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To the Graduate Council:

I am submitting herewith a thesis written by Kenneth Ray Broyles entitled "The Effect of Nitrogen Fertilization and Cutting Management on the Yield and Nitrogen Content of Two Sudangrass Varieties and Two Millet Species." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

Henry H. Fubourg
Major Professor

We have read this thesis
and recommend its acceptance:

Levin W. Dickson
David Brown

Accepted for the Council:

Edw. Hantling
Dean of the Graduate School

THE EFFECT OF NITROGEN FERTILIZATION AND CUTTING MANAGEMENT ON THE
YIELD AND NITROGEN CONTENT OF TWO SUDANGRASS VARIETIES AND
TWO MILLET SPECIES

A THESIS

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CHAPTER I

INTRODUCTION

Supplemental summer forages are in great demand by many Tennessee farmers. These forages help maintain a high level of production during the summer months when unfavorable climatic conditions often bring about a decrease in pasture and hay production and quality. Summer annuals are also valuable in that they can fit into a cropping system involving winter annuals. Little information is available to these farmers, however, to aid them in making the management decisions that need be made in order to obtain both high dry matter yields and high nitrogen content of the harvested forage.

Sudangrass, Sorghum sudanense (Piper) Stapf., and Pearlmillet, Pennisetum glaucum (L.), are two of the most important grasses utilized for supplemental summer forage in Tennessee. || Specific information is lacking as to how much nitrogen fertilizer must be applied and at what stage of growth these grasses should be cut or grazed in order to obtain high yields of nitrogen and dry matter and to sustain this production over the summer period.

Until data are available on such problems, definite management recommendations on supplemental summer forages cannot be made with assurance. This investigation was conducted in an attempt to obtain information that could be applied toward the solution of these problems.

The study reported here was designed to determine the combined effects of three nitrogen fertilization levels and four cutting intensities on the forage yields and nitrogen content of four summer

annual grasses. The grasses used in this study were: Sweet Sudangrass, a variety developed through hybridizing Leoti sorghum and common Sudan-grass, Piper Sudangrass, a variety developed from a double-cross of Tift Sudangrass and lines obtained from the Texas Agricultural Experiment Station and Kansas Agricultural Experiment Station; German millet, Setaria italica (L.) Beauv. var. stramineofructa Bailey; and Georgia hybrid No. 1, an experimental variety of Pearlmillet, produced from four inbred lines at the Georgia Coastal Plain Experiment Station, Tifton, by G. W. Burton, Principal Geneticist, U. S. Department of Agriculture.

CHAPTER II

REVIEW OF LITERATURE

The literature relating to nitrogen fertilization and cutting management of different grass species is extensive. However, literature directly related to the nitrogen fertilization and cutting management of Sudangrass and millets is limited.

Effects of Nitrogen Fertilization

The effect of nitrogen fertilization upon the growth and chemical composition of grasses has been studied by many investigators. Many workers have shown that applying nitrogen fertilizer to pure stands of grass has increased yields of grasses on most soils. Generally, these increased yields have been accompanied by increases in percent protein in the herbage. Occasionally, when the nitrogen fertilization rates have been low, little or no increase in protein percentages has been obtained.

Anderson et. al. (1) found in Kansas that the seed and forage yields of brome grass, Bromus inermis Leyss., were increased with increasing amounts of nitrogen up to approximately one hundred pounds per acre. When nitrogen was applied at rates of one hundred pounds or less per acre, the protein percentage in the fairly mature forage sampled was not increased appreciably. As heavier rates of nitrogen were applied, protein percentages were increased so that yield of protein per acre continued to increase. The nitrogen content of brome grass as reported

by Carey et. al. (9) was increased by additions of fertilizer from zero to one hundred and two hundred pounds of nitrogen per acre as ammonium nitrate. Applications of three hundred pounds produced little additional increase over the two hundred pound application.

In studies of nitrogen fertilization on Bermudagrass, Cynodon dactylon (L.) Pers., Burton et. al. (8) concluded that nitrogen applications significantly increased protein and fiber contents. Both protein and yields were increased as nitrogen was increased from zero nitrogen to four hundred pounds per acre.

Lewis and Long (23) found that highly significant increases in forage yields of eight grasses grown in the high-altitude meadows of Wyoming were obtained from nitrogen applications. Nitrogen applications increased the crude protein percentages and yield of the eight grasses studied. Brown (7) reports that there was no increase in protein of pasture species grown in the Northeast region when low rates of nitrogen fertilizer were applied.

Effects of Cutting Intensities

The hydrocyanic acid contained in Sudangrass compels farmers to allow the Sudangrass to reach a certain stage of growth before it is safe to pasture. Boyd et. al. (5) found that Sudangrass first or second growth of two feet or more in height was low in hydrocyanic acid and was relatively safe to graze. They felt that Sudangrass, short or tall, which is of a pale or yellowish-green color, is low in hydrocyanic acid and is relatively safe to graze. They concluded that Sudangrass should usually not be pastured until it has reached a minimum height of eighteen inches.

The chemical composition of Sudangrass hay as reported by Dawson et. al. (14) is closely correlated, in general, with the maturity of the plants at the time of cutting and, to a certain extent, with the number of days of growth when cut. As the number of days of growth increased, the protein percentage decreased. Crude fiber showed a slight tendency to increase as the number of days of growth increased. The average crude protein content of the hay decreased with advances in maturity, and the highest yield of crude protein was obtained when the Sudangrass was cut every thirty days. Crowder et. al. (13), experimenting with Sudangrass and millet selections for grazing and hay in Georgia, found that the protein content varied with fertilizer treatments, particularly nitrogen. A gradual decrease occurred in the protein content as the plants advanced in maturity.

Hoveland and McCloud, (19, 20) in extensive field experiments at Gainesville, Florida, studied the effects of row spacing, height of plants before cutting and height of the stubble remaining after cutting, on the growth of Pearlmillet. They concluded that rows spaced eighteen to twenty inches apart produced the higher yields. Under a pasture management, they recommended that Starr Pearlmillet be thirty inches tall before grazing began and be grazed down to a stubble height of ten to eighteen inches. For silage or green feed, they found that Starr Pearlmillet should be cut when it is four to five feet tall. Highest total yield was produced when the plants were cut when fifty-four inches tall and cut down to four inches; however, at this cutting the plants were lowest in protein content. The lowest dry matter yields were obtained

when the plants were twelve inches tall and were cut down to four inches, but this treatment resulted in the highest protein contents in harvested forage. In South Carolina, it was reported by Cathcart (10) that Pearlmillet produced 42.9 percent more nutrients per acre when grazed than when harvested for silage. Pearlmillet yielded 740 pounds of total digestible nutrients per acre and produced 68.2 cow-days of grazing per acre. The average yield per acre expressed in terms of alfalfa hay equivalent was 1,472 pounds when grazed and 1,030 pounds when ensiled.

Baker et. al. (3) concluded that the crude protein content of prairie hay in Nebraska decreased as cuttings were made later in the growing season. In general, as the maturity of the grasses from which the hay was made increased, the amount consumed by livestock decreased. The average daily gains decreased as the maturity of the hay increased. Briggs (6) obtained similar results in Oklahoma. Christinsen (11) concluded in 1932 that the digestibility of the nutrients in prairie grass declined as the season advanced.

Enlow and Coleman (17) found a much higher protein content in pasture grasses mowed frequently than in grasses cut only at the end of the season. This held true on both fertilized and unfertilized areas. Kohler (21) reported that young grasses have a higher protein content than older grasses. The percent protein content of the seed and tiller culms decreased as the number of days after planting increased. The protein showed maximum concentrations at or just prior to jointing. In a study with Kentucky bluegrass, Poa pratensis (L.), it was concluded by Mortimer and Ahlgren (25) that the percentage nitrogen content decreased as the

plant approached maturity. Ellett and Carrier (16) obtained similar results with bluegrass. They reported the total yield of dry matter varied inversely with the number of cuttings during the season. The decrease in percent protein of the forage harvested from grasses that were allowed to mature was sufficient to more than counterbalance the increase in dry matter yields. Laughlin (22), as well as Russell et. al. (28), found that the crude protein yields of brome grass were noticeably increased by the addition of nitrogen fertilizer. The crude protein content was higher during the early growth and declined as the grass approached maturity. Bird (4) compared several grasses at six different stages of growth and concluded that the total seasonal yield increased with each successive stage from the early stage to the early bloom stage. The percentages of crude protein decreased with each successive stage of cutting. In 1953, Pigden (27) reported a steady decline in protein content of several grasses throughout the season. Phillips et. al. (26) stated that several grasses, during the process of maturation, underwent continuous decreases in protein percentage. In Eastern Oregon, it was concluded by Cooper (12) that the crude protein content of hay decreased with advancing maturity and increased with increasing cutting heights. The protein percentages of the forage harvested from the portion of the plants above six inches of growth contained one percent more crude protein percent than the portion occurring between two and four inches. Watkins and Severen (31) reported that the content of some forages in El Salvador did not vary with the height of cutting but did vary with the intervals between cuttings. Samples harvested every month instead of

every two or three months were higher in protein and diminished in protein with a decrease in frequency of harvest. McCreery and Stelly (24), experimenting with cutting intervals of one, two, three and four weeks on Bermudagrass and crabgrass, Digitaria spp., found the shorter clipping intervals resulted in a higher protein content.

CHAPTER III

MATERIALS AND METHODS

Location and Field Plot Design

This study was conducted to determine the combined effects of nitrogen fertilization levels and cutting intensities on the forage yield and nitrogen content of two Sudangrass varieties and two millet species. The investigation was carried out on a Huntington soil located along the Tennessee River in Sequoyah Hills, on land leased by the Tennessee Agricultural Experiment Station from the Tennessee Valley Authority.

Each experimental plot consisted of three twenty-foot rows, three feet apart. The middle eighteen feet of the center row was harvested for yield; the two outside rows served as guard rows. Treatments were replicated four times and arranged in a split-split plot design. The main plots were nitrogen levels, grasses were the split plots and cutting intensities the split-split plots. Two of the four replications were on Huntington loam, one on Huntington sandy loam, and the fourth was partly on Inside silt loam and partly on Egam silt loam.

The combination of the three nitrogen levels, the four grasses, and the four cutting intensities made a total of forty-eight treatments.

The Sudangrass varieties used were Sweet Sudangrass and Piper Sudangrass. Sweet Sudangrass is a variety developed in Texas in 1932 through hybridizing Leoti sorghum and common Sudangrass. It is characterized by sweet and juicy stems and has some resistance to foliage

diseases and chinch bugs. Piper Sudangrass is the result of a double-cross made in Wisconsin in 1942 from Tift Sudangrass and lines obtained from the Texas and Kansas Experiment Stations. Piper is characterized by a lower level of hydrocyanic acid potential and is more resistant to leaf blight, Helminthosporium turcicum Pass., than Sweet Sudangrass.

The two millets used were German millet and Georgia hybrid No. 1 Pearlmillet. German millet is a species that first became important in the United States in the Central Basin of Tennessee. Georgia Hybrid No. 1 is an experimental variety of Pearlmillet, developed by G. W. Burton at Tifton, Georgia. It is characterized by good seedling vigor, high total yields and good recovery after cutting or grazing. Four inbred lines were involved in the production of this hybrid.

Each grass was grown at three levels of nitrogen fertilization, zero, sixty, and one hundred and twenty pounds of nitrogen per acre, applied as ammonium nitrate at the time of seeding.

At each nitrogen level, the four grasses were cut according to four different intensities: (1) when the growth reached a height of thirty inches, it was cut back to a six-inch stubble; (2) when the growth reached a height of thirty inches, it was cut back to a ten-inch stubble; (3) when the growth reached a height of twenty inches, it was cut back to a six-inch stubble; and (4) when the growth reached a height of fifty-four inches or early bloom, whichever came first, it was cut back to a four-inch stubble.

General Agronomic Information

Prior to seeding, a uniform application of 0-20-20 at the rate of 350 pounds per acre was drilled over the area.

On June 1, 1957, the experiment was seeded at the rate of eight pounds of seed per acre. A "Planet Junior" was used to seed the Sudan-grass varieties and the German millet. Because of the limited amount of Georgia Hybrid No. 1 seed available, and in order to avoid loss of seed in the planting operation, this variety was seeded by hand. The seeds were placed in a small open furrow and covered with a lawn rake. On June 3, 1957, approximately 1.75 inches of water was applied by overhead sprinkler irrigation to aid in stand establishment.

Cultivation was started when the grasses were three inches tall and continued as needed until the tallest growth reached the height of approximately thirty-five inches. The experiment was hoed once after the second cultivation to eliminate any weeds left in the rows.

Yield Measurements

The forage yields were taken when the grasses reached the desired heights, as determined with a yardstick. The yield rows of the three-row plots were trimmed on each end, so the harvested length was eighteen feet. Thus, the area harvested measured eighteen feet by three feet, or .0012 $\frac{1}{4}$ acre.

The plots were cut with a hand sickle. In order to insure that each plot was cut to the correct height, appropriate guide boards were used for each of the stubble heights.

The harvested forage from each plot was placed in a cloth bag for oven-drying. However, the first cutting of the fifty-four inch or early bloom treatment gave such high yields that green weights were taken for each plot and a sample for dry matter determination, weighing approximately five pounds, was collected.

The green forage was oven-dried in a forced-air oven at sixty to seventy degrees centigrade and then weighed to the nearest hundredth of a pound.

Chemical Analysis

The whole-dried samples were ground in a Wiley mill, mixed thoroughly, sub-sampled, and stored in bottles for chemical determination. From each of these, a one-gram sub-sample was analyzed for total nitrogen content. The Kjeldahl-Gunning Method (2) was used. A detailed description of the procedure used is presented in Appendix A.

Presentation of Data and Statistical Analysis

Dry matter yields of harvested forage are presented in terms of oven-dry yields in pounds per acre. Nitrogen percentage was determined on the forage harvested from each plot and at each cutting date. Yields of nitrogen in pounds per acre were computed from the two afore-mentioned measurements. The treatment mean dry matter yields for each cutting date are presented in Appendix B. In the text, the dry matter yields and nitrogen yields are reported as the mean of the replications for each treatment.

The dry matter and nitrogen yields and nitrogen percentages, plotted over time, were analyzed graphically.

In an attempt to determine the relationship between dry matter yields and percent nitrogen in the harvested forage, a simple regression analysis for these characters was carried out.

For the purpose of differentiating between treatment means, the multiple range test developed by Duncan (15) was utilized.

In the discussion of results, wherever the word "different" is used, it will be taken to mean "significantly different at the .05 level of probability", unless otherwise qualified.

Symbols used in the text, when referring to treatments, are presented in Table I.

TABLE 1

LEGEND FOR TREATMENT SYMBOLS

Symbols	Description
	Grasses
S	Sweet Sudangrass
P	Piper Sudangrass
M	German millet
H	Georgia hybrid No. 1
	Cutting Intensities
20-6	20" cut down to 6"
30-10	30" cut down to 10"
30-6	30" cut down to 6"
EB-4	Early bloom cut down to 4"
	Nitrogen Levels
N ₀	No nitrogen applied
N ₁	60 pounds of nitrogen applied per acre
N ₂	120 pounds of nitrogen applied per acre

CHAPTER IV

RESULTS AND DISCUSSION

The results reported are from three of the four replications in the experiment. These three replications were located on Huntington soil, which is a well-drained bottom soil. A relatively low coefficient of variation of 12.40 percent was obtained from the dry matter yield data of these three replications. The fourth replication occupied the lower portion of the experimental area. The soils of this area were Linside silt loam and Egam silt loam, which are moderately well-drained bottom soils. Since the experiment was irrigated on June 3 with 1.75 inches and a heavy rain of 1.41 inches followed on June 5 (Appendix E), excessive water conditions occurred on these soils. As a result, the grass stand obtained on the fourth replication, as opposed to the other three, was poor. Since a low coefficient of variation was obtained with the dry matter yield data of three replications only, and since the inclusion of the fourth replication would have increased the total variation to a much greater extent without contributing any additional information, this fourth replication was disregarded.

Results are discussed by individual characteristics studied. These groupings reflect the combined influences of nitrogen fertilization and cutting intensities and their interaction on: (1) the yield of dry matter, (2) the percent nitrogen in the dry matter harvested, and (3) the yield of nitrogen of the four grasses studied.

Dry Matter Yields

The summary of the results of the analysis of variance of dry matter yields is presented in Table 2. Considering the effects of nitrogen fertilization on all grasses at all cutting intensities, the yields of dry matter produced by each of the three levels of nitrogen fertilizer application were different. Nitrogen fertilizer applied at sixty pounds per acre produced higher yields of dry matter per acre than zero nitrogen fertilizer. The difference in the yield produced by sixty pounds of nitrogen and that obtained with one hundred and twenty pounds of nitrogen per acre was not significant at the .05 probability level, but it was significant at the .10 probability level, as indicated by the least significant difference in Table 3.

The four grasses produced different dry matter yields, regardless of nitrogen fertilization level or cutting intensity. The dry matter yields produced by Georgia hybrid No. 1 were larger than the yields produced by any other grass at the .01 probability level. Piper Sudan-grass produced larger dry matter yields than Sweet Sudangrass or German millet.

The four cutting intensities, regardless of grass or nitrogen level, yielded different amounts of dry matter. The EB-4 cutting produced dry matter yields which were larger than those obtained from the other cutting intensities. The 30-10 cutting produced numerically larger yields of dry matter than the 30-6 cutting, but the difference was not significant. Cutting intensity 20-6 produced lower yields than treatment 30-10, but not significantly less than treatment 30-6 (Table 3).

TABLE 2

ANALYSIS OF VARIANCE OF THE DRY MATTER YIELDS

Source of Variation	d.f.	Estimate of Variance	F
Total	143		
Nitrogen	2	19,625,346	15.12*
Replications	2	222,330	.17
Error (a)	4	1,298,332	
Grasses	3	57,649,727	137.79**
Grasses x Nitrogen	6	697,255	1.67
Error (b)	18	418,400	
Cuttings	3	9,494,718	11.00**
Cuttings x Nitrogen	6	243,448	1.35
Cuttings x Grasses	9	862,750	4.80**
Cuttings x Nitrogen x Grasses	18	172,574	.95
Error (c)	72	181,475	
Pooled Error	90	179,695	

C. V. = 12.40 percent.

*Significant at the .05 level of probability.

**Significant at the .01 level of probability.

TABLE 3

DRY MATTER YIELD COMPARISONS WITHIN NITROGEN APPLICATIONS,
GRASSES AND CUTTING INTENSITIES

MULTIPLE RANGE TESTS¹

<u>Nitrogen Applications</u>				
Number of Means	2	3		
S. S. Range ² .05	646	660		
Nitrogen Applications	N ₀	N ₁	N ₂	
Mean Yields Pounds/A	2764	3500	4038	
L. S. D. .10 between nitrogen levels		496		
	N ₀	N ₁	N ₂	
	2764	3500	4038	
<u>Grasses</u>				
Number of Means	2	3	4	
S. S. Range .05	320	336	346	
Grasses	M	S	P	H
Mean Yields Pounds/A	2150	3006	3419	5158
S. S. Range .01	439	460	472	
Mean Yields Pounds/A	2150	3006	3419	5158
<u>Cutting Intensities</u>				
Number of Means	2	3	4	
S. S. Range .05	403	423	435	
Cutting Intensities	20-6	30-6	30-10	EB-4
Mean Yields Pounds/A	3000	3138	3445	4152

¹Any two means underscored by the same line are not significantly different at the indicated level of probability.

²Shortest significant range.

The four grasses produced dry matter yields that were different due to cutting intensities. Georgia hybrid No. 1, at each cutting intensity, produced the highest dry matter yields. Each cutting intensity of German millet produced the lowest dry matter yields. The dry matter yields produced by the Sudangrass varieties at the four cutting intensities were ranked between the two millet species. The order of production of dry matter yields and the treatment differences are presented in Table 4.

Nitrogen Percentages

A graphic analysis of the dry matter yields, nitrogen percentages and nitrogen yields is presented in Figures 1 through 12. The means for three replications by cutting dates of the percent nitrogen, dry matter and nitrogen yields are presented in Appendix B. The graphic analysis points out the relationship of these three factors as they are affected by each treatment. The changes in percent nitrogen, as the yield of dry matter varies with the different cuttings throughout the growing season, can be observed readily on these graphs.

As the dry matter yields of each treatment increase, the percent nitrogen decreases. For example, the largest dry matter yield was obtained with the EB-4 cutting; at this cutting intensity, the percent nitrogen in the harvested forage was the lowest of any of the cutting intensities studied. The harvested forage from the 20-6 cutting yielded the lowest dry matter yield and this cutting produced the highest average

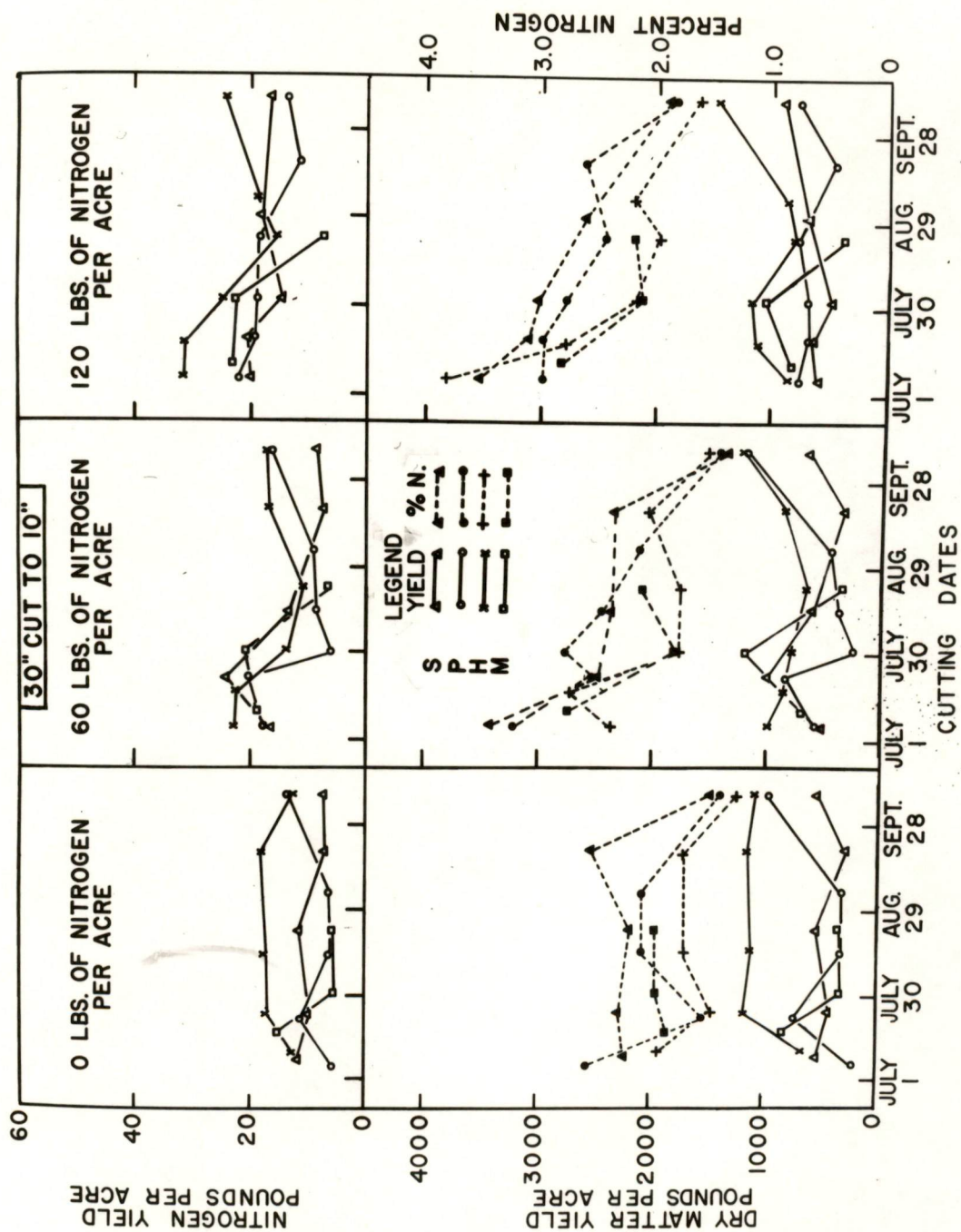


Figure 1. Seasonal distribution of dry matter and nitrogen production and associated nitrogen percentages of four grasses at three levels of nitrogen fertilization when cut from 30" down to 10".

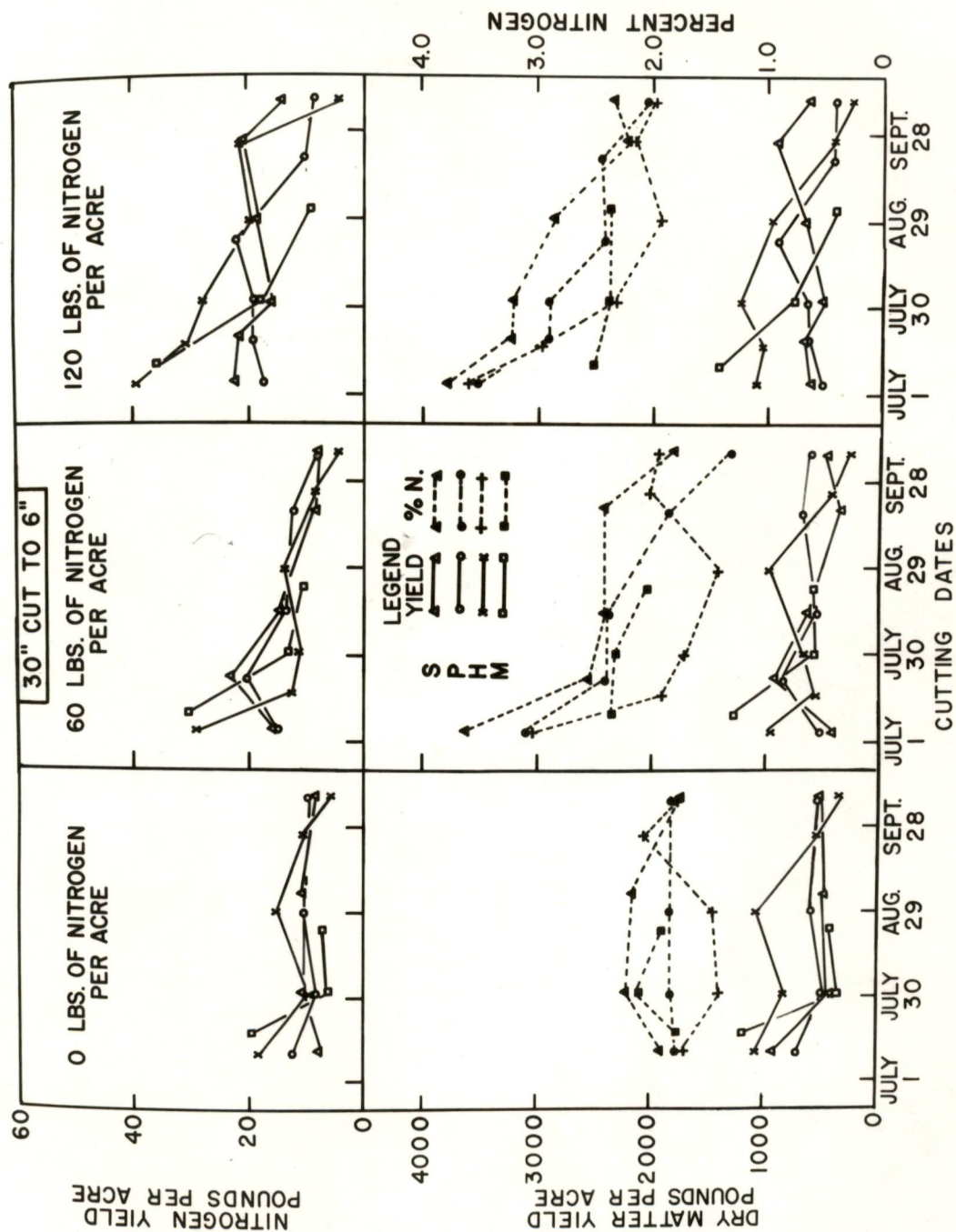


Figure 2. Seasonal distribution of dry matter and nitrogen production and associated nitrogen percentages of four grasses at three levels of nitrogen fertilization when cut from 30" down to 6".

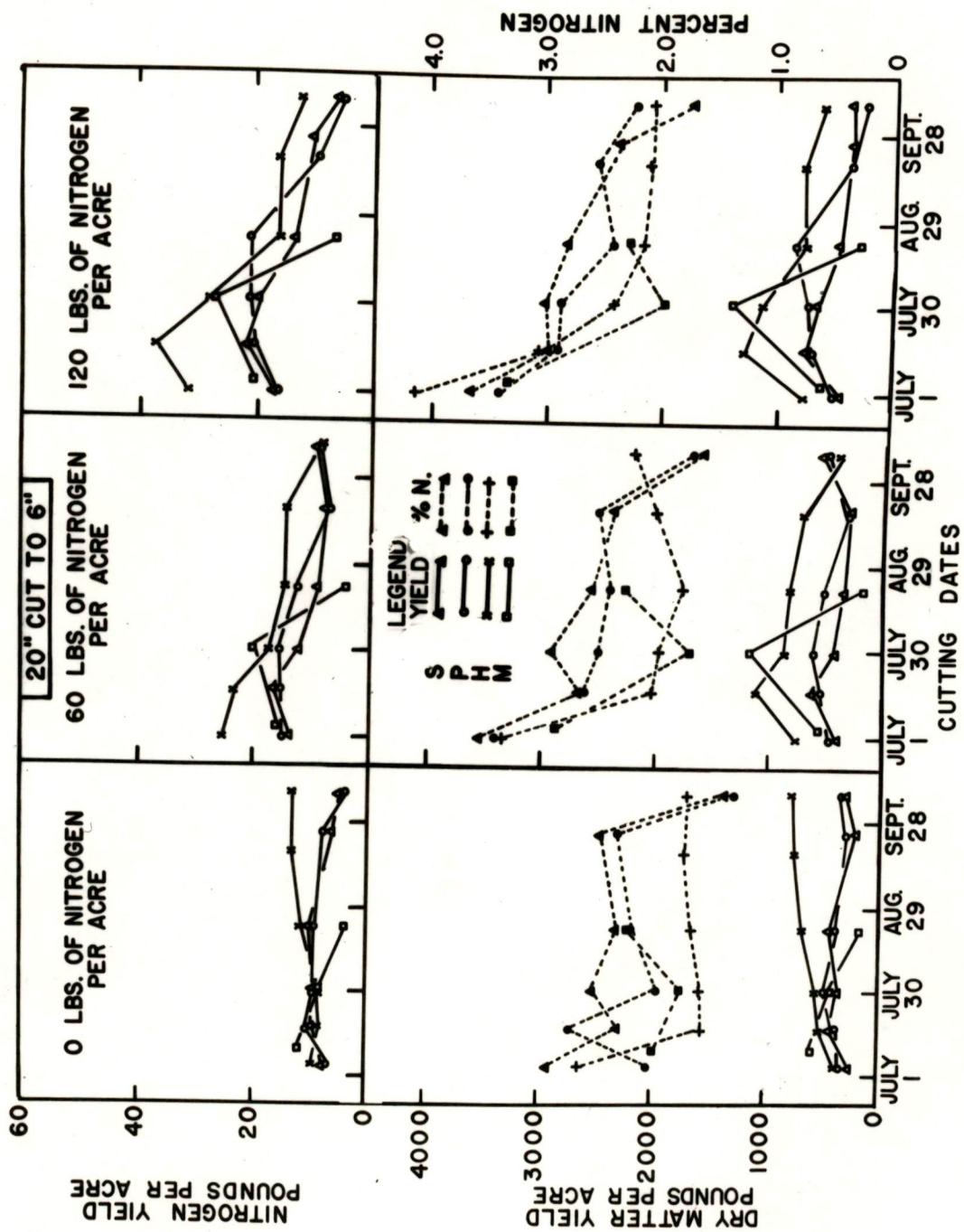


Figure 3. Seasonal distribution of dry matter and nitrogen production and associated nitrogen percentages of four grasses at three levels of nitrogen fertilization when cut from 20" down to 6".

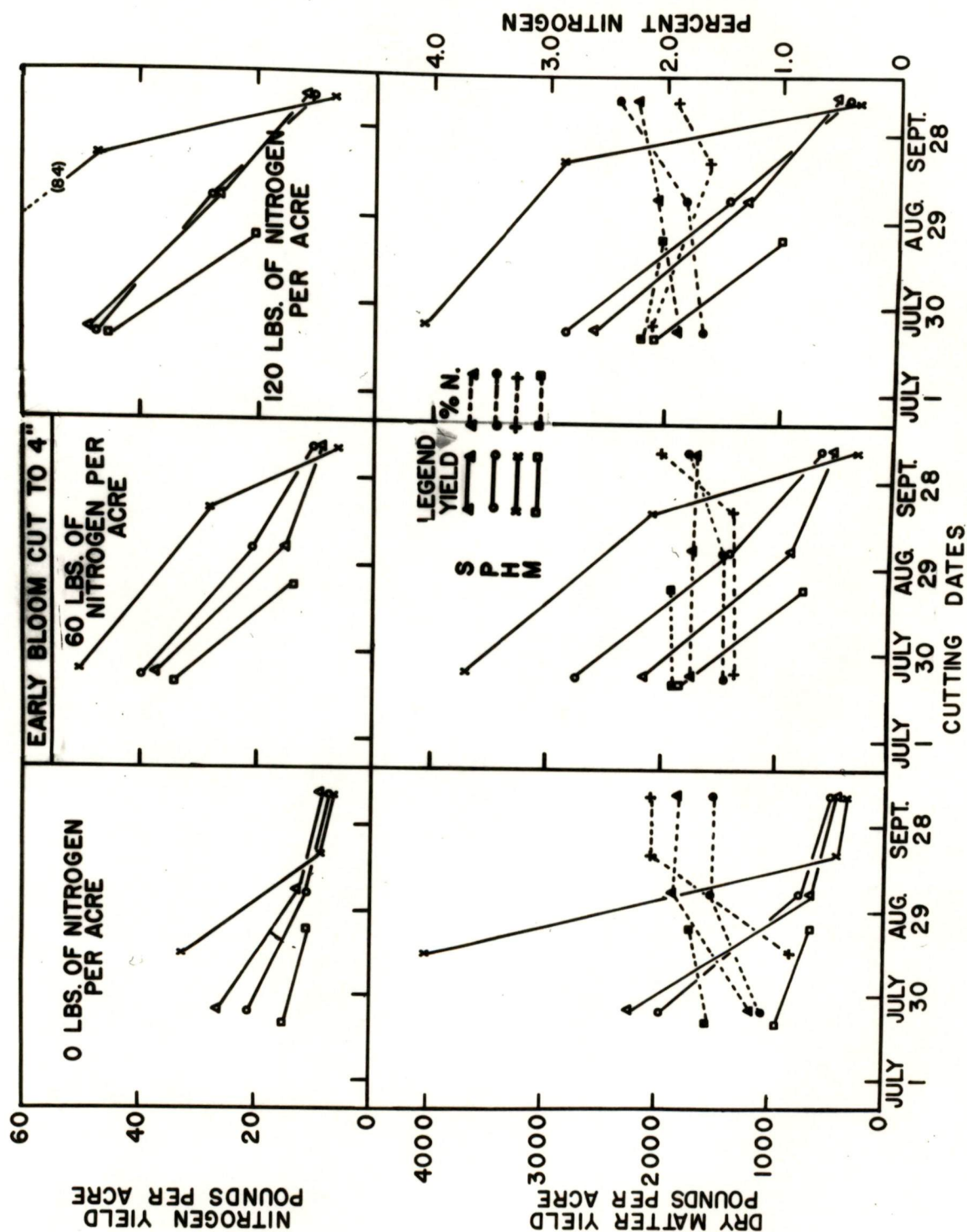


Figure 4. Seasonal distribution of dry matter and nitrogen production and associated nitrogen percentages of four grasses at three levels of nitrogen fertilization when cut from early bloom cut to 4".

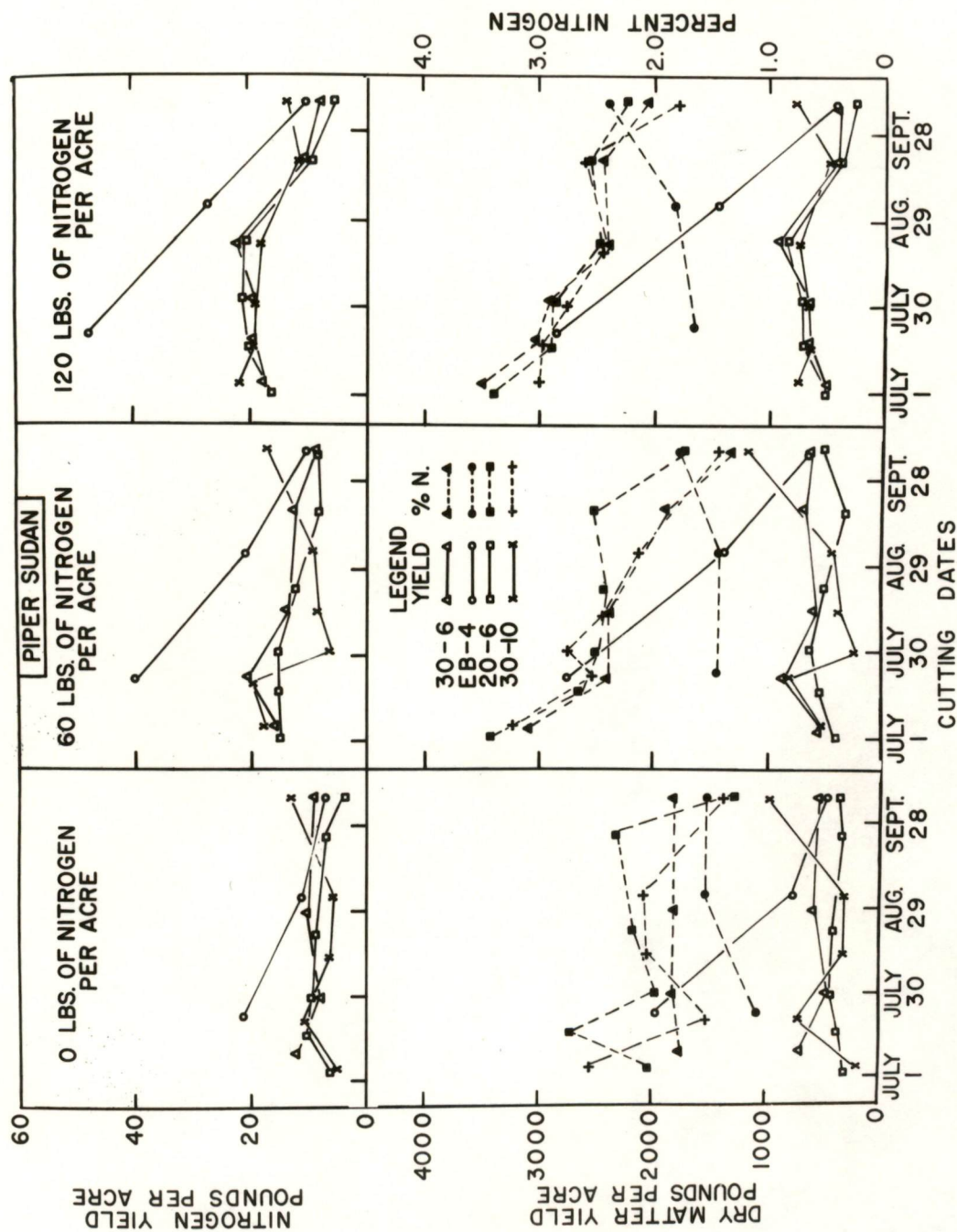


Figure 5. Seasonal distribution of dry matter and nitrogen production and associated nitrogen percentages of Piper Sudangrass at three levels of nitrogen fertilization when cut at four cutting intensities.

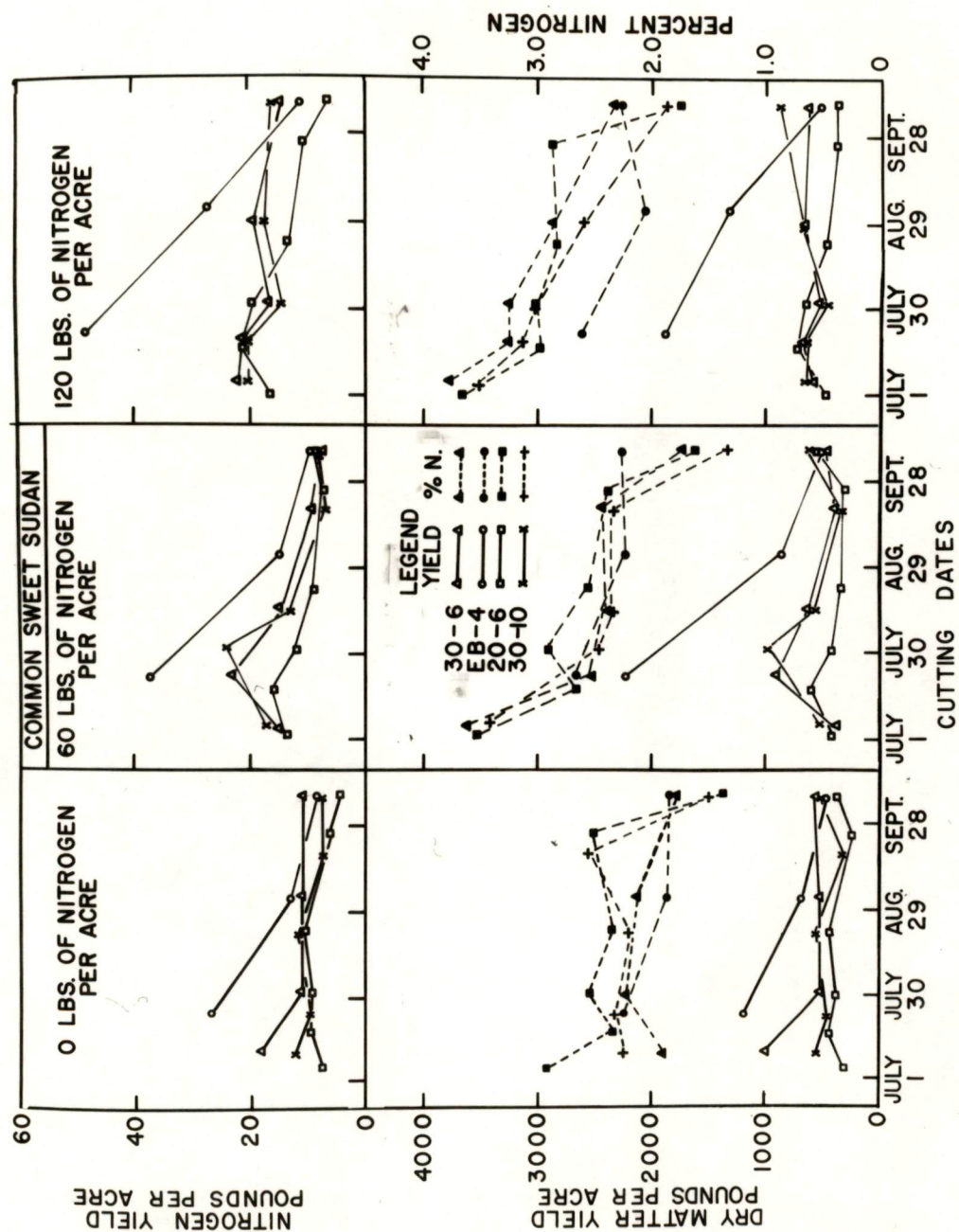


Figure 6. Seasonal distribution of dry matter and nitrogen production and associated nitrogen percentages of Sweet Sudangrass at three levels of nitrogen fertilization when cut at four cutting intensities.

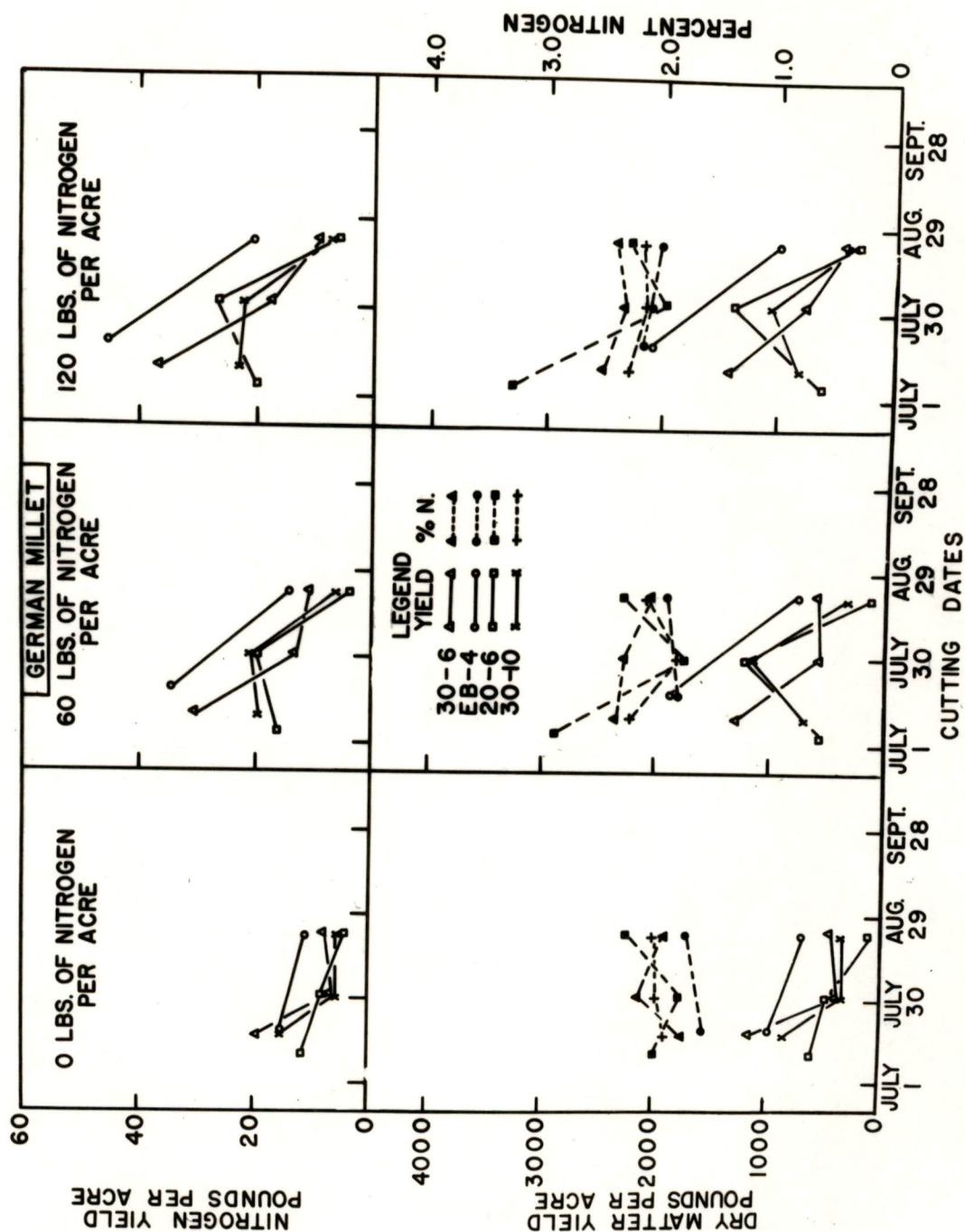


Figure 7. Seasonal distribution of dry matter and nitrogen production and associated nitrogen percentages of German millet at three levels of nitrogen fertilization when cut at four cutting intensities.

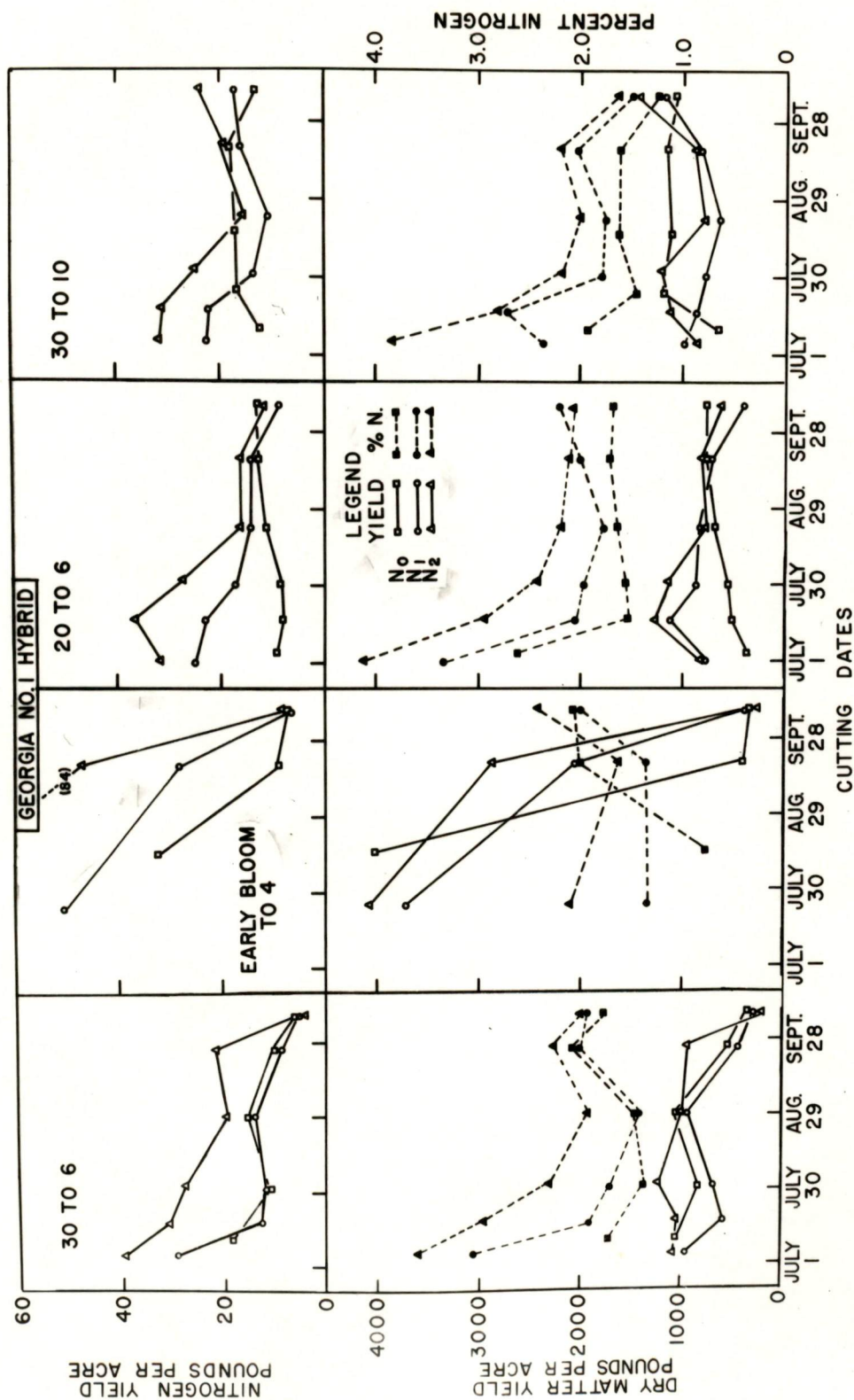


Figure 10. Seasonal distribution of dry matter and nitrogen production and associated nitrogen percentages of Georgia hybrid No. 1 at four cutting intensities when nitrogen fertilizer was applied at three levels.

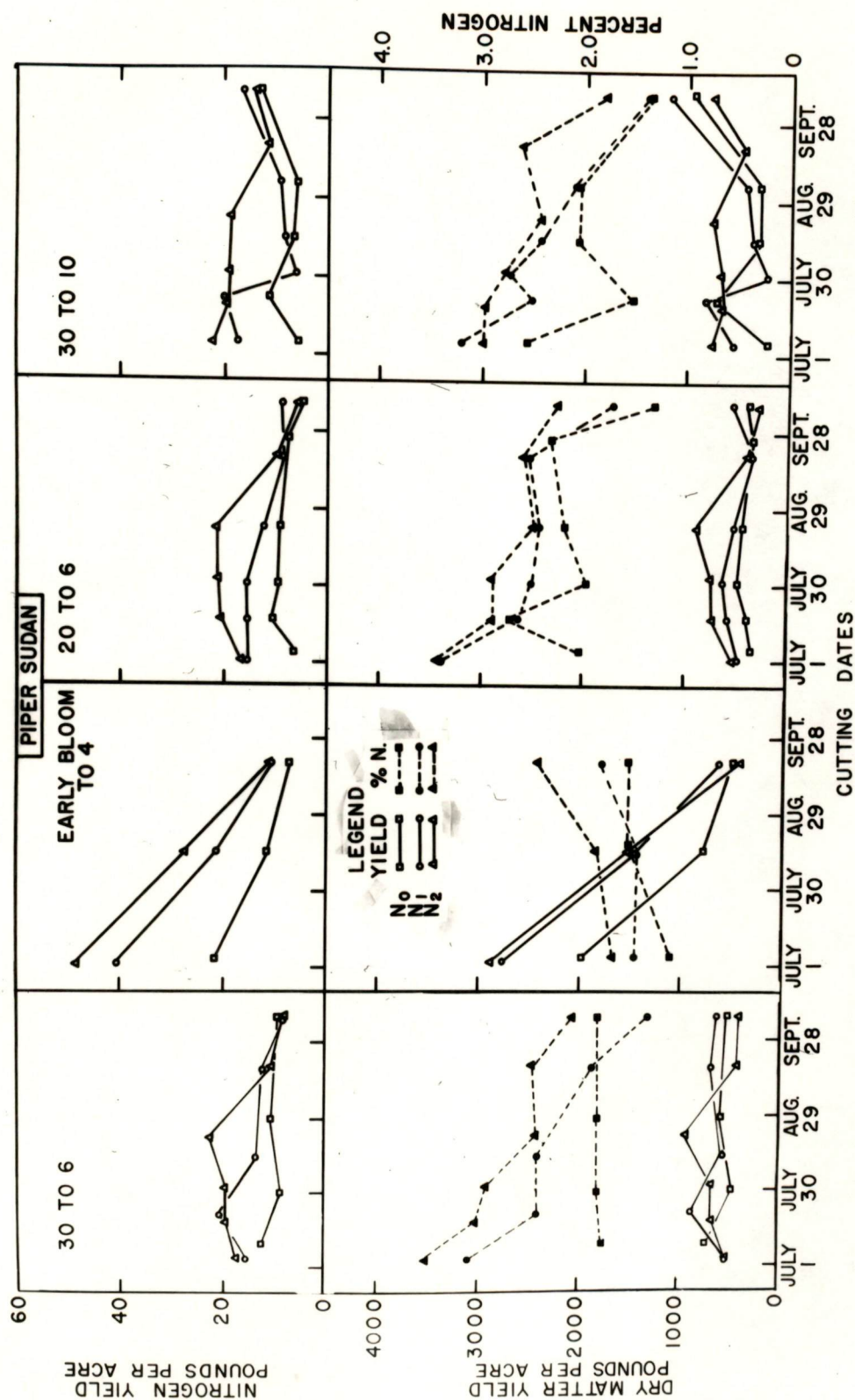


Figure 11. Seasonal distribution of dry matter and nitrogen production and associated nitrogen percentages of Piper Sudangrass at four cutting intensities when nitrogen fertilizer was applied at three levels.

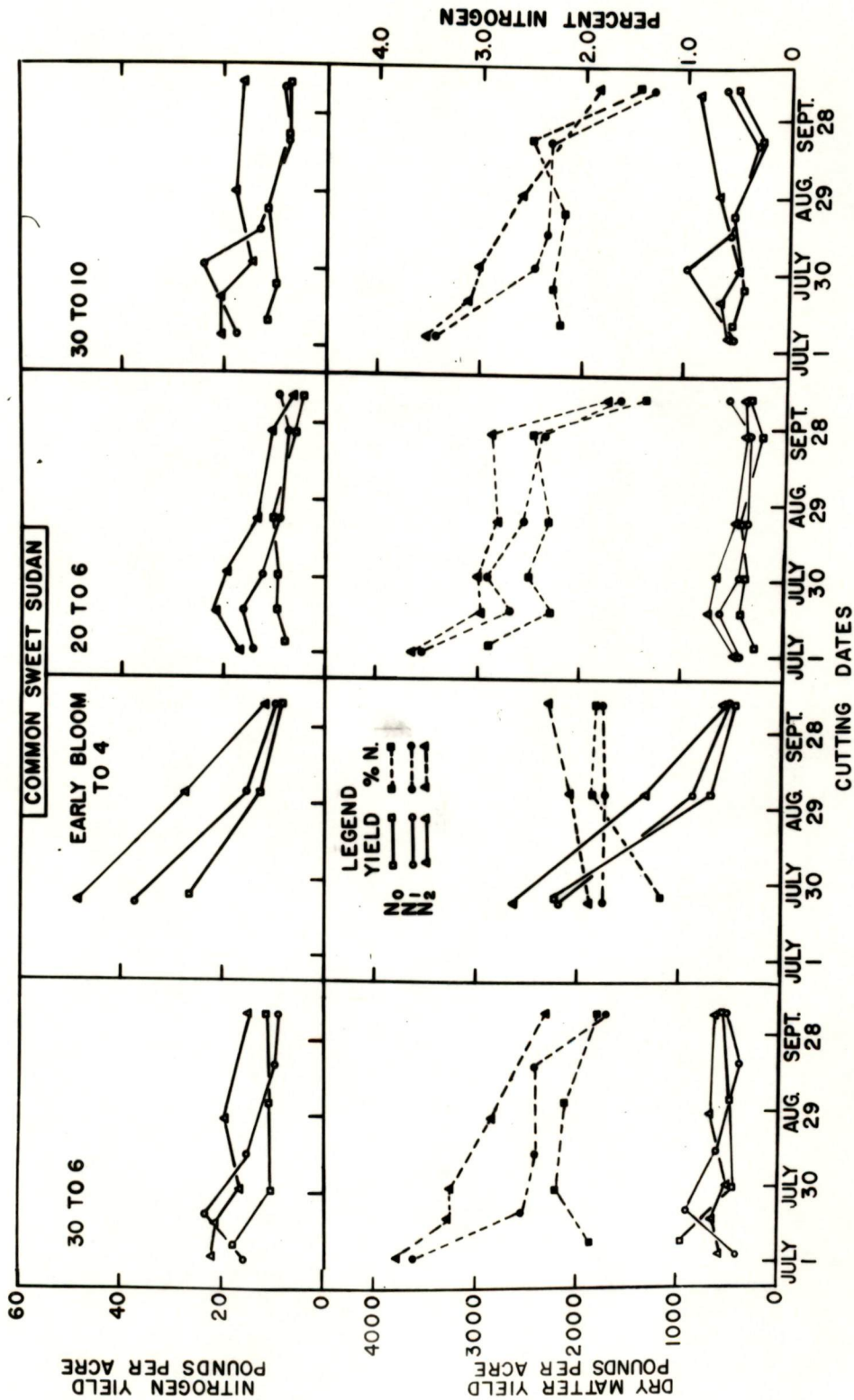


Figure 12. Seasonal distribution of dry matter and nitrogen production and associated nitrogen percentages of Sweet Sudangrass at four cutting intensities when nitrogen fertilizer was applied at three levels.

TABLE 4

INTERACTIONS BETWEEN GRASSES AND CUTTING INTENSITIES

Grasses	Cutting Intensities	Dry Matter Yields	
		Pounds Per Acre	Multiple Range Groupings
German Millet	20-6	1830	
"	30-10	1988	
"	30-6	2313	
"	EB-4	2467	
Sweet Sudangrass	20-6	2614	
"	30-6	2770	
"	30-10	2868	
Piper Sudangrass	20-6	2951	
"	30-6	3048	
"	30-10	3383	
Sweet Sudangrass	EB-4	3783	
Piper Sudangrass	EB-4	4294	
Georgia Hybrid No. 1	30-6	4421	
"	20-6	4607	
"	30-10	5542	
"	EB-4	6064	

percent nitrogen. Very little difference can be observed in the percent nitrogen of the forage harvested from the 30-10 and the 30-6 cuttings.

It is evident from the graphic analysis of the data that, as the dry matter yields of a given treatment increase, the percent nitrogen of the forage from that treatment decreases. The cutting intensities that produced the larger dry matter yields produced the lower nitrogen percentages. The cutting intensities that produced the smaller dry matter yields produced the higher nitrogen percentages. As nitrogen fertilizer was increased from zero to one hundred and twenty pounds per acre, the percent nitrogen in the harvested forage was increased. As cutting intensities decreased, and the height of the grasses increased, there was a general decrease in percent nitrogen of the harvested forage.

Relationship Between Dry Matter Yields and Nitrogen Percentages

To discover the relationship between nitrogen percentages and dry matter yields, the data were plotted in different ways. It was observed that the relationship between these two variables did not follow a straight line, but appeared to be logarithmic in nature. This observation was supported by the low correlation coefficients obtained when a linear regression analysis of percent nitrogen against dry matter yields was calculated for each of the three nitrogen fertilizer levels.

It was found that a log log transformation made it possible to account more fully for the variation in nitrogen percentages. As a

result, the logarithm of the average nitrogen percentage for each harvest of each grass and cutting intensity was plotted against the corresponding mean dry matter yield. Three functions were calculated, one for each nitrogen fertilization level (Figure 13).

The equations calculated were of the type

$$\log Y = \log a + b \log X \quad \text{or,}$$

$$Y = a X^b$$

where Y = nitrogen percentage of harvested forage and X = dry matter yield. The equations for estimating the relationship between the nitrogen percentages and the dry matter yields were:

$$\text{No nitrogen: } \text{-----} Y = 13.698X^{-.3185}$$

$$60 \text{ pounds nitrogen: } \text{-----} Y = 8.870X^{-.2185}$$

$$120 \text{ pounds nitrogen: } \text{-----} Y = 5.648X^{-.1238}$$

These equations explained 59.1 percent, 22.0 percent and 9.3 percent of the total variations for each of the nitrogen levels, respectively.

The regression analysis clearly indicates that as the dry matter yields increase the percent nitrogen in the harvested forage decreases.

Nitrogen Yields

A summary of the analysis of variance of the nitrogen yields is presented in Table 5. The coefficient of variation for nitrogen yield was 1.22 percent. The analysis of variance indicated differences in the nitrogen yields arising from nitrogen fertilization. There was an increase in the yield of nitrogen as the nitrogen fertilizer applications were increased from zero to sixty and to one hundred and twenty pounds

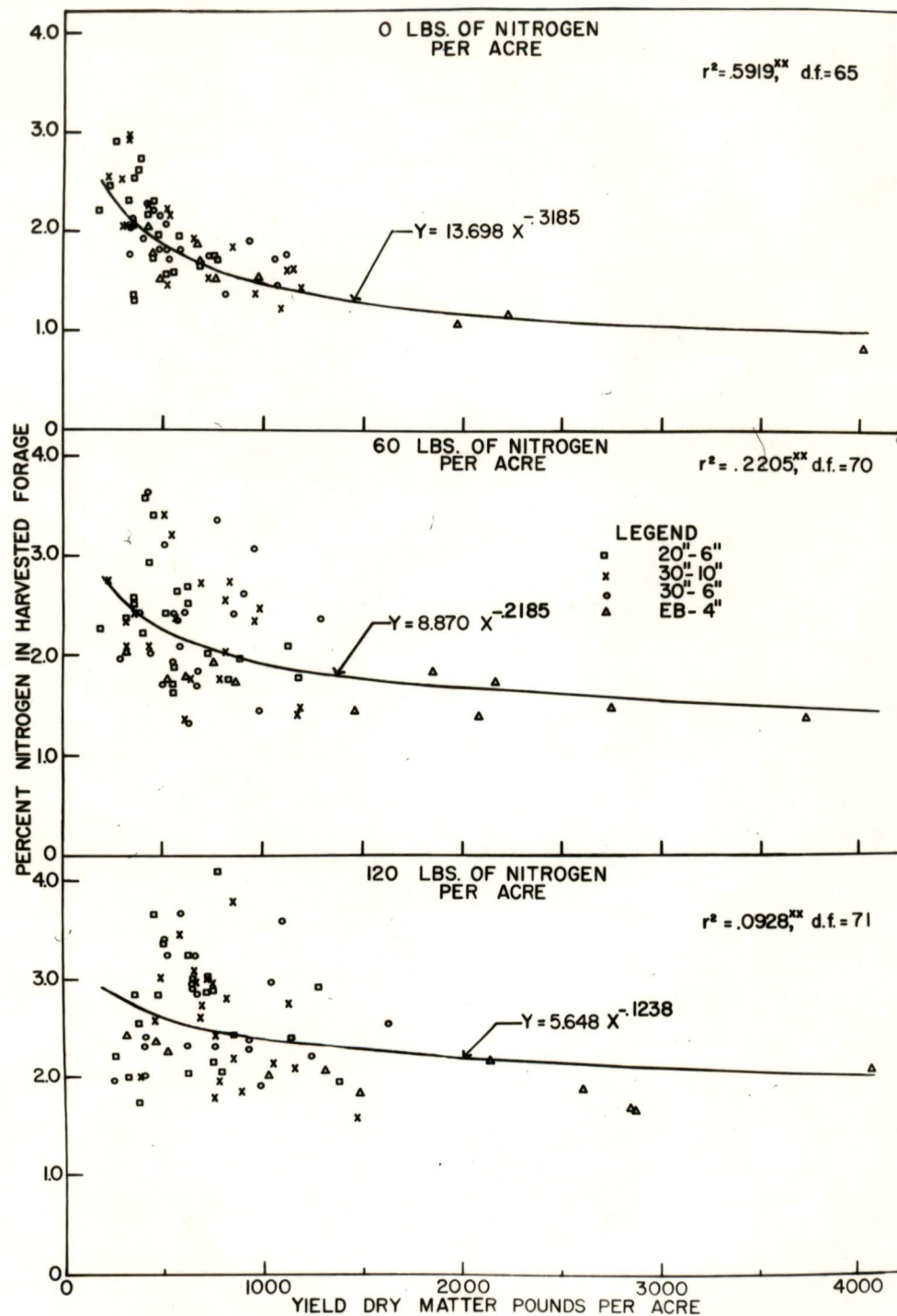


Figure 13. Relationship between dry matter yields and percent nitrogen in harvested forage.

TABLE 5

ANALYSIS OF VARIANCE OF THE YIELDS OF NITROGEN
IN HARVESTED FORAGE

Source of Variation	d.f.	Estimate of Variance	F
Total	143		
Nitrogen	2	31,822	52.42**
Replications	2	51	.08
Error (a)	4	607	
Grasses	3	18,384	84.33**
Grasses x Nitrogen	6	1,415	6.49**
Error (b)	18	218	
Cuttings	3	240	1.02
Cuttings x Nitrogen	6	54	.70
Cuttings x Grasses	9	235	3.05**
Cuttings x Nitrogen x Grasses	18	86	1.15
Error (c)	72	75	
Pooled Error	90	77	

C. V. = 1.22 Percent.

*Significant at the .05 level of probability.

**Significant at the .01 level of probability.

per acre (Table 6). In general, as the dry matter yield of a treatment increased the yield of nitrogen increased but not in the same proportion. The nitrogen yield did not increase at the same rate as did the dry matter yields since the percent nitrogen of the harvested forage decreased as the dry matter yield increased.

The nitrogen yields produced by the four grasses were different (Table 6). These differences are similar to those occurring between grasses for dry matter yields. The grass which produced the largest dry matter yield also produced the largest nitrogen yield. Georgia hybrid No. 1 produced yields which were larger than the yields of the other three grasses. The nitrogen yields produced by German millet were lower than those produced by the other grasses in this study. Piper Sudangrass produced numerically larger nitrogen yields than Sweet Sudangrass but this increase in yield was not significant.

The nitrogen yields produced by the four grasses were different at the three levels of nitrogen fertilization. The means are compared by the multiple range test in Table 7. As the nitrogen application was increased from zero nitrogen to one hundred and twenty pounds of nitrogen fertilizer per acre, there was an increase in the nitrogen yield in the harvested forage. It is worthy of note that the Sudangrasses fertilized with one hundred and twenty pounds of nitrogen per acre did not yield more nitrogen than Georgia hybrid No. 1 receiving half as much nitrogen fertilizer.

The means of the nitrogen yield produced by the four grasses at the four cutting intensities are compared by the multiple range test in Table 8. All cutting intensities of Georgia hybrid No. 1 produced

TABLE 6

NITROGEN YIELD COMPARISONS WITHIN NITROGEN APPLICATIONS
AND GRASSES

MULTIPLE RANGE TESTS

<u>Nitrogen Applications</u>				
Number of Means	2	3		
S. S. Range .05	10.0	10.2		
Rates of Nitrogen	N ₀	N ₁	N ₂	
Mean Yield Pounds/A	45.4	71.0	97.0	
<u>Grasses</u>				
Number of Means	2	3	4	
S. S. Range .05	7.4	7.8	8.0	
Grasses	M	S	P	H
Mean Yield Pounds/A	44.9	68.3	71.2	100.1

TABLE 7

INTERACTIONS BETWEEN GRASSES AND NITROGEN FERTILIZER APPLICATIONS
MULTIPLE RANGE TESTS

Grasses	Nitrogen Fertilizer Applied Pounds/A	Mean Yields of Nitrogen	
		Pounds Per Acre	Multiple Range Groups
German Millet	0	23.8	
Piper Sudangrass	0	43.3	
Sweet Sudangrass	0	47.2	
German Millet	60	47.5	
German Millet	120	59.6	
Georgia Hybrid No. 1	0	63.5	
Sweet Sudangrass	60	68.2	
Piper Sudangrass	60	74.4	
Sweet Sudangrass	120	89.5	
Georgia Hybrid No. 1	60	94.0	
Piper Sudangrass	120	96.0	
Georgia Hybrid No. 1	120	112.8	

TABLE 8

INTERACTIONS BETWEEN GRASSES AND CUTTING INTENSITIES

MULTIPLE RANGE TESTS

Grasses	Cutting Intensities	Mean Yields of Nitrogen	
		Pounds Per Acre	Multiple Range Groups
German Millet	20-6	39.5	
"	30-10	42.1	
"	EB-4	47.5	
"	30-6	50.8	
Sweet Sudangrass	EB-4	65.4	
Piper Sudangrass	EB-4	66.3	
Sweet Sudangrass	20-6	67.7	
"	30-10	69.2	
Piper Sudangrass	30-6	69.6	
Sweet Sudangrass	30-6	70.9	
Piper Sudangrass	20-6	73.5	
"	30-10	75.5	
Georgia Hybrid No. 1	EB-4	91.4	
"	30-6	95.4	
"	20-6	104.2	
"	30-10	109.8	

larger yields of nitrogen than those of any of the other grasses. The nitrogen yields produced by German millet, regardless of the cutting intensity, were the lowest of the grasses studied. The nitrogen yields produced by the Sudangrasses, as did the dry matter yields at each of the four cutting intensities, occupied the multiple range groups between the millet species.

The nitrogen yields produced at the four cutting intensities, regardless of grass or nitrogen level, did not produce yields that were significantly different. However, the order in which the yields rank themselves seems important. The mean yield of nitrogen produced by the four cutting intensities were: 74.2 pounds of nitrogen for the 30-10 cutting intensity, 71.7 pounds for the 30-6 cutting intensity, 71.6 pounds for the 20-6 cutting intensity, and 67.6 pounds for the EB-4 cutting intensity. When these nitrogen yields are compared to the dry matter yields, it is noted that the cutting intensities were ranked differently in the case of the nitrogen yields. The dry matter yields for each cutting intensity were: 4152 pounds for the EB-4 cutting, 3445 pounds for the 30-10 cutting, 3138 pounds for the 30-6 cutting and 3000 pounds for the 20-6 cutting.

General Discussion

Recommendations based upon the results of this experiment must necessarily be considered tentative for several reasons. The experiment was conducted for one season only on one soil series. The data were obtained from Sudangrasses and millets which were grown in rows three

feet apart, whereas they are more often grown broadcast or in closely drilled rows in general farm practice. The nitrogen fertilizer was all applied at time of seeding, rather than in several applications throughout the growing season. Georgia hybrid No. 1 is an experimental variety not yet released to the public.

In general, as the nitrogen fertilizer applications were increased from zero to sixty pounds per acre, there was a corresponding increase in dry matter yields at the four cutting intensities. Exceptions to this relationship occurred, notably in the case of the 30-6 and 30-10 cutting intensities of Georgia hybrid No. 1 (Appendix C). In these two cases, although a large yield response to one hundred and twenty pounds of nitrogen per acre was obtained, the application of sixty pounds of nitrogen per acre did not result in a dry matter yield appreciably larger than where no nitrogen fertilizer was applied. Reasons for these apparent discrepancies are obscure.

Regardless of the limitations of this experiment, there are several recommendations that can be made with respect to the growing of Sudangrass and millet for pasture, hay or silage.

The cutting intensities of 30-10 and 30-6 gave the better combination for high dry matter yields and nitrogen content of the harvested forage. It is felt, therefore, that Sudangrass and millet which are to be used for pasture be allowed to reach a height of thirty inches before they are grazed down to a height of six to ten inches. Sudangrass at this height should not offer any danger of hydrocyanic acid poisoning to cattle (5).

When the grasses are to be used for silage or hay, they should be cut at a stage of growth not earlier than somewhere between thirty inches in height and late boot or early bloom down to no less than a six-inch stubble, if recovery growth is desired.

In this study, increasing nitrogen fertilizer applications from zero to one hundred and twenty pounds per acre increased both dry matter and nitrogen yields of the harvested forage, in most cases.

Georgia hybrid No. 1 was the highest-producing grass in this study and was considered the best for hay, silage or pasture. German millet was by far the lowest producer. The sudangrasses were not significantly different; however, Piper Sudangrass appeared to be the better of the two studied, for it produced numerically higher yields and from observations made in the field it was noted that Piper Sudangrass was affected less by leaf blight than was Sweet Sudangrass. Both Sudangrass varieties were affected by rust, Ramulispora sorghi (Ell. and Ev.) Olive and Lefebvre. The millet species were not noticeably damaged by any plant disease. German millet was a shallow-rooted species, as indicated by the way the plants would frequently be pulled up during the process of cutting.

CHAPTER V

SUMMARY AND CONCLUSIONS

An investigation of the combined effects of nitrogen fertilization and cutting intensities on two varieties of Sudangrass and two species of millet was conducted at the University of Tennessee Agricultural Experiment Station, Sequoyah Hills, during the summer of 1957. The objective of the study was to determine what effects these factors produced on the yield of dry matter and the nitrogen content of the grasses studied.

The effects of these treatments were measured in terms of dry matter yield, percent nitrogen, and nitrogen yields of the different grasses. From this study, the following conclusions may be drawn:

1. Georgia hybrid No. 1 produced more total dry matter and nitrogen than any of the other grasses studied, and was followed by Piper Sudangrass, Sweet Sudangrass and German millet, in that order.
2. The EB-4 cutting intensity produced the largest yields of dry matter, and was followed by 30-10, 30-6, and 20-6, in that order.
3. The decreasing order of total nitrogen production by the four cutting intensities was: 30-10, 30-6, 20-6 and EB-4.
4. As the yields of dry matter of any individual treatment increased, the percent nitrogen of that treatment decreased. This relationship followed a straight line relationship when the logarithm of both variables was used or an exponential function when original data were utilized.

5. As cutting intensities decreased, and the height of the grasses increased, there was a general decrease in percent nitrogen of the harvested forage.

6. With increases in nitrogen fertilizer applications from zero nitrogen to one hundred and twenty pounds per acre, there was a corresponding increase in dry matter yields, nitrogen yields and nitrogen percentages of the harvested forage.

In summary, Georgia hybrid No. 1 was the grass which produced the highest amounts of both dry matter and nitrogen and was the best grass for pasture, hay or silage among those studied. Piper Sudangrass was the better variety of Sudangrass in this study, but it was not greatly superior to Sweet Sudangrass. The higher combination of both yields and percent nitrogen in the forage harvested were obtained when the forage was allowed to grow up to 30 inches and was cut down to a stubble height of preferably ten, and sometimes six inches.

Yields of dry matter and yields of nitrogen were increased with applications of nitrogen fertilizer up to one hundred and twenty pounds of nitrogen per acre.

SELECTED
BIBLIOGRAPHY

SELECTED BIBLIOGRAPHY

1. Anderson, K. L., Krenzin, R. E., and Hide, J. C., The effect of nitrogen fertilizer on brome grass in Kansas. Jour. Amer. Soc. Agron., 38:1058-1067. 1946.
2. Association of Official Agricultural Chemists. Methods of Analysis. 7th Ed. Par. 2.22. 1950.
3. Baker, M. L., Conrad, E. C., Arthaud, V. H. and Newell, L. C. Effects of time of cutting on yield and feeding value of prairie hay. Nebraska Agr. Exp. Sta. Bul. 403. 1951.
4. Bird, J. N. Stage of cutting studies: I. Grasses. Jour. Amer. Soc. Agron., 35:845-861. 1943.
5. Boyd, F. T., Aamodt, O. S., Bohstedt, G. and Truog, E. Sudangrass management for control of cyanide poisoning. Jour. Amer. Soc. Agron., 30:569-582. 1938.
6. Briggs, H. M., Gallup, W. D. and Darlow, A. E. The yield and feeding value of prairie hay as related to time of cutting. Oklahoma Agr. Exp. Sta. Bul. 320. 1948.
7. Brown, B. A. The chemical composition of pasture species of the Northeast Region as influenced by fertilizers. Jour. Amer. Soc. Agron., 32:256-265. 1940.
8. Burton, G. W. and DeVane, E. H. Effect of rate and method of applying different sources of nitrogen upon the yield and chemical composition of Bermuda grass, Cynodon Dactylon (L.) Pers., hay. Agron. Jour., 44:128-132. 1952.
9. Carey, V., Mitchell, H. L. and Anderson, K. The effect of nitrogen fertilization on the chemical composition of brome grass. Agron. Jour., 44:467-469. 1952.
10. Cathcart, S. L. Pearlmillet for grazing and silage. 57th Ann. Rept. of the South Carolina Exp. Sta. of Clemson Agr. College. Feb., 1945.
11. Christensen, F. W., and Hopper, T. H. Effect of weathering and stage of maturity on the palatability and nutritive value of prairie hay. North Dakota Agr. Exp. Sta. Tech. Bul. 260. 1932.
12. Cooper, C. S. The effect of time and height of cutting on the yield, crude protein content and vegetative composition of a native flood meadow in Eastern Oregon. Agron. Jour., 48:257-258. 1956.

13. ✓ Crowder, L. V., Parker, E. M. and Elrod, J. M. Sudangrass and millet selections for grazing and hay. Georgia Agr. Exp. Sta. Press Bul. 614. 1953.
14. Dawson, J. R., Graves, R. R. and Van Horn, A. G. Sudan grass as hay, silage, and pasture. U.S.D.A. Tech. Bul. 352. 1933.
15. Duncan, D. B. Multiple Range and Multiple F tests. Biometrics 11:1-42. 1955.
16. Ellett, W. B. and Carrier, L. The effect of frequent clipping on total yield and composition of grasses. Jour. Amer. Soc. Agron., 7:85-87. 1915.
17. ✓ Enlow, C. R. and Coleman, J. M. Increasing the protein content of pasture grasses by frequent light applications of nitrogen. Jour. Amer. Soc. Agron., 21:845-853. 1929.
18. Federer, W. T. Experimental design. New York, The MacMillan Company. 1955.
19. Hoveland, C. S. and McCloud, D. E. Growth of Pearl Millet as Influenced by Plant Management. Agronomy Abstracts. 1957.
20. Hoveland, C. S. and McCloud, D. E. Manage Millet for Better Yields. Sunshine State Agr. Res. Report. Vol. 2, No. 2, pp 14. April 1957.
21. Kohler, G. O. The effect of stage of growth on the chemistry of the grasses. Jour. Biol. Chem., 152:215-223. 1944.
22. Laughlin, W. M. Influences of fertilizers on the crude protein yields of bromegrass pasture in Matanuska Valley. Soil Sci. Soc. Amer. Proc., 17:372-374. 1953.
23. Lewis, R. D. and Lang, R. L. Effect of nitrogen on yield of forage of eight grasses grown in high altitude meadows of Wyoming. Agron. Jour., 49:332-335. 1957.
24. ✓ McCreery, R. A., and Stelly, M. Yield and protein content of pasture herbage as influenced by nitrogen fertilization and frequency of clippings. Soil Sci. Soc. Amer. Proc., 13:307-310. 1949.
25. ✓ Mortimer, G. B. and Ahlgren, H. L. Influence of fertilization, irrigation, and stage and height of cutting on yield and composition of Kentucky bluegrass. Jour. Amer. Soc. Agron., 28:515-533. 1936.
26. ✓ Phillips, T. G., Sullivan, J. T., Loughlin, M. E. and Sprague, V. G. Chemical composition of some forage grasses. I. Changes with plant maturity. Agron. Jour., 46:361-369. 1954.

27. Pigden, W. J. The relation of lignin, cellulose, protein, starch, and ether extract to the "curing" of range grasses. *Can. Jour. Agr. Sci.*, 33:364-378. 1953.
28. Russell, J. S., Bourg, C. W. and Rhodes, H. F. Effect of nitrogen fertilizer on the nitrogen, phosphorus, and cation content of brome grass. *Soil Sci. Soc. Amer. Proc.*, 18:292-296. 1954.
29. Snedecor, G. W. *Statistical Methods*. Iowa State College Press, Ames, Iowa. 5th Ed. 1956.
30. Sullivan, J. T., Phillips, T. G., Loughlin, M. E. and Sprague, V. G. Chemical composition on some forage grasses. II. Successive cuttings during the growing season. *Agron. Jour.*, 48:11-13. 1956.
31. Watkins, J. M. and Severen, M. L. Effects of frequency and height of cutting on the yield, stand, and protein content of some forages in El Salvador. *Agron. Jour.*, 43:291-296. 1951.

APPENDICES

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APPENDIX A

Procedure for Determining the Nitrogen Content
of Sudangrass and Millet

1. Place 1.0 gm. sample of oven-dry forage in Kjeldahl flask.
2. Add 10 gm. catalyst (K_2SO_4 and $CuSO_4 \cdot 5 H_2O$ in ratio of 100:3.2) and 35 ml. of concentrated sulfuric acid.
3. Heat below boiling until brothing ceases, then raise temperature to the boiling point, and continue for thirty minutes after digestion is complete.
4. Cool; add 250 ml. of tap water.
5. Place 500 ml. Erlenmeyer flask containing 100 ml. of 2 percent boric acid containing modified methyl blue indicator beneath the delivery tube of the condenser.
6. Add 4 to 5 pieces of mossy zinc and enough 45 percent sodium hydroxide to the digested material to make strongly alkaline.
7. Connect Kjeldahl flask to the condenser immediately after addition of sodium hydroxide.
8. Distill over approximately 300 ml. into boric acid.
9. Titrate the distillate using standard hydrochloric acid.
10. Calculate percentage nitrogen.

APPENDIX B (continued)

Dry Matter and Nitrogen Yields in Pounds Per Acre and Percent
Nitrogen of Harvested Forage¹

Cutting Inten- sity	Cutting date	No N			60 Lbs/A N			120 Lbs/A N		
		D.M.		Yd.	D.M.		Yd.	D.M.		Yd.
		Yd.		of N	Yd.		of N	Yd.		of N
		Lb/A	% N	Lb/A	Lb/A	% N	Lb/A	Lb/A	% N	Lb/A
Piper Sudangrass										
20-6	July 1				454	3.40	15.3	500	3.42	16.8
	4	331	2.04	6.8						
	17	392	2.73	10.7	592	2.64	15.6	710	2.90	20.5
	31	479	1.96	9.3	632	2.50	15.9			
	Aug. 1							732	2.89	21.2
	22	417	2.18	9.1	516	2.42	12.5	868	2.48	21.3
	Sept 18				347	2.52	8.7			
	19							382	2.58	9.9
	25	331	2.33	7.8						
	Oct. 9	363	1.30	4.6	543	1.71	8.9	266	2.25	5.9
30-6	July 4				506	3.10	15.5	508	3.52	17.4
	10	721	1.76	12.6						
	19							659	3.01	19.5
	22				866	2.40	20.8			
	31	476	1.83	8.7						
	Aug. 1							659	2.92	19.2
	14				567	2.41	13.8			
	22							933	2.43	22.3
	29	578	1.83	10.6						
	Sept 18				678	1.86	12.4			
30-10	19							422	2.45	10.3
	Oct. 9	519	1.82	9.1	637	1.32	8.3	417	2.05	8.4
	July 5	223	2.56	5.8	546	3.22	17.7	750	3.00	22.2
	19							659	2.99	19.6
	22	720	1.53	11.2	809	2.51	20.1			
	31				221	2.75	6.0			
	Aug. 1							694	2.77	19.0
	14	315	2.07	6.8	366	2.44	8.5			
	22							764	2.44	18.6
	Sept 4	306	2.08	6.3	427	2.10	9.0			
E.B.-4	19							457	2.61	11.9
	Oct. 9	957	1.37	13.4	1170	1.40	16.4	763	1.83	13.8
	July 22				2751	1.45	40.1	2869	1.69	48.0
	24	1987	1.09	21.4						
	Sept 4	758	1.53	11.6	1447	1.45	21.2	1492	1.84	27.4
	Oct. 9	498	1.52	7.4	618	1.77	10.8	462	2.41	10.9

APPENDIX B (continued)

Dry Matter and Nitrogen Yields in Pounds Per Acre and Percent
Nitrogen of Harvested Forage¹

Cutting Inten- sity	Cutting date	No N			60 Lbs/A N			120 Lbs/A N		
		D.M.		Yd.	D.M.		Yd.	D.M.		Yd.
		Yd.	% N	Lb/A	Yd.	% N	Lb/A	Yd.	% N	Lb/A
Georgia Hybrid No. 1										
20-6	July 1				774	3.35	25.5	777	4.12	32.0
	4	371	2.64	9.8						
	17	519	1.56	8.1	1127	2.06	23.6	1280	2.94	37.3
	31	554	1.58	8.7	890	1.98	17.7			
	Aug. 1							1148	2.42	27.7
	22	699	1.65	11.5	828	1.78	14.7	764	2.18	16.4
	Sept 18	758	1.74	13.2	734	2.01	14.8	796	2.11	16.5
	Oct. 9	772	1.70	13.3	403	2.22	9.0	626	2.11	12.9
30-6	July 4				963	3.06	29.4	1100	3.60	39.6
	10	1059	1.74	18.4						
	17				565	1.92	12.7	1044	2.95	30.9
	31	817	1.39	11.0	675	1.73	11.6			
	Aug. 1							1240	2.30	27.7
	29	1059	1.45	15.3	973	1.43	13.9	992	1.93	19.1
	Sept 25	519	2.06	10.7	441	2.01	8.9	928	2.25	21.1
	Oct. 9	339	1.77	5.9	298	1.95	5.0	250	1.99	4.9
30-10	July 5				963	2.35	22.8	842	3.83	31.6
	10	653	1.93	12.7						
	17				826	2.72	22.5	1127	2.79	31.0
	24	1194	1.45	17.2						
	31				777	1.77	13.7			
	Aug. 1							1167	2.16	24.8
	14	1113	1.63	17.6						
	22				635	1.75	10.9	777	1.97	15.4
Sept 18	1140	1.62	18.3	809	2.04	16.6	850	2.17	18.7	
Oct. 9	1089	1.24	13.0	1193	1.49	17.3	1473	1.62	24.0	
E.B.-4	July 24				3735	1.36	50.6	4065	2.13	84.7
	Aug. 14	4020	0.82	32.9						
	Sept 18	435	2.05	9.0	2081	1.36	28.2	2870	1.64	47.2
	Oct. 9	349	2.06	7.2	325	2.03	6.6	312	2.42	7.6

APPENDIX B (continued)

Dry Matter and Nitrogen Yields in Pounds Per Acre and Percent Nitrogen of Harvested Forage¹

Cutting Inten- sity	Cutting date	No N			60 Lbs/A N			120 Lbs/A N		
		D.M.		Yd.	D.M.		Yd.	D.M.		Yd.
		Yd.	% N	Lb/A	Yd.	% N	Lb/A	Yd.	% N	Lb/A
German Millet										
20-6	July 4				565	2.87	16.1	627	3.34	20.6
	10	583	1.97	11.7						
	31	454	1.75	8.1	1178	1.71	20.1			
	Aug. 1							1390	2.00	27.3
	22	183	2.22	4.0	188	2.27	4.0	323	2.33	6.5
30-6	July 10				1299	2.35	30.4	1430	2.54	36.4
	17	1119	1.76	19.6						
	31	352	2.12	6.9	578	2.33	13.3			
	Aug. 1							766	2.38	17.8
	22	409	1.92	7.5	583	2.06	11.0	403	2.40	9.3
30-10	July 10				699	2.74	19.2	817	2.83	23.1
	17	842	1.85	15.3						
	31	328	1.94	5.5	1175	1.79	20.8			
	Aug. 1							1049	2.14	22.4
	22	331	1.96	5.7	330	2.09	6.2	395	2.17	7.9
E.B.-4	July 19	976	1.55	15.2	1858	1.83	34.5	2103	2.18	45.9
	Aug. 22	678	1.70	11.4	756	1.91	14.4	1030	2.04	20.9

¹Mean of three replications.

APPENDIX C

Seasonal Dry Matter and Nitrogen Yields in Pounds Per Acre
and Average Percent Nitrogen of Harvested Forage

Cutting Inten- sity	No N			60 Lbs/A N			120 Lbs/A N		
	D.M. ¹		Yd. ¹	D.M.		Yd.	D.M.		Yd.
	Yd.		of N	Yd.		of N	Yd.		of N
	Lb/A	% N ²	Lb/A	Lb/A	% N	Lb/A	Lb/A	% N	Lb/A
<u>Sweet Sudangrass</u>									
20-6	2096	2.28	47.7	2690	2.57	69.2	3058	2.91	89.1
30-6	2397	1.96	47.1	2834	2.53	71.4	3081	3.05	94.1
30-10	2299	2.06	47.3	3003	2.35	70.7	3303	2.72	89.9
EB-4	3350	1.40	46.8	3557	1.73	61.7	4442	2.00	87.5
<u>Piper Sudangrass</u>									
20-6	2313	2.09	48.3	3084	2.49	76.9	3458	2.76	95.6
30-6	2294	1.79	41.0	3254	2.18	70.8	3598	2.70	97.1
30-10	2521	1.72	43.5	3539	2.20	77.7	4087	2.57	105.1
EB-4	3243	1.24	40.4	4816	1.50	72.1	4823	1.80	86.3
<u>Georgia Hybrid No. 1</u>									
20-6	3673	1.76	64.6	4756	2.21	105.3	5391	2.65	142.8
30-6	3793	1.62	61.3	3915	2.08	81.5	5554	2.58	143.3
30-10	5189	1.52	78.8	5203	2.00	103.8	6236	2.33	145.5
EB-4	4804	1.02	49.1	6141	1.39	85.4	7247	1.92	139.5
<u>German Millet</u>									
20-6	1220	1.95	23.8	1931	2.08	40.2	2340	2.32	54.4
30-6	1880	1.81	34.0	2460	2.22	54.7	2599	2.44	63.5
30-10	1501	1.76	26.5	2204	2.10	46.2	2261	2.36	53.4
EB-4	1654	1.61	26.6	2614	1.87	48.9	3133	2.13	66.8

¹Mean of three replications.²Obtained by division of seasonal mean nitrogen yield by seasonal mean dry matter yield.

APPENDIX D

Daily Temperature in Degrees Fahrenheit Reported at the
University of Tennessee,
Agricultural Experiment Station, Knoxville

Day	Month									
	June		July		Aug		Sept		Oct	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1	64	86	68	88	72	96	70	98	63	82
2	66	86	68	84	72	96	72	94	60	76
3	70	87	68	90	72	98	72	88	64	68
4	70	84	70	88	76	87	72	90	58	63
5	64	78	74	90	68	86	70	89	52	86
6	66	80	64	87	64	85	64	92	56	70
7	66	85	66	92	60	88	64	90	46	74
8	66	90	68	93	64	90	66	78	50	76
9	70	80	72	91	62	93	68	80	50	78
10	68	80	70	88	66	94	68	88	50	78
11	68	80	65	90	68	98	70	83	56	66
12	70	90	64	94	72	96	68	88	58	64
13	70	90	68	94	70	98	70	80	50	72
14	71	87	74	92	73	94	68	89	46	73
15	70	92	72	84	74	90	68	90	46	74
16	72	96	70	94	72	97	68	69	58	72
17	70	94	72	93	72	86	68	76	62	70
18	74	91	70	90	72	82	66	74	50	65
19	74	89	71	92	69	88	68	78	42	64
20	62	88	72	93	66	86	70	80	42	62
21	64	92	71	94	63	80	72	86	38	63
22	72	88	74	94	64	86	74	86	44	78
23	72	88	74	92	61	86	66	74	60	74
24	72	80	72	86	64	90	54	80	58	70
25	68	84	70	90	68	78	53	84	48	50
26	64	87	70	88	64	86	58	78	40	42
27	68	84	72	88	62	90	61	82	38	40
28	72	80	73	90	64	94	62	58	30	58
29	70	87	72	92	68	94	52	64	30	64
30	74	82	72	90	70	96	56	78	48	56
31	—	—	70	92	70	98	—	—	52	65

APPENDIX E

Daily Precipitation Reported in Inches at the University of
Tennessee Agriculture Experiment Station, Knoxville

Day	Month				
	June	July	Aug.	Sept.	Oct.
1					.03
2				.02	
3			.53	.21	.50
4			.60		1.60
5	1.41				.02
6	.22				
7					
8					
9		.05		.48	
10	.28				
11	.02			1.55	
12	.31			.44	
13				1.98	
14	.03			.34	
15			.24	.43	
16	.26			1.80	
17	.21	1.72	.09		.62
18			1.18		
19					
20					
21				.35	
22				.31	
23	.38	.58			.50
24	1.66				
25			.37		
26					.17
27					
28	.27			.56	
29	.29				
30	.09	.03			
31					
Total	5.43	2.38	3.01	8.47	3.44
Long Term Mean ¹	4.12	5.38	3.99	2.84	2.49

¹Period 1920-1956.