing areas within each pasture, 37.4 percent of pasture 1 was closely grazed and 38.8 percent of pasture 2 was closely grazed (less than 2 inches in height). These pastures were very similar in size, with pasture 1 and 2 measuring 1.48 and 1.43 acres, respectively. It was very interesting that with the similar size and percentage of close grazing, that a total of .55 acre was selectively grazed in each pasture.

In Figure 1, a schematic representation of the selectively grazed areas in each pasture is presented. It did not seem unusual that the alleyway ends of the pasture were short and selectively grazed, because of the presence of the watering system and the gate, along with the closest visual, auditory, and olfactory contact with the nearest pastured horses. However, it was not easily understood why the edges of both pastures were selectively grazed. The behavior and activity of the horses to move around the outermost edge of the enclosure (around the fence line) may have been the areas where grazing was first initiated. After grazing once began, the horses continued to return to the previously grazed areas on a priority basis due to the physical and chemical nature of the regrowth bermudagrass forage.

Regardless of the cause(s), selective or spot grazing has been observed in yearlings grazing rye-ryegrass and bermudagrass pastures in East Texas as well as mature horses grazing paddocks in England (Francis-Smith, 1977). From the measurements made at Overton, it can be

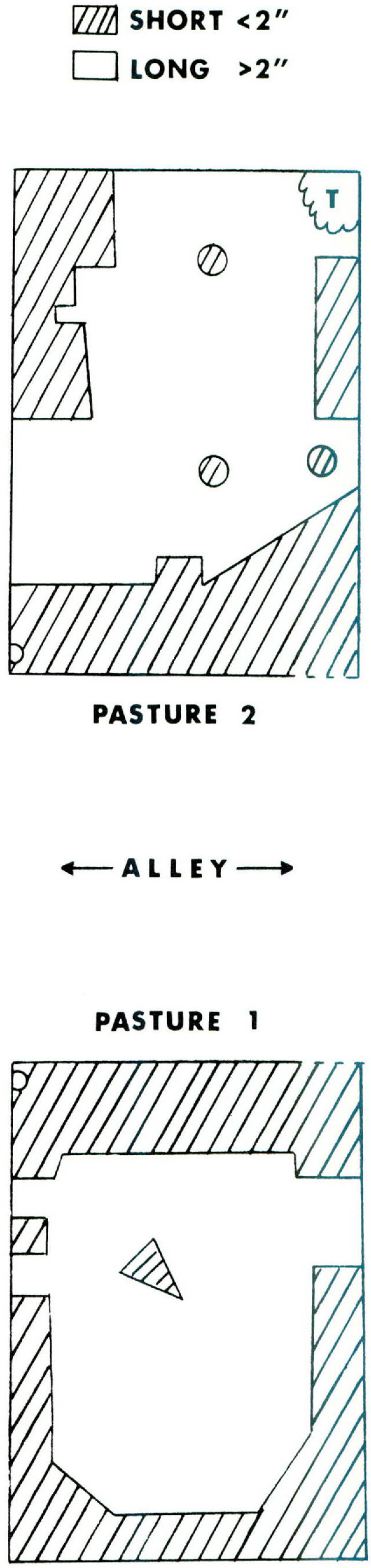

Figure 1. Schematic Representation of spot grazing of bermudagrass pastures.

estimated that close grazing areas (<2 in.) may often comprise 30 to 40 percent of the pasture area being grazed by horses stocked at levels approaching 1,400 lbs body weight per acre. Management techniques were not employed in this continuously grazed study to attempt to alter or change the impact of the selective grazing behavior. The first consideration may be given to the forage and its vigor and regrowth potential under these severe defoliation regimens. In general, the hybrid bermudagrasses have shown to be very resistant to frequent defoliation under grazing conditions. Thus, for stand maintenance or forage survival, management practices to change the distribution of grazing should be employed based on forage specie and desired performance. Possible management techniques to alleviate the selective grazing areas for a season-long period are to rotate pastures with different classes of livestock and/or shred or mow pastures. These techniques may prevent the complete destruction of forage(s) in a pasture. Bermudagrass pastures in the humid regions of the southeastern United States are resistant to stand destruction via grazing and probably represent one of the most reliable, permanent pastures for horses. Additional studies are required to ascertain the full impact of this inherent, selective grazing behavior of horses on different forages.

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The Effect of Interval and Intensity of Defoliation on Quality of Warm-Season Perennial Grasses

T. Clavero, and B. E. Conrad

Summary

There were significant differences in the leaf-stem ratio and IVDDM among grasses due to frequencies of harvest and cutting heights. The maximum values for leaf-stem ratio and IVDDM were obtained at a frequency of 21 days and 12 inches cutting height. Leaf-stem ratio alone was a poor indicator of digestibility differences. The less digestible grasses showed the highest leaf-stem ratio.

KEYWORD: Bunchgrass/cutting height/cutting frequency/digestibility.

Introduction

Warm-season grasses are known to have a high dry matter production but low quality. Also, it is well established that the yield of grass dry matter increases as the frequency of cutting decreases. On the other hand, as the growth period of grasses increases nutritive value decrease.

The maintenance of a balance between yield production and quality is a major factor affecting productivity. Both yield and quality, are important for the development of any pasture program; however, quality is highly important because of its direct relation on animal performance.

This paper reports the results of an experiment utilizing twelve warm-season perennial grasses to estimate quality when defoliated at different frequencies and intensities.

Materials and Methods

Seedlings of 12 warm-season grasses— Pretoria-90 (*Dicanthium annulatum*, Stapf), Lauresa (*Pennisetum orientale*), Old World Bluestem (*Bothriochloa* spp.), Verde and Klein-75 (*Panicum coloratum* L.), Wilman Lovegrass (*Eragrostis superba*), Nueces and Llano Buffelgrass (*Cenchrus ciliaris* L.), Morpa and Renner Lovegrass (*Eragrostis curvula*), Bell Rhodesgrass (*Chloris gayana*), and Alamo Switchgrass (*Panicum virgatum* L.)—were started in peat pots in the greenhouse in January 1985 and transplanted into four 20-inch rows, 20-ft long in April 1985.

Forage was harvested at two intervals (21 and 42 days) and two stubble heights (4 and 12 inches). Measurements included leaf-stem ratio and in vitro digestible dry matter (IVDDM).

Leaf and stem parts were separated from a single plant to determine leaf-stem ratio. Clipped samples were dried at 60°C in a forced air drying oven, ground in a Wiley mill to pass 1 mm screen and analyzed for in vitro digestible dry matter (IVDDM) by the method of Goering and Van Soest (1970).

All these data were subjected to analysis of variance and means were separated using Duncan's Multiple Range Test.

Results and Discussion

The leaf-stem ratios by years are shown in Table 1. There were significant differences in leaf-stem ratio among grasses. Lauresa and Morpa Lovegrass had the highest average leaf-stem ratio followed by Pretoria-90 Bluestem, Llano Buffelgrass, and Renner Lovegrass. These grasses all produced more than twice as many leaves as stems.

Leaf-stem ratio decreased approximately 40 percent as the harvest interval increased from 21 days to 42 days (Table 2). The increased harvest interval resulted in in-

TABLE 1. LEAF-STEM RATIO INFLUENCED BY YEARS

Grasses	Years 1985	1986	Mean Average
Lauresa	2.39 ab[1]	2.41 a	2.40 a
Pretoria-90	2.10 bc	2.09 c	2.09 b
Verde Kleingrass	1.24 ef	1.51 de	1.38 e
Klein-75	1.40 ef	1.30 f	1.35 e
Wilman lovegrass	1.03 f	1.50 de	1.26 f
Nueces buffelgrass	1.82 cd	1.56 d	1.69 c
Llano buffelgrass	1.89 cd	2.12 bc	2.01 b
Morpa lovegrass	2.80 a	2.29 ab	2.54 a
Renner lovegrass	2.07 bc	1.97 c	2.02 b
Rhodesgrass	.99 f	1.39 ef	1.19 f
Old World Bluestem	1.66 cde	1.54 de	1.60 cd
Alamo switchgrass	1.66 cde	1.61 d	1.63 cd
Mean	1.75	1.77	

[1]Values within a column followed by the same letter are not significantly different at the .05 level, Duncan's Multiple Range Test.

TABLE 2. MEANS OF LEAF-STEM RATIO ACROSS GRASSES AS INFLUENCED BY DEFOLIATION TREATMENTS

Frequency days	Leaf-stem ratio Height (in.) 4	12	Average
	1985		
21	2.09	2.29	2.19 a*
42	1.26	1.38	1.32 b
Average	1.67 a	1.84 a	
	1986		
21	1.96	2.49	2.22 a
42	1.22	1.42	1.32 b
Average	1.59 b	1.96 a	
	1985-86		
21	2.02	2 39	2.21 a
42	1.24	1.40	1.32 b
Average	1.63 b	1.89 a	

*Mean values on the same line or in the same column within a year followed by the same letter are not significantly different at the .05 probability level, Duncan's Multiple Range Test.

creases in stem elongation and many tillers entered the reproductive phase. The leaf-stem ratios for all cultivars decreased significantly with advancing maturity.

Means in leaf-stem ratio as effected by clipping height are also shown in Table 2. As may be noted during the establishment year clipping height did not have a significant influence on the leaf-stem ratio; however, in the second year there were differences. By clipping to 4 inches the leaf-stem ratio was reduced approximately 19 percent. The overall reduction considering both years was about 14 percent.

The IVDDM for the 12 grasses by years are shown in Table 3 and 4. Pretoria 90, the two Kleingrasses, and the two buffel entries were consistently of the highest quality whereas the two lovegrasses, Morpa and Renner were the lowest.

TABLE 3. SEASONAL TRENDS IN PERCENT IVDDM OF TWELVE GRASSES, 1985

	Harvest Dates 8/5	8/26	9/17	10/10	11/07	Mean
Lauresa	50.5	49.1	47.1	52.9	52.4	50.4 e
Pretoria-90	57.3	56.4	53.8	57.2	58.4	56.6 a
Verde K	56.1	57.7	53.9	60.1	58.2	57.2 a
Klein-75	54.6	55.3	55.3	57.3	58.3	56.2 a
Wilman L.	54.4	51.6	50.3	52.6	57.8	53.3 cd
Nuces B.	54.7	52.9	52.9	58 8	58.0	55.5 b
Llano B.	54.2	50.5	51.3	57.3	57.0	54.1 c
Morpa L.	40.5	39.1	37.3	40.0	41.4	39.7 f
Renner L.	40.7	39.7	39.2	40.7	40.9	50.2 f
Rhodes	48.9	51.0	49.4	49.9	50.6	40.0 e
Old World	53.0	51.6	52.4	53.8	53.7	52.9 d
Alamo	52.9	48.7	50.6	45.6	51.9	49.9 e
	51.5	54.4	53.7	56.0	53.1	

TABLE 4. SEASONAL TRENDS IN PERCENT IVDDM OF TWELVE GRASSES, 1986

	Harvest Dates 6/16	7/13	8/2	8/30	10/08	Mean
Lauresa	57.8	60.3	52.4	56.3	51.4	55.6 cd
Pretoria-90	60.6	65.0	57.0	58.3	56.3	59.4 a
Verde K	60.7	64.3	51.7	62.0	55.8	58.9 b
Klein-75	59.0	63.2	55.2	64.7	55.4	59.5 ab
Wilman L.	56.6	59.7	52.5	56.2	55.9	56.2 c
Nueces B.	57.9	63.5	54.3	57.6	56.6	58.0 b
Llano B.	57.4	63.6	55.6	58.8	57.3	58.5 b
Morpa L.	41.0	41.8	39.7	41.3	37.2	40.2 h
Renner L.	41.3	41.3	40.4	42.7	40.5	41.2 g
Rhodes	56.1	56.9	50.4	52.7	50.1	53.2 f
Old World	53.8	59.4	49.2	52.2	54.8	53.8 ef
Alamo	58.1	57.0	51.3	53.0	53.3	54.4 de
	59.9	62.8	55.1	54.7	52.1	

This study also showed that digestibility was affected by sampling dates within the season. In general, digestibility declined from spring to summer and recovered in late summer and early fall. This seasonal pattern in digestibility may be due to chemical composition of the plants rather than morphological characteristics because the leaf-stem ratio of these plants did not show any specific pattern during the growing season. The digestibility pattern could also have been due in part to environmental stress during the summer, which tends to accelerate the maturation processes.

Frequency of harvest, as would be expected, had a marked influence on the IVDDM (Table 5). IVDDM decreased 12 percent as harvest interval increased from 21 days to 42 days. The average decrease was 6.8 digestibility units which amounted to a decrease of .32 units per day between 21- and 42-day-old material.

Digestibility increased as the height of clipping was increased. This pattern was consistent during both years in all 12 grasses. This can largely be explained by the high proportion of dead leaf tissue at the bottom of the plants and the lower cell wall content in the young leaves at the top of the plants. The maximum values for in vitro dry matter digestibility was with a harvest interval of 21

TABLE 5. MEANS IN PERCENT IVDDM ACROSS GRASSES AS INFLUENCED BY CUTTING HEIGHT AND FREQUENCY

Frequency days	IVDDM (%)		
	1985		
	Height		
	4 inches	12 inches	
21	52.58	53.72	53.15a*
42	48.06	48.59	48.32 b
Average	50.32 b	51.16 a	
	1986		
21	55.90	57.79	56.84 a
42	47.56	48.56	48.06 b
Average	51.73 b	53.17 a	
	1985-86		
21	54.24	55.76	54.99 a
42	47.81	48.57	48.19 b
Average	51.03 b	42.16 a	

* Mean values on the same line or in the same column within a year followed by the same letter are not significantly different at the .05 probability level, Duncan's Multiple Range Test.

days and cutting height of 12 inches. The lowest value was with a 42-day interval and cutting height of 4 inches.

In summary, it appears that the leaf-stem ratio alone was a poor indicator of digestibility differences. Morpa having the highest mean leaf-stem ratio had the lowest digestibility value. These results indicate that grasses with high leaf-stem ratios do not always have high digestibility as there are other factors such as cell wall structure, and the level of lignin present which have an influence on digestibility yet may be independent of leaf-stem ratio.

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Effect of Defoliation Practices on Quality of Buffelgrass (*Cenchrus Cilliaris* L.)

T. CLAVERO AND E.C. HOLT

Summary

Buffelgrass (*Cenchrus ciliaris* L.) is an erect, tufted, perennial grass which is native to Africa, India, and Indonesia was introduced into Australia and America in the early 20th century. This research addressed the influence of defoliation intervals and height of clipping on nutritive value (digestibility and crude protein). The results showed significant differences due to frequency of harvest and cutting heights on quality. Crude protein content reached its maximum value at a 21-day cutting interval and a cutting height of 4 inches and decreased with increasing interval and height of cutting. IVDDM exhibited highest values at a frequency of 21 days and 12 inches cutting height, but with little actual differences due to height of cutting. IVDDM declined with age and season.

Introduction

Cenchrus ciliaris L. is a perennial grass that forms spreading tufts and sends out rhizomes. It is widely distributed in Africa, India, and Indonesia and it was introduced into Australia and America in the early 20th century. It is grown extensively in southern Texas.

Buffelgrass is known for having a high rate of growth under favorable conditions resulting in high forage yield and with generally acceptable forage quality characteristics.

If the essential objective in all grassland management practices is to maintain the grassland in highest rate of production and quality for an indefinite period, the frequency or interval and the closeness or intensity of utilization assume high significance in the management of grassland.

The main objective of this study was to determine the effects of different defoliation practices on quality of buffelgrass.

Materials and Methods

Selection 18-35 buffelgrass was planted at the Texas A&M University Plantation in the Brazos River Bottom, near College Station, Texas. This experiment was conducted for 2 consecutive years (1982 to 1983) and consisted of six treatment combinations of two intervals of cutting (21 and 42 days) and three intensities of cutting (heights of 4, 8, and 12 inches), in a factorial design in randomized blocks with four replications. Individual plots consisted of 40-inch rows, 32.8 ft long. Harvest was with a flail mower from a 16.4 ft length of row, but the remainder of the row was cut at the designated height and frequency. The field was fertilized and irrigated to maintain active growth during the experiment.

KEYWORDS: Buffelgrass/cutting height/cutting frequency/crude protein/IVDDM.

Samples were taken from each plot at each harvest, dried at 140°F, weighed, and ground in a Wiley mill to pass a 1 mm screen. Subsequently, the samples were analyzed for nitrogen content using a Technicon Autoanalyzer (Industrial Method No. 334-74A/A+) and converted to crude protein (CP) (CP = N X 6.25) and for in vitro digestible dry matter (IVDDM) by the method of Goering and Van Soest (1970).

Results and Discussion

The crude protein data are summarized in Table 1 and shown by harvest date in Table 2. Crude protein tended to decrease as the growing season progressed in both 1982 and 1983. Average mean protein value across years and heights of cutting was highest when clipping was every 21 days (7.57 percent) and lowest with clipping each 42 days (5.51 percent). A similar result was reported by Shankarnarayan (1977), Asare (1970), and Combellas and Gonzalez (1972). In addition, a study by Rodriguez and Garcia (1980) demonstrated that crude protein content decreased with age, independent of the part of the plant studied.

Crude protein content decreased from 1982 to 1983 with a 21-day harvest interval while there was essentially no change at the 42-day harvest interval.

Also, pooled data for the 2-year period showed that the average crude protein content was affected by height of cutting. Crude protein content decreased significantly with each increase in cutting height above 4 inches in both years though the actual changes were small. One possible explanation for this may be the greater amount of stem material at greater heights due to more rapid growth, but actual leaf and stem percentages were not determined. There are controversial reports in the literature on the response of buffelgrass to cutting height. Osman and Abudiek (1982) reported that more severe clipping resulted in generally higher protein content compared with moderate clipping. On the contrary Asare (1970) and Watkins (1951) indicated that clipping height is not important in crude protein in tropical grasses.

The maximum value of crude protein content was with a harvest interval of 21 days and cutting height of 4 inches, the lowest value was with a 42-day interval and cutting height of 12 inches.

The effect of cutting interval and height of clipping on in vitro digestible dry matter (IVDDM) is presented in Tables 3 and 4. Digestibility was affected by age and sampling dates within a season. This effect was very consistent during both years, digestibility being inversely related to age and declining from spring to fall. IVDDM decrease as harvest interval increased from 21 days to 42 days. The decrease amounted to 10.5 digestible units in 1982 and 3 digestible units in 1983. Rodriguez and Gar-

TABLE 1. CRUDE PROTEIN CONTENT OF BUFFELGRASS AS INFLUENCED BY DEFOLIATION TREATMENTS

Frequency (days)	CP(%) Height (in.) 4	8	12	Average
		1982		
24	8.53	7.20	7.75	8.16 a[1]
42	5.90	5.40	5.30	5.53 b
AVERAGE	7.21 a	6.80 b	6.53 c	
		1983		
21	7.48	6.93	6.53	6.97 a
42	5.73	5.53	5.25	5.50 b
AVERAGE	6.60 a	6.23 b	5.89 c	
		1982-83		
21	8.01	7.27	7.17	7.57 a
42	5.82	5.46	5.28	5.51 b
AVERAGE	6.89 a	6.52 b	6.21 c	

[1]Mean values on the same line or in the same column within a year followed by the same letter are not significantly different at the .05 probability level, Duncan's Multiple Range Test.

TABLE 2. CRUDE PROTEIN CONTENT BY DATE AS INFLUENCED BY FREQUENCY AND HEIGHT OF CUTTING

1982

Frequency days	Height in.	June 9	June 30	July 22	Aug. 12	Sept. 2	Sept. 21	Nov. 3
				Percent				
21	4	9.71	9.23	8.71	8.40	8.25	8.10	7.25
21	8	9.60	8.93	8.54	8.18	7.86	7.63	6.80
21	12	9.61	8.58	7.99	7.48	7.20	6.93	6.48
42	4	—	6.73	—	6.15	—	5.55	5.13
42	8	—	6.35	—	5.75	—	4.98	4.65
42	12	—	6.03	—	5.68	—	4.93	4.50

1983

Frequency days	Height in.	June 2	June 23	July 13	Aug. 3	Aug. 25	Sept. 16	Oct. 7
				Percent				
21	4	8.63	8.14	7.00	7.14	7.05	6.50	7.68
21	8	8.53	7.84	6.25	6.84	7.08	5.15	6.83
21	12	8.40	7.54	5.93	6.78	6.65	4.49	6.20
42	4	8.13	—	4.55	—	5.53	—	4.63
42	8	8.05	—	4.38	—	5.18	—	4.38
42	12	8.00	—	4.03	—	5.00	—	3.95

TABLE 3. IVDDM OF BUFFELGRASS AS INFLUENCED BY DEFOLIATION TREATMENTS

Frequency (days)	IVDDM(%) Height (inches) 4	8	12	Average
		1982		
21	64.8	65.4	65.9	65.4 a[1]
42	54.3	54.9	55.4	54.8 b
AVERAGE	59.5 c	60.1 b	60.7 a	
		1983		
21	61.7	62.4	62.9	62.3 a
42	58.8	59.1	59.7	59.1 b
AVERAGE	60.2 c	60.7 b	61.3 a	
		1982-83		
21	63.3	63.9	64.4	63.8 a
42	56.5	57.0	57.6	56.9 b
AVERAGE	59.9 c	60.4 b	61.0 a	

[1]Mean values on the same line or in the same column within a year followed by the same letter are not significantly different at the .05 probability level, Duncan's Multiple Range Test.

TABLE 4. IVDDM BY DATE OF HARVEST AS INFLUENCED BY FREQUENCY AND HEIGHT OF CUTTING

1982								
Freq-uency days	Height inches	June 9	June 30	July 22	Aug. 12	Sept. 2	Sept. 21	Nov. 3
		Percent						
21	4	69.46	68.75	67.63	65.90	62.33	60.43	58.75
21	8	70.10	69.08	68.30	67.10	63.20	60.80	59.13
21	12	70.88	70.10	68.65	67.18	64.05	61.35	59.40
42	4	—	59.80	—	56.55	—	51.95	48.58
42	8	—	60.83	—	57.23	—	52.38	48.80
42	12	—	61.03	—	57.40	—	53.70	49.35

1983								
Freq uency days	Height inches	June 2	June 23	July 14	Aug. 4	Aug. 25	Sept. 16	Oct. 7
		Percent						
21	4	65.13	69.64	68.57	62.34	59.34	56.08	52.07
21	8	64.60	70.11	68.89	62.80	60.20	56.70	53.21
21	12	64.96	70.13	68.92	64.41	61.13	57.03	53.95
42	4	64.85	—	63.40	—	57.33	—	48.80
42	8	64.62	—	63.98	—	58.20	—	49.26
42	12	64.63	—	64.62	—	59.92	—	49.48

cia (1980), Combellas and Gonzalez (1972), and Fiano (1978) observed that in vitro digestibility decreased with an increase in the age of the grasses, independent of the part of the plant studied.

One possible explanation for the rapid decline of digestibility of buffelgrass with age may be closely related to increase in cell wall content. This could have been due in part to the rapidly increasing proportion of dead leaf tissue and perhaps to higher temperature and water stress, thereby accelerating the maturation processes of still green leaf tissue and the associated lignification of the cell walls.

In vitro dry matter digestibility percentages in each of the 2 years and the average of the 2 years decreased as the height of cutting increased though the actual differences were small.

Average digestibility for each of the 2 years differed very little. However, digestibility of 21-day material was less the second year than the first and the opposite was true for 42-day material. This may be accounted for partly by the reduced vigor in the second year resulting in less differences in yield between the two frequencies and likely less stem elongation at 42-days in the second than the first year. Since stems are generally less digestible than leaves, the smaller differences in stem content in the second year could account for some of the differences between the first and second year.

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Annual Ryegrass Variety Tests at Overton in 1985-86

L. R. Nelson, G. W. Evers, S. Ward, and J. Crowder[1]

Summary

This report presents forage yield data for the 1985-1986 winter growing season on annual or Italian ryegrass grown in Northeast Texas at Overton. Crown rust data was recorded in Southeast Texas near the Gulf Coast at Angleton. Highly favorable environmental conditions resulted in above average forage yields with a mean yield of 14,780 lbs/A dry matter for the test for the entire growing season.

Introduction

Annual ryegrass or Italian ryegrass is a small seeded grass planted in the fall (September through November) which normally produces high quality forage into May. Each year new varieties are marketed in East Texas. In an attempt to obtain as much information as possible, new as well as older varieties are yield tested annually. Data on yield, winter injury, and crown rust are

KEYWORDS: Lolium multiflorum/Italian ryegrass/forage yield/dry matter.

obtained. The forage yields are usually obtained at Overton, and crown rust ratings are taken at Angleton since environmental conditions favor disease buildup near the Gulf Coast. This report will present forage yields obtained in a ryegrass variety test at the Texas A&M University Agricultural Research and Extension Center at Overton, (Table 1) and crown rust ratings recorded at the Texas A&M University Agricultural Research Station at Angleton.

Procedure

Twenty ryegrass genotypes, one Bromus specie and one Festulolium (ryegrass x fescue specie) specie were planted into a prepared seedbed on September 20, 1985. A seeding rate of 35 lbs/A was used for all entries. A preplant fertilizer application of 60-60-80 lbs/A of N, P_2O_5, K_2O, respectively, had been applied. The experiment was topdressed with urea at a rate of 100 lbs N/A on October 16, and 50 lbs N/A on January 22. Forage plots were harvested with a Hege 211 B forage harvestor which has a sickle bar. All entries were cut at a 2-inch height and the test was harvested five times. Percent dry matter (oven-dried forage) was determined in order to obtain total dry matter.

Results and Discussion

The growing season was very unusual in that we had a very dry period from December through February and wet conditions from March through mid-June. These conditions were ideal for ryegrass and resulted in a late (June 11) harvest, and the highest ryegrass forage yield we have recorded at Overton in the past 11 years. Furthermore, no winterfreeze damage resulted in the 1985 to 1986 growing season. Therefore, these growing conditions favored those genotypes with high yield potential during warmer than normal winter-spring weather conditions. During growing seasons with normal or below normal temperatures some of these varieties will winterkill and their yields will be limited or greatly reduced. Therefore, data from several years of testing has an advantage in making variety selections. Several of the entries in this test are experimental lines and they are not commercially available in the United States.

In the November 21 harvest, high yields were obtained for all varieties. Because of dry conditions and cool weather the second harvest was not made until March 3 when significant differences were obtained between varieties. A very high yield was obtained in the fourth and fifth harvests. Wet growing conditions in April and

TABLE 1. RYEGRASS FORAGE CLIPPING VARIETY TEST AT OVERTON, TEXAS, 1985-1986

Variety	Harvest Dates: Nov.21	Mar. 3	Mar. 21	Apr. 28	June 11	Total Forage Yield	Crown Rust Rating %
	pounds oven-dried forage per acre						
Cervus	2,392	3,068	1,789	5,114	4,922	17,280	15
Dama	2,120	2,414	1,522	5,228	5,359	16,640	10
Gulf	1,599	3,423	1,589	5,612	4,392	16,610	10
Fla. 80-1K	2,289	3,764	1,538	5,576	3,271	16,430	1
Marshall	2,367	2,969	1,488	5,522	3,775	16,120	33
Tx-R-85-1	2,041	3,324	1,321	5,030	4,035	15,750	13
Fla X 1985LR	2,055	3,352	1,087	5,054	4,019	15,560	4
Cebeco Elm 10	2,081	2,443	1,655	4,934	4,351	15,460	70
Tetragold	1,573	3,367	1,957	5,023	3,279	15,190	9
Urbana	2,002	3,239	1,137	4,561	4,009	14,940	35
Tosca	2,002	2,926	1,288	4,910	3,689	14,810	50
Ellire	2,002	2,372	1,472	4,778	4,131	14,750	20
Kemal (Festulolium)	1,964	2,628	1,371	4,694	4,069	14,720	2
Exalta	1,664	2,386	1,337	3,553	5,720	14,660	15
Bromus catharticus	1,612	2,600	1,421	4,339	4,557	14,520	—
Tx-R-84-1	2,081	2,940	1,538	4,231	3,551	14,340	4
Cebeco Lm 8	2,145	2,755	1,271	4,327	3,793	14,290	20
Minaret	2,601	2,713	1,639	4,429	2,670	14,050	5
Cebeco Lm W2	1,768	2,628	1,120	4,417	3,220	13,150	90
Cebeco Elm 9	1,781	2,244	1,438	3,931	3,511	12,900	75
Cebeco E1R4	2,093	2,273	1,354	3,457	3,278	12,450	35
Ursus	1,573	1,974	920	3,019	2,970	10,450	5
Mean	1,991	2,809	1,421	4,624	3,935	14,780	
LSD (10%)	NS[2]	827[1]	NS[2]	1,187[1]	1,190[1]	2,542[1]	
CV	29	25	33	21	25	15	

[1]Differences in yield between varieties within a harvest date, of less than the LSD value are due to chance.
[2]No significant differences.
Planted on September 20, 1985.

May caused the ryegrass to remain vegetative and continue to produce forage rather than produce seed heads.

Crown rust was very severe during spring 1986 at Angleton. Data are the average of two replications. The following rust rating system was used:

Visual Score	Variety Reaction
0-5	Resistant
6-15	Moderately Resistant
16-35	Moderately Susceptible
36-100	Susceptible

Gulf was released as a resistant variety and it remains as a moderately resistant variety. Marshall is a moderately susceptible variety.

Oat, Rye, and Wheat Forage Variety Tests At Overton in 1985-86

L.R. NELSON, S. WARD, AND J. CROWDER

Summary

This report presents forage data for the 1985 to 86 winter growing season for oats, rye, and wheat at Overton, Texas. Highly favorable growing conditions, with no winterkill or freeze damage resulted in good forage yields. Oats produced higher forage yields than wheat or rye. The mean yields across all varieties for oats, wheat, and rye was 9,700, 6,700, and 5,510 lbs DM/A, respectively.

Introduction

These experiments were conducted to determine the forage yielding potential of small grain varieties and experimental lines in East Texas. Also, we wanted to determine the seasonal distribution of forage for the small grain varieties and to test their winterhardiness and disease resistance.

KEYWORDS: *Triticum aestivium/Avena sativa/Secale cereale/* small grain forage/yield dry matter.

Procedure

Available commercial and experimental wheat, oat, and rye varieties were planted in three separate experiments at Overton during early September 1985. In the wheat test there were 26 entries which included 23 wheats and three triticale varieties. Among the wheat lines there were 3 hybrids, 6 hard red winter wheats, and 14 soft red winter wheats. There were 14 rye genotypes in the rye tests, of which several were experimentals being submitted by the Noble Foundation. There were 14 genotypes included in the oat test.

All tests were planted in a prepared seedbed which had been fertilized with 60-60-80 lbs/A of N, P_20_5 and K_20, respectively. Planting dates were September 9 for rye, and September 12 for oats and wheat. Seeding rate was 120 lbs/A and seed were planted with a drill into six row plots 12 ft in length with 8-inch row spacing. Each experiment was replicated four times. All experiments were topdressed with urea at a rate (actual N) of 100 and 50 lbs/A on October 16, 1985 and January 22, 1986.

Forage plots were harvested with a Hege forage plot harvestor, which has a sickle bar and were cut at 2-inches height. Percent dry matter (oven-dried forage) was determined in order to obtain total dry matter. A 10 percent least significant difference was computed for each harvest on each test. This value can be used to make comparisons between varieties. Differences greater than this value are real 9 times out of 10 and may be considered significant.

Results and Discussion

Oat forage yields are presented in Table 1. Above normal temperatures during December, January, and February resulted in good forage production during this period. A uniform distribution of forage resulted which is unusual for oats. No winterkilling occurred and diseases were not observed during 1985 to 1986 in this test.

Rye forage yields are presented in Table 2. Yields were about average for 1985 to 1986. Dry weather in December through February limited rye yields during that period. The warm winter probably resulted in the rye plants changing to a reproductive growth stage quite early (producing a seed head), and thus, late spring forage yields were reduced.

Wheat forage yields are presented in Table 3. Yields were about normal or above normal for wheat in East Texas. Good forage distribution was obtained. Lower yields on March 20 were due to moisture stress prior to that harvest. No winterkilling or significant diseases were observed in this study.

Results of these studies should be used with caution. More than one year's data is desirable when variety recommendations are made because of interaction with weather conditions. Since the growing season of 1985 to 86 was unusually warm, this is especially the situation.

TABLE 1. OAT VARIETY FORAGE TEST AT OVERTON, TEXAS, 1985 TO 1986

	Harvest Dates				
Variety	Nov. 19	Feb. 28	Mar. 20	Apr. 28	Total Yield
	pounds oven-dried forage per acre				
Bob	2,236	2,684	1,742	4,242	10,904
Four-twenty-two	2,328	2,526	1,617	4,300	10,771
Walken	2,704	2,824	2,293	2,939	10,760
Coker 227	2,346	3,227	1,955	2,576	10,104
Harpool 833	2,477	2,263	2,133	3,187	10,060
Tx-82M 5061	2,386	2,543	1,706	3,275	9,910
Tx-81C 676	2,424	2,192	1,297	3,929	9,842
Mesquite	1,832	2,719	2,080	3,131	9,762
Big Mac	1,942	2,034	2,186	3,395	9,557
Tx-81C 3643	2,034	2,490	1,298	3,721	9,543
Tx-82M 4350	2,072	2,947	1,226	2,746	8,991
Tx-83Ab 2923	2,481	1,771	1,386	3,145	8,783
Tx-81C 606	2,037	1,982	1,404	3,342	8,765
Tx-82C 6023	2,034	1,771	2,186	2,061	8,052
Mean	2,238	2,427	1,751	3,285	9,701
LSD (%)	640[1]	878[1]	780[1]	1,079[1]	1,959
CV (%)	23	28	35	26	16

[1]Differences in yield between varieties within a harvest date of less than the LSD value, are due to chance.

TABLE 2. RYE FORAGE VARIETY TEST AT OVERTON, TEXAS, 1985-1986

	Harvest Dates				Total Yield
Variety	Nov. 21	Feb. 28	Mar. 20	Apr. 11	
	pounds oven-dried forage per acre				
Fla. Exp. 201					
ES-79-1	1,586	3,440	355	852	6,233
Gurley GI-87	1,729	2,309	887	791	5,716
Noble Foundation 14	1,729	2,079	1,048	852	5,708
Fla. Syn-T	1,807	2,584	419	699	5,509
Maton	1,651	1,545	1,435	821	5,452
Gurley GI-87X	1,703	2,064	742	897	5,406
Noble Foundation	1,495	2,049	935	882	5,361
Noble Foundation 142	1,599	2,140	871	714	5,324
Bonel	1,547	1,926	951	882	5,306
Elbon	1,378	2,064	1,000	669	5,111
Noble Foundation 125	1,586	1,957	774	700	5,017
Fla. 401	1,521	1,085	435	1,064	4,105
Wintergrazer 70B	988	932	1,080	1,080	4,080
X-73-19	1,222	963	709	912	3,806
Mean	1,539	1,938	831	844	5,152
LSD (10%)	331[1]	708[1]	417[1]	NS[2]	1,049[1]
CV	18	30	42	35	17

[1]Differences in yield between varieties within a harvest date, of less than the LSD value are due to chance.
[2]No significant differences.

TABLE 3. WHEAT FORGE VARIETY TEST AT OVERTON, TEXAS, 1985 TO 1986

Variety	Harvest Date: Nov. 22	Feb. 28	Mar. 20	Apr. 24	Total Yield
	pounds oven-dried forage per acre[1]				
Exp. Tx-78-7303	1,352	3,060	505	3,137	8,054
Beagle Triticale	1,404	1,438	312	4,709	7,863
Exp. Tx-80-38	1,404	3,014	457	2,913	7,789
TAM-W-107	1,335	1,827	1,395	2,792	7,348
Bradford	1,525	1,964	818	2,977	7,284
Coker 68-15	1,525	1,986	1,010	2,689	7,211
Souixland	1,491	1,964	1,371	2,356	7,182
McNair 1003	1,352	2,809	674	2,157	6,992
Exp. Tx-80-22	1,317	2,581	553	2,521	6,972
Caldwell	1,369	1,256	818	3,413	6,855
Noble Foun. 126	1,352	2,238	1,106	2,103	6,799
Nelson	1,300	3,151	794	1,506	6,751
Fillmore	1,265	1,895	1,083	2,181	6,724
Rosen	1,265	2,238	481	2,695	6,678
HW 3015	1,335	2,626	914	1,767	6,642
Councill Triticale	1,508	1,438	1,131	2,545	6,622
Fla. 201 Triticale	1,300	685	770	3,745	6,500
Auburn	1,335	1,073	890	3,163	6,460
Adder	1,213	1,804	962	2,460	6,439
HW 3022	1,387	1,827	890	2,182	6,285
Exp. Tx 82-185	1,404	2,398	818	1,513	6,132
HW 3021	1,265	2,215	673	1,959	6,113
Compton	1,560	1,781	1,010	1,714	6,065
Noble Foun. 67	1,352	1,530	1,106	2,066	6,054
Pioneer 2157	1,352	1,644	1,106	1,556	5,658
TAM-W-108	1,335	890	1,178	1,998	5,401
Mean	1,369	1,974	878	2,504	6,726
LSD (10% level)	NS[2]	NS	NS	1,031[3]	1,442[3]
CV	11	42	42	29	15

[1]Yield data are from three replications as one replication was discarded due to lack of uniformity.
[2]No significant differences between varieties.
[3]Differences in yield between varieties within a harvest date, of less than the LSD value are due to chance.

Oat Silage Yield as Affected by Time of Application of Nitrogen Fertilizer, Seeding Rate, and Planting Date

J. C. Read and R. M. Jones

Summary

This test was conducted at Texas A&M University Research and Extension Centers at Dallas and Stephenville to determine if time of nitrogen (N) fertilizer application, plant density, and planting date would affect yield and winterkill of oats. Winter-hardy ('H833') and winter-sensitive ('Cornado') cultivars were planted. The only winterkill was on plots of the early planting date of Cornado at Dallas which had 100 percent stand loss. There were no differences in silage yield due to either time of N application or seeding rate at Dallas but there were differences for both of these treatments at Stephenville. Plots of the early planting date produced the highest yields in most cases.

KEYWORDS: Oats/winterkill/nitrogen fertilizer/Dallas and Stephenville.

Introduction

Oats are grown extensively for grazing and silage producion in Texas but lacks winter hardiness when compared to other small grains. In central Texas oats perform good in most years but there is a risk of winterkill when a colder than normal winter occurs. More cold tolerant cultivars of oats have been developed for this region. Fall applications of N fertilization can have an effect on winter survival, but the rates that may promote winterkill have not been established. Also, little is known concerning the effects at plant populations on winter survival. This test was undertaken to determine if either seeding rate, timing of nitrogen fertilizer application, or date of planting would influence winterkill and which of these treatments would optimize forage yield.

Procedure

This test was conducted at Dallas and Stephenville using H833, a winter-hardy oat, and Cornado, a winter-sensitive oat. Dates of planting were 9 Oct 85 and 6 Dec 85 at Dallas and 6 Nov 85 and 6 Dec 85 and Stephenville. Earliest planting date at both locations was later than desired because of extreme dry conditions in September at Dallas and in September and October at Stephenville. Nitrogen applications were 0, 50, 100, and 150 lbs/A in the fall prior to planting and 150, 100, 50, and 0 lbs/A in the spring so that each plot received a total of 150 lbs of N/A. Planting rates were 1, 2, 3, and 4 bu/A. A split plot design with dates as whole blocks with four replications was used.

Results and Discussion

The mean silage yield for Dallas was 3,767 lbs/A and for Stephenville was 2,738 lbs/A (Tables 1 and 2). In all cases except for the 9 Oct 85, planting date for H833 at Dallas there was an increase in silage yield due to an increase in planting rate (Table 1). The means for both locations were 3,425, 3,371, 3,275, and 2,930 lbs/A for the 4, 3, 2 and 1 bu/A seeding rate, respectively. One bu per acre had significantly lower yields but the 2, 3, and 4 bu plantings were not significantly different from each other. At Dallas there were no differences due to planting rate (Table 1). The trend was for an increase in yield with increased planting rate. Table 1 shows that at Stephenville there was a significant increase in yield due to increased planting rate.

TABLE 1. EFFECT OF PLANTING DATE AND DENSITY ON OAT SILAGE YIELD OF TWO CULTIVARS AT DALLAS AND STEPHENVILLE

Seeding rate	H833		Cornado		Mean
	9 Oct 85	6 Dec 85	9 Oct 85	6 Dec 85	
bu/A					lb/A
Dallas					
4	5,354 b*	4,975a	0	5,070a	3,850ns
3	5,544ab	4,754ab	0	5,025a	3,831
2	5,800a	4,652b	0	4,890a	3,836
1	5,503ab	4,248c	0	4,452b	3,551
Mean	5,550	4,657	0	4,859	3,762
Stephenville					
	6 Nov 85	6 Dec 85	6 Nov 85	6 Dec 85	
4	2,741a*	2,603a	3,848a	2,807a	3,000a
3	2,529ab	2,532a	3,877a	2,703a	2,910ab
2	2,334b	2,390ab	3,712ab	2,421a	2,714
1	1,634c	1,940b	3,341b	2,403b	2,329
Mean	2,309	2,366	3,695	2,584	2,738

*Mean in a column for each location not followed by a common letter differ significantly (5% level) using Duncan's Multiple Range Test.

Table 2 shows that there was no significant difference due to timing of N fertilizer applications at Dallas but rather a general trend for increased yield with increased fall fertilization. Table 2 shows that there are differences due to timing of N fertilizer applications for both cultivars at Stephenville. Opposed to the Dallas location the higher yields were associated with the higher N applications in the spring.

No differences in winter survival were due to either timing of N fertilizer applications or planting rate. Winter survival differences were due to planting date and cultivars. A freeze occurred in late November causing a 100 percent stand loss of the 9 Oct 85 planting of Cornado at Dallas.

TABLE 2. OAT SILAGE YIELD AS AFFECTED BY TIMING OF NITROGEN FERTILIZER APPLICATIONS ON TWO CULTIVARS AT TWO PLANTINGS AT DALLAS AND STEPHENVILLE

Time of N appl. Fall	Spring	H833 9 Oct 85	H833 6 Dec 85	Cornado 9 Oct 85	Cornado 6 Dec 85	Mean
		lb/A				
Dallas						
150	0	5,735a*	4,772ns	0	5,040a	3,887ns
100	50	5,830a	4,510	0	4,900ab	3,810
50	100	5,550a	4,604	0	4,878ab	3,758
0	150	5,086b	4,744	0	4,620b	3,613
Mean		5,550	4,658	0	4,860	2,738
Stephenville						
		6 Nov 85	6 Dec 85	6 Nov 85	6 Dec 85	
150	0	2,468ns	2,018b*	3,419b	2,380b	2,624b
100	50	2075	2,472a	3,629ab	2,589ab	2,639b
50	100	2,230	2,540a	4,016a	2,757a	2,886a
0	150	2,462	2,434a	3,714ab	2,608ab	2,805ab
Mean		2,309	2,366	3,695	2,584	2,738

*Mean in a column for each location followed by a common letter differ significantly (5% level) using Duncan's Multiple Range Test.

Alfalfa Variety Trials—Yoakum 1984-85 and 1985-86

A. M. SCHUBERT AND C. L. POHLER

Summary

Sixteen alfalfa cultivars have been tested under rainfed conditions at the Texas A&M University Agricultural Research Station at Yoakum since fall 1984. While there have been substantial ranges in yields, the degree of variation among replications have been great. This has resulted in no statistical differences for some harvest periods or broad groupings of cultivars by Duncan's Multiple Range Test. However, performance of most cultivars appear to be acceptable. Harvests will be continued this crop year, allowing a 3-year assessment of adaptation and performance.

Introduction

Alfalfa acreage in the South Central, Coastal Bend, and Upper Coast Texas Crop Reporting Districts is very small. Only 2,000 of the 442,000 acres of hay reported in the South Central District in 1985 were alfalfa, and 1,000 of 95,000 acres of hay in the Upper Coast were alfalfa. The Coastal Bend district acreage was too small to report.

Alfalfa production is frequently viewed as intensive, high yielding, and usually irrigated production which is viable only if stands remain for decades. While biological and environmental stresses may not allow the high production levels or stand persistence seen in some regions, much of the southern half of Texas may support rainfed alfalfa for hay or grazing at more modest levels of both productivity and production costs. As an initial step in determining the feasibility of such production, we initiated a variety trial in fall 1984 to assess production and persistence of selected alfalfa cultivars at the TAMU Agricultural Research Station at Yoakum.

Procedure

Sixteen alfalfa cultivars were planted November 29, 1984 at a seeding rate of 19 lbs/A. The seed were obtained from the Regional Plant Introduction Station at Experiment, Georgia. Prior to planting all seed was inoculated with the appropriate rhizobium using the Pelgel method. The experimental site is located on the TAMU Agricultural Research Station at Yoakum in Lavaca County. The soil is in the Denhawken-Elmendorf complex (Fine, montmorillonitic, hyperthermic Vertic Ustochrepts), has a high clay content, and is moderately alkaline (pH 8). Plots are 15-ft long and 12-ft wide. The experimental design is a randomized complete block with four replications.

The test was planted on a prepared seedbed in which Balan (4 qt/A) had been incorporated. The seed were distributed over the plot area by hand and rolled with a "culti-packer." Cultural practices have included: 1/25/85—fertilized with 150 lbs/A 0-46-0; 6/28/85—hoed for weed control; 11/6/85—fertilized with 150 lbs/A 0-46-0; and 11/20/86—fertilized with 150 lbs/A 0-46-0. The plots have not been irrigated.

Yield sampling areas are 15 ft X 4 ft and are harvested with a Lawn Genie flail mower equipped with a catcher. In the harvesting protocol, the fresh forage is cut, dumped onto a tarp, and weighed on a milk scale tared for the tarp. A moisture sample is collected and stored in a closed plastic bag. The moisture sample is weighed wet, transferred to a cloth bag, and dried with heated, forced-air. The dry forage is weighed and percent dry matter calculated to convert the plot fresh weight to weight of dry forage. A quadrat was hand-harvested from a representative site in each plot to correct for any weeds or grass in the sample weight. Data were analyzed using analysis of variance (ANOVA) and Duncan's Multiple Range (DMR) procedures of the Statistical Analysis System.

During the first year of the test, intervals between harvest dates were probably longer than desirable. In the second year, we harvested at approximately 10 percent bloom; this worked out to an approximately 40-day interval during good growing conditions. Cutting height was normally 4 inches, except for the last harvest in 1985 which was cut at 6 inches to minimize possible stress from the late harvest.

Plots have also been rated for stand density and rust infestation, but the data is not presented in this report. The stands for Florida 77 and Hy-Phy are substantially less dense than other cultivars, which may be related to their relatively poor performance.

Results and Discussion

During the first harvest season, yields were significantly different among cultivars only in the third harvest (Table 1). The average yield of dry alfalfa was 2,448 lbs/A for the first clipping (June 4); 1,624 for the second cutting (July 2); 1,057 for the third cutting (July 30); and 600 for the fourth cutting (December 5). The average seasonal yield for 1985 was 5,729 lbs of dry forage per acre. Even in the third cutting, which had statistically significant variation among cultivars, the DMR groupings were large. The highest yielding group included 13 of the 16 cultivars.

Harvest dates in 1986 were March 24, April 30, June 11, July 10, September 11, and December 4. Yields were significantly different among cultivars for the second, third, and fourth cuttings and for the annual totals (Table 2). Annual dry forage production ranged from 6,812 lbs/A for Hy-Phy to 10,556 lbs/A for Apollo. Again, the DMR groups were large with the highest yielding group including 14 of the 16 cultivars tested.

In both years, WL 318, Apollo, Raidor, Cal West 481, and Cimarron were among the eight highest-yielding cultivars; and Florida 77 and Hy-Phy tended to be relatively low-yielding. As previously stated, the stands of the two lower-yielding cultivars were relatively thin.

It should be noted that while the yield figures presented indicate relative performance, they are probably over-

KEYWORDS: Alfalfa/*Medicago sativa*/forage/production/yield.

estimates of what a producer would actually obtain, especially in hay production. There are two reasons for believing this to be true: (1) end-of-row effects in the small plots increase plot weights; and (2) we have no leaf loss from air drying as would occur in normal hay production.

Initial observations indicate that even under conditions of summer drought, production and stand survival has been acceptable for the alfalfa cultivars tested. There have been no severe disease or insect problems. Rust was found in the plots this spring, but it did not appear to cause much damage. Harvesting and observation of plots are continuing this growing season. Following this season, yield trends for the 3 years will be analyzed and some estimates of the biological and economic potential of alfalfa made for this area.

Literature Cited

1. 1985 Texas County Statistics. Texas Agricultural Statistics Service. Texas Department of Agriculture and U.S. Department of Agriculture.

TABLE 1. ALFALFA VARIETY TRIAL AT YOAKUM, TEXAS 1984-85

Variety	First Harvest	Second Harvest	Third Harvest	Fourth Harvest	Total lbs/A
WL 318	2,890	2,354	1,308 ab*	651	7,203
RAIDOR	2,822	1,886	1,529 a	839	7,076
APOLLO	2,889	1,899	1,561 a	603	6,952
CAL WEST 481	2,905	1,787	967 abc	868	6,527
CLASSIC	2,762	1,903	1,235 ab	624	6,524
CIMARRON	2,620	1,713	1,143 abc	625	6,101
PIONEER 532	2,223	1,996	1,254 ab	544	6,017
BARON	2,523	1,614	948 abc	570	5,655
PIONEER 526	2,395	1,693	1,057 abc	472	5,617
SHENANDOAH	2,378	1,713	970 abc	475	5,536
SOUTHERN SPECIAL	2,234	1,613	1,029 abc	617	5,493
ARMOR	2,041	1,723	1,093 abc	482	5,339
CAL WEST 475	2,169	1,469	1,087 abc	562	5,287
VANCOR	2,625	1,210	741 bc	423	4,999
FLORIDA 77	1,964	627	505 c	947	4,043
HY-PHY	1,733	789	485 c	305	3,312
MEAN	2,448	1,624	1,057	600	5,729
F-TEST	P=40%	P=18%	P=1%	P=63%	P=16%

*Means in each column followed by the same letter are not signficantly different at the 5% probability level as indicated by Duncan's Multiple Range Test.

TABLE 2. ALFALFA VARIETY TRIAL AT YOAKUM, TEXAS 1985-1986

Variety	First Harvest	Second Harvest	Third Harvest	Fourth Harvest	Fifth Harvest	Sixth Harvest	Total lbs/A
Apollo	2,033	1,273 ab*	2,687 a	2,384 a	999	1,180	10,556 a
Cal West 475	2,582	1,251 abc	1,734 bc	2,341 a	903	1,407	10,217 a
Cal West 481	1,979	1,373 a	1,936 b	2,453 a	966	1,423	10,130 a
Shenandoah	2,348	986 abcde	2,035 b	2,071 ab	875	1,673	9,987 ab
WL 318	1,997	1,073 abcde	2,066 b	2,235 ab	908	1,410	9,689 ab
Pioneer 526	2,215	1,063 abcde	1,847 bc	2,177 ab	907	1,464	9,672 ab
Raidor	1,950	909 cde	1,984 b	2,545 a	962	1,241	9,591 ab
Cimarron	2,268	940 cde	1,688 bc	2,052 ab	813	1,370	9,131 abc
Baron	1,962	1,188 abcd	1,712 bc	2,019 ab	848	1,289	9,017 abc
Pioneer 532	1,859	1,071 abcde	1,712 bc	2,231 ab	969	1,129	8,970 abc
Classic	1,739	850 de	1,670 bc	2,176 ab	952	1,543	8,929 abc
Armor	1,666	1,024 abcde	1,632 bc	1,968 ab	908	1,716	8,914 abc
Southern Special	1,841	1,030 abcde	1,528 bc	2,105 ab	843	1,065	8,412 abc
Vancor	2,235	860 cde	1,475 bc	1,709 bc	873	1,130	8,280 abc
Florida 77	1,672	967 bcde	1,281 c	1,700 bc	864	1,119	7,603 bc
Hy-Phy	1,698	682 e	1,209 c	1,293 c	776	1,155	6,812 c
Mean	2,003	1,034	1,762	2,091	898	1,332	9,119
F-Test	P=42%	P=1%	P=0.1%	P=0.1%	P=84%	P=74%	P=4%

*Means in each column followed by the same letter are not significantly different at the 5% probability level as indicated by Duncan's Multiple Range Test.

Seasonal Production of Annual Forage Legumes at Overton, 1985-86

G. R. SMITH AND C.L. GILBERT

Summary

Sixty-three annual clovers, including arrowleaf, crimson, rose, ball, and berseem, were evaluated for forage production and adaptation at Overton in 1985 to 1986. Six vetches, including common, hairy, and bigflower were also evaluated. Annual clover forage production ranged from 4,104 to 1,142 lbs DM/A for 'RH-18' rose clover and 'MS Expl. 1' berseem clover, respectively. Vetch production ranged from 3,238 to 91 lbs DM/A for 'Hairy' and 'Nova II', respectively.

Introduction

Reseeding winter-annual legumes have the potential to provide high-quality grazing during late fall, winter, and spring without the costs of nitrogen fertilizer. The distribution of forage production from these legumes is a direct complement to warm-season perennial grasses. The objectives of these experiments were: 1) to determine seasonal distribution of annual forage legume dry matter production; and 2) to determine the general adaptation of annual forage legumes to East Texas soil and climatic conditions.

Procedure

Twenty-eight annual clovers and six vetches were drilled into a mixed 'Coastal' and common bermudagrass sod on October 15, 1985. A small-plot drill with six double-disk openers, spaced 9 inches apart, was used to place seed one-half inch deep in 5 X 10-ft plots. The clovers were harvested at 2.25 inches and the vetches at 1.75 inches with a rotary mower.

Thirty-five varieties or experimental lines of subterranean (sub) clover were established in 4 X 4-ft plots on a prepared seedbed October 18, 1985. Square-foot quadrants were hand-harvested at 1.5 inches.

All plots were fertilized prior to planting and according to soil tests with 100 lbs/A P_2O_5, 162 lbs/A K_2O, and 1.5 lbs/A B. Seeding rates, and *Rhizobium* inoculants for each legume species are shown in Table 1. Peat inoculant, supplied by the Nitragin Co., was applied at 1 oz per pound of seed with Pelgel solution used as an adhesive to stick inoculant to the seed.

Each experiment was arranged in a randomized complete block design with four replications. At each harvest, forage samples were weighed, dried at 70°C for 48 hours, and weighed again. Percent dry matter was calculated and used to estimate forage production per acre.

Results and Discussion

Arrowleaf and rose clover were the most productive forage legumes evaluated in 1985 to 1986, followed by crimson clover, ball clover, and hairy vetch (Tables 2-5). Common vetch, berseem clover, and sub clover were severely stressed by low rainfall (0.7 in) in March, resulting in low forage production. Seasonal distribution of forage production varied widely according to species. Crimson clover was the most productive in March and April with yield dropping sharply in May. In contrast, ball clover production peaked in May, but early season yields were low. The highest yielding rose clover experimental lines produced the most forage in April with production extending into May. Early maturing rose clover varieties, such as 'Kondinin' and 'Hykon' were very unproductive due to low yields in April and May. Arrowleaf clover was productive in April with peak forage yields in May. Forage production of hairy vetch peaked in April and extended into May. Due to low rainfall in March, sub clover production in 1985 to 1986 was somewhat atypical. 'Woogenellup' was the earliest maturing variety in this study and was the highest yielding in late March. 'Mississippi Ecotype' and 'Tallarook' were the latest varieties and the most productive at the late April harvest. Forage production of 'Mt. Barker' and 'Nangeela', mid-season varieties, was strongly limited by the dry conditions in March.

KEYWORDS: Forage/clover/vetch.

TABLE 1. SEEDING RATES AND *RHIZOBIUM* INOCULANTS USED IN EVALUATION OF ANNUAL FORAGE LEGUMES

Species	Seeding Rate	Inoculant Type[1]
	—lbs/A—	
Arrowleaf	14.3	0
Ball	3.6	B
Berseem and Crimson	19.6	R
Rose and Subterranean	19.6	WR
Common Vetch	35.0	C
Hairy and Bigflower Vetch	25.0	C

[1]Supplied by the Nitragin Co., Milwaukee, WI. Applied at 1.0 oz per pound of seed with Pelgel solution as an adhesive.

TABLE 2. SEASONAL FORAGE PRODUCTION OF SOD-SEEDED ANNUAL CLOVERS AT OVERTON, TEXAS, 1985 TO 1986

	Harvest Date			
Variety	3-13-86	4-8-86	5-9-86	Total
	pounds of dry matter per acre			
Meechee arrowleaf	774	1,135	1,692	3,601
Yuchi arrowleaf	822	1,194	1,575	3,591
Common Ball	304	967	2,176	3,447
Segrest Ball	447	850	2,004	3,301
Amclo arrowleaf	599	1,029	1,559	2,187
Autauga crimson	1,105	1,535	521	3,161
Chief crimson	859	1,541	664	3,064
Dixie crimson	1,089	1,440	468	2,997
Tibbee crimson	1,008	1,434	351	2,793
MS Expl. 3 berseem	385	382	878	1,645
Bigbee berseem	388	411	843	1,642
84 Bigbee berseem[1]	322	349	678	1,349
MS Expl. 2 berseem	349	330	669	1,348
85 Bigbee berseem[2]	290	358	670	1,318
MS Expl. 1 berseem	314	251	577	1,142
C.V. = 36.2%			LSD (0.05) = 409	

[1]Supplied by Funk's in 1984. [2]Supplied by Funk's in 1985.

TABLE 3. SEASONAL FORAGE PRODUCTION OF SOD-SEEDED ROSE CLOVER AT OVERTON, TEXAS, 1985-1986

Variety/Line[1]	Harvest Date 3-13-86	4-7-86	5-13-86	Total
	pounds of dry matter per acre			
RH-18	693	1,908	1,503	4,104
RD-3	668	2,009	1,260	3,937
RH-7	561	1,891	1,479	3,931
RD-17	652	1,931	1,191	3,774
RM-13	648	1,890	1,230	3,768
RF-20	765	1,827	1,081	3,673
RM-16	648	1,749	1,245	3,642
Wilton	628	1,440	1,524	3,592
RR-12	619	1,413	1,532	3,564
RO-15	676	1,699	1,136	3,511
RJ-3	622	1,656	1,220	3,498
Kondinin	935	311	128	1,374
Hykon	788	334	78	1,200
C.V. = 7.9%		LSD (0.05) = 383		

[1]Letter-number combinations denote experimental rose clover lines from the Overton clover breeding program.

TABLE 4. SEASONAL FORAGE PRODUCTION OF SUBTERRANEAN CLOVER AT OVERTON, TEXAS, 1985-1986

Variety/Line[1]	Harvest Date 3-24-86	4-29-86	Total
	pounds of dry matter per acre		
Woogenellup	1,830	875	2,705
Tallarook	1,250	1,307	2,557
SE 22	756	1,322	2,078
SK 43	649	1,408	2,057
SI 35	737	1,291	2,028
LO 32	1,074	947	2,021
Miss. Ecotype	659	1,357	2,016
SG 1	726	1,289	2,015
311499	1,018	980	1,998
319145	851	1,132	1,983
168638	861	1,103	1,964
SC 2	971	985	1,956
LO 712	740	1,146	1,886
Nangeela	974	894	1,868
SB 28	1,005	826	1,831
311498	838	962	1,800
LO 593	753	978	1,731
LO 1598	711	1,017	1,728
209924	1,175	551	1,726
291917	852	867	1,719
184962	867	846	1,713
SK 15	472	1,235	1,707
SB 23	636	1,069	1,705
SH 2	489	1,174	1,663
SE 23	512	1,147	1,659
SB 20	877	771	1,648
SD 26	801	846	1,647
Meteora	442	1,198	1,640
Mt. Barker	899	699	1,598
SK 42	544	911	1,455
SF 26	635	781	1,416
401573	648	744	1,392
SD 42	526	853	1,379
SG 16	325	1,006	1,331
SI 41	389	895	1,284
C.V. = 27.5%		LSD (0.05) = 805	

[1]Numbers or letter-number combinations denote experimental sub clover lines from the Overton clover breeding program.

TABLE 5. SEASONAL FORAGE PRODUCTION OF VETCH AT OVERTON, TEXAS, 1985-1986

Variety	Harvest Date 3-14-86	4-8-86	5-12-86	Total
	pounds of dry matter per acre			
Hairy	692	1,443	1,103	3,238
Woodford bigflower	450	930	1,095	2,475
Cahaba White	639	206	845	
Vantage	538	157	695	
Vanguard	417	202	619	
Nova II	63	28	91	
C.V. = 33.5%			LSD (0.05) = 634	

Breeding Arrowleaf Clover For Resistance To Bean Yellow Mosaic Virus

G. R. SMITH, I. J. PEMBERTON, AND C.L. GILBERT

Summary

Three cycles of evaluation and selection of arrowleaf clover (*Trifolium vesiculosum* Savi.) for resistance/tolerance to bean yellow mosaic virus (BYMV) have been conducted. 'Yuchi' arrowleaf is susceptible to BYMV with mortality ranging from 23 to 29 percent. Each cycle of selection improved tolerance to BYMV and plants approaching resistance have been identified in cycle 3. Mortality rate dropped to near zero after one cycle of selection. Germplasm superior to Yuchi in tolerance to BYMV has been identified.

Introduction

Arrowleaf clover (*Trifolium vesiculosum* Savi.) is an important forage crop in East Texas and across the U.S. southern region. Bean yellow mosaic virus (BYMV) is one of several virus diseases that have the potential to severely reduce forage and seed yield of arrowleaf clover. In 1985, a breeding program was initiated at the Texas A&M University Agricultural Research and Extension Center at Overton with the objective to develop virus

KEYWORDS: Disease resistence/selection/tolerance/*Trifolium vesiculosum*.

resistant clover germplasm. Multiple virus resistance was the eventual goal with BYMV resistance as the first component.

Materials and Methods

General culture and inoculation

Arrowleaf clover seed was pre-germinated on moist germination in petri dishes, then transferred to plastic trays with individual pots (5.5 in^3) or cone-containers (10 in^3). Growth media was prepared as shown in Table 1. All studies were conducted in a greenhouse.

Alsike clover (*T. hybridum L.*), infected with BYMV strain 204-1, was obtained from O. W. Barnett, Clemson University, South Carolina, and maintained as the inoculum source. Inoculum was prepared by grinding BYMV infected tissue (one leaf/1 ml buffer) in sodium phosphate buffer (4.5 g diethyldithiocarbamic acid per liter 0.03 M Na_2HPO_4) with mortar and pestle. Plants were mechanically inoculated by rubbing carborundum-dusted (600 mesh) leaves with a cotton swab saturated with inoculum. The youngest and second youngest fully expanded leaves were inoculated on consecutive days, respectively.

Germplasm and selection procedures

Three cycles of evaluation and selection have been completed to date. In cycle 1, 78 half-sib breeding lines of arrowleaf and the variety 'Yuchi' were inoculated with BYMV at 32 days of age (n = 17 per line). At 73 days, the plants were rated from 1 to 4 (mild to severe) based on symptom severity. Mild symptoms included slight mosaic or chlorosis and/or little leaf distortion. Severe symptoms included plant death, severe mosaic and chlorosis, leaf distortion, and stunting. Nineteen plants exhibiting the least severe symptoms were selected and 95 hand crosses made. Thirteen hundred and six Fl's from cycle 1 crosses were evaluated in cycle 2 (1986). Plants were inoculated at 40 and 41 days of age. Seventy-five days after inoculation, notes were made on symptom severity and top growth was harvested for dry matter yield. Twenty-nine plants with the mildest symptoms were selected and 196 crosses made. BYMV infection of selections was confirmed using ELISA procedures by Dr. M. R. McLaughlin, USDA-ARS, Mississippi State, Mississippi. Eleven hundred and eighty-three Fl's from crosses in cycle 2 were evaluated in cycle 3 (1987). Plants were inoculated at 41 and 42 days of age and evaluated for symptom severity at 100 days.

TABLE 1. GREENHOUSE MEDIA FOR CLOVER

Component	Quantity	Notes
	—bu—	
Coarse peat	0.50	screen through 1.3 cm mesh
Coarse vermiculite	0.25	
Coarse perlite	0.25	
Coarse washed sand and fine gravel mix	0.25	not builders sand
Total	1.25	
Fertilizer[1]	—g—	
0-0-60	7.50	Peters soluble
9-45-15	14.75	Peters soluble
Micronutrient mix[2]		Peters soluble (STEM)
Dolomitic lime	125.00	pass a #20 sieve
Gypsum	125.00	pass a #20 sieve

[1]Maintenance fertilizer (69.5 g KH_2PO_4/20L of water; 100 ml/6 in pot) was applied at 60-day intervals.
[2]When placed in containers, the mix was watered to capacity with 1 tsp Peters soluble trace element mix per 20L of water.

Results and Discussion

The performance of the 78 half-sib lines (original population) in cycle 1 is shown in Table 2. Line ratings ranged from 2.6 to 4.4 for lines 1 and 29, respectively. Yuchi arrowleaf rated 3.8 with a mortality of 29 percent. The ratings improved in cycle 2 ranging from 1.8 to 3.1 for crosses 36 and 10, respectively (Table 3). Dry matter production ranged from 0.40 to 0.21 g DM/plant for crosses 26 and 11, respectively (Table 4). Yuchi produced 0.27 g DM/plant on 20 surviving plants.

Figure 1 gives a summary of three cycles of selection in arrowleaf clover for resistance/tolerance to BYMV. We are making progress toward BYMV resistance using the selection procedures and germplasm described here. In cycle 3, 14 plants have been identified with either no or very mild virus disease symptoms. Confirmation of BYMV infection of these selections is in progress.

TABLE 2. REACTION OF ARROWLEAF CLOVER LINES TO MECHANICAL INOCULATION WITH BYMV

Line[1]	Rating[2]	Mortality
		—percent—
1	2.6[3]	6
24	2.7 a	0
64	2.8 a	12
21	3.2 a	12
71	3.5 ab	18
Yuchi (check)	3.8 bcd	29
3	3.8 bcd	6
4	3.8 bcd	12
17	3.8 bcd	18
36	4.1 cd	35
29	4.4 d	47

[1]Five most tolerant and five most susceptible lines from a total of 78 inoculated. Seventeen plants tested per line.
[2]Symptom severity rating: 1 = mild symptoms, 4 = severe symptoms, 5 = dead plant.
[3]Means followed by the same letters are not significantly different according to Fisher's LSD, P = 0.05.

TABLE 3. VIRUS DISEASE SYMPTOM SEVERITY OF ARROWLEAF CLOVER CROSSES INOCULATED WITH BYMV 204-1

Top 20%			Bottom 20%		
Cross	n	Score[1]	Cross	n	Score[1]
36	12	1.83	22	18	2.66
62	12	1.83	18	16	2.68
79	9	1.88	29	17	2.70
67	15	1.93	40	18	2.72
37	16	1.94	9	20	2.75
65	6	2.00	55	17	2.76
66	11	2.00	42	14	2.78
84	3	2.00	Yuchi[2]	20	2.85
74	6	2.00	28	7	2.85
20	19	2.05	12	14	2.85
31	19	2.05	86	7	2.85
23	15	2.06	11	18	2.88
57	11	2.09	24	18	2.88
83	10	2.10	6	20	3.00
21	18	2.11	1	13	3.07
8	17	2.11	10	7	3.14
C.V. = 28.8%			LSD (0.05) = 0.626		

[1]Score on scale of 1 to 4, with 4 exhibiting the most severe virus symptoms and 1 the least severe.
[2]Mean score of 20 surviving plants. Twenty-six Yuchi plants were inoculated and six died (death rate = 23.1%).

TABLE 4. DRY MATTER PRODUCTION OF ARROWLEAF CLOVER CROSSES INOCULATED WITH BYMV 204-1

Top 20%			Bottom 20%		
Cross	n	Yield	Cross	n	Yield
		g DM plant^{-1}			g DM plant^{-1}
26	18	0.402	24	18	0.273
74	6	0.396	64	5	0.272
78	10	0.395	Yuchi[a]	20	0.269
83	10	0.391	22	18	0.266
31	19	0.384	18	16	0.265
3	6	0.383	47	17	0.262
34	20	0.382	13	9	0.258
65	6	0.381	56	18	0.258
66	11	0.374	40	18	0.255
62	12	0.373	53	13	0.255
67	15	0.364	55	17	0.244
8	17	0.363	12	14	0.228
43	20	0.359	10	7	0.215
44	12	0.356	6	20	0.211
21	18	0.355	85	4	0.210
27	18	0.352	11	18	0.208
C.V. = 35.8			LSD (0.05) = 0.092		

[a]This is the mean of 20 surviving plants. Twenty-six Yuchi plants were inoculated and six died (death rate = 23.1%). Mean DM yield including dead plants is 0.207 for Yuchi. Uninoculated Yuchi produced 0.802 g DM plant^{-1}-(n=10).

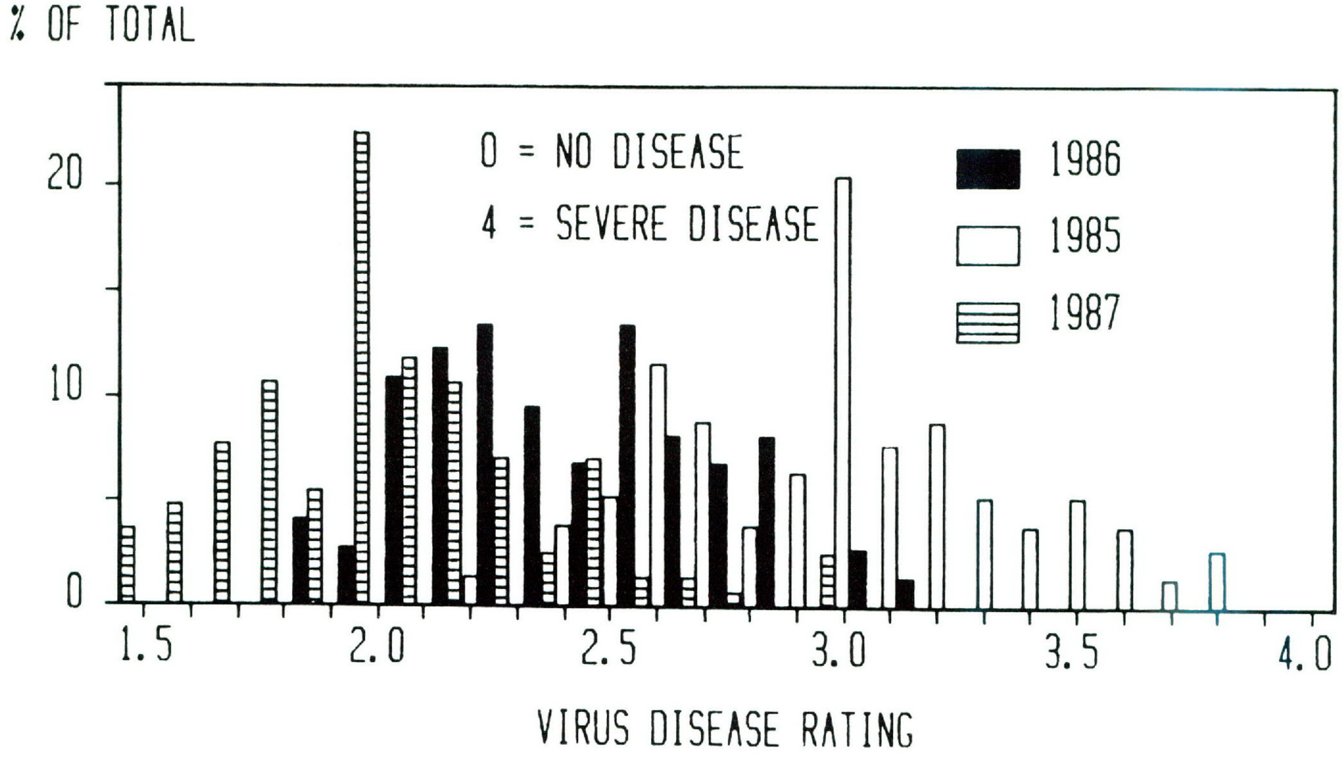

Figure 1. Virus disease rating of three arrowleaf clover populations infected with BYMV 204-1.

First-Year Performance of Alfalfa Cultivars in the Semi-Arid Subtropics of the Lower Rio Grande Valley

R. P. WIEDENFELD

Abstract

First-year alfalfa yields at Weslaco averaged better than 16,000 lbs dry weight/A in 1986, and no statistically significant differences between cultivars were found. No differences in stand density, plant height, degree of flowering or rust susceptibility were found between cultivars as well. Moisture availability strongly limited plant growth, but the crop was quick to recover and respond when rainfall was received.

Introduction

Alfalfa (*Medicago sativa* L.) is particularly appealing to growers because it produces a very palatable, high protein forage. The Lower Rio Grande Valley of Texas has the medium textured well-drained soils with higher pHs suitable for this crop (Evers and Dorsett, 1986), but alfalfa's extreme sensitivity to cotton root rot is thought to limit its potential in this area. Cultivar performance trials further north in Texas have reported good first-year alfalfa yields at Angleton (Evers 1985), College Station (Holt and Simecek, 1985), and Overton (Smith and Gilbert, 1985). This study was conducted to determine what constraints would be encountered in alfalfa production in a subtropical semi-arid environment, and to compare yields for several commercial alfalfa cultivars under these conditions.

Procedures

A field study was established on the Texas A&M Center at Weslaco on a Willacy fine sandy loam soil (Udic Argiustoll). Twelve alfalfa cultivars were planted in 10- X 20-ft plots in a randomized block design with three replications. Planting was done on 31 Oct 1985 on a rotovated seed bed by hand broadcasting inoculated seed at the rate of 30 lbs/A, then racking, followed by flood irrigation. No further fertilization, pesticide application, or irrigation was applied. Yields were determined at early bloom stage using a flail-type harvester, and a subsample was dried to convert yields to dry weight.

Results

The alfalfa field study at Weslaco was harvested seven times in 1986 due primarily to good rainfall amount and distribution (Fig. 1). Total yields averaged better than 16,000 lbs dry weight/A, and there were no statistically significant differences between cultivars (Table 1). Observations made for each plot just before the first harvest showed no differences between cultivars in stand density, plant height and degree of flowering, although there was

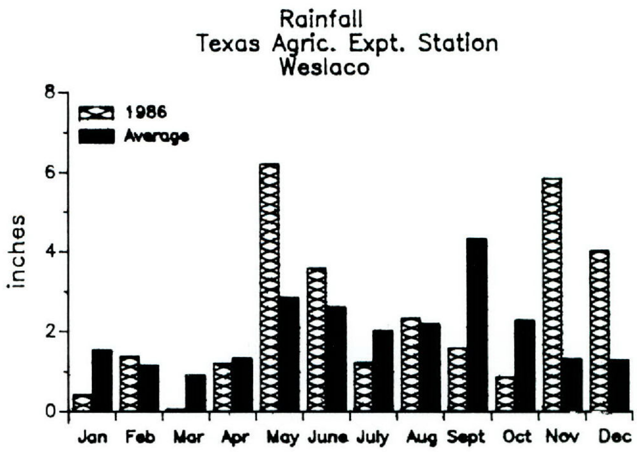

Figure 1. Monthly rainfall total at Weslaco for 1986 and 71-year average.

TABLE 1. YIELD OF ALFALFA CULTIVARS IN THE LOWER RIO GRANDE VALLEY, 1986

Cultivar	Date of Harvest							
	Feb. 20	Apr. 9	May 13	June 12	July 9	Aug. 7	Sept. 11	Total
	lbs dry matter/A							
Cibola[1]	2,289	4,522	2,026	2,894	2,331	1,337	1,295	16,694
P-5929[2]	2,211	4,379	1,912	2,907	2,138	1,440	1,600	16,587
Southern Special[3]	1,946	4,199	2,191	3,139	2,125	1,362	1,539	16,501
CUF-101[1]	2,324	4,730	2,011	2,712	2,262	1,250	1,161	16,449
WL-83T57-2[3]	2,189	4,621	1,891	2,986	2,323	1,183	1,199	16,393
Pierce[4]	2,181	4,514	1,623	2,906	2,127	1,485	1,246	16,083
NAPB-29[5]	2,124	4,737	1,739	3,048	2,198	1,088	1,040	15,975
Valador[4]	1,948	4,183	2,225	2,991	2,075	1,318	1,054	15,795
WL-83T51[3]	2,180	4,655	1,737	2,776	2,056	1,128	1,184	15,716
Granada[5]	1,911	4,487	2,120	2,954	2,056	1,184	905	15,618
Baron[5]	2,188	4,523	2,007	3,087	1,872	1,034	856	15,567
Florida-77[2]	2,430	4,719	1,617	3,001	1,604	722	815	14,908

[1]University of California. [2]Pioneer Hi-Bred. [3]WL Company. [4]Northrup King. [5]North American Plant Breeders.

KEYWORDS: *Medicago sativa* L./yield/stand density/plant height/flowering/rust susceptibility/drought tolerance.

tremendous variability in the number of flowers per plot. Since rust was also observed in the plots, a numerical rating was assigned based on severity. Again, substantial variability between plots occurred, but no statistically significant differences in rust rating between cultivars were found.

Observations on the overall study area during the year revealed the importance of moisture availability on alfalfa production. As soil moisture was depleted, crop growth slowed to nothing, but was quick to respond when some rain was received. Also, a large oval patch encompassing several plots appeared to decline in the middle of the study. Investigations led to the conclusion that some soil property resulted in reduced available water for that particular area.

This study will be continued in order to determine how different rainfall levels and distributions will affect alfalfa production, to determine persistance of alfalfa after several years in this climate, and to determine whether differences between cultivars exist for these parameters.

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Clare Subterranean Clover for South Texas Pastures

W. R. Ocumpaugh

Summary

'Clare' subterranean clover has received increased attention in South Texas over the last two growing seasons. 'Clare' is well adapted to the high pH soils of the region and has demonstrated a significant yield advantage over most of the standard subclover cultivars previously used. Preliminary observations indicate that it is similar in natural re-establishment ability to 'Woogenellup' subclover.

KEYWORDS: Subterranean clover/South Texas/clover evaluation/yields/iron-chlorosis/soil pH/'Clare'/'Mt Barker'/'Woogenellup'/reseeding/ carrying capacity.

Introduction

Subterranean clover is a winter annual forage legume that has been planted by an increasing number of cattlemen in Central and South Texas over the last few years. Subclover is popular because it is low growing, and the seed is formed in small burs near the soil surface allowing seed production under continuous grazing. Nearly all of the commercial cultivars available have been developed in Australia, and the majority of the commercial seed is imported from that country. The most commonly sold cultivar in Texas has been 'Mt. Barker', with a lesser amount of 'Woogenellup'. Both of these cultivars have been observed to show iron chlorosis on high pH soils. Most of the soils in Central and South Texas are pH 7 or above. The cultivar 'Clare', also developed and imported from Australia, has been reported in the literature to be better adapted to high pH soils. Previous evaluations of 'Clare' on neutral or acidic soils at Beeville and other locations in the south have not resulted in any substantial yield advantages. This report summarizes several plot and pasture evaluations comparing 'Clare' with 'Mt. Barker' as well as other cultivars on neutral to high pH soils.

Procedure

All studies were planted with 10 to 12 lbs/A of seed that were inoculated with "Pelinoc" system using WR type rhizobium. Specific planting dates varied with each experiment from mid- October to mid-November. Sod plantings were made with a "Tye" no-till drill on 10-inch row spacing. All plots were planted on prepared seedbed using a Kincaid plot drill with 12-inch row spacings. Phosphorous fertilizer was applied as 0-46-0 if a soil test indicated a need. The minimum amount (if any was applied) was 100 lbs/A with a maximum of 200 lbs/A of 0-46-0. The soils were either Clareville, Parrita, and Weesatche sandy clay loams ranging from pH 7 at the Clareville sites to pH 8+ at the Parrita sites.

Results and Discussion

The 1985 to 1986 plot study harvested on February 20, 1986 showed that 'Clare' outyielded 'Mt. Barker' and all the other subclover cultivars by about 200 percent (1,675 vs. 850 lbs/A). By the second harvest in April, 'Clare' yields were similar to the other cultivars. These plots were left undisturbed and allowed to re-establish in the fall and winter of 1986 to 1987. The stand ratings of 'Clare' and 'Woogenellup' were similar and also superior to all other entries. As has been previously observed, the reseeding stand of 'Mt. Barker' was inferior to 'Woogenellup'. No harvests were made on these plots in 1987, but height measurements taken on March 17, 1987 showed that 'Clare' was 5 inches taller than 'Mt. Barker' (16 vs. 11 inches). The soil at this site was a Parrita sandy clay loam and the pH was 8.1.

In fall 1986, 'Clare' and 'Mt. Barker' comparison studies were made at several sites on soils ranging in pH from near

7 to 8+. In each experiment, the cultivars were planted in four to seven replications. On a Clareville soil (pH 7), the first harvest yields taken on January 28 resulted in a small advantage to 'Clare' (1,450 vs. 1,125 lbs/A) compared to 'Mt. Barker'. A second experiment on this same soil but harvested February 12 resulted in a greater yield and similar advantage to 'Clare' (3,100 vs. 2,025 lbs/A). This experiment was weedy and resulted in a large variation in yield estimates. A third experiment planted on a Parrita soil (pH 8) resulted in a more decisive advantage to 'Clare' (3,850 vs. 2,900 lbs/A). A fourth plot experiment planted in an adjacent area but harvested on March 5 resulted in a more than 250 percent yield advantage to 'Clare' (5,450 vs. 2,100 lbs/A). Second harvests from these plots revealed small differences in forage yield between 'Clare' and 'Mt. Barker'.

'Clare' has never been observed to exhibit the classical symptoms of iron deficiency chlorosis in any of these studies. 'Mt. Barker', on the other hand, does exhibit symptoms of iron chlorosis on the high pH soils when soil moisture levels are high.

A grazing study was initiated in fall 1986 to compare 'Clare' and 'Mt. Barker' subclover planted in 'Kleingrass 75' sod to kleingrass alone. The kleingrass alone was fertilized with 50 lbs of nitrogen in the spring and again in the fall. There were two 5-acre pastures of each clover and of the N-fertilized kleingrass. The soils at this site were Parrita and Weesatche (pH 7.6 to 7.9). The study has not yet been in progress long enough to make definite statements on animal performance, but the (March, April, and May) carrying capacity of the 'Clare' pastures is superior to both the 'Mt. Barker' and N-fertilized kleingrass (five heifers versus three heifers/pasture).

Despite all the yield advantages of 'Clare' subclover on these high pH soils, 'Clare' does have some potential shortcomings. 'Clare' does not have the winter hardiness of 'Mt. Barker'. It did survive the winter of 1983 to 1984 and 1984 to 1985 at Beeville when the temperature dropped to 9°F (December 24, 1983) and similarly severe weather the following year. 'Clare' plots showed more tissue damage than all other subclovers evaluated in those winters. We have also observed some yet unidentified weaknesses in 'Clare' subclover speculated to be nutritional and/or viral. The literature indicates that 'Clare' subclover is not as efficient in the uptake of some micronutrients as is 'Mt. Barker' and other cultivars. We have observed what appears to be a virus on some plots of 'Clare' subclover. Adjacent 'Mt. Barker' plots seem to be resistant. In years to come, we will continue these evaluations; however, another "new" cultivar known as 'Koala' might be a possible substitute for 'Clare' on high pH soils.

Annual Medic Evaluation for South Texas Pastures

W. R. Ocumpaugh

Summary

A number of annual medic species have been observed to grow throughout Texas. However, commercial seed is not available for these "wild" ecotypes. Seed of several cultivars have been imported from Australia and evaluated in South Texas. The annual medics have the potential to produce earlier than most of the true clovers now being evaluated. Total dry matter yields near 5,000 lbs/A were observed in the 1986 to 1987 growing season, with 25 to 40 percent available by early January.

Introduction

The medics evaluated were winter annual legumes of several species of the genus *Medicago*. The most commonly known annual medic in South Texas is "burr clover," and is observed to grow in pastures, in yards, and along roadsides. These medics have several characteristics that make them well adapted to South Texas. They grow well on high pH soils, have a high content of hard seed, and produce a vigorous seedling that establishes rapidly in the fall. Like other legumes, the medics are only productive with adequate levels of phosphorous fertilizer. The annual medics also have some weaknesses; mainly, a higher bloat potential than the true clovers and more susceptibility to tissue damage from periodic freezes that occur in South Texas. This report summarizes some of the current evaluation efforts at TAES- Beeville on annual medics.

Procedure

Cultivar Test

Seed for the cultivars evaluated was imported from Australia via Ramsey Seed in California and Kaufman-Seeds in Arkansas. Eight cultivars representing four species were planted on a prepared seedbed on October 20, 1986. The soil at this site is a Clareville sandy clay loam with a pH of about 7.1. The area had previously grown alfalfa for hay for 3 years, so the soil nitrogen levels were undoubtedly high. Seeds of some cultivars were provided by both seed companies, thus three cultivars were planted in duplicate. All cultivars were planted at 12 lbs of seed per acre with a plot drill in a randomized block design with four replications. Seeds were inoculated with a "Medic special" rhizobium using the "Pelinoc" system of the Nitragin Company. The area received 100 lbs/A of 0-46-0 and was treated with 3.5 pints/A of Eptam (pre-plant incorporated) on the day of planting for control of weeds. 'Tetragold' ryegrass was also planted in the experiment, but was planted at 35 lbs/A about 2 weeks later to avoid the potential damage from Eptam. Some apparent Eptam damage was observed on certain medic plots. There was a slight shriveling of leaves in two areas of the field, but there was no indication of any one cultivar being more damaged than another. Plots were

KEYWORDS: Annual medic/South Texas/plant introductions/legume evaluation/ yields.

harvested for yield on January 6, February 10, and March 18, 1987.

Plant Introductions

In an adjacent area, some 270 PIs representing 16 species of annual medics were planted for initial evaluation on November 6, 1987. This site received 100 lbs/A of 0-46-0 at the same time as the cultivar experiment, but was not treated with Eptam. These evaluations were conducted with a limited number of seed (less than 75 seeds) so were direct planted in a single row 5-ft long with a plot drill. The seeds were inoculated as described in the cultivar trial. Due to a limited number of seed, none of these PIs were replicated, but several of the medic cultivars used in the cultivar test were inserted periodically in this planting to be used for comparisons. These plots were not harvested, but were rated for forage potential on February 18 and April 17, 1987 using the cultivar 'Jemalong' as the standard.

Results and Discussion

Cultivar Test

The dry matter yields of the cultivar test by harvest and total for the season are presented in Table 1. In total yield, there are only small differences between the cultivars evaluated. 'Paraggio', the latest maturing cultivar ranked in the middle at the first harvest, and was either top or second from top in the last and second harvest, respectively. 'Jemalong', the second highest in total yield has been evaluated at Beeville in a previous test. 'Jemalong' was the top yielding cultivar in that test. In that previous test 'Jemalong' also suffered the least amount of tissue damage following a severe freeze (9°F). 'Snail' and 'Serena' are two cultivars that were planted in duplicate in this test. They ranked highest in the first harvest and lowest in the last harvest. 'Snail' medic has a very large seed and it germinates and establishes very rapidly. However, it also has a very large stem and does not respond well to mechanical defoliation. In a previous test, 'Snail' and 'Paraponto' experienced the most tissue damage following a freeze.

Plant Introductions

Of the 270 PIs evaluated, over one third rated high at one or both of the rating times. PI 384665 rated higher than the check cultivars in both ratings. This PI is from the species *M. truncatula* which is the same species as 'Paraggio' and 'Jemalong'. Several PIs from *M. orbiculais*, *polymorpha*, and *M. scutellata* were rated as high or higher than the check cultivars in one or both of the ratings taken.

These data suggest that the annual medics need to be considered as one of the potential winter annual legumes for South Texas. They are more productive than the true clovers in the mid-winter period. The yields obtained from the medic cultivar study in early January were as good as or better than yields obtained from clover cultivar evaluations taken some 3 weeks later. These legumes need further evaluation in South Texas, particularly in areas south of Beeville where the potential for a hard freeze is minimal. A 5-acre planting of 'Jemalong' was made at La Copita Research Area (south of Alice) to observe growth and reseeding ability. It was planted in late November 1986 and has grown quite well. It produced seed, but only time will tell if it will re-establish and persist.

TABLE 1. SEASONAL PRODUCTION OF ANNUAL MEDICS AT BEEVILLE, 1986 TO 1987

Medic Cultivar	Harvest Dates Jan. 6	Feb. 10	Mar. 18	Total
	Pounds of dry matter per acre			
Paraggio[t]	1,341bc*	1,816ab	1,841a	4,997a
Jemalong[t]	1,220cd	1,769ab	1,535ab	4,524ab
Snail[s]	2,107a	1,042d	1,034bcd	4,418ab
Paraponto[r]	1,085cd	1,475abcd	1,744ab	4,304ab
Sephi[t]	882d	1,958a	1,265abcd	4,105ab
Sapo[r]	998cd	1,331bcd	1,707ab	4,037abc
Circle Valley[p]	1,372bc	1,434abcd	1,204abcd	4,010abc
Serena[p]	1,691ab	1,447abcd	728cd	3,865abc
Paraponto[r]	854d	1,488abcd	1,402abcd	3,744bc
Snail[s]	1,743ab	986d	974bcd	3,704bc
Serena[p]	1,404bc	1,587abc	657d	3,648bc
Tetragold Ryegrass	340e	1,124cd	1,455abc	2,920c

t = *M. truncaluta*, s = *M. scutellata*, r = *M. rugosa*, p = *M. polymorpha*.
*Yields followed by the same letter are not significantly different at the 0.05 level using Duncan's Multiple Range Test.

Seasonal Production of Experimental Rose Clover at Six Texas Locations

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Summary

Seasonal forage production of rose clover was evaluated at Overton, Dallas, College Station, Yoakum, Brenham, and Beeville in 1985 to 1986. Total production, averaged over four locations, ranged from 4,022 to 3,050 lbs DM/A for nine experimental rose clover lines from the Overton clover breeding program, while rose clover check varieties ranged from 3,129 to 1,793 lbs DM/A. Five experimental lines were identified with production characteristics superior to check varieties and other experimental lines. Rose clover was shown to be well-adapted to a range of Texas geographic locations in 1985 to 1986.

Introduction

Rose clover (*Trifolium hirtum* All.) is a winter annual legume with potential for use in Texas forage systems. Attributes of rose clover include a wide soil type adaptation, moderate drought tolerance and good reseeding characteristics. This species is not adapted to wet soil conditions and current commercial varieties are early maturing for most Texas locations. Experimental rose clover lines from the clover breeding program at Overton were evaluated for seasonal forage production at six Texas locations in 1985-1986. The objectives were: 1) enhance information concerning adaptation of rose clover to Texas environments, and 2) identify experimental rose clover lines suitable for germplasm or variety release.

Procedure

Experimental lines and check varieties of rose clover were established in fall 1985 at Overton, Dallas, College Station, Yoakum, Brenham, and Beeville. Planting rate was 20 lbs/A. Specific planting information for each site is shown in Table 1. Plots were harvested four times at Yoakum, three times at Overton and Brenham, twice at College Station and Beeville, and once at Dallas. At each harvest, forage samples were weighed, ovendried and weighed again. Percent dry matter of the samples was used to calculate dry matter forage yield per acre.

Results and Discussion

Acceptable stands were obtained at all sites. Plots were harvested beginning in January at Yoakum and extending into May at Overton and Brenham. Seasonal production at each site is shown in Tables 2 to 7.

'Kondinin' and 'Hykon' are early maturing varieties, and are currently the only named varieties of rose clover available as commercial seed. 'Wilton' rose clover has not been produced as certified seed since 1967. Kondinin and Hykon early season yield was generally high, at some sites slightly exceeding first harvest yields of the experimental lines. At sites with multiple harvests, mid- and late-season production of Kondinin and Hykon was far below the yield of the experimental lines. Wilton was intermediate in total forage production between the best experimental lines and the early varieties. Drought conditions at Beeville limited rose clover production to one early harvest and one late hand-clipped harvest. Kondinin and Hykon were winterkilled at Dallas in early December. The two experimental rose clover lines planted at Dallas were limited to one harvest by drought conditions.

Brenham, Overton, College Station, and Yoakum collected multiple harvest (regrowth) data on nine rose clover experimental lines and three check varieties. Total season production from these four locations is summarized in Table 8. Based on performance averaged over these four environments, the lines RH-18, RD-3, RD-17, RF-20, and RM-16 have a slight production advantage over the other four experimental lines. The late maturing experimental line RD-3 produced 28 percent more total forage than Wilton, the best check variety, aver-

KEYWORDS: Rose clover/legume/forage production.

TABLE 1. PLANTING INFORMATION BY LOCATION

Location	Planting date	Plot size	No. of replications	Soil type
		(ft)		
Overton[1]	10-15-85	5x10	4	Sawtown fsl
Brenham[2]	10-10-85	5x15	4	Houston bc
Yoakum[2]	11-1-85	6x20	4	Hallettsville fsl
College Station[2]	10-11-85	5x20	3	Ships c
Beeville[3]	10-25-85	5x20	6	Parrita scl
Dallas[4]	10-14-85	5x16	4	Houston bc

[1]Ten experimental entries plus Kondinin, Hykon, and Wilton checks.
[2]Nine experimental entries plus Kondinin, Hykon, and Wilton checks.
[3]Nine experimental entries plus Kondinin and Hykon checks.
[4]Two experimental entries plus Kondinin and Hykon checks.

TABLE 2. SEASONAL FORAGE PRODUCTION OF SOD-SEEDED ROSE CLOVER AT OVERTON, TEXAS, 1985-1986

Variety	Harvest Date 3-13-86	4-7-86	5-13-86	Total
	Pounds of dry matter per acre			
RH-18	693	1,908	1,503	4,104
RD-3	668	2,009	1,260	3,937
RH-7	561	1,891	1,479	3,931
RD-17	652	1,931	1,191	3,774
RM-13	648	1,890	1,230	3,768
RF-20	765	1,827	1,081	3,673
RM-16	648	1,749	1,245	3,642
Wilton	628	1,440	1,524	3,592
RR-12	619	1,413	1,532	3,564
RO-15	676	1,699	1,136	3,511
RJ-3	622	1,656	1,220	3,498
Kondinin	935	311	128	1,374
Hykon	788	334	78	1,200
C.V. = 7.9%			LSD (0.05) = 383	

aged across four locations. RD-3 produced twice as much forage as the early varieties Kondinin and Hykon, averaged across four locations. Early season production of the best experimental lines was equal or slightly less than Kondinin or Hykon. Based on the 1985 to 1986 season, rose clover is well-adapted across a broad range of geographic locations in Texas. The experimental rose clover lines from the Overton clover breeding program were more productive than the check varieties at all six locations.

TABLE 3. SEASONAL FORAGE PRODUCTION OF ROSE CLOVER AT BRENHAM, TEXAS,1985-1986

Variety	Harvest date 2-20-86	3-26-86	5-13-86	Total
	Pounds of dry matter per acre			
RD-3	1,948	1,927	1,908	5,783
RH-18	1,893	1,756	1,969	5,618
RM-16	2,054	1,577	1,887	5,518
RD-17	2,052	1,842	1,480	5,374
RF-20	1,933	1,908	1,525	5,366
RJ-3	2,053	1,785	1,493	5,331
RR-12	1,799	1,361	2,140	5,300
RO-15	1,820	1,930	1,521	5,271
RH-7	1,664	1,887	1,598	5,149
Wilton	1,576	1,565	1,750	4,891
Hykon	2,094	451	0	2,545
Kondinin	1,774	329	0	2,103
C.V. = 8.8%			LSD (0.05) =	576.6

TABLE 4. SEASONAL FORAGE PRODUCTION OF ROSE CLOVER AT YOAKUM, TEXAS,1985-1986

Variety	Harvest Date 1-24-86	2-25-86	3-25-86	5-1-86	Total
	Pounds of dry matter per acre				
RD-17	118	582	1,527	485	2,712
RD-3	145	427	1,393	503	2,468
RF-20	132	468	1,229	555	2,384
Hykon	114	886	1,053	273	2,326
RM-16	119	460	1,156	534	2,269
RH-18	133	451	982	533	2,099
RO-15	100	417	1,141	417	2,075
RJ-3	142	405	993	459	1,999
Kondinin	134	927	730	172	1,963
Wilton	107	352	727	449	1,635
RH-7	128	471	711	302	1,612
RR-12	121	482	500	341	1,444
C.V. 18.7				LSD (0.05) =	560

TABLE 5. SEASONAL FORAGE PRODUCTION OF ROSE CLOVER AT COLLEGE STATION, TEXAS, 1985-1986

Variety	Harvest Date 3-5-86	4-4-86	Total
	Pounds of dry matter per acre		
RH-18	1,503	2,426	3,929
RD-3	1,551	2,352	3,903
RM-16	1,570	2,247	3,817
RF-20	1,630	2,172	3,802
RD-17	1,018	2,642	3,660
RO-15	1,151	2,447	3,598
RJ-3	1,749	1,756	3,505
RH-7	1,299	1,814	3,113

TABLE 5. (Cont'd)

Variety	Harvest Date 3-5-86	4-4-86	Total
	Pounds of dry matter per acre		
Wilton	698	1,703	2,401
RR-12	577	1,317	1,894
Kondinin	987	745	1,732
Hykon	927	625	1,552
C.V. = 21.4		LSD (0.05) =	1,144

TABLE 6. FORAGE PRODUCTION OF ROSE CLOVER AT BEEVILLE, TEXAS, 1985-1986

Variety	Harvest date 2-18-86	5-2-86	Total
	Pounds of dry matter per acre		
RH-18	1,512	3,813	5,325
RM-13	1,427	2,765	4,192
RO-15	1,381	2,390	3,771
RM-16	1,380	2,399	3,779
RJ-3	1,374	2,426	3,800
RD-3	1,322	3,369	4,691
RF-20	1,299	2,883	4,182
RD-17	1,271	2,718	3,989
RR-12	999	3,374	4,373
RH-7	878	2,882	3,760
Kondinin	2,298	2,395	4,693
Hykon	1,849	1774	3,623
C.V. = 26.2%		LSD (0.05) =	1,800

TABLE 7, FORAGE PRODUCTION OF ROSE CLOVER AT DALLAS, TEXAS, 1985-1986

Variety	Harvest date 4-29-86
	lbs DM/acre
RD-20	1261
RD-3	896
Kondinin	0[1]
Hykon	0[1]

[1]Winterkilled early December.

TABLE 8. PERFORMANCE OF ROSE CLOVER AT FOUR TEXAS LOCATIONS IN 1985-1986

Line	Location: Overton	Brenham	Yoakum	College Station	Average
	Pounds of dry matter per acre				
RH-18	4,104	5,618	2,099	3,929	3,937
RD-3	3,937	5,783	2,468	3,903	4,022
RH-7	3,931	5,149	1,612	3,113	3,451
RD-17	3,774	5,374	2,712	3,660	3,880
RF-20	3,673	5,366	2,384	3,802	3,806
RM-16	3,642	5,518	2,269	3,817	3,811
RR-12	3,564	5,300	1,444	1,894	3,050
RO-15	3,511	5,271	2,075	3,598	3,613
RJ-3	3,498	5,331	1,999	3,505	3,583
Kondinin	1,374	2,103	1,963	1,732	1,793
Hykon	1,200	2,545	2,326	1,552	1,905
Wilton	3,592	4,891	1,635	2,401	3,129
LSD (0.05)	383	576	560	1144	
C.V. %		7.9	8.8	18.7	21.4

Nutrient Screening for Clover Response

V. A. Haby, G. R. Smith, C. Gilbert, and A. T. Leonard

Summary

'Kondinin' rose and 'Mt. Barker' subterranean were utilized to evaluate clover response to three rates each of nine plant nutrients in an acid Lilbert loamy fine sand in a glasshouse experiment. The experimental design was a randomized complete block. Nutrients tested were phosphorus, potassium, calcium, magnesium, sulfur, zinc, manganese, boron, and molybdenum. Treatments consisted of a check, all nutrients at the 1x rate, and all nutrients at the 2x rate. In addition, the zero and the 2x rates of each individual nutrient were tested at the 1x rate of the eight other nutrients. Summation of the total yields from four harvests of each clover variety indicated a 134% response to phosphorus, a 46% response to boron, and a 23% response to potassium. Calcium, magnesium, sulfur, and molybdenum increased yields up to 10%. Manganese and zinc failed to increase yields.

Introduction

Clovers are normally interseeded into a Coastal bermudagrass sod for a winter forage in East Texas. Establishment success has been variable, and has usually been attributed to low rainfall and dry soil conditions. The poor nutrient supplying power of these soils may also contribute to poor clover establishment. This study was devised as a quick way to evaluate plant responsiveness to various nutrients in order to save valuable field research time.

Procedure

Two subterranean clover varieties were seeded into potted surface soil from a Lilbert loamy fine sand (loamy, siliceous, thermic, Arenic Plinthic Paleudult) in a glasshouse. The soil had been dried and homogenized prior to treatment. Treatments consisted of nine nutrients selected as possibly deficient or toxic in acid soils. Nutrients studied included boron (B), calcium (Ca), potassium (K), magnesium (Mg), manganese (Mn), molybdenum (Mo), phosphorus (P), sulfur (S), and zinc (Zn). Rates and materials applied are indicated in Table 1. Chloride and sodium salts were used where necessary to avoid nutrient contamination.

The Lilbert soil was obtained from a mature pine forest. Initial analysis for selected nutrients follows: P - 3.2, K - 20.8, Ca - 251, Mg - 13.4, Mn - 16.8, Zn - 1.34, and S - 3.39. All values are parts per million. Initial soil pH was 5.6. Procedures were those routinely used by the Texas Agricultural Extension Service Soil Testing Laboratory.

The treatment plan consisted of a check in which no nutrients were applied, all nutrients applied at the 1x rate, and all nutrients applied at the 2x rate. Additional treatments consisted of selectively varying individual nutrients applied at the zero and 2x rates while maintaining all other nutrients at the 1x rate of application. The all nutrient 1x rate thus became a common medium rate for each nutrient. Appropriate nutrient concentrations were mixed into the soil. Inoculated seeds of each clover variety were planted into appropriate pots of soil.

Two harvests were made the spring following initial seeding. The soil was allowed to dry during the summer, then was rehydrated and reseeded to the same clover varieties. Two additional clover harvests were made that fall. Plants from each harvest were dried, ground, and chemically analyzed. Soils were sampled after each two clover harvests, dried, screened to <-mesh and chemically analyzed. Preliminary statistical analyses for significant effects of individual nutrients were done by MSUSTAT. Detailed regression analyses for response surfaces can be determined by the procedure for the general linear model in SAS.

Results and Discussion

The most deficient nutrients for clover production in this Lilbert soil are indicated in Table 2. With no nutrients added to the soil, yields for both clovers were lowest. The following three nutrients were tested by withholding each but adding the 1x rate of the other eight. Addition of the other eight nutrients without P slightly increased yields of both clovers over the four harvests. Phosphorus was the most limiting nutrient for clover production in this soil. Clover yields were increased 134% by fertilization of the soil with P (data not shown). Subterranean clover plant response to P was quadratic and had peaked at 50 lbs P/A, whereas plant uptake of P was linear to 0.36% at the 100 lbs/A rate. This suggests that soil test calibrations should not be based on nutrient uptake data. Soil test P increase was approximately linear, increasing from about 2 ppm at zero P to 13 ppm at the 100 lbs/A application rate.

Boron was the second most deficient nutrient in this Lilbert soil. Subterranean clover response to B was nearly linear to the 2 lbs B/A rate. Plant B content increased as the rate of B was increased. Clover yield was increased 46 percent by fertilization of this soil with B (data not shown).

Potassium was the third most limiting nutrient in this test. Fertilization with K increased clover yields 23 percent (data not shown). Subterranean clover response to

TABLE 1. PLANT NUTRIENTS, RATES, AND FERTILIZER MATERIALS

Plant Nutrient	Rates 0	Rates 1x	Rates 2x	Fertilizer Material
		lb/A		
B	0	1.0	2.0	Boric Acid
Ca	0	690	1,380	Hydrated Lime
K	0	80	160	Potassium Chloride
Mg	0	30	60	Magnesium Chloride
Mn	0	3.0	6.0	Manganese Chloride
Mo	0	.19	.38	Sodium Molybdate
P	0	50	100	Phosphoric Acid
S	0	30	60	Sodium Sulfate
Zn	0	3.0	6.0	Zinc Chelate

KEYWORDS: Soil fertility/phosphorus/potassium/calcium/magnesium/ sulfur/zinc/manganese/boron/molybdenum/rose clover/ Mt. Barker clover/Lilbert acid, sandy soil.

TABLE 2. CLOVER RESPONSE IN UNTREATED SOIL AND IN SOIL TREATED WITH EIGHT NUTRIENTS MINUS PHOSPHORUS, BORON, OR POTASSIUM

Nutrient	Clover Yield		
	Subterranean	Rose	Total
	grams/pot		
Control	3.90	3.13	7.03
−P	5.77	3.77	9.54
−B	9.44	8.71	18.15
−K	11.68	8.11	19.79

applied K and plant uptake were nearly linear as the rate was increased to 160 lbs/A.

Clover yield increases to other nutrients were Mg and Mo - 10 percent, Ca - 9 percent, S - 6 percent, and Zn and Mn had no affect on yields at the rates applied to this soil.

Effect of Fluid Fertilization on Coastal Bermudagrass. I. Spacing Between Dribble Bands of Urea-Ammonium Nitrate

V. A. Haby, J. V. Davis, and A. T. Leonard

Summary

Urea-ammonium nitrate (UAN), a 32 percent nitrogen (N) solution, was dribble banded on 10- X 20-ft plots of Coastal bermudagrass at spacings of 7, 14, 21, and 28 inches between bands. Rates of applied N were 40, 80, and 120 lbs/A prior to each flush of growth. Data from individual years indicate that dry matter yields were equal for all dribble band spacings. Initially, the grass contacted by the fluid N turns yellow. New growth in the band area turns dark green, leaving the between band spaces with a N deficient pale green appearance. Nitrogen deficiencies between bands had disappeared from actively growing grass within 3 weeks. Streaks were evident at harvest in the widest band treatments when grass growth was limited due to drought.

Introduction

Although the fluid fertilizer market is expanding nationwide, the use of these fertilizers is almost negligible on Coastal bermudagrass in the East Texas Timberlands. Fluids offer alternative fertilizer sources to the standard solid materials presently dominating the forage market. Apparently, fluids were tried as broadcast spray applications in the early 1960s, and fear of excessive loss of N by the spray broadcast application method turned the producer away from use of these fertilizers. Data in this report are an evaluation of dribble banding fluid urea-ammonium nitrate (32 percent N) for Coastal bermudagrass production.

KEYWORDS: Urea-ammonium nitrate/Coastal bermudagrass/fluid fertilizers/dribble banded.

Procedure

Fluid urea-ammonium nitrate (UAN, 32-0-0) was applied to Coastal bermudagrass. Nitrogen rates of 40, 80, and 120 lbs N/A were dribble banded at spacings of 7, 14, 21, and 28 inches prior to each flush of grass growth. Three N applications and harvests were made in 1984, four in 1985, and five in 1986. Treatments were applied in a randomized complete block experimental design. Three replications of each treatment were applied at two research locations. One was on a Gallime fine sandy loam (fine-loamy, siliceous, thermic Glossic Paleudalf). The other was on a Lilbert loamy fine sand (loamy, siliceous, thermic Arenic Plinthic Paleudult). Initially, all plots received 100 lbs P_2O_5 and 160 lbs of K_2O/A, followed by 200 lbs K_2O/A in early October 1984. In mid-April 1985, 200 lbs K_2O and 100 lbs P_2O_5/A were applied to all plots. In January 1986, 200 lbs K_2O/A was applied. This same rate of K_2O was applied along with 100 lbs P_2O_5/A in early April. Harvests were made by cutting 4.9 ft from the middle of each plot with a harvested plot length of about 18 ft. A dry matter sample was collected from each plot for moisture and chemical analysis.

Results and Discussion

Response of Coastal bermudagrass to dribble band spacings of UAN on both soils is presented in Table 1. Total yields each year indicate no differences due to distances of

TABLE 1. RESPONSE OF COASTAL BERMUDAGRASS TO DRIBBLE BANDED RATES OF NITROGEN AS UAN APPLIED AT FOUR BAND SPACINGS AND THREE NITROGEN RATES ON LILBERT AND GALLIME SANDY ACID SOILS

Band Spacing	Dry Matter Yields[1]					
	Lilbert Soil			Gallime Soil		
	1984	1985	1986	1984	1985	1986
	Tons/Acre					
7	4.2a	5.4a	6.8a	6.6a	8.2a	7.6a
14	4.2a	6.0a	7.0a	6.6a	8.0a	7.2a
21	3.8a	5.3a	6.7a	6.6a	8.0a	7.6a
28	4.0a	5.5a	6.8a	6.7a	8.0a	7.0a
Nitrogen Rates						
lbs/A						
40	3.4a	4.4a	6.1a	5.5a	6.7a	6.8a
80	4.2b	5.7b	7.0b	7.0b	8.4b	7.6b
120	4.5b	6.5c	7.3b	7.4c	9.0b	7.7b

[1]Yields within data sets for band spacings or N rates by year and soil when followed by the same letter are not significantly different at $p<0.05$ by Newman-Keuls mean comparisons.

7 to 28 inches between dribble bands. This was evident even at the individual rates of N on both sites.

Coastal bermudagrass rhizomes are abundant in surface soils. These rhizomes compete vigorously for moisture and nutrients, producing a profusion of stolons which are capable of rooting at nodes. The rooting ability of the Coastal bermudagrass stolons apparently allows roots to grow into the fertilized bands. The band-applied N can then be translocated to stolons growing between fertilizer bands.

Streaking was observed within a day following application, regardless of the band spacing. This occurred first as a yellowing of existing vegetation that was contacted by the UAN. New, dark green grass growth later defined the band and a pale green nitrogen deficiency existed between bands. The grass outgrew this deficiency. The narrower the band spacing, the faster this occurred, until even the 28-inch band spaces were grown-over 3 and 4 weeks following fertilizer application when the grass was growing vigorously. The unfertilized N deficient streaks between bands remained until harvest when the grass was not growing vigorously due to a stress condition.

Nitrogen rates, averaged over all band spacings, indicated that Coastal bermudagrass continued to increase significantly up to the 80 and 120 lbs/A levels, though not significantly at the 120 lbs/A rate in all cases. The Gallime soil was much more responsive to fertilizer treatment than was the Lilbert soil.

Band spacings at individual nitrogen rates had no effect on dry matter yield at either site in any year of this study.

Iron-deficiency Chlorosis in Clovers

R. R. GILDERSLEEVE AND W. R. OCUMPAUGH

Summary

Little information is available regarding the amount of genetic variation among and within *Trifolium* species for resistance to iron (Fe)-deficiency chlorosis. Two calcareous Parrita sandy clay loam sites that had a history of expression of Fe-deficiency chlorosis problems in small grains and forage sorghum was used to conduct field studies in 1985 to 1986 and 1986 to 1987. Six clover species: arrowleaf, berseem, crimson, red, rose, and subterranean clovers were compared for differences in dry matter production and expression of chlorosis symptoms. Clover species could be ranked for their adaptability to calcareous soil conditions: berseem = red = rose > crimson >> subterranean > arrowleaf. In addition, at least one subterranean clover cultivar ('Clare') has shown complete resistance, suggesting that differences may exist within as well as between clovers for resistance to Fe-deficiency chlorosis.

KEYWORDS: Calcareous soils/*Trifolium* spp.

Introduction

Iron-deficiency chlorosis symptoms have been observed at several Texas locations. The experiments reported here were conducted to determine whether differences exist among clover species for resistance to Fe-deficiency chlorosis when grown in calcareous soil and the extent of production losses in susceptible clovers.

Procedures

1985 to 1986

Field experiments were conducted from October 1985 through May 1986 on a calcareous Parrita sandy clay loam soil (pH = 8.0) that had a history of expression of Fe-deficiency chlorosis in small grains and forage sorghum and an adjacent site that supported normal plant growth. Cultivars of five clover species. ('Yuchi' arrowleaf, 'Bigbee' berseem, 'Dixie' crimson, 'Kondinin' rose, and 'Mt. Barker' subterranean clovers), two oat cultivars ('TAM 312' and 'Coker 227'), and common hairy vetch were planted with a Kincaid plot drill on Oct. 24, 1985. Seeding rates were 12 lbs/A for the clovers, 30 lbs/A for oats and 20 lbs/A for vetch. All legume seed was inoculated with an appropriate commercial *Rhizobium* strain just prior to planting. The experiments were arranged in a randomized complete block design with three blocks and two plots of each cultivar per block. Plot size was 5 ft X 20 ft with five rows per plot. One-half of the plots received a biweekly foliar application of a 2 percent w/v $FeSO_4$ solution during vegetative growth (November to March).

Notes were recorded biweekly on plant height, evidence of chlorosis, and stage of growth. Visual estimates of chlorosis were recorded using the following scale: 0=no chlorosis, 1=0-25 percent chlorosis, 2=26-50 percent chlorosis, 3=51-75 percent chlorosis, 4=>75 percent chlorosis. Plots were harvested on February 17 and April 16, 1986 using a flail-type forage plot harvester. Dry matter yield estimates were corrected for percent stand and weed variations.

1986 to 1987

A field experiment was conducted from October 1986 through May 1987 on a calcareous Parrita sandy clay loam soil (pH 8.2) where 'Honeygrazer' forage sorghum showed severe chlorosis symptoms the previous growing season. Arrowleaf ('Yuchi' and 'Meechee'), berseem ('Bigbee'), crimson ('Dixie'), red ('Kenstar') and subterranean ('Mt. Barker' and 'Clare') clovers were inoculated with the appropriate commercial *Rhizobium trifolii* strain and planted on October 29, 1986. Two randomized complete block design areas were planted adjacent to one another, with three blocks each of all cultivars. One area received frequent irrigation with a sprinkler irrigation system to ensure expression of the Fe-deficiency chlorosis symptoms. Notes were recorded biweekly on plant height, stage of growth and evidence of chlorosis. Soil samples were taken as needed to determine changes in soil moisture. Plots were harvested on February 12 and March 24 as described for the 1985 experiment. Following each harvest, the irrigation system was moved to the area which had not received additional water the previous growth period.

Results and Discussion

1985 to 1986

Field chlorosis scores for the 'chlorosis' area of the 1985 to 1986 experiment are shown in Figure 1. 'Yuchi' arrowleaf, 'Dixie' crimson, and 'Mt. Barker' subterranean clovers began to exhibit Fe-deficiency chlorosis symptoms shortly after emergence, as did the oat cultivars and the vetch. Slight chlorosis symptoms (scores <2) were observed early in the growing season on the same clover cultivars and TAM 312 oats on the 'normal' area, but all plots rapidly outgrew the chlorosis symptoms (data not shown). Chlorosis symptoms remained on the susceptible cultivars in the 'chlorosis' areas until mid-January 1986, gradually disappearing as the soil moisture decreased. We experienced very dry conditions from December 1985 to April 1986 and all plots grew normally with no additional chlorosis symptoms appearing on susceptible cultivars. However, following the second harvest (April 16), and several heavy rains, chlorosis symptoms reappeared in 'Yuchi' arrowleaf and 'Mt. Barker' subterranean clovers, and TAM 312 oats ('Dixie' crimson clover had already senesced).

There were significant differences ($P<.01$) between cultivars for seasonal dry matter production (see Table 1) in the 1985 to 1986 experiment. However, no differences ($P>.05$) appeared within cultivars due to the Fe application or between the two soil areas of the experiment for total dry matter production. The authors believe that the dry conditions during the growing season masked expected losses in production in the suceptible cultivars. Therefore, the second experiment (1986 to 1987) included irrigation as needed to induce the chlorosis symptoms.

1986 to 1987

Site 1 received periodic supplemental water via a sprinkler irrigation system from November 1986 to February 12, 1987 (Harvest 1) and during April 1987. Site 2 received supplemental irrigation from February 13, 1987 to March 24, 1987 (Harvest 2). Irrigation was applied to maintain soil moisture in the 15 to 20 percent range. The chlorosis scores of susceptible clovers graphed in Figure 2 indicate that the symptoms could be consistently induced at both sites when additional water was applied.

Dry matter production by harvest of the clover cultivars at each site appears in Table 2. There are significant ($P<.05$) differences between cultivars in dry matter production at each site, but the presence or absence of chlorosis during a harvest period does not appear to affect yields in a consistent manner. However, Site 1 plots did generally yield less than Site 2 plots, and susceptible clovers always had more chlorosis symptoms at Site 1 (Figure 2), whether or not, supplemental irrigation was used to maintain high soil moisture during the growth period. Physical observations of the two sites suggest that soil variations are playing an important role in the inconsistant yields.

TABLE 1. TOTAL DRY MATTER PRODUCTION OF CLOVER, OAT, AND VETCH CULTIVARS, 1985 TO 1986

Cultivar	'Chlorosis' area −Fe	'Chlorosis' area +Fe	'Normal' area −Fe	'Normal' area +Fe
	Pounds/Acre		Pounds/Acre	
Yuchi arrowleaf	4,251bcd	4,279bcd	4,068bcde	4,485bcd
Bigbee berseem	6,003a	5,961a	5,643a	5,647a
Dixie crimson	4,535abc	4,231bcd	4,890ab	4,523bc
Kondinin rose[1]	722f	1,035f	3,797f	3,358f
Mt. Barker sub	2,616de	2,756de	2,293g	2,533fg
Hairy vetch	4,590abc	5,370ab	3,921bcde	3,831cde
TAM 312 oats	3,488cde	3,569cde	3,533de	3,565cde
Coker 227 oats	4,288bcd	4,333bc	3,877cde	4,099bcde
LSD .05	1,535	1,535	974	974

[1]'Kondinin' rose clover was harvested only once during the season on the 'chlorosis' area, due to poor stands.

TABLE 2. DRY MATTER PRODUCTION OF CLOVER CULTIVARS AT SITES 1 AND 2, BY HARVEST, 1986 TO 1987

Cultivar	Harvest 1: 2/12/87 Site 1 (Irr.)	Harvest 1: 2/12/87 Site 2 (Non-irr.)	Harvest 2: 3/24/87 Site 1 (Non-irr.)	Harvest 2: 3/24/87 Site 2 (Irr.)
	Pounds/Acre		Pounds/Acre	
Yuchi arrowleaf	2,049bc	2,499cd	1,364cd	1,852b
Meechee arrowleaf	1,637c	1,649e	895d	1,743b
Bigbee berseem	4,261a	4,681a	2,092ab	2,401a
Dixie crimson	2,655b	1,965de	2,419a	2,621a
Kenstar red	1,704bc	2,639c	1,204cd	1,596b
Mt. Barker sub	2,062bc	1,882de	834d	1,640b
Clare sub	2,513bc	3,322b	1,752bc	1,817b
LSD .05	956	624	641	344

The results of these experiments suggest that high soil moisture conditions play an important role in the expression of Fe-deficiency chlorosis in susceptible clovers growing in calcareous soils. However, other soil and environmental factors must also be involved in whether or not expression of chlorosis translates into yield depression of a susceptible cultivar at a later date. Of the clover cultivars studied, 'Bigbee' berseem, 'Kenstar' red, 'Kondinin' rose, and 'Clare' subterranean clovers all appear to be resistant to the Fe- deficiency chlorosis and productive on calcareous soils. 'Dixie' crimson clover will show moderate chlorosis at early growth stages, but apparently recovers and is productive. 'Yuchi' and 'Meechee' arrowleaf clovers, and 'Mt. Barker' subterranean clover may all exhibit severe chlorosis symptoms and some production losses may occur.

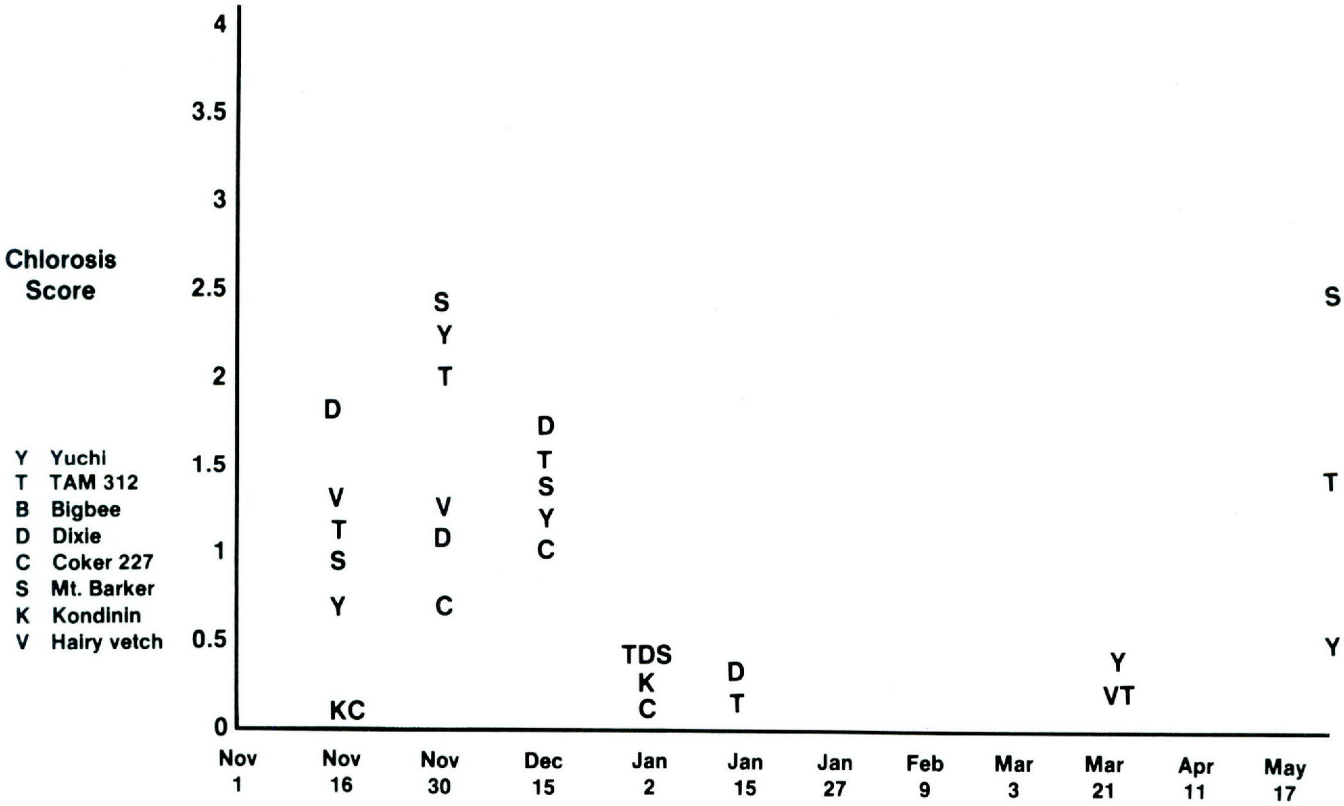

Figure 1. Visual chlorosis scores in Nov, 1985 to May, 1986.

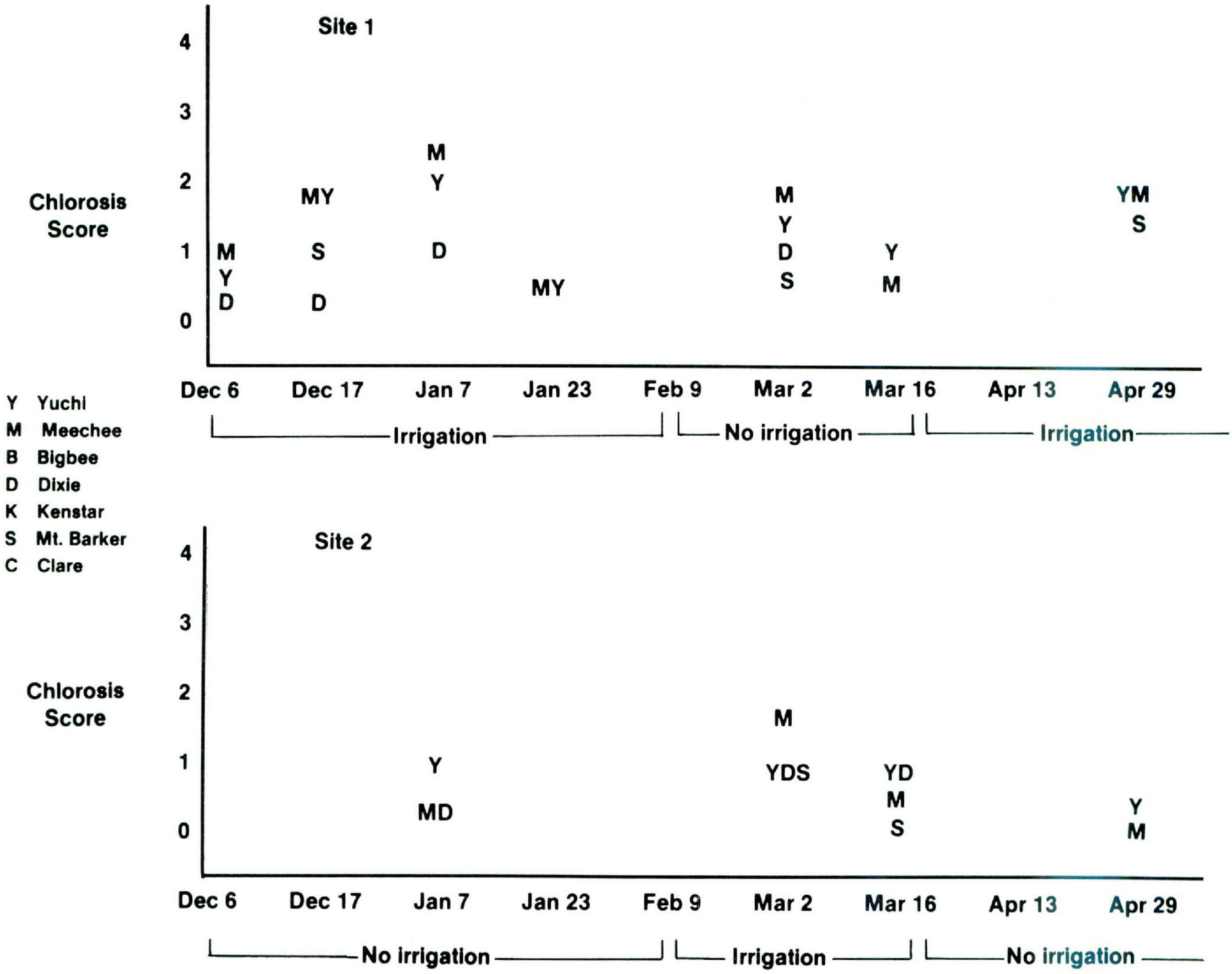

Figure 2. Visual chlorosis scores for Sites 1 and 2, without irrigation from Dec, 1986 to Apr, 1987.

Effect of Fluid Fertilization on Coastal Bermudagrass. II. Method of Application of Urea-Ammonium Nitrate

V. A. Haby, J. V. Davis, and A. T. Leonard

Summary

Urea-ammonium nitrate (UAN), a 32 percent nitrogen (N) solution, was spray broadcast, surface dribble banded at 14-inch band spacings, or subsurface dribble banded at 14-inch band spacings onto 10- X 20-ft Coastal bermudagrass plots. Rates of applied N were 40, 80, and 120 lbs/A prior to each growth of grass. Data from individual years indicated that dry matter yields were equal for all application methods. Nitrogen rates significantly increased dry matter yield on the Lilbert and Gallime sandy, acid soils.

KEYWORDS: Urea-ammonium nitrate/method of application/ Coastal bermudagrass/acid soils/sandy soils.

Introduction

Urea-ammonium nitrate (UAN) is normally most efficiently applied as a band application to crops on the majority of soils. Broadcast spray application to the soil surface without incorporation is usually the least efficient method of application. On some perennial forage crops such as Coastal bermudagrass, it is not possible to incorporate spray broadcast N. This experiment was designed to evaluate the effect of spray broadcast, surface, and subsurface banded applications of UAN on Coastal bermudagrass yield and quality.

Procedure

Fluid UAN at rates of 40, 80, and 120 lbs/A was spray broadcast, dribble banded on the surface at 14-inch band spacings, or dribble banded subsurface at the 14-inch band spacing on Coastal bermudagrass prior to each flush of growth. Three N applications and harvests were made in 1984, four in 1985, and five in 1986. The N rates and methods of application were applied in a randomized complete block experimental design. All treatments were replicated three times at two research locations. One was on a Gallime fine sandy loam (fine-loamy, siliceous, thermic Glossic Paleudalf). The other was on a Lilbert loamy fine sand (loamy, siliceous, thermic Arenic Plinthic Paleudult). Initially, all plots received 100 lbs P_2O_5 and 160 lbs of K_2O/A, followed by 200 lbs K_2O/A in early October 1984. In mid-April, 1985, 200 lbs K_2O and 100 lbs P_2O_5/A were applied to all plots. In January 1986, 200 lbs K_2O/A were applied to all plots. This same rate of K_2O was reapplied along with 100 lbs P_2O_5/A in early April. Harvests were made by cutting 4.9 ft from the middle of each plot with a harvested plot length of about 18 ft. A dry matter sample was collected from each plot for moisture and chemical analysis.

Results and Discussion

Response of Coastal bermudagrass to methods of application of UAN on both soils each year is presented in Table 1. Yields indicated that methods of application had no differential effect on Coastal bermudagrass production. This appears to be contrary to published data, but may be due to the acidity level of these soils. Both soils have a pH near 5.0, and at this acidity level less loss of N is expected from ammonia volatilization.

Attempts to dribble band the UAN below the soil surface were relatively ineffective due to the dense sod and root system of the Coastal bermudagrass growing in these sandy, acid soils. The coulters could not be forced deeper than about two inches at the existing weight of the applicator. An additional 150 lbs per coulter would be needed to force the coulter to cut deep enough into the sod to place the UAN at the proper depth.

The subsurface attempts at dribble banding sometimes placed the UAN just below the soil surface, but most of this treatment was mixed with the loose soil exposed by the coulter and back- swept applicator knife. This placed most of the fluid in direct contact with soil moisture and could cause more rapid hydrolysis and possibly NH_3 volatilization of the urea component of the UAN.

Increasing the N rate to 120 lbs/A significantly increased grass dry matter yields on the Lilbert soil the first 2 years. In 1986, the 120 lbs/A N rate was not significantly different than the 80 lbs/A rate. By the third year on the Gallime soil, there were no significant yield differences due to N rate. At least two factors could have caused this declining effectiveness of the higher N rates. Residual N could have been built up to a level that nullified differences due to N rates. A more likely explanation may be that the high rates of N increased the level of soil acidity to the point that dry matter yield of Coastal bermudagrass was decreased. This generally occurs below pH 4.8. Data are not shown but the 120 lbs N/A rate produced significantly less grass than the 80 lbs/A N rate the fifth cutting in 1986.

TABLE 1. RESPONSE OF COASTAL BERMUDAGRASS TO UAN APPLIED AT NITROGEN RATES OF 40, 80, AND 120 LBS/A AS SPRAY BROADCAST, SURFACE DRIBBLE, AND SUBSURFACE DRIBBLE BAND TREATMENTS

	Dry Matter Yield[1]					
	Lilbert Soil			Gallime Soil		
Application Method	1984	1985	1986	1984	1985	1986
	Tons/Acre					
Spray Broadcast	4.2a	5.8a	6.4a	5.9a	8.1a	7.0a
Surf. Dribble Band	4.0a	5.4a	6.3a	6.3a	8.8a	7.5a
Sub-Surf. Dribble Band	4.0a	5.6a	6.4a	6.0a	8.3a	6.8a
Nitrogen Rates						
lbs/A						
40	3.6a	4.2a	5.6a	4.6a	6.8a	6.7a
80	4.0a	5.8a	6.5a	6.4b	8.8b	7.3a
120	4.6b	6.9c	7.0a	7.1c	8.6b	7.3a

[1]Dry matter yields within individual sets of data by site, year, method of application, or nitrogen rate, followed by the same letter are not significantly different at $p<.05$ by Newman-Keuls mean comparisons.

Effect of Fluid Fertilization on Coastal Bermudagrass. III. Nitrogen Source Comparisons

V. A. HABY, J. V. DAVIS, AND A. T. LEONARD

Summary

Nitrogen (N) source comparisons were conducted on Coastal bermudagrass growing on Lilbert and Gallime acid, sandy soils in 1984, 1985, and 1986. Nitrogen rates of 0, 40, 80, and 120 lbs/A were applied prior to each growth of grass. Treatments were applied and harvests were made three times in 1984, four times in 1985, and five times in 1986. Nitrogen sources were urea, ammonium nitrate, ammonium sulfate, urea with calcium added, and urea-ammonium nitrate with and without combinations with sulfur and boron at rates of 16 and 0.4 lbs/A, respectively, each application. All nitrogen sources and combinations produced equal forage yields all years on the lower production Lilbert soil. On the Gallime soil in 1984, urea- ammonium nitrate with ammonium sulfate added compared favorably with ammonium nitrate and ammonium sulfate for forage production. Other N sources and nutrient combinations produced equivalent yields of grass. Urea and urea-ammonium nitrate produced similar yields, but ammonium nitrate produced significantly more grass than either of them, averaged over all N rates. A significant yield increase occurred between 80 and 120 lbs N/A at both sites in 1984 and 1985, but yields at both sites were equal at the 80 and 120 lbs/A N rates in 1986. No significant yield differences occurred among N sources on the Gallime soil in 1986.

Introduction

Fertilizer imports and a continuing weak agricultural economy have contributed to lower priced nitrogen (N) fertilizers. Market competitiveness has modified the views previously held by agricultural personnel concerning use of various N fertilizer sources. Research continues to seek answers to the questions relative to use of the various N fertilizer sources. This report contains results of comparisons of the more common N fertilizers, some applied with calcium (Ca), sulfur (S), or boron (B) to plots treated with phosphorus (P), potassium (K), zinc (Zn), and molybdenum (Mo).

Procedure

Nitrogen source treatments included urea-ammonium nitrate (UAN), applied to plots treated with 4.5 lbs of Zn and 46 grams of Mo/A-equivalent compared to UAN without Zn and Mo. Urea- ammonium nitrate with 16 lbs S/A from ammonium thiosulfate was compared to UAN with 16 lbs S/A from ammonium sulfate. Additional treatments included UAN with 0.4 lb B/A, urea with calcium chloride added at the ratio of 1:.34 urea:Ca, urea, ammonium nitrate, ammonium sulfate, and a zero N check. The 16 lbs S and the 0.4 lb B/A were applied with each rate of N prior to regrowth of each cutting of grass. These N sources were applied to 10- X 20-ft plots which were treated with 100 lbs P_2O_5 and 160 lbs K_2O/A in spring 1984. An additional application of 200 lbs K_2O/A was made in October 1984. Overall treatments of 100 lbs P_2O_5 and 200 lbs K_2O/A were made in April 1985. The 1986 uniform treatments included 200 lbs K_2O/A in January, and 200 lbs K_2O and 100 lbs P_2O_5/A in April. Harvests were made after first trimming 1 ft off the end of each plot with a Hege 211B forage plot harvester. Approximately 85 ft^2 were harvested from each plot and weighed. A 200 to 400 gram sample was collected from each plot for moisture and chemical analysis. Analysis of variance and Newman-Keuls mean comparisons were run on these data using MSUSTAT.

KEYWORDS: Nitrogen/fluid fertilizers/Coastal bermudagrass/ nitrogen sources/acid soils/sandy soils.

Results and Discussion

The Lilbert soil was a lower production site than the Gallime. Nitrogen sources and combinations of UAN with S and B, and urea with Ca, averaged over all N rates, were equally effective for grass production on the Lilbert soil through 3 years of evaluations (Table 1).

Nitrogen source comparisons on the Gallime soil indicated that UAN plus ammonium thiosulfate, ammonium nitrate, and ammonium sulfate all produced similar dry matter yields in 1984. Ammonium nitrate produced equal yields compared to ammonium sulfate and both treatments were better than UAN. Sulfur and B mixed with UAN had no significant effect on yield. The 1985 total dry matter production indicates that UAN, UAN plus S from ammonium sulfate, urea, ammonium nitrate, and ammonium sulfate all produced similar dry matter yields. In 1986 there were no significant yield responses due to N sources on the Gallime soil.

Forage production on the Lilbert soil nearly equalled that on the Gallime soil in 1986. The Gallime soil was unlimed for the study. Soil pH in the surface depth from selected plots indicated that increased soil acidity levels to below pH 4.8 probably caused yield reductions in this soil. Increased production on the Lilbert soil in 1986 may have been due to continued application of potash during the 3 years of the study.

Nitrogen rate increases up to 120 lbs/A continued to increase forage yield at both sites in 1984 and 1985. In 1986 the 80 lbs/A N rate produced dry matter yields equal to those at the 120 lbs/A rate. A buildup of residual N in the soil, or increasing soil acidity could have contributed to this. The 120 lbs/A N rate significantly decreased forage yield in the fifth cutting on the Gallime soil in 1986 (data not shown).

Interaction of N sources and rates on dry matter yields in 1985 indicated that at the 40 and 80 lbs N/A rates, ammonium nitrate and ammonium sulfate increased dry matter yields to a similar extent, and produced significantly greater yields than other N sources (data not shown). When the N rate was increased to 120 lbs/A, all N sources increased yields to the same extent, indicating that the 120 lbs/A rate provided adequate N even with any losses which may have occurred.

Addition of S to UAN as ammonium thiosulfate or as ammonium sulfate, had no effect on forage yield. The Lilbert soil contained 43 lbs S and the Gallime contained 69 lbs of available S/A in the top 3 ft in 1984. Both soils have about 2 ft of surface sand above a sandy clay. Three years of intensive production were not able to deplete S from these soils. Application of ammonium thiosulfate with UAN produced no yield advantage compared to UAN alone in this 3-year field study.

Addition of Ca to urea at the ratio of 0.34 Ca:1.0 N had no effect on increasing grass yield compared to urea alone at rates of 40, 80, and 120 lbs N/A, each application, on these acidic soils. Addition of Zn, Mo, and B to these soils failed to increase forage yields.

TABLE 1. COASTAL BERMUDAGRASS RESPONSE TO NITROGEN SOURCES AND SOURCE COMBINATIONS WITH CALCIUM, SULFUR, AND BORON, AND TO NITROGEN RATES AVERAGED OVER ALL SOURCES

	Dry Matter Yield[1]					
	Lilbert Soil			Gallime Soil		
Nitrogen Sources	1984	1985	1986	1984	1985	1986
	Tons/Acre					
UAN + Zn and Mo	3.6a	5.2a	6.1a	5.2ab	6.5abc	6.2a
UAN − Zn and Mo	3.8a	5.1a	6.4a	5.2ab	6.3ab	6.4a
UAN + 16 lb ATS-S	3.5a	4.9a	6.5a	5.2abc	6.2a	6.4a
UAN + 16 lb AMS-S	3.5a	5.4a	6.5a	5.5bcd	6.5abc	6.6a
Urea + Ca (1:.34)	3.6a	4.9a	6.0a	5.3abc	6.3ab	6.8a
UAN + 0.4 lb B/A	4.0a	4.8a	6.3a	5.1a	6.2a	6.4a
Urea	3.6a	4.7a	5.9a	5.3abc	6.4abc	6.3a
Ammonium Nitrate	3.9a	5.1a	6.3a	5.8d	7.2c	6.5a
Ammonium Sulfate	3.8a	5.7a	6.5a	5.5cd	7.0bc	6.3a
Nitrogen Rate[2]						
lbs/A						
0	1.6a	2.6a	3.4a	1.8a	2.6a	3.5a
40	3.6b	4.8b	6.2b	5.0b	6.2b	7.1b
80	4.6c	6.0c	7.6c	6.9c	8.3c	7.6c
120	5.0d	7.0d	7.9c	7.6d	9.0d	7.5c

[1]Dry matter yields within an individual year and site, by nitrogen source or by nitrogen rate followed by a similar letter are not significantly different at $p<.05$ by Newman-Keuls mean comparisons.
[2]Individual nitrogen rates with added S, Ca, or B were applied prior to each flush of grass growth.

Effect of Fluid Fertilization on Coastal Bermudagrass. IV. Urea-Ammonium Nitrate Blends with Phosphorus, Potassium, and Magnesium

V. A. Haby, J. V. Davis, and A. T. Leonard

Summary

Blends of nitrogen (N), phosphorus (P), potassium (K), and magnesium (Mg) were made with urea-ammonium nitrate (32-0-0), ammonium polyphosphate (11-37-0), muriate of potash (0-0-60), and magnesium chloride (0-0-0-8.1 percent Mg). Pounds of nutrients applied per acre for each flush of Coastal bermudagrass growth as individual treatments were 80-0-0, 80-22-0, 80-0-60, 80-22-60, and 80-22-60-12. Each treatment was applied as a broadcast spray, surface dribble banded, and subsurface dribble banded. Coastal bermudagrass dry matter production generally increased due to P fertilization the second year on the Lilbert soil site. Potassium began to provide significant yield increases the third year on the Gallime soil site. Surface dribble banding these solutions increased yields the second year on the Lilbert soil and the first year on the Gallime soil. In most years, method of application had no significant effect on forage production on these acid, sandy soils.

KEYWORDS: Fluid fertilization/fluid blends/Coastal bermudagrass/acid soils/sandy soils.

Introduction

Urea-ammonium nitrate solutions, as with solid fertilizers, can be combined into blends with phosphorus (P), potassium (K), magnesium (Mg), and other soluble fertilizer materials. East Texas soils are generally deficient in P and K, and Mg has increased grass yield in at least one research trial at Overton. This research was designed to evaluate the combinations of UAN with P, K, and Mg applied as broadcast spray, surface dribble bands, and subsurface dribble bands. Treatments were designed to determine Coastal bermudagrass response to these fertilizer nutrients on two soils, and to evaluate forage response to methods of application of the blends of N, P, K, and Mg.

Procedure

Fluid blends of N, P, K, and Mg were made with urea-ammonium nitrate (UAN, 32-0-0), ammonium polyphosphate (11-37-0), muriate of potash (0-0-60), and magnesium chloride (0-0-0-8.1 percent Mg). Pounds of nutrients applied as $N-P_2O_5-K_2O-Mg/A$ for each flush of grass growth were 80-0-0, 80-22-0, 80-0-60, 80-22-60, and 80-22-60-12. Each treatment was applied spray broadcast, or surface dribble banded, or subsurface dribble banded. Spacings between dribble bands were 14 inches. These solutions were applied to 10- X 20-ft plots. Harvests were made after first trimming 1 ft off the end of each plot with a Hege 211B forage plot harvester. A 4.9-ft center swath was harvested from the length of each plot and was weighed. A dry matter sample was collected from each plot for moisture and chemical analysis. Yield data were analyzed statistically by MSUSTAT for analysis of variance and Newman-Keuls mean comparisons.

Results and Discussion

Yields were not increased at either site by fertilization with P, K, or Mg the first year of the study (Table 1). The blend of N and P significantly increased dry matter yield on the Lilbert soil the second year. A trend indicates that P and K blended with N increased yields on the Gallime soil, but a significant yield increase occurred when Mg was added with the N, P, and K. The combination of N, P, and K significantly increased dry matter production on the Lilbert soil the third year. Any nutrient combination that included K significantly increased forage production the third year on the Gallime soil. Both research sites were previously in poorly fertilized hay meadow-pasture situations prior to initiation of this study. There was apparently sufficient nutrient recycling occurring to provide a small reserve of soil P, K, and Mg for 1 or 2 years of intensive forage production.

Surface dribble band application of these nutrient solutions improved dry matter yield compared to subsurface dribble banding on the Lilbert soil the second year, and slightly increased yield compared to the spray broadcast application. Dribble banding on the Gallime soil significantly improved dry matter production compared to spray broadcast application the first year. It is noteworthy that banding fluid blends of N, P, K, and Mg improved dry matter yield; whereas, banding UAN solution alone did not improve yields compared to the spray broadcast application. It may be possible that concentrating the P in a band limited its contact with the soil, thereby preventing its precipitation as insoluble aluminum phosphates, allowing the P to remain available to the plant.

TABLE 1. RESPONSE OF COASTAL BERMUDAGRASS TO COMBINATIONS OF PHOSPHORUS, POTASSIUM, AND MAGNESIUM WITH UAN, AND TO METHODS OF APPLICATION OF THESE SOLUTIONS TO LILBERT AND GALLIME SOILS

Nutrient Blend[2]	Dry Matter Yield[1]					
	Lilbert Soil			Gallime Soil		
$N-P_2-O_5-K_2O-Mg$	1984	1985	1986	1984	1985	1986
lbs/A	Tons/Acre					
80- 0- 0- 0	3.9a	3.8a	4.9a	6.3c	6.1a	4.8a
80-22- 0- 0	3.9a	5.0c	6.2bc	6.1bc	6.6ab	5.4a
80- 0-60- 0	3.4a	4.2ab	5.5ab	5.3a	6.5ab	6.8b
80-22-60- 0	3.8a	4.9bc	7.0d	5.7ab	6.9ab	7.7b
80-22-60-12	3.9a	4.9bc	6.7cd	6.1bc	7.6b	7.5b
Applic. Method						
Spray broadcast	3.7a	4.5ab	5.9a	5.5a	6.6a	6.5a
Surf. Drib. Bd.	3.8a	4.9b	6.3a	6.0b	7.0a	6.6a
Subsurf. " "	3.8a	4.3a	6.0a	6.2b	6.8a	6.2a

[1]Dry matter yields within an individual year and site, by solution blends or by method of application, followed by a similar letter are not significantly different at $p<.05$ level of probability by Newman-Keuls mean comparisons.
[2]Actual rates of N, P_2O_5, K_2O, and Mg at each application.

A Five-year Summary of Nitrogen Source Studies on Bermudagrass Production

W. B. Anderson

Summary

A summarization of 5 years of intensive field testing in more than 100 trials, compares performance of nitrogen (N)sources for bermudagrass production. These investigations were conducted at two different locations with widely contrasting soil types (a calcareous clay soil and an acid sandy soil). On the acid sandy soil, all the N sources performed rather equally well with no statistically significant differences in bermudagrass yields. However, on the calcareous soil, ammonium sulfate fertilizer showed a consistent trend for somewhat inferior yields of bermudagrass in each of the 5 years. Urea produced bermudagrass yields as good as or better than other N sources tested, indicating no serious risk of N loss from topdressing urea on bermudagrass.

Introduction

Urea fertilizer has rapidly become one of the lowest price sources of N fertilizer in recent years as a result of beneficial manufacturing costs. Nevertheless, there is a reluctance on the part of agricultural producers to topdress with urea fertilizer. This reluctance is due to some past reports of N loss from urea applied on the soil surface. High N losses have been reported in numerous laboratory tests. However, laboratory conditions are not usually typical of natural field situations. A small amount of plant residue on the soil surface generally supplies a ready source of urease enzyme. This enzyme is activated by moisture and can hydrolyze the urea to a volatile form which can result in N loss. Laboratory tests generally are conducted in a closed chamber to measure gaseous volatile N loss. These conditions tend to maintain the fertilizer, plant residue, and soil surface all in a moisture situation which is optimal for N loss to occur. On the other hand, under natural field situations, drying cycles usually are prevalent after night dew or light showers. Drying effects of sunshine and wind movement on the plant residue and soil surface result in dry conditions not conducive to urease enzyme hydrolysis. The purpose of these studies was to investigate the potential for urea N loss compared to other N sources under natural field conditions.

Procedure

Field trials were conducted on established bermudagrass stands at two different locations with contrasting soil types. A Ships clay soil series was a calcareous pH 7.8 soil located on the Texas A&M University farm in the Brazos River Bottom. The Lufkin fine sandy loam soil series was an acid soil with pH of 4.9. It was located on a producer's farm several miles distance from the other site. The same individual plots (6 ft X 20 ft) were maintained over the 5-year period. Phosphorus and potassium fertilizers were applied in the spring as required according to soil test levels. Nitrogen fertilizers were applied at a rate of 100 lbs/A/cutting with four replications of each treatment. The N fertilizer sources compared were: ammonium nitrate (NH_4NO_3-34% N), ammonium sulfate $(NH_4)_2SO_4$ - 21% N), urea ammonium nitrate (UAN-28% N), urea (46% N), and urea + Ca. A no nitrogen control treatment was also included. The dry N fertilizers were broadcast by hand. The UAN is a liquid fertilizer which was dribble banded on the grass surface from small plastic bottles by hand at about 14-inch spacings. The urea + Ca treatment was urea ammended with $CaCl_2$ at a N:Ca ratio of 0.25 on a chemical equivalent basis. A soluble source of Ca had been suggested as an inhibitor to urea hydrolysis N loss. The urea and $CaCl_2$ were dissolved together and applied in dribble bands by the method given above.

Numerous trials were conducted at varied times throughout the growing season to capture intervals of varied duration between fertilization and the occurrence of significant rainfall (>0.2 inch). This was to determine how long N fertilizers, especially urea, could remain on the soil surface without risk of N loss. Also, it was an attempt to ascertain whether or not different climatic environment with early, mid, or late season affected urea hydrolysis and N loss. On the Ships clay soil site, supplemental irrigation was available to terminate the interval duration of potential urea hydrolysis when rainfall did not occur at the desired period. However, irrigation was not available at the Lufkin sandy soil site. Bermudagrass yields were measured at maturity by harvesting a 3-ft X 17-ft strip from the 6-ft X 20-ft plots. A small sample was collected from each plot for moisture determination and yield values reported on an over-dry basis.

Results and Discussion

Yield of bermudagrass grown on Ships clay soil as influenced by different N sources over a 5-year period is shown in Table 1. Several tests were conducted each year at varied times throughout the growing season to obtain results representative of the whole season. The yield data were averaged over all of the tests for a given year and reported as dry matter in pounds per acre per cut. These average yields per cut were then averaged over the 5-year period. The first part of Table 1 selected only the yields for Coastal bermudagrass, whereas the second part (all bermudagrasses) includes several other experimental bermudagrass cultivars as well as coastal. Lower yields from some of the experimental cultivars, due to thinner stands, pulled down the over-all average yields. However, the data still gave valid comparisons between N fertilizer sources since relative performance was being evaluated rather than maximum yield.

The 5-year average yield values for Coastal bermudagrass dry matter production in pounds per acre per cut are illustrated in Figure 1. Urea fertilizer performed as well as or better than ammonium nitrate, which was used as the standard by which to compare. Since urea apparently did not suffer any significant loss of N, one would not expect a response to $CaCl_2$ ammendment in preventing N loss. There was a trend evident each year indicating ammonium sulfate as inferior on the calcareous Ships clay soil, although not quite enough to be statistically significant. However, when yields from all of the bermudagrass cutlivars were averaged together over the 5-year period on the Ships clay soil, the average yields were pulled down somewhat as previously mentioned and illustrated in Figure 2. Also, the tendency for inferiority of ammonium sulfate performance increased to a statistically significant effect while urea persistently performed as well as or better than ammonium nitrate. This was in 71 different trials with each treatment replicated four times and over a wide range of environmental conditions spanning the 5-year period.

Coastal bermudagrass production on an acid Lufkin fine sandy loam soil as influenced by N fertilizer sources over a 5-year period is shown in Table 2. A total of 26 trials were conducted on this soil over the 5-year period. Since no supplemental irrigation was available at this site, an extremely dry year, such as occurred in 1984, severely reduced yields. The ammonium sulfate performed as well as the other N fertilizers on this acid soil in contrast to the calcareous soil situation. The performance of N fer-

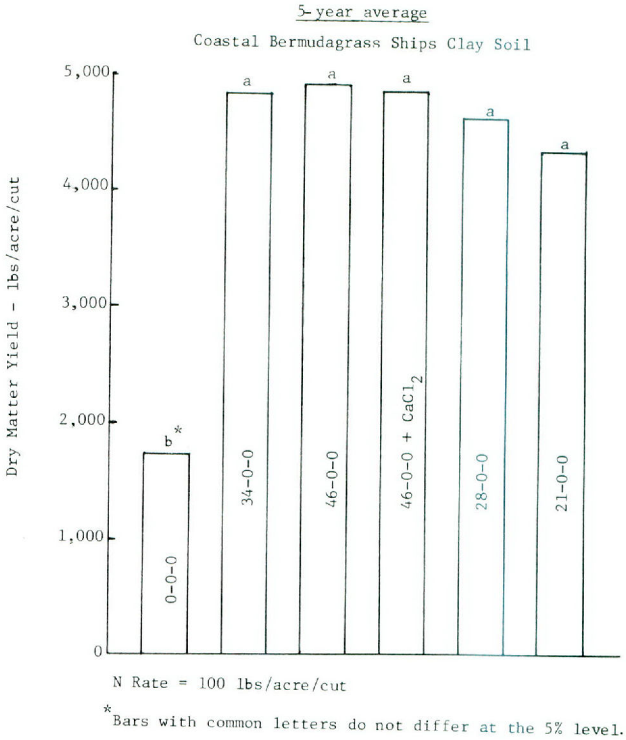

Figure 1. (right) Coastal bermudagrass yield on Ships clay soil as influenced by nitrogen fertilizer source.

TABLE 1. YIELD OF BERMUDAGRASS GROWN ON SHIPS CLAY SOIL AS INFLUENCED BY N FERTILIZER* SOURCE

Coastal Bermudagrass Year	No. of Tests	Control	Nitrate	Urea	Urea + Ca	UAN	Sulfate
		Average dry matter yield (lbs/A/cut)					
1982	6	2,246	5,752	5,749	6,070	5,914	5,379
1983	5	1,404	4,629	4,710	4,674	4,489	3,950
1984	6	1,537	3,578	4,229	4,156	3,307	3,516
1985	6	1,284	4,926	4,909	4,600	4,629	4,433
1986	6	2,066	5,141	4,915	4,699	4,801	—
Average		1,707b**	4,805a	4,902a	4,839a	4,628a	4,319a

All Bermudagrasses Year	No. of Tests	Control	Nitrate	Urea	Urea + Ca	UAN	Sulfate
		Average dry matter yield (lbs/A/cut)					
1982	13	1,819	4,407	4,376	4,592	4,485	4,046
1983	9	1,397	3,999	3,977	3,963	3,897	3,450
1984	6	1,537	3,578	4,229	4,156	3,307	3,516
1985	22	1,362	3,977	3,899	3,906	3,843	3,564
1986	21	2,084	4,585	4,456	4,325	4,272	3,657
Average		1,640c**	4,109a	4,186a	4,188a	3,961ab	3,647b

* N rate = 100 lbs/A.
**Values within a row with a common letter are not significantly different (P<.05).

TABLE 2. DRY MATTER YIELD OF COASTAL BERMUDAGRASS GROWN ON A LUFKIN FINE SANDY LOAM SOIL AS INFLUENCED BY N FERTILIZER* SOURCE

Coastal Bermudagrass Year	No. of Tests	Control	Nitrate	Urea	Urea + Ca	UAN	Sulfate
		Average dry matter yield (lbs/A/cut)					
1982	2	1,931	4,438	4,660	4,732	4,330	5,044
1983	6	1,568	4,326	4,200	4,736	4,377	3,836
1984	2	691	2,731	2,432	3,130	2,551	2,892
1985	8	1,132	4,233	4,066	4,238	4,074	4,089
1986	8	2,979	4,530	4,576	4,344	4,238	—
Average		1,660b**	4,052a	3,987a	4,236a	3,914a	3,965a

* N rate = 100 lbs/A.
**Values within a row with a common letter are not significantly different (P<.05).

tilizer sources averaged over 5 years is illustrated in Figure 3. Since there was no significant difference between the N fertilizer sources, apparently there is no added risk in top-dressing urea versus the other N fertilizers. Even though fertilizers remained on the soil surface for as long as several weeks in some cases before being moved into the soil profile by rainfall, urea performed as well as other N sources. This indicates that under these natural field conditions neither urea hydrolysis nor N loss was of serious concern as some had predicted.

TABLE 3. GRAZING TIME DISTRIBUTION

SR	Percent of total time spent grazing			
	0-6HR	6-12HR	12-18HR	18-24HR
Day 1	15	24	34	26
Day 4	13	26	31	30
Day 7	14	24	30	31
Means	14	25	32	29

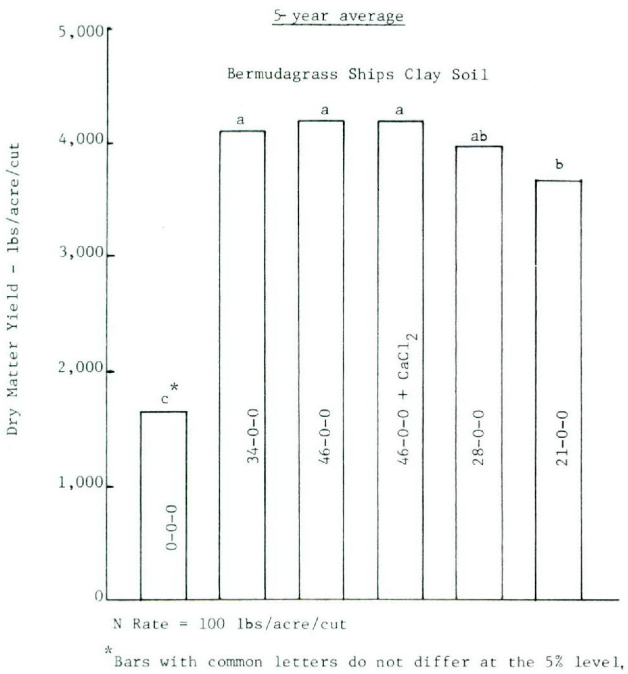

Figure 2. Average yield of bermudagrasses on Ships clay soil as influenced by nitrogen fertilizer source.

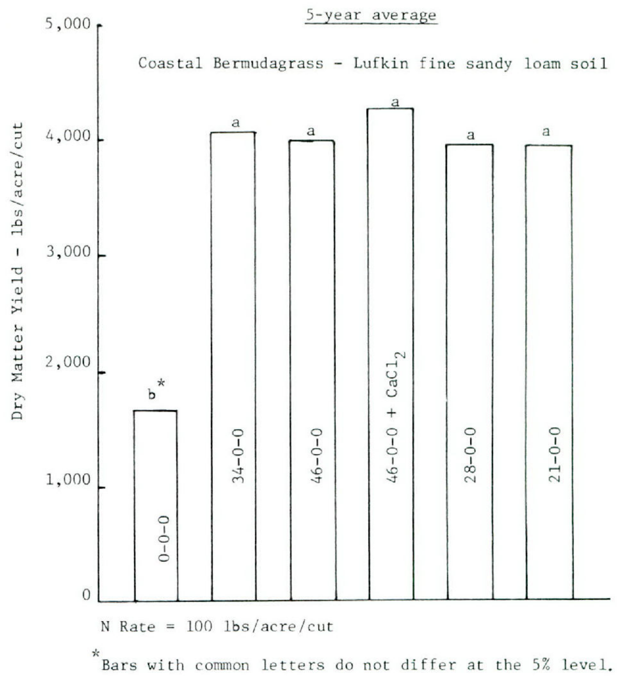

Figure 3. Yield of coastal bermudagrass on Lufkin fine sandy loam soil as influenced by nitrogen fertilizer source.

Nitrogen Response of Arrowleaf Clover Seedlings Grown on Field Soils

H. H. Schomberg and R. W. Weaver

Introduction

Prior to the development of an efficient nitrogen-fixing symbiosis, legumes rely on nitrogen from seed reserves and the soil. Studies have shown that growth can be N limited in both grain and forage legume seedlings dependent on *Rhizobium* (Cooper, 1979; Fishbeck and Phillips, 1981; Silsbury, 1984). Early growth of white clover and subterranean clover is faster when plants are supplied with some mineral N (Ryle et al., 1979; Silsbury, 1984). Arrowleaf clover seedling growth and dinitrogen fixation was stimulated by the addition of 14 mg N pot^{-1} when the plants are grown in N free sand (Schomberg and Weaver, 1986). Establishment of arrowleaf clover in the field may be poor due to its small seed size and low N reserves (Evers, 1982). We conducted an experiment to

KEYWORDS: Nitrogen/arrowleaf/clover/seedlings/Robertson County, Texas.

evaluate the response of arrowleaf clover, to starter levels of N when grown on soil.

Procedure

Cores of soil were collected from four sites in Robertson County, Texas by pressing metal cans of 7.6 cm in diameter 11.4 cm in height into the soil. Soils at sites 1 and 2 are Padina sands (loamy, siliceous, thermic Grossarenic Paleustalf) having a soil pH of 6.4. Native grass and briar were growing on site 1 and Coastal bermudagrass (*Cynodon dactylon* L.) was established at site 2. The soil at site 3 is a Benchley clay (fine, montmorillonitic, thermic Vertic Argiustoll) having a soil pH of 5.5. A mixture of bermudagrass and arrowleaf clover (*Trifolium vesiculosum* Savi) was growing at this site. The soil at site 4 was a Houston clay (fine, montmorillonitic, thermic Udic Pellusterts) having a soil pH of 5.5. A mixture of native grasses was growing at this site. Twenty soil cores were collected from each site during March. The top of each core of soil was fertilized with 191 mg K, 116 mg P, and 73 mg Mg which was added as a solution prior to planting. Micronutrients were added according to a nutrient solution composition of Silsbury (1984) . The solution provided 1.75 mg B, 1.75 mg Mn, 0.17 mg Zn, 0.08 mg Cu, 0.04 mg Mo, and 4.0 mg Fe to each core. Nitrogen was also added in solution to provide rates of 0, 14, and 28 mg N $core^{-1}$. The N source was KNO_3 and rates corresponded to 0, 30.7, and 61.4 kg N ha^{-1} on an $area^3$ basis. The cores were seeded with Yuchi arrowleaf clover on March 16, 1987 and inoculated with *Rhizobium leguminosarum* biovar *trifolii* strain RP115-2. Ryegrass (*Lolium multiflorum* Lam.) was also planted and fertilized with 0 and 14 mg N $core^{-1}$ to evaluate the available nitrogen from each soil and to determine if nitrogen was the most limiting nutrient for plant growth. The seeds were covered with a 2 mm layer of sand and kept moist until emergence. Plants were grown in a greenhouse and thinned to seven $core^{-1}$ after emergence. The bottom of each core was set in a plastic dish (15 mm diameter) that served as a water reservoir. Visual observation of the soils was used to determine when water was needed. Twenty-eight days after planting, and again 28 days later the plant shoots were clipped and dried at 65°C for 48 hours for dry weight determination. Analysis of variance was used to determine differences in dry weights of shoots due to nitrogen levels within a soil.

Results and Discussion

The influence of N on arrowleaf clover dry weight grown on soils from four field sites is shown in Table 1. Addition of N to the soils from sites 1 and 2 resulted in increased growth of ryegrass, but did not result in a significant increase in the shoot dry weight of arrowleaf clover. Addition of 14 mg of N to soils from sites 3 and 4, promoted the early growth of both arrowleaf clover and ryegrass. Addition of 14 mg N to cores of soil from site 3 doubled the dry weight of arrowleaf clover. For the same treatment soil from site 4, plant dry weight was increased by 1.7 times. The dry weight of arrowleaf clover did not show an additional increase by addition of 28 mg N to soils from either of these two sites. Plants clipped after regrowth of 28 days showed similar dry weight trends for the soils from the four sites (data not shown).

TABLE 1. EFFECT OF NITRATE NITROGEN ON SHOOT DRY WEIGHTS OF ARROWLEAF CLOVER AND RYEGRASS GROWN IN SOIL CORES IN A GREENHOUSE

Species	Nitrogen Rate	Dry Weight Soil 1	Soil 2	Soil 3	Soil 4
		mg $core^{-1}$			
Arrowleaf	0	124.7	152.3	145.0	236.0
	14	183.0	186.0	310.0	393.8
	28	162.7	211.7	406.0	451.5
LSD (.05)		NS	NS	158.9	125.3
Ryegrass	0	136.8	184.3	129.5	201.5
	14	476.8	411.5	516.2	462.8
LSD (.05)		51.7	195.8	61.1	49.1

NS - Not significant.

The results from this study indicate that early growth of arrowleaf clover is enhanced by the addition of starter N, and though not shown here, it may increase early nitrogen fixation. In a previous study, additions of some mineral N to sand increased both dry weight of arrowleaf clover and nitrogen fixation (Schomberg and Weaver, 1986). Kunelius (1974a,b) observed better establishment of alfalfa (*Medicago sativa* L.) and birdsfoot trefoil (*Lotus corniculatus* L.) in low N soils when 25 kg N ha^{-1} was added at planting and weeds were controlled.

Soil pH was low in soils from sites 3 and 4, and the additional growth when N was added may have been related to an amelioration of a pH effect. Weaver et al. (1987) found that growth of arrowleaf clover in an acidic soil was nearly equal to growth in the same soil when the pH was neutralized if supplemental mineral N was provided.

Arrowleaf clover establishment in soils with low N availability may be enhanced by the addition of starter N. The role of mineral N during early growth of arrowleaf clover needs further evaluation in both the greenhouse and field to determine soil conditions that result in beneficial plant responses. An additional complexity from application of mineral N is enhanced competition from weeds and grasses.

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Forage Response to Residual Soil Phosphorus and pH. I. Marshall Ryegrass

J.B. Hillard, V.A. Haby, F.M. Hons, J.V. Davis, and A.T. Leonard

Summary

Marshall ryegrass yield response relative to residual soil phosphorus (P) and to soil pH change due to limestone treatments applied in 1983 was evaluated. Ryegrass harvested in 1986 was strongly influencd by the level of lime applied in 1983. Dry matter production for plots receiving no lime was 3,423 lbs/A, whereas yields for plots treated with 0.3 and 1.7 tons of limestone/A were 4,576 and 7,417 lbs/A, respectively. Increasing residual soil phosphorus produced higher dry matter yields, with the magnitude of the effect being mitigated by the level of limestone applied or soil pH. At the highest limestone rate, or above pH 6, increasing residual soil P had a much smaller impact on ryegrass yield than observed in the absence of or at the low limestone rate. Increased soil pH produced by limestone application had a much greater effect on ryegrass yields than did residual soil P. Optimum yields were estimated to occur above pH 6, implying that exchangeable aluminum played a significant role in limiting yields at lower soil pH.

Introduction

East Texas soils are becoming increasingly acidic. A summary of soil test results evaluated in the late 1960's revealed that 2 percent of these soils were testing below pH 5.2. A similar evaluation in the early 1980's indicated that 12 percent of these soils were testing below pH 5.0. As soil acidity increases, plant utilization of nutrients becomes less efficient. This study was designed to evaluate the effect of limestone and phosphorus application on forage production in a strongly acidic soil.

KEYWORDS: Liming / phosphorus / soil acidity / annual ryegrass.

Procedure

This study was initiated in July 1983, on a Lilbert loamy fine sand with a surface 6-inch depth pH of 4.5. Limestone treatments of 0, 0.3, and 1.7 tons/A were applied as main plots in a split plot design. The sub plot treatments were P_2O_5 rates of 0, 30, 61, 92, 123, 245, and 491 lbs/A roto-tilled incorporated into the soil along with the limestone. The same P_2O_5 rates were re-applied to the individual plots in 1984. Each of these treatment combinations was replicated eight times. Phosphorus was supplied as triple superphosphate. Limestone was applied as 100 percent minus 7-mesh and 27 percent minus 100-mesh agricultural grade limestone, consisting predominantly of $CaCO_3$ with a minute amount of $MgCO_3$. Individual plots were 9 × 15 ft.

Soil samples were collected from the surface 6-inch soil depth in summer 1985. Marshall ryegrass was seeded into the plots in October after the final Coastal bermudagrass harvest. Urea was applied to the experiment at the rate of 60 lbs N/A in mid-December, in early February, and following each of the first two cuttings. The site was adequately fertilized with potassium and sulfur. Three harvests were made in 1986. Approximately 64 ft^2 of each plot was cut, weighed, and sampled for moisture content. Yields were calculated from these data. Coastal bermudagrass was sorted from the ryegrass in the moisture samples from the second and third harvests. Yields were adjusted according to the weight percent ryegrass each plot contained. Yield data were analyzed statistically using SAS.

Results and Discussion

The effects of applied limestone and phosphorus on annual ryegrass production are presented in the analysis of variance (Table 1). Limestone and phosphorus rates had a significant impact on dry matter yields, as did the lime × P interaction.

Ryegrass yield was strongly influenced by limestone, especially at the highest rate of lime (Table 2). Dry matter yields, as a function of limestone rates averaged across all P treatments, showed an 1,153 lbs/A increase in yield for the 0.3 ton per acre rate compared to the 0 lime check. The 1.7 ton/A lime treatment increased yields 3,994 lbs/A over the 0 lime check and 2,841 lbs/A above the 0.3 ton/A lime rate.

Ryegrass dry matter yield increased with increasing residual soil P (Table 3). The results shown in Table 3 represent the effects of residual P on ryegrass yields when averaged across all limestone treatments. These data indicated ryegrass yield had increased as residual soil P increased. The data provide more meaningful information when the effects of lime and phosphorus are viewed at the same time by examining the lime × P interaction. The analysis of variance indicated the interaction was significant ($p<0.05$) for harvests 1 and 2, and the combined annual total yield. The interactive effects are shown below in Table 4.

The interaction data (Table 4) indicated ryegrass yield at the high lime rate was increased to a much lesser extent by increasing residual soil P than occurred at the 0 and 0.3 ton lime/A rates. Soil testing in 1985 showed a significant lime × P treatment interaction on soil P availability (Table 5). The interactive effect of lime on soil P did not explain the interactive effect on ryegrass yield. However, exchangeable Al was reduced as soil acidity declined from the application of limestone, making P uptake more efficient in the absence of exchangeable Al. Therefore, limed soil may show less effect of residual soil P on ryegrass yield as P uptake may have been more efficient when soil acidity declined due to limestone treatment.

The data were fitted to a regression equation by regressing ryegrass yield against applied limestone and residual soil P. The best fit equation for the data was found to be $Y = 2791.1 + 2.25(\text{Lime}) + 39.8(P) - 0.0094(\text{Lime} \times P) - 0.00027(\text{Lime}^2)$, where Y equals ryegrass dry matter yield. With all parameters significant, this equation implies ryegrass responded to applied limestone in a curvilinear fashion that was influenced by the level of residual soil P and applied lime. Predicted ryegrass dry matter yields as a function of residual soil P at the three levels of limestone are shown in Figure 1.

The yield potential of Marshall ryegrass in this strongly acidic soil was greatly enhanced by raising soil pH. The yield increases were most likely occurring as a result of increased plant nutrient availability along with the amelioration of phytotoxicity induced by significant levels of exchangeable Al and Mn present in acid soils. Increasing residual soil P did lead to higher dry matter yields, but to a lesser extent than achieved when using limestone.

TABLE 1. ANALYSIS OF VARIANCE RESULTS FOR LIME AND PHOSPHORUS TREATMENT EFFECTS ON RYEGRASS DRY MATTER YIELDS

	Significance of Effect[1]			
Source	Harvest 1	Harvest 2	Harvest 3	Total
Lime	**	**	**	**
Phosphorus	NS	**	**	**
Lime*Phosphorus	*	*	NS	**

[1]*-significant at $p<0.05$. ** - significant at $p<0.01$. NS - non significant.

TABLE 2. RYEGRASS RESPONSE TO LIMESTONE RATES

Limestone Rate	Soil pH	Dry Matter Yield			
		Harvest 1	Harvest 2	Harvest 3	Total
Tons/A		Pounds/Acre			
0	4.50	387	1,215	1,821	3,423
0.3	4.65	432	1,769	2,375	4,576
1.7	6.20	721	3,284	3,412	7,417

TABLE 3. RYEGRASS RESPONSE TO RESIDUAL SOIL P

Residual Soil P	Dry Matter Yield			
	Harvest 1	Harvest 2	Harvest 3	Total
(ppm)	Pounds/Acre			
3.4	494	1,920	2,292	4,706
4.7	478	1,981	2,492	4,951
7.6	510	2,022	2,335	4,867
11.5	474	2,001	2,577	5,052
13.9	515	2,039	2,583	5,137
23.6	536	2,207	2,584	5,327
44.4	585	2,460	2,890	5,935

TABLE 4. INTERACTIVE EFFECTS OF LIMESTONE AND RESIDUAL SOIL PHOSPHORUS ON TOTAL RYEGRASS DRY MATTER YIELDS

	Dry Matter Yield		
P_2O_5 Rate	Limestone Rate, lb/A		
	0	600	3,400
lbs/A	Pounds/Acre		
0	2,966	4,273	6,853
30	3,393	4,197	7,392
61	3,172	3,816	7,615
92	2,963	4,546	7,649
123	3,209	4,882	7,266
245	3,680	4,709	7,594
491	4,621	5,613	7,569

TABLE 5. INTERACTIVE EFFECTS OF LIMESTONE AND PHOSPHORUS RATES ON SOIL P AVAILABILITY

P_2O_5 Rate	Limestone Rate, lbs/A		
	0	600	3,400
lbs/A	ppm		
0	4.73	2.80	2.73
30	5.13	4.08	4.83
61	6.98	7.63	8.23
92	10.48	11.25	12.70
123	14.32	11.67	15.55
245	19.50	19.85	31.38
491	37.85	39.97	55.40

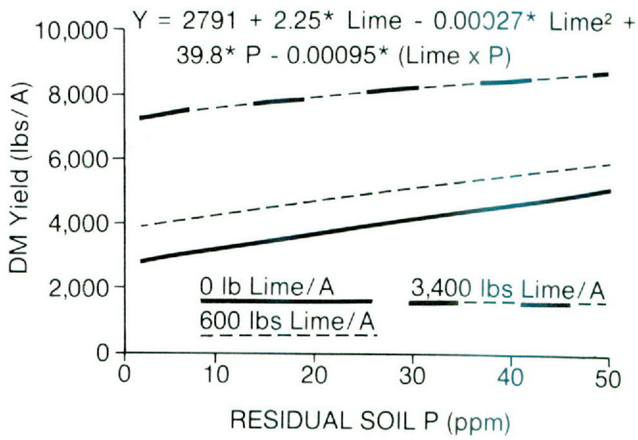

Figure 1. Ryegrass yield in response to applied limestone and residual soil P.

Forage Response to Residual Soil Phosphorus and pH. II. Coastal Bermudagrass

J.B. Hillard, V.A. Haby, F.M. Hons,
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Summary

Coastal bermudagrass yield response relative to residual soil phosphorus (P) and to soil pH change due to limestone treatments applied in 1983 was evaluated. Limestone and initial P treatments were incorporated into the surface of the Lilbert soil in mid-1983. A duplicate P application was surface applied and incorporated in early 1984. Coastal bermudagrass and ryegrass forages have been grown on this site to evaluate residual effects of these treatments. The luxurious growth of ryegrass in the high lime treated plots shaded the growth of Coastal bermudagrass during early spring. In the 0 lime and low lime treated plots, the poor growth of ryegrass allowed the more acid tolerant Coastal bermudagrass to start rapid growth earlier. At the mid-October harvest, the 1.7 ton/A treatments increased Coastal bermudagrass yields 939 lbs/A compared to the 0.3 ton/A lime treatments. Over all harvests, Coastal bermudagrass did not respond to limestone treatment during 1986. Dry matter yields did increase progressively with increasing residual soil phosphorus in 1986.

Introduction

East Texas soils are becoming increasingly acidic. The effect of this increased acidity often does not noticeably lower yields of monocultured Coastal bermudagrass, an acid-tolerant crop. Plant utilization of many nutrients becomes less efficient as soil acidity increases. This study was designed to evaluate the effect of limestone application on Coastal bermudagrass production and phosphorus (P) use efficiency in a strongly acid, sandy soil.

Procedure

This study was initiated in July 1983, on a Lilbert loamy fine sand having a surface 6-inch depth pH of 4.5. Limestone treatments of 0, 0.3, and 1.7 ton/A were applied as main plots in a split plot design. The sub plot treatments were P_2O_5 rates of 0, 30, 61, 92, 123, 245, and 491 lbs/A as superphosphate and roto-till incorporated into the soil along with the limestone. The same P_2O_5 rates were re-applied to individual plots in 1984. Each of these treatment combinations was replicated eight times. Limestone was applied as 100 percent minus 7- mesh and 27 percent minus-100 mesh agricultural grade limestone, consisting predominantly of $CaCO_3$ with a minute amount of $MgCO_3$. Individual plots were 9 × 15 ft.

Soil samples were collected from the surface 6-inch depth in summer 1985. Potassium was applied to this site at the rate of 200 lbs K_2O/A on December 18, 1985.

KEYWORDS: Liming/phosphorus/Coastal bermudagrass/soil acidity.

A total of 240 lbs N/A was applied to the preceding ryegrass crop. Following the final 1986 ryegrass harvest in May, 100 lbs N/A was applied for Coastal bermudagrass production. Additional 100 lbs N/A applications of $(NH_4)_2SO_4$ were made after each of the first two harvests. Potash was applied on July 3, 1986 at the rate of 60 lbs K_2O/A. Approximately 64 ft^2 of each plot was cut, weighed, and sampled for moisture content. Yields were calculated from these data. First harvest yields were adjusted upwards to reflect the amounts of Coastal bermudagrass contained in the last two ryegrass harvests.

Results and Discussion

The overall effects of limestone and phosphorus treatment on Coastal bermudagrass yield are presented in the analysis of variance (Table 1). Coastal bermudagrass yield showed a negative yield response to limestone application in the first harvest, the second harvest produced no response, and the third harvest exhibited a positive response to limestone treatment (Table 2). The negative response to limestone observed in the first harvest was due to the vigorous ryegrass growth which occurred in plots receiving 1.7 ton lime/A, and to a lesser extent in plots receiving 0.3 ton lime/A. Shading in plots with heavy ryegrass growth accounted for the reduced Coastal bermudagrass yield in these plots. Yields were relatively low during the second harvest because of drought and which may have served to diminish treatment effects. The positive response to limestone which occurred in the third harvest was attributed to increased soil pH.

Coastal bermudagrass dry matter yields were increased by increasing levels of residual soil P (Table 3). Harvest 2 was the exception as this harvest followed a droughty period. Yield data presented in Table 3 were averages of all limestone rates. The yield increases appeared progressively larger with higher residual soil P. However, results were somewhat complicated by the presence of a significant lime × P interaction for total dry matter yield (Table 1). The interactive effects of limestone treatment and residual soil P are presented in Table 4. When the yield data was regressed against lime rate and residual soil P, the following best-fit regression equation was obtained: $Y = 9138 - 1.93\ (Lime) + 86.4\ (P) + 0.045\ (Lime{*}P) + 0.00051\ Lime^2) - 1.24\ (P^2)$, where y equals Coastal bermudagrass yield. This equation indicates Coastal bermudagrass yield response to residual soil P followed a quadratic pattern that was influenced by limestone rate. Coastal bermudagrass yield as a function of residual soil P at the three limestone rates as derived by this regression equation is shown in Figure 1.

From yield data presented in Table 4 and Figure 1, Coastal bermudagrass yields reached a maximum at a lower level of residual soil P in plots receiving no limestone treatment than in those plots receiving limestone. At all limestone rates the response to residual soil P was curvilinear, with maximum dry matter yield occurring in the medium to high soil test level of residual soil P. Interpretation of this years results were somewhat complicated by the effects of variable ryegrass growth during the period when the Coastal bermudagrass was beginning its spring growth.

In conclusion, Coastal bermudagrass has shown a greater response to residual soil P than to limestone treatment. While the lime × P interaction somewhat obscured the picture, yields were highest in the medium to high soil test levels of available soil P. Because the plots have now been continuously cropped for several years, the residual effects of limestone treatment may finally be making a contribution to improved Coastal bermudagrass production as seen in the yield increase due to limestone treatment for the third harvest.

TABLE 1. THE ANALYSIS OF VARIANCE RESULTS FOR COASTAL BERMUDAGRASS DRY MATTER YIELD AS AFFECTED BY LIMESTONE AND PHOSPHORUS TREATMENT

	Significance of Effect[1]			
Source	Harvest 1	Harvest 2	Harvest 3	Total
Lime	**	NS	**	NS
Phosphorus	**	NS	**	**
Lime*Phosphorus	NS	**	NS	*

[1]*-significant at $p<0.05$, **-significant at <0.01, and NS-nonsignificant.

TABLE 2. COASTAL BERMUDAGRASS RESPONSE TO LIMESTONE RATES (TAES—OVERTON)

Limestone Rate	Soil pH	Dry Matter Yield Harvest 1	Harvest 2	Harvest 3	Total
Tons/Acre		Pounds/Acre			
0	4.50	3,902	2,125	3,901	9,928
0.3	4.65	3,072	2,145	3,812	9,028
1.7	6.20	2,597	2,166	4,751	9,514

TABLE 3. COASTAL BERMUDAGRASS RESPONSE TO RESIDUAL SOIL P

Residual Soil P	Harvest 1	Dry Matter Yield Harvest 2	Harvest 3	Total
ppm	Pounds/Acre			
3.4	2,837	2,021	3,762	8,620
4.7	2,795	2,152	4,117	9,064
7.6	3,159	2,198	4,129	9,486
11.5	3,160	2,190	4,171	9,521
13.9	3,129	2,222	4,173	9,524
23.6	3,626	2,105	4,201	9,932
44.4	3,625	2,129	4,530	10,284

TABLE 4. INTERACTION OF LIMESTONE AND RESIDUAL SOIL PHOSPHORUS ON COASTAL BERMUDAGRASS DRY MATTER YIELDS

		Dry Matter Yield		
		Limestone Rate, lbs/A		
P Rate	Soil P Status	0	600	3,400
lbs/A		Pounds/Acre		
0	v.low	9,280	8,657	7,876
30	v.low	9,798	8,794	8,551
61	low	9,855	8,910	9,696
92	med	10,451	8,343	9,770
123	med	9,819	8,850	9,904
245	high	9,336	10,002	10,428
491	v.high	10,923	9,652	10,236

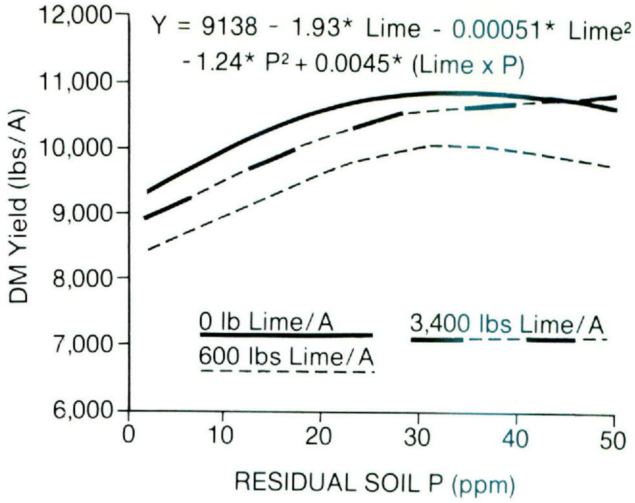

Figure 1. Coastal bermudagrass yield in response to applied limestone and residual soil P.

Herbicide Evaluation As Sod Desiccants on Dallisgrass

G. W. Evers

Summary

Fall application of chemicals to desiccate warm season perennial grasses would improve establishment of sod seeding cool season clovers and grasses. None of the herbicides now cleared possess all the desirable qualities of the ideal grass desiccant. Paraquat, Glyphosate, and Dalapon were compared to new chemicals developed for post-emergence grass control in cotton and soybeans. Varing rates of Fusilade, Poast, Dowco 453, HOE-00661, and CGA-82725 were evaluated over 2 years on a dallisgrass sod. Dowco 453, HOE-00661, and the higher Fusilade rates resulted in the best desiccation but were also the most phytotoxic in terms of summer dallisgrass recovery. Fusilade and Poast might be more effective as desiccants on bermudagrasses which are more tolerant of these chemicals.

KEYWORDS: Sod seeding/overseeding/herbicides/desiccants.

Introduction

Warm season perennial grasses are the basis for the livestock industry in the southeastern United States. Dallisgrass, bahiagrass, and bermudagrasses begin growth about April 1 and stay green until frost in late fall. A potential area for improving livestock production efficiency and reducing cost of gain is fall sodseeding of ryegrass, clover, and/or small grains to provide grazing during the winter and early spring and nitrogen for the summer grasses following the clover.

The primary obstacle to sod seeding is the competition of the well established grass sod to the young emerging grass or clover seedlings. Paraquat, Glyphosate, and Dalapon are available as sod desiccants. However, they all have limitations for use on the warm season perennial grasses in the southeast. Paraquat provides fast desiccation but only holds the grass back about 1 week. Glyphosate is effective but is phytotoxic to dallisgrass and bahiagrass. Dalapon must be applied at least 3 weeks before sod seeding, which reduces the grazing season of the summer grass. Nor is Dalapon persistant. Bermudagrass will begin to green up 5 weeks after application (2 weeks after sod seeding) which interferes with the establishment of a cool season grass or clover. Dalapon also has been observed to retard dallisgrass recovery the following summer.

The ideal chemical for sod seeding would be one that desiccates quickly, is effective for 2 to 3 months, is not toxic to cool season forages being seeded, and allows good recovery of the warm season perennial grass in the spring. Studies were conducted for 2 years on a dallisgrass sod to compare new chemicals with those presently being used as sod desiccants.

Procedure

The studies were conducted on dallisgrass at the Texas Agricultural Experiment Station at Angleton. Experimental design was a randomized block with four replications. Plots were 6 X 15 ft. Herbicides were applied with a CO_2 pressurized sprayer at 30 psi at the rate of 16.5 gal water/A. The test site was sod seeded to Gulf ryegrass after herbicide application. Time of herbicide application before seeding varied among chemicals and is reported in the tables. The degree of dallisgrass desiccation was scored on the day of seeding. Since sod desiccation primarily effects early forage production, only the first ryegrass harvest is reported. Recovery of the dallisgrass was scored on August 1, 1983 and 1984.

Results and Discussion

1982 to 1983 Study

The dallisgrass sod was satisfactorily desiccated by the day of ryegrass planting for all treatments except CGA-82725, Poast, and the low Fusilade rate (Table 1). Observations the previous fall showed that CGA-82725 and Poast were more phytotoxic when the dallisgrass was growing under good moisture conditions.

The first ryegrass harvest was late. Differences between herbicide treatments were smaller than normal because of the late germination due to poor moisture conditions. Paraquat, as discussed earlier, has quick activity but fails to hold the grass sod back as shown by the low ryegrass yields at the first harvest. Glyphosate did an excellent job of sod desiccation as indicated by the high ryegrass production. However, less than 10 percent of the dallisgrass stand

TABLE 1. HERBICIDE EVALUATION FOR SOD SEEDING ON DALLISGRASS 1982 TO 1983

Herbicide	Rate (A.I.)	Application before seeding	Desiccation rating[1]	First ryegrass harvest	Dallisgrass recovery rating[2]
	lb/A		Oct. 20	lb DM/A	Aug. 1
Control	—	—	1.00	898	5.00
Paraquat	0.5	1 day	4.75	1,176	5.00
Glyphosate	0.5	1 wk	3.75	2,073	.75
Dalapon	3.75	3 wk	4.25	1,409	1.00
CGA-82725 + 1% C.O.[3]	0.25	3 wk	1.50	1,194	4.50
CGA-82725 + 1% C.O.	0.12	3 wk	1.00	1,077	4.75
Poast + 1 ¼% C.O.	0.12	1 wk	1.75	916	4.75
Poast + 2 ½% C.O.	0.12	1 wk	1.75	1,050	3.75
Fusilade + C.O.	0.06	3 wk	2.25	1,048	4.50
Fusilade + C.O.	0.12	3 wk	4.00	1,277	4.00
Fusilade + C.O.	0.25	3 wk	3.75	1,526	1.75
Fusilade + C.O.	0.25	1 wk	1.25	727	1.75
HOE-00661	0.5	1 wk	4.00	1,454	2.25
HOE-00661	0.75	1 wk	4.50	1,400	1.25
HOE-00661	1.0	1 wk	4.75	1,607	1.25
HOE-00661	2.0	1 wk	5.00	1,723	.75
HOE-00661	3.0	3 wk	5.00	1,696	1.00

[1]0 = no desiccation, 5 = 100% desiccation.

[2]Dallis recovery rating 0 = no dallis, 1 = <10% dallis stand, 2 = 25% dallis stand, 3 = 50% dallis stand, 4 = 75% dallis stand, 5 = 100% dallis stand.

[3]Crop oil at 1 qt/A.

recovered the following year.

One-eighth pound of Fusilade was necessary for good sod desiccation. Under good fall moisture conditions, 0.06 lb may have been adequate. Rates of 0.25 lb were phytotoxic as shown by the poor dalligrass recovery the following summer. The low ryegrass production when Fusilade was applied 1 week before planting may be due to poor sod desiccation or phytotoxicity to the ryegrass. All rates of HOE-00661 did an excellent job of sod desiccation, but resulted in poor dallisgrass recovery. However, they were not as phytotoxic as Glyphosate.

1983 to 1984 Study

Paraquat, Glyphosate, and the 0.12 and 0.25 lb/A rate of Fusilade provided good dallisgrass sod desiccation as they had the year before (Table 2). Dowco 453 which was tested for the first time also resulted in good dallisgrass desiccation. Ryegrass stands and growth were very poor because of unusually cold temperatures in late December. Temperatures remained below freezing for 4 days with a minimum temperature of 14°F. Glyphosate, Dalapon, Dowco 453, and the two high rates of Fusilade produced the best ryegrass. Dallisgrass recovery the following summer was very poor except for Paraquat, Poast, and the low rates of Fusilade and CGA-82725.

None of the chemicals tested provided the ideal combination of quick and persistent fall desiccation with good dallisgrass recovery the following summer. Poast had poor desiccation at ryegrass planting but good dallisgrass recovery the following summer. Desiccation at planting might be improved by applying Poast 3 to 4 weeks before planting instead of one. Previous observations indicate that bermudagrass is more tolerant to these chemicals than dallisgrass. Further studies should be carried out on other warm season perennial grasses and with other potential chemicals.

TABLE 2. HERBICIDE EVALUATION AS SOD DESICCANTS ON DALLISGRASS 1983-84

Herbicide	Rate (A.I.)	Application before seeding	Desiccation rating[1]	Ryegrass stand	First ryegrass harvest	Dallisgrass recovery[2]
	lb/A			%	lb DM/A	
Control	—	—	0	6	30	5.00
Paraquat	0.5	1 day	4.0	10	23	4.75
Glyphosate	0.5	1 wk	5.0	100	527	0.75
Dalapon	3.75	3 wk	1.75	100	541	1.00
Fusilade	.06 + C.O.[3]	3 wk	2.0	14	110	3.75
Fusilade	.12 + C.O.	3 wk	4.5	72	437	1.00
Fusilade	.25 + C.O.	3 wk	5.0	100	607	0.25
Poast	.12 + C.O.	1 wk	1.0	11	44	4.50
Poast	.25 + C.O.	1 wk	2.25	18	168	3.25
Dowco 453	.06 + C.O.	3 wk	5.0	100	453	1.00
Dowco 453	.12 + C.O.	3 wk	5.0	100	364	0
CGA-82725	.12 + C.O.	3 wk	2.75	14	54	3.25
CGA-82725	.25 + C.O.	3 wk	2.75	22	127	2.00
L.S.D. .05			0.6	9	118	1.00

[1]0 = no desiccation, 5 = 100% desiccation.
[2]Recovery ratio 0 = no dallisgrass, 1 = 20%, 2 = 40%, 3-60%, 4-80%, 5 = 100% recovery.
[3]Crop oil at 1 qt/A.

Subterranean Clover Response to Preemergence, Postemergence, and Grass Desiccant Herbicides

G. W. Evers

Summary

This study was conducted to determine the specific response of subterranean clover to various rates of eight herbicides. The upper rates for preemergence-incorporated Balan and Eptam are 2 and 3 lbs/A, respectively. A 5- to 7-day delay between Eptam application and clover planting is also suggested. Post emergence herbicides Rhonox and Basagran controlled broadleaf weeds. Basagran would be the preferred chemical because it is less phytotoxic to the clover and also controls sedges. Poast, Fusilde, Dowco 453, and CGA-82725 provided good grass control with no damage to the clover.

Introduction

Subterranean clover acreage is increasing in Texas (Evers and Dorsett, 1986). Small plot research studies fre-

KEYWORDS: Subterranean clover/subclover/herbicides.

quently require pure stands of subterranean clover. Although herbicides are the most practicable means of weed control, few herbicides are cleared for clovers. Information on the response of subterranean clover to these cleared herbicides is very limited. Initial screening of herbicides at only one or two rates has shown that 2,4-DB will cause leaf deformations and stunting of clover seedlings and that high rates of Eptam and Balan may be phototoxic (Evers, 1983a; Evers, 1983b).

The predominant use of cool season annual clovers will be in mixtures with warm season perennial grasses. The most limiting factor to establishing and reseeding annual clovers in the fall is the grass competition. Some chemicals have been evaluated on dallisgrass (Evers, 1987) and Coastal bermudagrass (Grichar et al., 1987) as grass desiccants. The more promising chemicals need to be checked for postemergence phytotoxicity to the clover for their use on pastures after the clover has volunteered.

Preemergence and postemergence herbicides were evaluated on subterranean clover to provide additional information for use in weed control and as grass desiccants.

Procedure

Mt. Barker subterranean clover was planted on a prepared seedbed in 8-inch rows at 20 lbs/A on October 20, 1983. Soil type was a Lake Charles clay which was fertilized with 60 lbs P/A the day before planting. Experimental design was a randomized block with four replications. Plot size was 6 X 15 ft. Herbicides were applied with a CO_2 pressurized sprayer at 30 psi in 16.5 gal water/A. Balan and Eptam were applied and incorporated with a garden tiller immediately before planting. Postemergence herbicides were applied on November 11 when the clover seedlings were in the unifoliate to the first true leaf stage. The first rainfall after planting was 0.55 inches on October 31.

Ten seedlings were excavated at random from each plot on January 6 and dried to determine seedling weight. Plots were harvested to a 1.5-inch height with a flail mower on March 20 and April 27. Weeds on the test site were nutsedge *(Cyperus spp.)*, common chickweed *(Stellaria media)*, henbit *(Lamium amplexicaule)*, swinecress *(Coronopus didymus)*, and annual bluegrass *(Poa annua)*.

Results and Discussion

By November 17, Eptam had caused reduced stands, stunting of seedlings, and sealing of the cotyledons. The degree of damage increased with herbicide rate. There were also some phytotoxic effects on the 1- and 2-lb Basagran, 0.5- and 1.0-lb Rhonox, and 3-lb Balan treatments. The high rate of Basagran and Rhonox and 3-lb Eptam treatments resulted in significantly lower seedling weights than the control (Table 1). Seedling weight decreased as herbicide rate increased for all herbicides except Eptam and Fusilade. This same trend occurred for forage production at the first harvest. Rhonox and the high rate of Balan and Eptam produced significantly lower yields than the control. Lack of soil moisture caused the very low second harvest yields and probably prevented any significant differences than may have occurred. Only the high Rhonox rate resulted in significantly reduced forage production than the control for the season.

None of the herbicide treatments produced significantly more forage than the control because of the complex weed population. Eptam was the only herbicide that con-

TABLE 1. RESPONSE OF SUBTERRANEAN CLOVER TO VARIOUS RATES OF PREINCORPORATED AND POSTEMERGENCE HERBICIDES

Herbicide	Rate (A.I.)	Seedling dry weight	Yield 20 Mar	Yield 27 Apr	Yield Total
	lb/A	grams	lb/A	lb/A	lb/A
Balan	1.0	0.275	2,136	403	2,539
Balan	2.0	0.273	2,010	403	2,413
Balan	3.0	0.178	1,575	604	2,179
Eptam	2.0	0.218	1,692	403	2,095
Eptam	3.0	0.158	2,010	547	2,557
Eptam	4.0	0.178	1,508	417	1,925
Rhonox	.25	0.220	2,034	633	2,666
Rhonox	.5	0.198	1,625	561	2,186
Rhonox	1.0	0.105	1,005	676	1,681
Basagran	.5	0.200	2,002	374	2,376
Basagran	1.0	0.165	1,843	489	2,332
Basagran	2.0	0.090	1,734	619	2,353
Control		0.253	2,111	417	2,528
Poast + C.O.[1]	.5	0.240	1,843	360	2,203
Poast + C.O.	1.0	0.208	2,136	417	2,553
Fusilade + C.O.	.5	0.208	2,211	389	2,600
Fusilade + C.O.	1.0	0.233	1,943	403	2,346
Dowco 453 + C.O.	0.5	0.275	1,901	360	2,261
Dowco 453 + C.O.	1.0	0.223	1,843	432	2,274
CGA-82725 + C.O.	0.5	0.245	2,136	403	2,539
L.S.D. .05		0.088	427	379	646

[1]Crop oil at 1 qt/A.

trolled all weeds but it was also the most phytotoxic to subterranean clover. The company marketing Eptam has suggested delaying clover planting 5 to 7 days after herbicide application since half life in moist loam soil at 70 to 80°F is approximately 1 week. This has been tried and the phytotoxic effects were reduced. However, the high rate of 4 lbs/A should still be avoided with subterranean clover. The remaining herbicide treatments only removed some of the weed species, and therefore, did not completely eliminate weed competition.

Balan controlled all weeds except nutsedge. The poor clover growth at the 3-lb rate indicates that no more than 2 lbs/A should be used. Rhonox was the most damaging postemergence herbicide evaluated. Only the 0.25-lb rate would be safe but may not provide effective weed control.

Basagran had provided effective broadleaf weed control in earlier studies without harming subterranean clover. In this study the 1- and 2-lb rate reduced seedling weight. This was a temporary effect since there was no significant difference between any of the Basagran treatments and the control for yield. In previous studies Basagran was applied at 0.5- to 1.0-lb rates and applied to slightly older clover seedlings. Basagran appears to be one of the best postemergence herbicides for broadleaf weed and sedge control in clovers. Recommended rate in soybeans, peanuts, and corn is 0.75 to 1.0 lb/A. To be effective, the broadleaf weeds must be young and growing. Basagran is not cleared for clovers at this time.

Poast, Fusilade, Dowco 453, and CGA-82725 caused no damage to subterranean clover. Their potential use would be as a fall application to a warm season perennial grass after volunteer or seeded clovers had emerged. The rates used in this study are 2 to 4 times greater than would be used as desiccants. However, they do not control broadleaf weeds or sedges. Their phytotoxicity to the summer grass is also a problem (Evers, 1987). A possible broad spectrum of weed control in pure clover stands might be obtained by mixing one of these herbicides with Basagran. This hypothesis will be assessed in the future.

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Use of Postemergence Herbicides for Weed Control on Clovers

W. J. Grichar, G. W. Evers, C. L. Pohler, and A. M. Schubert

Summary

Six postemergence herbicides were evaluated at two rates on berseem, rose, and subterranean clovers. Basagran and Kerb caused no injury to any of the clovers. Chiptox and 2,4-D were the most phytotoxic but were less severe on subterranean than rose and berseem clovers. Applying 2,4-DB caused temporary leaf deformation and some plant stunting but resulted in no permanent injury.

Introduction

Producer concern about weed problems in pastures generally does not occur until after the weeds are present. Therefore, any possible chemical weed control is limited to postemergence herbicides. Unfortunately, most herbicides cleared for established rangeland and pasture, such as dicamba (Banvel, Weedmaster), picloram (Grazon, Torodon), and atrazine (Aatrex) are toxic to clovers (Ag Consultant and Fieldman, 1986; Smith, 1975; Conrad and Stritzke, 1980; Smith, 1986). There is limited data to indicate Basagran (Evers, 1983) and MCPA (Conrad and Stritzke, 1980) will control some broadleaf weeds without injury to the clover. Investigations of other potential postemergence herbicides for pastures containing clovers are needed.

Procedure

Soil type in the test area was a Mabank fine sandy loam with a pH of 7.8. The test was planted on October 29. Clover seeding rate was 15 lbs/A. The clover varieties were drilled into a prepared seedbed using a John Deere grain drill with a Tye seeder attachment. One hundred and fifty pounds per acre of 0-69-0 was applied on November 20.

Soil moisture at planting was excellent and 0.14 inches of rain fell on November 7 and 0.22 and 0.38 inches on November 13 and 14, respectively.

A small plot compressed air bicycle sprayer with three SS11002 nozzles spaced 20 inches apart was used to apply the postemergence herbicides 72 days after planting on January 26. Broadleaf weeds ranged in height from 2 to 6 inches. The sprayer delivered 20 gallons of water per acre at 25 psi pressure. Experimental design was a randomized complete block with four replications. Plot size was 76 inches wide by 26 ft long. A rating index (0 equals no injury or weed control to 100 equals complete injury or control) was used to evaluate the herbicide treatments. Broadleaf weed species included henbit (*Lamium amplexicaule*) and cutleaf eveningprimrose

KEYWORDS: Postemergence herbicides/injury/berseem/rose/subterranean.

(*Oenothera laciniata*). Plots were rated 23 days (February 18, 1987) and 57 days after treatment (March 24, 1987).

Results and Discussion

When the rose clover as evaluated (Table 1), 23 DAT ratings indicated that 2,4-D at 0.75 and 1.5 lbs ai/A, Chiptox at 2.0 and 3.0 lbs ai/A and Rhonox at 1.0 lb ai/A produced significantly higher injury than the other treatments. Broadleaf weed ratings indicated that only Basagran at 0.75 lbs ai/A resulted in less than 80 percent control. When the test was rated 57 DAT, only the two rates of 2,4-D caused major injury.

Subterranean clover (Table 2) was the most tolerant clover species to the postemergence herbicides. However. when evaluated 23 DAT, the 1.5 lbs ai/A rate of 2,4-D and Chiptox at 2.0 and 3.0 lbs ai/A resulted in significantly higher clover injury than the untreated check. At the

TABLE 1. EFFECTS OF POSTEMERGENCE HERBICIDES ON BROADLEAF CONTROL AND ROSE CLOVER

		Percent Control or Injury[1]		
		18 Feb. 1987 (23 DAT)		24 Mar. 1987 (57 DAT)
Treatment	Rate lbs ai/A	Broadleaf weeds	Clover	Clover
1. Check	—	0 e	0 d	0 c
2. 2,4-D	0.75	95 abc	86 a	97 a
3. 2,4-D	1.5	96 ab	86 a	100 a
4. 2,4-DB	1.0	86 bc	5 d	0 c
5. 2,4-DB	2.0	88 abc	8 d	0 c
6. Basagran + CO[3]	0.75	68 d	0 d	0 c
7. Basagran + CO	1.5	85 bc	5 d	0 c
8. Kerb 50W	1.5	91 abc	0 d	0 c
9. Kerb	3.0	94 abc	3 d	0 c
10. Rhonox (MCPA isooctyl ester)	0.5	83 c	8 d	0 c
11. Rhonox	1.0	95 ab	20 c	0 c
12. Chiptox (MCPA sodium salt)	2.0	93 abc	53 b	0 c
13. Chiptox	3.0	99 a	56 b	16 b

[1]Control and Injury Index: 0 = none, 100 = complete.
[2]Means followed by the same letter are not significantly different at the 0.05 level of significance (Duncan's Multiple Range Test).
[3]CO = crop oil (Agridex at 1 qt/A).

TABLE 2. EFFECTS OF POSTEMERGENCE HERBICIDES ON BROADLEAF WEED CONTROL AND SUBTERRANEAN CLOVER

		Percent Control or Damage[1]		
		18 Feb. 1987 (23 DAT)		24 Mar. 1987 (57 DAT)
Treatment	Rate lbs ai/A	Broadleaf weeds	Clover	Clover
1. Check	—	0 c[2]	0 d	0 c
2. 2,4-D	0.75	86 a	20 abcd	13 bc
3. 2,4-D	1.5	90 a	30 ab	43 a
4. 2,4-DB	1.0	86 a	6 bcd	10 bc
5. 2,4-DB	2.0	70 ab	6 bcd	15 bc
6. Basagran + CO[3]	0.75	60 b	6 bcd	8 bc
7. Basagran + CO	1.5	88 a	8 bcd	3 c
8. Kerb 50W	1.5	70 ab	0 d	0 c
9. Kerb	3.0	80 ab	0 d	0 c
10. Rhonox (MCPA isooctyl ester)	0.5	76 ab	10 bcd	6 bc
11. Rhonox	1.0	86 a	3 cd	0 c
12. Chiptox (MCPA sodium salt)	2.0	83 a	36 a	31 ab
13. Chiptox	3.0	93 a	28 abc	18 bc

[1]Control and Injury Index: 0 = none, 100 = complete.
[2]Means followed by the same letter are not significantly different at the 0.05 level of significance (Duncan's Multiple Range Test).
[3]CO = crop oil (Agridex at 1 qt/A).

57 DAT rating 2,4-D at 1.5 lbs ai/A and Chiptox at 2.0 lbs ai/A produced significant higher injury than the untreated check.

At the 23 DAT evaluation on berseem clover (Table 3), only Basagran and Kerb did not produce a significant higher injury than the untreated check. Chiptox, 2,4-D and the high rate of Rhonox were very hard on Berseem. The 57 DAT rating reveal that injury was reduced in all herbicide treatments except the 1.5 lbs ai/A rate of 2,4-D and the 3.0 lbs ai/A rate of Chiptox which were 83 and 80 percent, respectively.

Basagran and Kerb caused no injury to any of the clover species. Kerb is cleared for use on clovers but moisture is necessary to activate the herbicide and the clover can not be grazed or harvested for 120 days after application. Applying 2,4-DB only harmed berseem but did cause temporary leaf deformation and some stunting of the other clovers. Chiptox and 2,4-D caused minor injury to subterranean clover but caused 50 to 85 percent on rose and berseem clovers.

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TABLE 3. EFFECTS OF POSTEMERGENCE HERBICIDES ON BROADLEAF WEED CONTROL AND BERSEEM CLOVER

		Percent Control or Injury[1]		
		18 Feb. 1987 (23 DAT)		24 Mar. 1987 (57 DAT)
Treatment	Rate lbs ai/A	Broadleaf weeds	Clover	Clover
1. Check	—	0 d[2]	0 c	0 c
2. 2,4-D	0.75	96 abc	85 a	16 bc
3. 2,4-D	1.5	93 abc	81 a	83 a
4. 2,4-DB	1.0	96 abc	41 b	5 c
5. 2,4-DB	2.0	88 c	56 ab	11 c
6. Basagran + CO[3]	0.75	91 abc	0 c	0 c
7. Basagran + CO	1.5	90 bc	0 c	0 c
8. Kerb 50W	1.5	90 bc	0 c	0 c
9. Kerb	3.0	93 abc	3 c	0 c
10. Rhonox (MCPA isooctyl ester)	0.5	88 c	43 b	0 c
11. Rhonox	1.0	96 abc	83 a	11 c
12. Chiptox (MCPA sodium salt)	2.0	96 ab	83 a	30 b
13. Chiptox	3.0	98 a	85 a	80 a

[1]Control and Injury Index: 0 = none, 100 = complete.
[2]Means followed by the same letter are not significantly different at the 0.05 level of significance (Duncan's Multiple Range Test).
[3]CO = crop oil (Agridex at 1 qt/A).

Use of Postemergence Grass Herbicides for Coastal Bermudagrass Burndown and Clover Establishment

W. J. Grichar, G. W. Evers, C. L. Pohler, and A. M. Schubert

Summary

Seven postemergence grass herbicides were applied to Coastal bermudagrass to determine if these compounds could be used to reduce grass competition and enhance clover establishment. Poast, Selectone, Assure, Whip, Fusilade 2000, Verdict, and SC-1084 were applied at three rates and evaluated in the fall and early summer to determine burndown and subsequent spring regrowth. None of the chemicals evaluated were phytotoxic to subterranean clover which was overseeded on the Coastal. Poast, Selectone, Verdict, SC-1084, and the low Fusilade rate produce the ideal combination of good fall desiccation and spring recovery of Coastal bermudagrass.

Introduction

The greatest potential and use for cool season annual clovers is in mixtures with warm season perennial grasses (Evers, 1984). Clover persistence from year to year is dependent on production of a good seed crop in the spring and successful germination and establishment the following fall. Competition from the perennial grass sod in the fall is the greatest determent to obtaining a good volunteer clover stand (Evers and Dorsett, 1986). Producers try to reduce fall grass competition by grazing and mowing.

A possible and more effective method may be used if a chemical desiccant applied in the fall would burn back the grass but not harm the young clover seedlings. Applying the proper rate of such a chemical is critical in that it needs to be high enough to top kill the grass in the fall but low enough to permit grass recovery the following spring. Seven postemergence herbicides were applied at three rates to identify potential chemicals for use in promoting clover establishment and persistence in a Coastal bermudagrass sod.

Procedure

Coastal bermudagrass test site with a soil type of Tremona loamy fine sand and a pH of 5.2 was shredded to a height of 4 to 6 inches. A compressed air bicycle sprayer with three SS11002 nozzles, spaced 20 inches apart was used to apply the postemergence grass herbicides on October 9, 1985. The sprayer delivered 20 gallons of water per acre at 25 psi pressure. All treatments, except Whip, included a non-phytotoxic oil (Agridex) added at the rate of 1 qt/A. Experimental design was a randomized complete block with four replications. Plot size was 76 inches wide X 26 ft long. Mt. Barker subterranean clover was planted with a Tye sod seeder at the rate of 10 lbs/A into the treated plots on October 17, 1985 and 0.51 inch of rainfall was received on October 18. One hundred and fifty pounds per acre of 0-46-0 was applied to the plots on November 6.

Percent burndown and subsequent regrowth of the coastal was evaluated five times from fall into early summer. A rating index (0 equals to no burndown or regrowth; 100 equals complete burndown or regrowth) was used to evaluate the herbicidal treatments. Four 1-ft square quadrants were clipped from each plot to determine percent clover, weeds, and bermudagrass in each plot. Then plots were harvested using a Lawn Genie mower and individual plot weights recorded. Plots were harvested on February 20, 1986, and April 3, 1986.

Results and Discussion

Desication of Coastal bermudagrass was slow for all chemicals with only 20 to 42 percent burndown 9 DAT (days after treatment) (Table 1). At 29 DAT, Selectone, Fusilade, and SC-1084 resulted in about 90 percent desiccation. Poast and Verdict were also effective at higher application rates. There was a general decrease in percent burndown from 29 to 56 DAT for all chemicals except Fusilade and SC-1084. The low rate of Poast (0.125 lb ai/A), Assure at 0.0625 and 0.125 lbs ai/A and all Whip treatments had significantly lower burndown than the other treatments at 56 DAT.

A rating for Coastal regrowth in early summer (June 20) revealed that only Fusilade at 0.25 or 0.375 lbs ai/A and SC-1084 at 0.4 lbs ai/A were significantly lower in regrowth from the untreated check, indicating that these rates may have resulted in Coastal bermudagrass kill. Treatments resulting in a combination of good fall burndown and spring recovery of Coastal bermudagrass were Poast, Selectone, Verdict, SC-1084, and the low Fusilade rate.

The dry fall 1985 resulted in only fair stands and yields of subterranean clover (Table 2). Clover and total forage yields did decrease as herbicide rate increased for Selectone, Whip, Verdict, and SC-1084 at the first harvest. It did not appear there was any phytotoxicity to the subterranean clover. At the second harvest only Poast at 0.375 lb ai/A had a significantly higher total yield than the control. One year's data is not sufficient to make recommendations. But the results are encouraging that some of these chemicals could be helpful in establishing and maintaining clovers in warm season perennial grasses.

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KEYWORDS: Postemergence grass herbicides/burndown/regrowth/coastal bermudagrass/subterranean clover.

TABLE 1. PERCENTAGE BURNDOWN AND REGROWTH OF COASTAL BERMUDAGRASS AFTER TREATMENT WITH HERBICIDES

Treatment	Rate lbs ai/A	Percent Burndown 10/17/85 (9 DAT)[1]	11/07/85 (29 DAT)	12/06/85 (56 DAT)	Percent Regrowth 4/18/86	6/20/86
1. Check	—	O c[2]	O h	O e	100 a	100 a
2. Poast (1.53#/gal) CO[3]	0.125	20 b	66 ef	36 d	50 bc	98 a
3. Poast+CO	0.25	30 ab	88 abc	81 ab	43 bcd	98 a
4. Poast+CO	0.375	37 ab	93 ab	85 ab	36 bcdef	94 a
5. Selectone 2E+CO	0.2	32 ab	90 abc	58 c	45 bc	96 a
6. Selectone +CO	0.3	37 ab	93 ab	80 ab	41 bcde	88 ab
7. Selectone +CO	0.4	27 ab	94 a	90 ab	36 bcdef	98 a
8. Assure (0.8#/gal) +CO	0.0625	32 ab	61 f	30 d	52 b	97 a
9. Assure+CO	0.125	42 a	79 bcd	40 d	50 bc	99 a
10. Assure+CO	0.25	27 ab	93 ab	80 ab	32 bcdef	87 ab
11. Whip 1EC	0.2	27 ab	47 g	25 d	50 bc	98 a
12. Whip	0.3	27 ab	57 fg	32 d	50 bc	98 a
13. Whip	0.4	27 ab	70 def	33 d	50 bc	93 a
14. Fusilade 2000 1E+CO	0.125	32 ab	94 a	99 a	17 fgh	86 ab
15. Fusilade 2000+CO	0.25	37 ab	95 a	100 a	10 gh	65 c
16. Fusilade 2000+CO	0.375	30 ab	98 a	100 a	1 h	42 d
17. Verdict (2.0#/gal) +CO	0.0625	27 ab	78 cde	60 c	42 bcd	99 a
18. Verdict+CO	0.125	32 ab	94 a	76 bc	28 cdefg	98 a
19. Verdict+CO	0.25	37 ab	96 a	86 ab	16 fgh	91 ab
20. SC-1084 4E+CO	0.2	20 b	91 abc	84 ab	22 defgh	94 a
21. SC-1084+CO	0.3	35 ab	88 abc	97 ab	20 efgh	94 a
22. SC-1084+CO	0.4	25 ab	93 ab	96 ab	8 gh	76 bc

[1]DAT=Days after treatment.
[2]Means followed by the same letter are not significantly different at the 0.05 level of significance (Duncan's Multiple Range Test).
[3]CO=crop oil (Agridex at 1 qt/A).

TABLE 2. YIELDS FROM VARIOUS HERBICIDE TREATMENTS

Treatment	Rate lbs ai/A	20 Feb. 1986 Dry Clover Weight lbs/A	20 Feb. 1986 Total Dry[1] Weight lbs/A	3 April 1986 Dry Clover Weight lbs/A	3 April 1986 Total Dry Weight lbs/A
1. Check	—	520 a[2]	1,884 a	1,333 ab	2,404 b
2. Poast (1.53#/gal)+CO[3]	0.125	515 a	1,158 abcd	1,444 ab	2,644 b
3. Poast+CO	0.25	434 a	810 bcd	1,602 ab	2,513 b
4. Poast+CO	0.375	451 a	1,203 abcd	2,390 a	3,994 a
5. Selectone 2E+CO	0.2	654 a	1,581 abcd	1,702 ab	2,530 b
6. Selectone+CO	0.3	335 a	700 cd	1,749 ab	2,752 b
7. Selectone+CO	0.4	243 a	623 d	1,309 ab	2,350 b
8. Assure (0.8#/gal)+CO	0.0625	468 a	1,293 abcd	1,314 ab	2,249 b
9. Assure+CO	0.125	813 a	1,760 abc	1,691 ab	2,572 b
10. Assure+CO	0.25	534 a	1,275 abcd	1,956 ab	2,668 b
11. Whip 1EC	0.2	794 a	1,796 ab	910 b	1,943 b
12. Whip	0.3	518 a	1,236 abcd	1,360 ab	2,170 b
13. Whip	0.4	414 a	1,051 abcd	1,880 ab	2,506 b
14. Fusilade 2000 1E+CO	0.125	459 a	1,399abcd	1,152 b	2,230 b

TABLE 2. (Cont'd)

Treatment	Rate lbs ai/A	20 Feb. 1986 Dry Clover Weight lbs/A	20 Feb. 1986 Total Dry[1] Weight lbs/A	3 April 1986 Dry Clover Weight lbs/A	3 April 1986 Total Dry Weight lbs/A
15. Fusilade 2000+CO	0.25	592 a	1,196 abcd	1,013 b	2,123 b
16. Fusilade 2000+CO	0.375	675 a	1,644 abcd	1,150 b	2,032 b
17. Verdict (2.0#/gal)+CO	0.0625	662 a	1,180 abcd	1,507 ab	2,536 b
18. Verdict+CO	0.125	450 a	946 abcd	1,083 b	2,081 b
19. Verdict+CO	0.25	385 a	721 cd	1,278 ab	2,464 b
20. SC-1084 4E+CO	0.2	463 a	1,086 abcd	1,614 ab	2,411 b
21. SC-1084+CO	0.3	400 a	899 abcd	1,770 ab	2,434 b
22. SC-1084+CO	0.4	363 a	759 bcd	1,999 ab	2,578 b

[1]Total dry weight=clover + grass + weeds.
[2]Means followed by the same letter are not significantly different at the 0.05 level of significance (Duncan's Multiple Range Test).
[3]CO=crop oil (Agridex at 1 qt/A).

Use of Non-Destructive Techniques to Estimate Herbage Mass in Bermudagrass (*Cynodon* spp.)

M.A. PETERSON AND M.A. HUSSEY

Summary

Eleven bermudagrass genotypes (*Cynodon* spp.) were evaluated in 1984 and 1985 at Weslaco, Texas (26°N. Lat.) in an attempt to determine potential relationships between the disk meter, plant height, and herbage mass. Results obtained in this study suggest that the relationships between herbage mass and plant height or disk height, was a function of age, cultivar, and season of the year.

Introduction

The use of destructive sampling techniques to estimate herbage mass from pastures is labor intensive, time consuming, and often produces questionable results. Due to limitations on financial resources, inadequate sample numbers are often collected resulting in yield estimates which are not statistically valid. In an effort to increase sample numbers without increasing sampling time, double-sampling techniques are used to estimate forage-on-offer.

Foliage height has been useful in estimating forage yield. Whitney (1974), in an experiment using kikuyugrass (*Pennisetum clandestinum*) and digitgrass (*Digitaria decumbens*), was able to explain 94 percent of the variation in dry matter production for both species using plant height. Similarly, Alexander (1962) indicated that height may be useful in the estimation of forage yield, but that variation between species and seasons required the development of separate regression equations.

Similar conclusions have been made when height has been utilized to estimate "forage-on-offer" in bermudagrass (*Cynodon* spp.) pastures (Kanyama-Phiri and Conrad, personnel communication).

The disk meter has also been utilized to estimate herbage mass. Castle (1976), using the simple disk meter, reported that linear regressions explained 80 to 90 percent of the variation for yield in cutting experiments, but only 39 to 62 percent of the variation for yield in grazing experiments.

The objective of this study was to determine the potential that plant height and the disk meter have in ranking forage cultivars for yield in management studies.

Procedure

Eleven bermudagrass genotypes, consisting of released as well as experimental germplasm were evaluated at Weslaco, Texas (26° N. Lat.) (Hussey et al., 1985). At 6-week intervals, plant height (three estimates per plot) and disk meter height (two estimates per plot) were obtained prior to harvest with a flail type mower. Estimates of plant height represented a mean height of the canopy (not extended height), while the disk meter reading was the height that a 0.5 m disk settled to after being dropped from 1.0 m.

KEYWORDS: Plant height/disk meter/forage yield.

For analysis, mean plant height and mean disk heights from each plot were utilized. Linear regression was utilized to express the relationship between canopy, disk height, and forage yield.

Results and Discussion

For the study, the relationship between height and forage yield was highly dependent on date of cutting, year, and cultivar. When all harvests for the year were analyzed (Table 1) a better relationship was found between height and yield in 1985 (r = .76**) than in 1984 (r = .45**). When only the cultivar Brazos was utilized, a much better relationship was reported between height and yield in 1984 (r = .94**) than in 1985 (r = .75**). While cultivar effects were not statistically significant at the 0.05 level (data not shown), it was possible to obtain very good relationships between height and certain cultivars. In general, for the upright growing types (T-68 and African Stargrass) plant height was explained more than 90 percent of the variation for forage yield.

Disk meter readings were made only in 1985. Again, the data indicated that separate regression equations will be required for every combination of cultivar and season (data not shown). When all genotypes were bulked (Table 2) the relatiohship between herbage mass and disk height explained 58 percent of the variation for yield and 84 percent of the variation for yield in the cultivar Brazos.

The study indicates that plant height may be a better technique for estimating herbage mass from plots than the disk meter. From this limited data set (Table 3) we can see that with the exception of genotype B-12, plant height did a better job of ranking cultivars (compared to destructive sampling) than did the disk meter. However, under plot conditions, stand density is uniform. Since the disk meter combines density and height in its estimate, the disk meter may be expected to provide better estimates of forage yield under grazing than estimates of plant height. This has yet to be tested.

TABLE 1. RELATIONSHIP BETWEEN HERBAGE MASS AND PLANT HEIGHT IN *CYNODON* SPP.

	Year	
All Cultivars	1984	$Y = 141 + 71.1 \times R^2 = .45^{**}$
	1985	$Y = 116.8 + 112.2 \times R^2 = .76^{**}$
BRAZOS	1984	$Y = 547.0 + 118.8 \times R^2 = .94^{**}$
	1985	$Y = 559.0 + 167.5 \times R^2 = .75^{**}$

TABLE 2. RELATIONSHIP BETWEEN HERBAGE MASS AND DISK METER HEIGHT IN *CYNODON* SPP.

	Year	
All Cultivars	1985	$Y = 901.2 + 231.3 \times R^2 = .58^{**}$
BRAZOS	1985	$Y = 2378.3 + 350.1 \times R^2 = .84^{**}$

TABLE 3. RANKING OF ELEVEN CYNODON CULTIVARS BASED ON CUTTING, PLANT HEIGHT, AND SETTLED DISK HEIGHT

Cultivar	Cutting	Height	Disk
I. Star	1	1	2
T-68	2	2	1
B-13	3	4	7
P-7	4	6	9
Coastal	5	5	8
B-2	6	7	5
Brazos	7	10	4
B-12	8	3	9
B-1	9	8	3
T-44	10	11	6
NK-37	11	9	11

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Characterization of Grass Root Systems

M.A. Hussey and S. Simecek

Summary

Six warm-season grass species were compared in a greenhouse study for selected rooting characteristics. A wide range of variation was observed between species for rooting depth as well as total root length. Rhodesgrass was observed to have the greatest rooting depth of all species investigated. Preliminary evaluation of root elongation data indicates that this character may be related to ease of establishment across species.

Introduction

A major objective of grass breeding programs in Texas is to "enhance the establishment, persistence, and en-

KEYWORDS: Rooting depth/root length/shoot/root ratio.

vironmental stress tolerance of adapted species." Since stand establishment problems (low seeding vigor) and moisture stress are two factors which act simultaneously to limit the success of forage species, a need exists to develop selection techniques which will enable plant breeders to develop stress tolerant genotypes.

Previous research has indicated that increased seed weight within a species is one method of improving seedling vigor and successful stand establishment (2). Research with Agropyron spp. has also suggested that rooting depth and root elongation rate may also be related to successful establishment (3). More recent work involving Old World Bluestems has indicated that small differences in rooting depth or root distribution may greatly influence the drought resistance of a species (1).

In order to develop techniques which will facilitate selection for stress tolerance in warm-season grasses, a study was initiated to study grass root systems. The objective of this study was to compare buffelgrass, kleingrass, two Old World Bluestem cultivars, Laurisagrass, and rhodesgrass for rooting depth, total root length, and shoot to root ratio.

Procedures

Six commonly utilized grass species were evaluated in a greenhouse experiment (Table 1). The study was conducted by transplanting seedlings (3 to 5 tillers) into polyethylene tubes (5.0 cm X 200 cm) containing fritted clay (>10 mm). The tubes were inserted into PVC pipe and insulated to maintain a root zone temperature of less than 35°C. Individual tubes were fitted with an automatic watering system to facilitate daily watering and weekly fertilization (macro- and micronutrient).

On a weekly basis, the polyethylene tubes were raised from the PVC pipe and the depth of the fastest growing roots marked. All tubes were harvested when the first visible root reached the bottom of the tube (5 weeks).

The experiment was harvested by removing the polyethylene tubes from the PVC pipe. The tubes were slit vertically and washed free of the fritted clay to facilitate the removal of the entire root system. Two replications were fixed immediately in 70 percent ethyl alcohol, while four replications were dried at 60°C for 48 hours for dry matter determination. Total root length was determined using a Comair automatic root length scanner with two scans being made per sample.

TABLE 1. CULTIVARS UTILIZED IN THE EVALUATION OF WARM-SEASON GRASS ROOT SYSTEMS

Genus and Species	Cultivars
1. Bothrichloa ishaemum	WW-Spar
2. Bothrichloa caucasian	Caucasian
3. Cenchrus ciliaris (buffelgrass)	Common Llano Nueces 409704 409704 OT
4. Chloris gayana (rhodesgrass)	Bell Hunter Pioneer
5. Panicum coloratum (kleingrass)	Selection 75
6. Penniseteum orientale (Laurisagrass)	Laurisagrass

Results and Discussion

Mean rooting depth, total root length, and shoot to root ratio for the study is shown in Table 2. In general, rhodesgrass was found to have the longest root system of the six species investigated. However, observations under field conditions indicate that there is little difference in the mean rooting depth of rhodesgrass and buffelgrass (4).

For buffelgrass, the mean rooting depth reported for Common, Llano, and Nueces is similiar to those values reported in previous studies. The introductions 409704 and 409704 OT were significantly different from the results obtained for the commercial cultivars (Table 2), and were more similiar in rooting habit to Laurisagrass.

While little difference was observed for rooting depth between WW-Spar and Caucasian Bluestem, there was a significant difference in total root length (21.6 m vs. 11.8 m). This is similar to data from Oklahoma which suggests that there is little difference in rooting depth between the two species, but that WW-Spar has more roots deeper in the soil profile (1).

In general, the species which were observed in this study to have deep root systems (rhodesgrass, buffelgrass, kleingrass) are easier to establish than are the species with shallow root systems (Caucasian, Laurisagrass, WW-Spar). Future efforts will be directed toward determining the potential of root system modification for characters in the improvement of warm-season perennial grasses.

TABLE 2. MEAN ROOTING DEPTH, TOTAL ROOT LENGTH, AND SHOOT/ROOT RATIO OF SIX WARM SEASON SPECIES

Species	Rooting Depth	Total Root Length	Shoot/ Root
1. Rhodesgrass	176	110.0	2.10
2. Buffelgrass	146	41.7	2.40
3. Kleingrass	146	45.2	2.10
4. Laurisagrass	87	30.7	1.70
5. WW-Spar	69	21.6	2.40
6. Caucasian	71	11.8	1.80
PI 409704	85	22.9	2.50
409704 OT	129	29.9	2.60

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Use of Pepsin-Cellulase for Estimating Forage Nutritive Value

D. W. Stair, M. A. Hussey, and H. Lippke

Summary

An experiment was conducted in 1986 to determine the feasibility of replacing rumen fluid with fungal cellulase. Comparisons were made between in-vivo, in-vitro, and cellulase digestibility. Highly significant correlations were observed between in-vivo digestibility (IVD) and in-vitro (IVDMD) (r = .95**), as well as between IVD and cellulase solubility (CDMD) (r = .97**). Correlations were also highly significant between IVDMD and CDMD (r = .94**). Results suggest that cellulase solubility may replace traditional in-vitro analysis for warm-season perennial grasses.

Introduction

In-vitro analysis (IVDMD) to predict forage in-vivo (IVD) digestibility has been widely utilized by plant breeders and agronomists to estimate forage nutritive value. While the technique has been widely applied, numerous problems are associated with it.

Of primary concern to the agronomist is that a donor animal (fistulated steer) must be maintained in order to provide a source of rumen fluid. Numerous studies have addressed the variability associated with rumen fluid and results obtained with IVDMD analysis (Clark and Mott, 1960; Van Dyne, 1962; Drew, 1966; Troelsen and Hansel, 1966; Minson and McLoed, 1972). Due to this variation, alternate methods of estimating forage IVD are required.

The use of cellulase enzymes as a replacement for rumen fluid was first proposed in the mid-1960's, however, the initial cellulase preparations were too pure to provide good relationships with in-vivo samples. In recent years, numerous studies have been reported in which good relationships have been obtained between fungal cellulase digestion and in-vitro or in-vivo digestibilities (Bughara and Sleper, 1986; Jones and Hayward, 1975).

The purpose of this study was to evaluate a commercially available source of cellulase for its effectiveness in estimating forage IVDMD and IVD.

KEYWORDS: Cellulase/digestion/rumen fluid.

Procedure

An experiment was conducted to evaluate the relationship between IVD or IVDMD and pepsin-cellulase solubility (CDMD). For all experiments IVDMD was determined according to the methods of Goering and Van Soest (1970) and pepsin-cellulase solubility was determined by a modification of the methods of Jones and Hayward (1973). For this study, 0.2 grams of forage were incubated in 30 ml of acid-pepsin for 24 hours, the supernatant removed by suction through gas dispersion tubes (coarse porosity), and 30 ml of 1 percent (v/v) buffered cellulase added.

Treatment 1 (CDMD-1) consisted of a 24-hour cellulase incubation while treatment 2 (CDMD-2) consisted of a 5-hour incubation, removal of the cellulase solution, and 19 hours in fresh cellulase solution. The samples utilized in this study (Table 1), consisted of 14 samples of known in-vivo digestibility (47.4 to 72.4 percent). In-vitro analysis and CDMD were compared by regression analysis and using Spearmann Rank Correlations.

Results and Discussion

Initial comparisons between IVD and CDMD yielded highly significant r^2 values (Table 2), while Spearmann Rank correlations indicated that CDMD ranked forage samples as well as in-vitro analysis (Table 3). However, a close look at the spread of the IVD samples revealed that two points were clustered at about 72 percent IVD while the remainder of the samples (12) had values between 47 and 60 percent (Table 3). For this reason, the two points were removed and the data set reanalyzed. The removal

TABLE 1. IN-VIVO SAMPLES UTILIZED IN PEPSIN-CELLULASE STUDY

Sorghum-sudans	Bermudagrasses	Ryegrasses
47.35	48.31	72.00
48.62	49.14	72.37
50.50	51.21	
53.64	57.45	
53.87	60.18	
55.04		
56.03		

TABLE 2. RELATIONSHIP BETWEEN CDMD-1, CDMD-2, IVDMD, AND *IN VIVO* DIGESTIBILITY

		r^2
CDMD-1	Y = 31.62 + .56x	r^2 = .94**
CDMD-2	Y = 31.40 + .53x	r^2 = .94**
IVDMD	Y = 15.87 + .64x	r^2 = .91**

TABLE 3. SPEARMANN RANK CORRELATIONS FOR CDMD-1, CDMD-2, IVDMD, *IN-VIVO* DIGESTIBILITY

	n = 14	n = 12
CDMD-1	.89**	.84**
CDMD-2	.88**	.80**
IVDMD	.85**	.76**

of the ryegrass samples reduced the magnitude of the correlation coefficients as well as the coefficients of determination (r^2) (Table 4). Even though the magnitude of the correlation coefficients was reduced, the relationship between CDMD and IVD was better than the relationship between IVDMD and IVD. This suggests that cellulase may replace rumen fluid to determine the relative digestibility of warm-season grasses.

Caution should be used in extrapolation from this data set since only a single source of cellulase was utilized. It has been reported that cellulase sources differ widely in their activities and sources with a high endo- : ectocellulytic activity ratio are generally preferred. Results from Bughara and Sleper (1986) suggest that B values as high as 1.00 may be obtained when higher activity cellulases are utilized, and thorough comparison of cellulase sources should be made prior to recommending the use of a single source.

Based on experience in our lab, errors associated with CDMD are less than those for in-vitro analysis. To date, we have analyzed approximately 6,000 samples using pepsin-cellulase and have yet to have the bermudagrass standards deviate by more than two digestibility units between runs.

TABLE 4. PEARSON CORRELATION COEFFICIENTS AND R^2 VALUES FOR CDMD-1, CDMD-2, IVDMD, AND *IN-VIRO* DIGESTIBILITY

	Pearson coefficients		r^2
	n=14	n=12	n=12
CDMD-1	.97**	.85**	.73**
CDMD-2	.97**	.86**	.73**
IVDMD	.95**	.82**	.66**

**—Denotes correlation significant at the .001 level for all tables.

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Use of Preemergence Herbicides for Establishment of Clovers

W. J. GRICHAR, G. W. EVERS, C. L. POHLER, AND A. M. SCHUBERT

Summary

Seven preemergence herbicides were evaluated at two rates for clover injury and weed control on berseem, rose, and subterranean clovers. Surflan at 0.75 and 1.5 and Sonalan at 0.5 and 1.0 lb ai/A resulted in the least amount of clover injury when rated at 36 and 90 days after herbicide application. Clover injury at the low rate of Furloe were 31 percent or less by 3 months after applications. Dual, Lasso, Blazer, and Aatrex resulted in 60 to 100 percent injury of clover. Broadleaf weed control was 75 percent or greater for all herbicide treatments.

Introduction

Pure clover stands free of grasses and weeds are desirable for seed production and management studies. Weeds reduce clover growth and N_2- fixation through competition for moisture, nutrients, and light. Most cleared herbicides for forage legumes are limited to perennials such as alfalfa, trefoil, and white clover (Ag Consultant and Fieldman, 1986). Even for experimental purposes, data on tolerance of annual clovers to preemergence herbicides is scarce. Some information does exist for arrowleaf (Smith and Powell, 1979) and subterranean (Evers, 1981) clovers. Bigbee berseem and rose clover are two new species for Texas which are well adapted to specific soil types in the state (Evers and Dorsett, 1986). Response of these two clover species to herbicides is nonexistent. Seven preemergence herbicides were evaluated for phytotoxicity to berseem, rose, and subterranean clover species. Herbicides were identified that could be used for weed control on research studies and provide a basis for further research to gain clearance for use by producers.

KEYWORDS: Preemergence herbicides/Berseem clover/Rose clover/ Subterranean clover/weed control.

Procedure

Soil type in the test area was a Strabor loamy sand with a pH of 6.8. The test was planted on November 5, 1986. Clover seeding rates were 15 lbs/A. The clover varieties were planted on a prepared seedbed using a John Deere grain drill with a Type seeder attachment. One hundred and fifty pounds per acre of 0-46-60 was applied on November 20.

Soil moisture at planting was excellent and 0.14 inches of rain fell on November 7 and 0.22 and 0.38 inches on November 13 and 14, respectively.

Experimental design was a randomized complete block with four replications. Broadleaf weed species included henbit (*Lamium amplexicaule*) and cutleaf evening-primrose (*Oenothera laciniata*).

Herbicide treatments were applied on November 6. A small plot compressed air bicycle sprayer with three SS11002 nozzles spaced 20 inches apart was used to apply the preemergence herbicides one day after planting. The sprayer delivered 20 gallons of water per acre at 25 psi pressure. A rating index (0 equals no injury or weed control to 100 equals complete injury or control) was used to evaluate the herbicide treatments 36 and 90 days after herbicide application.

Results and Discussion

Plots were rated 36 days after treatment (December 12, 1986) and 90 days after treatment (January 29, 1986). When evaluated on subterranean clover (Table 1) only Surflan at 1.5 lbs ai/A and Sonalan at 0.5 and 1.0 lb ai/A did not cause injury significantly different from untreated check when rated 90 days after treatment (DAT). The low rate of Surflan and Furloe caused only minor injury to subterranean clover. Dual at 1.5 and 3.0 lbs ai/A, Blazer at 0.5 and 1.0 lb ai/A, and Aatrex 1.0 and 2.0 lbs ai/A caused subterranean clover injury above 77 percent. All herbicide treatments produced broadleaf weed control of 88 percent or greater when rated 90 DAT.

Rose clover (Table 2) demonstrated a tolerance to Surflan at 0.75 and 1.5 lbs ai/A and Sonalan at 0.5 and 1.0 lb ai/A. Furloe at 2.0 lb ai/A caused moderate injury to rose clover. Percent clover kill exceeded 70 percent in the other treatments with Lasso at 3.0 lbs ai/A and Aatrex at 1.0 and 2.0 lbs ai/A resulting in complete clover kill.

On berseem clover (Table 3), the two rates of Surflan and Sonalan also produced significantly less injury at the 90 DAT rating. Dual, Lasso, Blazer, and Aatrex all caused injury of 90 percent and above. Berseem clover response to Furloe was intermediate. Broadleaf weed control was above 82 percent with all herbicide treatments.

Of the preemergence herbicides evaluated, Surflan and Sonalan showed the greatest potential for use on cool season annual clovers. Furloe may also be of some benefit if some phytotoxicity of the clover is acceptable.

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TABLE 1. EFFECTS OF HERBICIDE TREATMENTS ON BROADLEAF WEEDS AND SUBTERRANEAN CLOVER

		Percent Control[1]			
		12 Dec. 1986 (36 DAT)		29 Jan. 1987 (90 DAT)	
Treatment	Rate lbs ai/A	Clover	Broadleaf weeds	Clover	Broadleaf weeds
1. Check	—	0 d[2]	0 c	0 d	0 c
2. Dual 8E	1.5	75 b	98 a	77 ab	97 a
3. Dual	3.0	80 b	100 a	77 ab	97 a
4. Lasso 4E	1.5	71 b	99 a	70 b	97 a
5. Lasso	3.0	77 b	99 a	62 b	96 ab
6. Blazer 2L	0.5	99 a	100 a	99 a	97 a
7. Blazer	1.0	100 a	100 a	98 a	99 a
8. Aatrex 4L	1.0	100 a	100 a	100 a	100 a
9. Aatrex	2.0	100 a	100 a	100 a	100 a
10. Surflan (4#/gal)	0.75	13 d	99 a	27 c	96 a
11. Surflan	1.5	0 d	91 b	22 cd	97 a
12. Sonalan (3#/gal)	0.5	15 d	95 ab	20 cd	88 b
13. Sonalan	1.0	2 d	89 b	12 cd	94 ab
14. Furloe 4EC	2.0	36 c	94 ab	27 c	91 ab
15. Furloe	4.0	87 ab	95 ab	75 b	98 a

[1]Control and Injury Index: 0 = none, 100 = complete.

[2]Means followed by the same letter are not significantly different at the 0.05 level of significance (Duncan's Multiple Range Test).

TABLE 2. EFFECTS OF HERBICIDE TREATMENTS ON BROADLEAF WEEDS AND ROSE CLOVER

		Percent Control or Injury[1]			
		12 Dec. 1986 (36 DAT)		29 Jan. 1987 (90 DAT)	
Treatment	Rate lbs ai/A	Clover	Broadleaf weeds	Clover	Broadleaf weeds
1. Check	—	0 d[2]	0 d	0 c	0 c
2. Dual 8E	1.5	82 a	96 a	62 ab	96 a
3. Dual	3.0	93 a	99 a	73 a	82 ab
4. Lasso 4E	1.5	89 a	89 ab	70 a	75 b
5. Lasso	3.0	98 a	100 a	100 a	99 a
6. Blazer 2L	0.5	98 a	97 a	94 a	94 a
7. Blazer	1.0	90 a	98 a	67 a	90 ab
8. Aatrex 4L	1.0	100 a	100 a	100 a	100 a
9. Aatrex	2.0	100 a	100 a	100 a	100 a
10. Surflan (4#/gal)	0.75	17 cd	65 c	10 c	95 a
11. Surflan	1.5	18 c	92 ab	26 c	93 ab
12. Sonalan (3#/gal)	0.5	0 d	65 c	0 c	82 ab
13. Sonalan	1.0	5 cd	77 bc	3 c	83 ab
14. Furloe 4EC	2.0	61 b	80 abc	31 bc	92 ab
15. Furloe	4.0	83 a	92 ab	73 a	95 a

[1]Control and Injury Index: 0=none, 100=complete.
[2]Means followed by the same letter are not significantly different at the 0.05 level of significance (Duncan's Multiple Range Test).

TABLE 3. EFFECTS OF HERBICIDE TREATMENTS ON BROADLEAF WEEDS AND BERSEEM CLOVER

		Percent Control or Injury 1			
		12 Dec. 1986 (36 DAT)		29 Jan. 1987 (90 DAT)	
Treatment	Rate lbs ai/A	Clover	Broadleaf weeds	Clover	Broadleaf weeds
1. Check	—	0 d[2]	0 c	0 d	0 c
2. Dual 8E	1.5	95 a	98 a	90 a	97 a
3. Dual	3.0	97 a	100 a	99 a	93 ab
4. Lasso 4E	1.5	97 a	100 a	97 a	99 a
5. Lasso	3.0	100 a	100 a	99 a	99 a
6. Blazer 2L	0.5	100 a	100 a	99 a	100 a
7. Blazer	1.0	100 a	100 a	99 a	100 a
8. Aatrex 4L	1.0	100 a	100 a	100 a	100 a
9. Aatrex	2.0	100 a	100 a	100 a	100 a
10. Surflan (4#/gal)	0.75	21 c	84 b	15 cd	82 b
11. Surflan	1.5	10 cd	98 a	11 cd	98 a
12. Sonalan (3#/gal)	0.5	2 cd	92 ab	17 cd	87 ab
13. Sonalan	1.0	12 cd	84 b	5 d	93 ab
14. Furloe 4EC	2.0	50 b	99 a	25 c	96 a
15. Furloe	4.0	81 a	97 a	65 b	97 a

[1]Control and Injury Index: 0=none, 100=complete.
[2]Means followed by the same letter are not significantly different at the 0.05 level of significance (Duncan's Multiple Range Test).

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