EFFECT OF EIGHT FERTILIZER TREATMENTS ON FORAGE YIELDS OF FOUR ANNUAL SORGHUM VARIETIES

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CHAPTER I

INTRODUCTION

Sudangrass and other sorghum varieties have been important forage crops in the United States for more than fifty years. During hot, dry, summer weather, when many forage species go dormant, sudangrass and allied sorghum species continue to yield well, thus filling the need for supplemental midsummer feed which is a major problem to livestock producers and dairymen. Sorghums can be grown in nearly every state on a wide range of soils and under many different climatic conditions. These annual sorghum varieties can be grown successfully as a supplemental pasture or hay crop in Oklahoma through the hot dry months and have gained widespread acceptance.

Sorghum varieties differ in yield primarily because of their inherent yield potentials and response to environmental conditions. Specific information is lacking as to the amount of fertilizer which must be applied to these annual sorghum varieties in order to obtain maximum forage yields. Until data are available on such problems, recommendations on supplemental summer forages cannot be made with assurance. This experiment 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 response of sudangrass and sorghum-sudan hybrids to fertilizers on forage yields.

Varieties used in this study were: Piper common sudangrass, Lahoma sweet sudangrass, one sorghum-sudangrass hybrid, variety SX-11, and one sorgo-sudangrass hybrid, variety Sweet Sioux.

CHAPTER II

REVIEW OF LITERATURE

The literature relating to the history and adaptability of annual sorghum varieties is rather broad and that which deals with nitrogen fertilization of different grass species is extensive, but a noticeable absence exists of literature directly related to the effects of different levels of nitrogen-phosphorus-potassium (N-P-K) on the forage production of various sudangrasses and sorghum-sudan hybrids.

History and Origin of Varieties

Sudangrass (Sorghum sudanense (Piper) Stapf.), a close relative of the sorghums, was introduced from Africa by the United States Department of Agriculture in 1909 (27, 31, 36, 40, 44, 46).

Piper sudangrass was developed from a double-cross of Tift sudangrass and lines obtained from the Texas Agricultural Experiment Station and Kansas Agricultural Experiment Station by the Wisconsin Agricultural Experiment Station. It was released for commercial production in 1950 (9, 27, 35, 42, 44).

Lahoma, a sweet variety described by Denman (21) was selected by the Oklahoma Agricultural Experiment Station for resistance to foliar diseases, leafiness and palatability, was released in 1954. The parent breeding material came from the Texas Agricultural Experiment Station.

SX-11, as reported by Burger et al. (9), is an F_1 sorghum-sudan hybrid produced by crossing male-sterile Kafir with a cross of Sweet and Greenleaf sudangrass.

Sweet Sioux, a sorgo-sudan hybrid was produced by crossing Sorghum vulgare Pers. and Sorghum sudanense, Hitchc. according to Griffith (28).

Adaptation and Use of Varieties

Gangstad (27) reported that sudangrass and other forage sorghums were adapted in nearly every state of the Union on a wide range of soil and under many different climatic conditions. Miles (38) reported in 1949 that sudangrass was used as a grazing and hay crop in most of the subtropical regions of the world. He also stated that it was one of the most popular summer grazing crops in Queensland.

Sudangrass reportedly is versatile in supplying forage needs. If it was too mature to be green-chopped, it could be used for hay or allowed to further mature and be ensiled. A combination of pasture, green-chop, hay and silage was possible in the same year according to Helm (32), Rather (46), Jones and Miller (35), and Schultz (49).

Sudangrass was reported to be well adapted at Nha Ho in Vietnam according to Neese (39), and in India according to Ormiston (41).

Kalton and Thompson (36) reported that sudangrass was an outstanding temporary pasture crop during the summer months of July, August, and September in Iowa. Some of its outstanding advantages included: rapid growth and quick recovery after grazing or cutting; drought and high temperature tolerance; high palatability and nutritious forage; high carrying capacity when grazed rotationally and widespread adaptation

on fertile soils throughout the state.

Sudangrass has been reported to be well adapted to many states by numerous researchers (2,12,31,32,35,43,44,46,47,49).

Piper, common sudangrass has been the only sorghum-type forage recommended for grazing in Wisconsin and Minnesota, and is widely recommended for use in 33 states reported the Wisconsin researchers (2). It was the best variety recommended for all of Iowa in 1957 according to Kalton and Thompson (36).

Piper was the best adapted sudangrass variety in Nevada and was recommended because of its high yields and low prussic acid potential according to Robinson et al. (48). Jones and Miller (35) reported it could recover quickly from grazing or clipping as well as being highly productive, low in prussic acid content and resistant to leaf blight and anthracnose.

Piper sudangrass was the first to recover under the hay system of management among the varieties Wheeler, Sweet and Greenleaf in Illinois as reported by Burger et al. (6,7,8,9).

Lahoma, sweet sudangrass when tested in Oklahoma showed late maturity, good leafiness and palatability, and greater resistance to leaf diseases than any other sweet sudangrass, but was severely damaged during wet seasons. It was recommended for planting only in central and western Oklahoma according to Denman (21). Kalton and Thompson (36), reported it was slow growing, poor in ability to recover and low in yield when compared with Piper. Lahoma was not recommended for forage production in California according to Jones and Miller (35).

SX-11, a sorgo-sudan hybrid, has been reported to be adapted to many states such as Illinois by Burger et al. (9) and Wisconsin (2), but it was cited as being relatively higher in prussic acid potential than Piper sudangrass.

Sweet Sioux, a sorgo-sudan hybrid, was reported to be well adapted to Wisconsin and Pennsylvania (2), as well as to Oklahoma where the summers are much warmer. Similar reports can be found from other sections of the country.

Forage Yield as Affected by Varieties

Generally yields of forage sorghums are higher than sudangrass. According to Hughes et al. (33), yields from sudangrass were not particularly high when compared to forage sorghums. The yields were about 1 to 3 tons on dry land and 5 to 6 under irrigation, in contrast with yields from the forage type sorghums on the order of 3 to 5 tons on dry land and 8 to 10 tons or more under irrigation.

The average yield of forage sorghums from four years of testing at the Perkins, Oklahoma, Agronomy Research Station by Davies (17,18, 19,20) was 4.8 tons of oven-dry forage per acre. At the same place, variety trials of hybrid grass sorghums and sudangrass were conducted by Denman (22) in 1963. He reported that the top yielding variety was SX-11 with 6787 pounds of oven-dry forage per acre, whereas yields of Sweet Sioux, Piper and Lahoma were 5968, 5063 and 4054 pounds per acre, respectively. All varieties were statistically different in forage yields.

Burus and Wedin (11) reported that Piper sudangrass managed as hay yielded 3.3 tons per acre at first cutting, followed by 1.5 tons of regrowth.

Denman (21) in describing "Lahoma", a variety of sweet sudan, placed its yield from 500 to 6000 pounds of oven-dry forage per acre.

Burger et al. (9) reported that in studies where the cutting height was 5 or 6 inches and herbage was removed three times or less, SX-11 had been superior to Piper in forage production.

Griffith (28) reported that yields of Sweet Sioux and SX-11 were significantly higher than Piper and it in turn was significantly higher than Lahoma.

It has been reported (2) from an experiment conducted in Pennsylvania that Sweet Sioux, which averaged 5.8 tons of oven-dry forage per acre was not significantly different from SX-11, but in Oklahoma it was significantly different to Piper.

According to the research conducted in Nebraska by Peters (44), Piper and SX-11 were not significantly different in yield of oven-dry forage.

Most reported variety trials indicated that Piper was statistically superior to Lahoma (15,27,45,47) in forage production.

Yield as Affected by Fertilizer Treatments

The effects of fertilizing forages with nitrogen has received considerable attention by agronomists for many years.

Ensminger and Pearson (26) stated that nitrogen has been a deficient element in the cultivated soil of the world since the beginning of

agriculture.

Lewis and Lang (37) found that highly significant increases in forage yields of eight grasses grown in the high-altitude meadows of Wyoming were obtained from nitrogen applications.

Ramage et al. (45) studied the effect of nitrogen application as ammonium nitrate to orchard grass. They found that the 100 pound nitrogen rate produced the greatest yield, and this rate also gave the most efficient return on a cost basis.

Anderson et al. (1) studied the effect of nitrogen fertilizer (ammonium nitrate) on bromegrass in Kansas and found that forage yields increased with increasing amounts of nitrogen up to approximately 100 pounds of the element per acre. Beyond that rate, the fertilizer became relatively less effective in stimulating yields.

Colville (14) reported on a study conducted in Nebraska for eight years in which he found the application of 80 and 120 pounds of nitrogen per acre per year produced the top yields of bromegrass forage.

Burton and Devane (10) studied the effect of nitrogen fertilizer upon the yield of bermudagrass hay. They found that 200 pounds of nitrogen per acre produced hay the most economically.

Drapala and Johnson (23) reported that millets and sudangrass showed dramatic responses to nitrogen fertilizer, and efficiently utilized surface applications. Peters et al. (42) pointed out that the usual recommendation for nitrogen fertilization of sudangrass in Nebraska was 40 to 80 pounds per acre.

Ellis (25) studied the effect of nitrogen fertilizer on yield and composition of irrigated sudangrass. He found that an application

of 200 pounds of nitrogen per acre almost doubled the total seasonal dry forage production. Only slightly more forage was produced when 400 pounds of nitrogen were applied.

Broyles and Fribourg (5) working with sudangrass in Tennessee, concluded that significantly higher yields were produced when 60 pounds of nitrogen per acre was applied at seeding time than when no nitrogen fertilizer was used. The difference in the yield produced by 60 pounds of nitrogen and that produced by 120 pounds of nitrogen per acre was not significant at the 5 percent probability level but was significant at the 10 percent level.

According to Nelson (40), phosphorus was apparently the first limiting factor for increasing yields of alfalfa on a Norge fine sandy loam soil in Oklahoma and yields were increased with applications up to 80 pounds of P_2O_5 per acre. He also reported that after this soil was fertilized with phosphorus, potassium became a limiting factor and yield increases were obtained with potassium fertilization.

Bickford (4) found that less fertilizer phosphorus was taken up by forage sorghum when applied in a dry soil than when applied in moist soil. Yields were much greater when the phosphorus fertilizer was applied to moist zones of soil as compared to the placement in dry soil.

Grunes (29) reported the additon of nitrogen fertilizer generally increased the plant uptake of fertilizer phosphorus from bands of concentrated superphosphate in North and South Dakota. This resulted in vigorous growth and higher yields.

In a study of Piper sudangrass, Sullivan (50) concluded that the total uptake of nitrogen and phosphorus increased with increased P_2O_5 fertilization and high temperature. He noted that growth response to phosphorus fertilizer was limited by 70° F. temperature which was too cool for the most rapid growth of sudangrass.

Humphrey (34) reported that the amount of available phosphorus might largely control plant response to nitrogen. When phosphorus was deficient in the foothill range of California, where grasses were strongly dominant, fertilization with nitrogen had little effect on plant growth. Whereas, the addition of phosphorus resulted in abundant growth.

Williams and Smith (51) found that the application of nitrogen and phosphorus fertilizers increased the yields of hard red winter wheat, but potassium had no effect.

Results from two years of study at Thorsby, Alabama, by Bennett et al. (3) indicated that the average uptake of nitrogen and potassium by sweet sudangrass was 170 and 223 pounds per acre, respectively. The amount of potassium taken up by plants was increased by most practices that increased yields as long as the potassium supply of the soil was not limited. But according to Williams (52), even though there was definite luxury comsumption of potassium by Sumac 1712 forage sorghum, it did not increase forage yields.

Rates of fertilizer for forage crops was also studied by Williams (52) in 1962 at New Mexico. He found that nitrogen and phosphorus were both required to produce high forage yields. Nitrogen at 160 pounds per acre for forage sorghum, 200 pounds for sudangrass in

combination with 80 pounds of available phosphorus for forage sorghum and 50 pounds for sudangrass was recommended. The results showed that nitrogen was the main cause of the yield increase, but they remained higher where phosphorus or potassium was applied with the nitrogen.

Yield as Affected by Other Factors

Harlan (30) reported that in several studies monthly clipping of a forage crop resulted in a greater total yield at the end of a single season than a single clipping at maturity.

Daniel (16) found the forage yield of Lahoma sudangrass was significantly higher from a 30 day clipping frequency than from a 10 or 20 day harvest cycle. The highest yield was obtained from clipping at a six inch height every 30 days. This agrees with the results reported in 1961 by Elder et al. (24).

Chandrapanya (13) studied the effect of fertilizer treatments on protein content and hydrocyanic acid level of four annual forage sorghum varieties. He found the initial application of 60-0-0, or 60-30-0 fertilizer to all varieties, with 60 pounds of nitrogen added after each harvest did not significantly increase the protein production or HCN content above that from plants which received no fertilizer throughout the season. Piper was significantly lower in HCN than any variety tested, while SX-11 was the highest. Lahoma contained a higher protein content throughout the season than any of the other three varieties.

CHAPTER III

MATERIALS AND METHODS

In the summer of 1964 the effect of eight fertilizer treatments on the forage yields of two sudangrasses and two sorghum-sudan hybrids was studied on a Norge loam soil at the Agronomy Research Station, Stillwater, Oklahoma. The varieties used in this study are shown in Table I, with the eight fertilizer treatments listed in Table II.

The field layout consisted of a randomized complete block design with four replications. Each plot consisted of 5 rows, 12 inches apart and 20 feet long. Only the three inside rows of each plot were harvested for determination of the fertilizer effect on forage production.

All varieties were seeded with a one-row, hand-operated Planet Junior garden planter on June 24, 1964. Piper and Lahoma were seeded at the rate of 20 pounds per acre, whereas SX-11 and Sweet Sioux were seeded at the rate of 30 pounds per acre. Nitrogen was applied at planting time at two levels: 0 and 60 pounds per acre, and immediately after each cutting an additional 60 pounds of nitrogen per acre were applied in the form of ammonium nitrate (33.5% nitrogen). Phosphorus and potassium were only applied at planting time in the forms of superphosphate (0-20-0), and muriate of potash (0-0-60), at rates per acre on an elemental basis of 0, 30, 60 and 90 pounds of phosphorus, and 0 and 30 pounds of potassium. In all cases, the fertilizer was applied

TABLE I

FOUR ANNUAL FORAGE SORGHUM VARIETIES

USED IN THIS STUDY

Variety		Type
PIPER	Sorghum sudanense, (Piper) Stapf.	Common Sudangrass
LAHOMA	Sorghum sudanense, (Piper) Stapf.	Sweet Sudangrass
SX-11	Sorghum vulgare, Pers. X Sorghum sudanense, (Piper) Stapf.	Sorghum-Sudan hybrid
SWEET SIOUX	Sorghum vulgare, Pers. X Sorghum sudanense, (Piper) Stapf.	Sorgo-Sudan hybrid

TABLE II

FERTILIZER TREATMENTS EXPRESSED IN POUNDS OF N-P-K ON AN ELEMENTAL BASIS APPLIED INITIALLY IN THIS STUDY

Treatment Number	Elemental N-P-K Applied Initially Pounds per Acre
1	00-00-00
2	60-00-00
3	60-30-00
4	60-30-30
5	60-60-00
6	60-60-30
7	60-90-00
8	60-90-30

with a three foot Gandy spreader.

On June 25, approximately 2 inches of supplemental water was applied by overhead sprinklers to aid in stand establishment and subsequently applied as needed throughout the study. Signs of moisture stress in the plant leaves was the criteria used to determine the time of application. Cultivation was also provided when needed during the study.

The forage was harvested three times at the boot stage. The first harvest was made on August 6, about six weeks after planting; the second about four weeks later on September 9; and the third, six weeks later on October 25, 1964. The yields were determined by cutting to a stubble height of 6 inches above the soil surface with a three feet wide sickle-type Jari mower.

The total forage green weight was recorded for each plot. Random samples from each harvested plot were selected and weighed for dry weight determinations, then dried in a forced air oven at 150° F. for 72 hours. The dry samples were then weighed and recorded and the forage dry-weight produced per plot was calculated.

All data were analyzed in the Computing Center at the Statistical Laboratory of Oklahoma State University, Stillwater, Oklahoma. Statistical analyses were made on the data from the forage yield for each variety, treatment and combination.

CHAPTER IV

RESULTS AND DISCUSSION

The results of this study which concerned the forage yield of four annual sorghum varieties as affected by eight fertilizer treatments will be presented by cuttings for clarity and convenience.

Forage Production: First Cutting

Forage yields of the four annual sorghum varieties at the time of the first cutting on August 6, about six weeks after planting, as affected by the eight fertilizer treatments are shown in Figure 1. The hybrid varieties Sweet Sioux and SX-11 were highest in yield, whereas, Lahoma produced the least forage at this time.

When these data were analyzed statistically as shown in Table III, highly significant differences in forage yields were found among replications, varieties, and treatments. The reasons for such significant differences in yield among replications perhaps can be explained by an uneven application of water initially which resulted in irregular germination and growth. Highly significant differences in forage production among varieties was the result of high yields from Sweet Sioux and SX-11, and very low yields from Lahoma as indicated in Table IV. The addition of 60 pounds, or more, of phosphorus with an initial application of 60 pounds of nitrogen resulted in a significant increase in forage production as shown in Table V, regardless of whether potassium

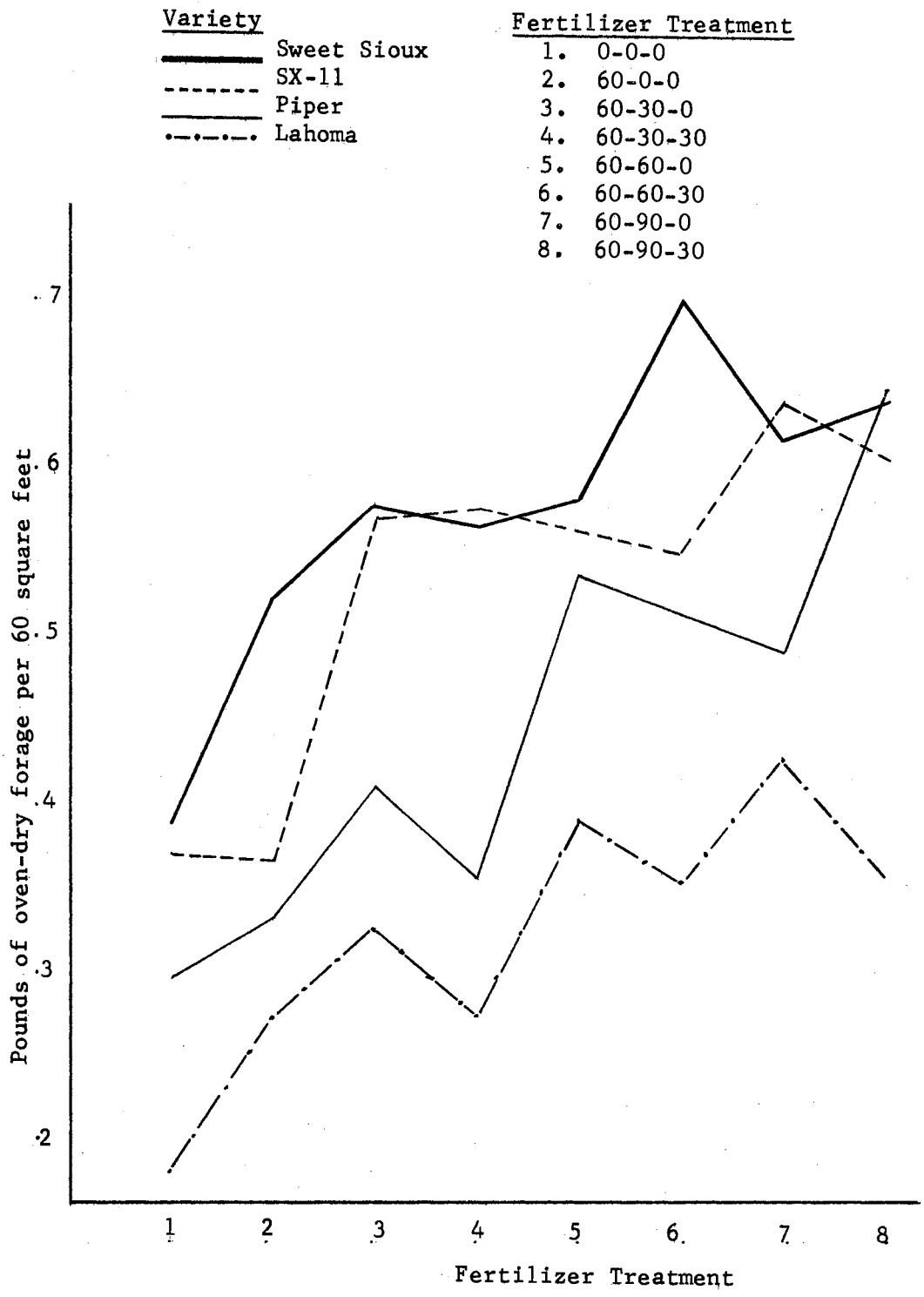

Figure 1. Forage Production of Four Annual Sorghum Varieties at the Time of the First Cutting on August 6, 1964 as Affected by Eight Fertilizer Treatments.

TABLE III

STATISTICAL ANALYSES OF FORAGE YIELDS FROM FOUR ANNUAL SORGHUM VARIETIES AT THE TIME OF THE FIRST CUTTING ON AUGUST 6, 1964 ABOUT SIX WEEKS AFTER PLANTING

Source of Variation	Degrees of Freedom	Mean Square	F.
Total	127		
Replication	3	8.0202	7.7668**
Variety	3	39.0089	37.7762**
Fertilizer	7	12.8784	
Phosphorus	2	8.0295	7.7758**
Potassium	1	0.0003	0.0003
P. x K.	2	0.5292	0.5125
Others	2	36.5156	
/1 A	1	69.8654	67.6577**
/2 B	1	3.6691	3.0690
Variety x Fertilizer	21	1.0277	0.9952
Error	93	1.0326	

**Denotes statistical significance at the 1 percent probability level.

/1 A = Treatment 0-0-0 and 60-0-0 vs. Other Treatments.

/2 B = Treatment 0-0-0 vs. Treatment 60-0-0.

TABLE IV

FORAGE YIELD OF FOUR ANNUAL SORGHUM VARIETIES

FROM THE FIRST CUTTING

Variety	Yield Oven-dry Forage lb/60ft^2	*
Sweet Sioux	5.7216	|
SX-11	5.2856	|
Piper	4.4616	|
Lahoma	3.2856	|

*Any two means covered by the same line are not significantly different at the 5 percent level of probability.

L.S.D. 5% = 0.5044

L.S.D. 1% = 0.6680

TABLE V

AVERAGE FORAGE YIELD OF FOUR ANNUAL SORGHUM VARIETIES AT THE TIME OF THE FIRST CUTTING AS AFFECTED BY EIGHT FERTILIZER TREATMENTS

Treatment	Yield Oven-dry Forage lbs/60 ft^2	*
60 - 90 - 30	5.6063	
60 - 90 - 00	5.4213	
60 - 60 - 30	5.2931	
60 - 60 - 00	5.1763	
60 - 30 - 00	4.6863	
60 - 30 - 30	4.3956	
60 - 00 - 00	3.7050	
00 - 00 - 00	3.0756	

*Any two means covered by the same line are not significantly different at the 5 percent level of probability.

L.S.D. 5% = 0.7134

L.S.D. 1% = 0.9447

was added or not. Phosphorus applied at 30 pounds per acre with 60 pounds of nitrogen and with or without 30 pounds of potassium gave an increase in forage yield that was highly significant when compared to the unfertilized plots. The application of 90 pounds of phosphorus initially with 60 pounds of nitrogen seemed to show a trend of increased forage yields when compared to those plots which received 30 or 60 pounds of phosphorus with 60 pounds of nitrogen per acre. Nitrogen alone did not significantly increase the forage production above the yields from the unfertilized plots.

Second Cutting

Forage yields of the second cutting about four weeks after the first harvest are illustrated in Figure 2. No significant differences in forage production among varieties were detected at this time as shown in Tables VI and VII. Fertilizer treatments produced highly significant differences in forage yields primarily as the result of the addition of either phosphorus or potassium alone, or in combination to the nitrogen when compared to those obtained from plots which received no fertilizer or nitrogen alone as shown in Table VIII.

Third Cutting

Forage yields of the third cutting, about six weeks after the second, are illustrated in Figure 3. A highly significant difference in forage production occurred among varieties as shown in Table IX. This difference was perhaps due to the ability of Piper to readily recover after the second cutting at this time of the year in comparison to the others thus producing more growth as shown in Table X. Lahoma

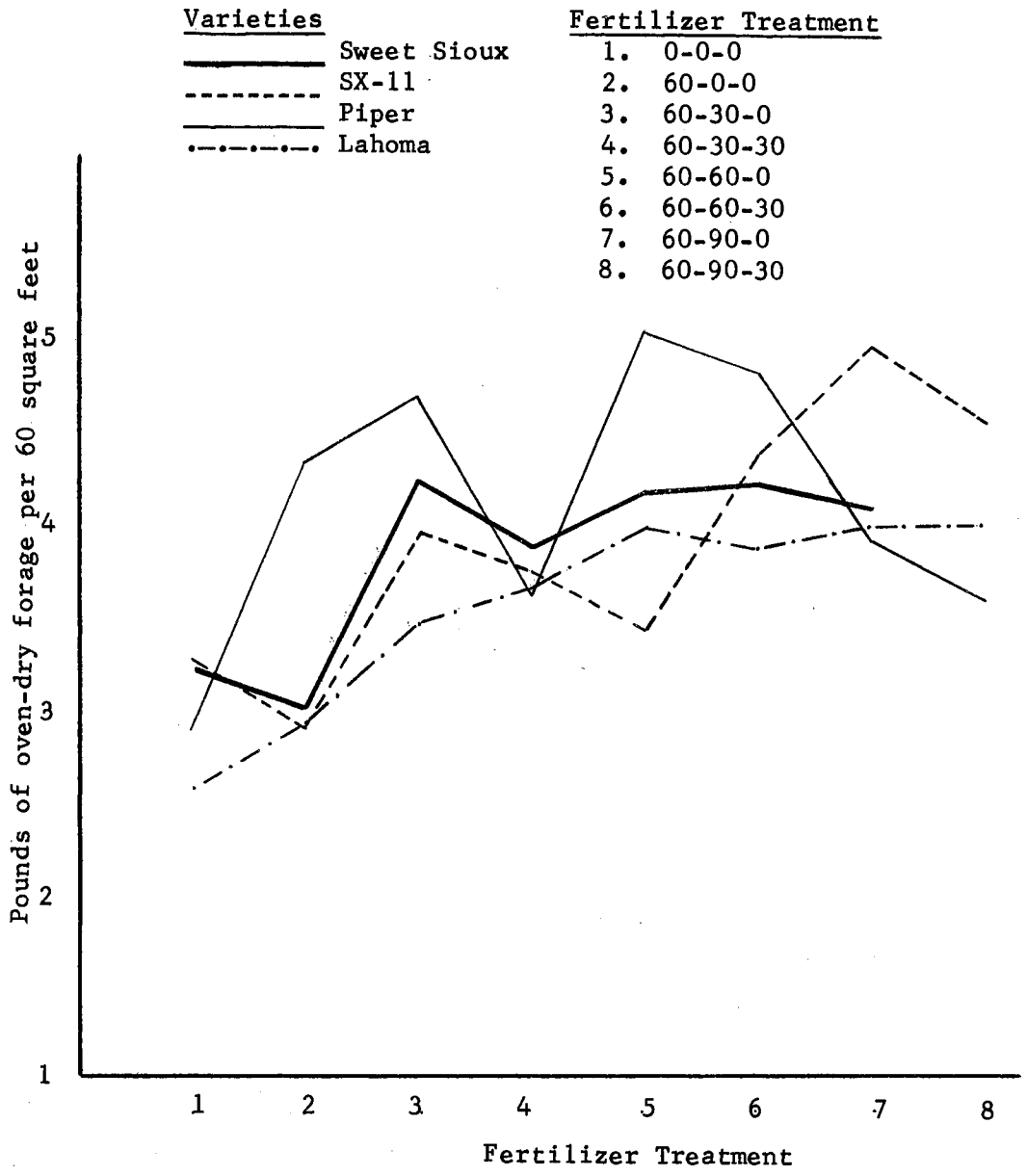

Figure 2. Forage Production of Four Annual Sorghum Varieties at the Time of the Second Cutting on September 9, 1964 as Affected by Eight Fertilizer Treatments.

TABLE VI

STATISTICAL ANALYSES OF FORAGE YIELDS FROM FOUR ANNUAL SORGHUM VARIETIES AT THE TIME OF THE SECOND CUTTING ON SEPTEMBER 9, 1964 ABOUT FOUR WEEKS AFTER THE FIRST HARVEST

Source of Variation	Degrees of Freedom	Mean Square	F.
Total	127		
Replication	3	3.3345	2.8910
Variety	3	1.6492	1.4298
Fertilizer	7	3.7866	
Phosphorus	2	1.0596	0.8031
Potassium	1	0.3492	0.2644
P. x K.	2	0.6479	0.4904
Others	2	11.3710	
/1 A	1	21.8428	18.9433**
/2 B	1	0.9015	0.7816
Variety x Fertilizer	21	0.8299	0.7196
Error	93	1.1534	

**Denotes statistical significance at the 1 percent probability level.

/1 A Treatments 0-0-0 and 60-0-0 vs. Other Treatments.

/2 B Treatment 0-0-0 vs. Treatment 60-0-0.

TABLE VII

FORAGE YIELD OF FOUR ANNUAL SORGHUM VARIETIES

FROM THE SECOND CUTTING

Variety	Yield Oven-dry Forage lbs/60 ft^2	*
Piper	4.1103	
Sweet Sioux	3.8747	
SX-11	3.8744	
Lahoma	3.5488	

*Any two means covered by the same line are not significantly different at the 5 percent level of probability.

L.S.D. 5% = 0.5406

TABLE VIII

AVERAGE YIELD OF FOUR ANNUAL SORGHUM VARIETIES AT THE TIME OF THE SECOND CUTTING AS AFFECTED BY EIGHT FERTILIZER TREATMENTS

Treatment	Yield Oven-dry Forage lbs/60 ft.^{2}	*
60 - 60 - 30	4.3225	
60 - 90 - 00	4.2213	
60 - 60 - 00	4.1450	
60 - 30 - 00	4.0788	
60 - 90 - 30	4.0713	
60 - 30 - 30	3.6894	
60 - 00 - 00	3.3019	
00 - 00 - 00	2.9662	

*Any two means covered by the same line are not significantly different at the 5 percent level of probability.

L.S.D. 5% = 0.7541

L.S.D. 1% = 0.9986

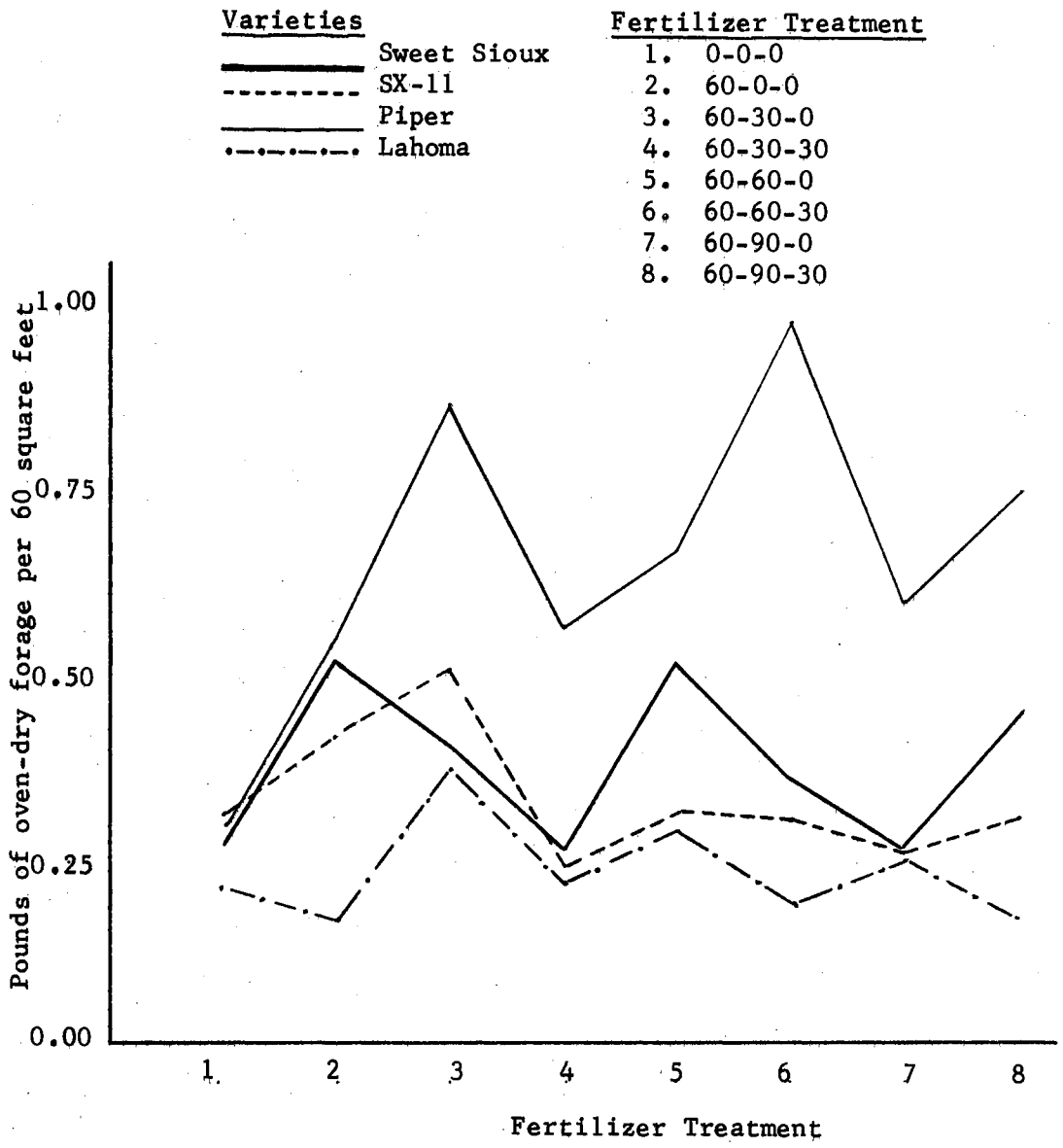

Figure 3. Forage Production of Four Annual Sorghum Varieties at the Time of the Third Cutting on October 25, 1964 as Affected by Eight Fertilizer Treatments.

TABLE IX

STATISTICAL ANALYSES OF FORAGE YIELDS FROM FOUR ANNUAL SORGHUM VARIETIES AT THE TIME OF THE THIRD CUTTING ON OCTOBER 25,1964 ABOUT SIX WEEKS AFTER THE SECOND HARVEST

Source of Variation	Degrees of Freedom	Mean Square	F.
Total	127		
Replication	3	0.0799	1.4890
Variety	3	1.0004	18.6375**
Fertilizer	7	0.1146	
Phosphorus	2	0.0414	0.7713
Potassium	1	0.0408	0.7608
P. x K.	2	0.1843	3.4336*
Others	2	0.1549	2.8856
Variety x Fertilizer	21	0.0513	0.9550
Error	93	0.0537	

*Denotes statistical significance at the 5 percent probability level.

**Denotes statistical significance at the 1 percent probability level.

TABLE X

FORAGE YIELD OF FOUR ANNUAL SORGHUM VARIETIES

FROM THE THIRD CUTTING

Variety	Yield Oven-dry Forage lbs/60 ft^2	*
Piper	0.6475	|
Sweet Sioux	0.3788	|
SX-11	0.3325	|
Lahoma	0.2341	|

*Any two means covered by the same line are not significantly different at the 5 percent level of probability.

L.S.D. 5% = 0.1150

L.S.D. 1% = 0.1523

produced significantly less forage at this time than the other three varieties. Sweet Sioux and SX-11 produced essentially the same amount during this time. Differences in yields as affected by fertilizer treatments were largely due to an interaction between phosphorus and potassium as shown in Table IX. A fertilizer combination of N-P-K at the rate of 60-60-30, on an elemental basis, produced significantly higher yields than 60-30-30 at the 5 percent level of probability.

All Cuttings

Forage yields from all cuttings of four annual sorghum varieties in 1964 as affected by eight fertilizer treatments are shown in Figure 4. The hybrid variety Sweet Sioux was highest in yield, whereas Lahoma produced the least forage.

When these data were analyzed statistically as shown in Table XII, highly significant differences in forage yields were found among varieties and treatments. Highly significant differences in forage production among varieties were the result of higher yields from Sweet Sioux, SX-11 and Piper, and very low yields from Lahoma as indicated in Table XIII. The addition of 30 pounds or more of phosphorus with an application of 60 pounds of nitrogen at planting time and 60 pounds after each cutting resulted in a significant increase in forage production as shown in Table XIV, regardless of whether potassium was added or not. Phosphorus application at 60 or 90 pounds per acre on an elemental basis with 60 pounds of nitrogen at the time of seeding and 60 pounds after each cutting resulted in a trend of increased forage yields when compared with a phosphorus application of 30 pounds with 60 pounds of nitrogen per acre. Nitrogen alone applied at 60 pounds per acre and

TABLE XI

AVERAGE YIELD OF FOUR ANNUAL SORGHUM VARIETIES AT THE TIME OF THE THIRD CUTTING AS AFFECTED BY EIGHT FERTILIZER TREATMENTS

Treatment	Yield Oven-dry Forage lbs/60 ft^2	*
60 - 30 - 00	0.5338	
60 - 60 - 30	0.4519	
60 - 60 - 00	0.4425	
60 - 90 - 30	0.4169	
60 - 00 - 00	0.4125	
60 - 90 - 00	0.3381	
60 - 30 - 30	0.3219	
00 - 00 - 00	0.2681	

*Any two means covered by the same line are not significantly different at the 5 percent level of probability.

L.S.D. 5% = 0.1626

L.S.D. 1% = 0.2154

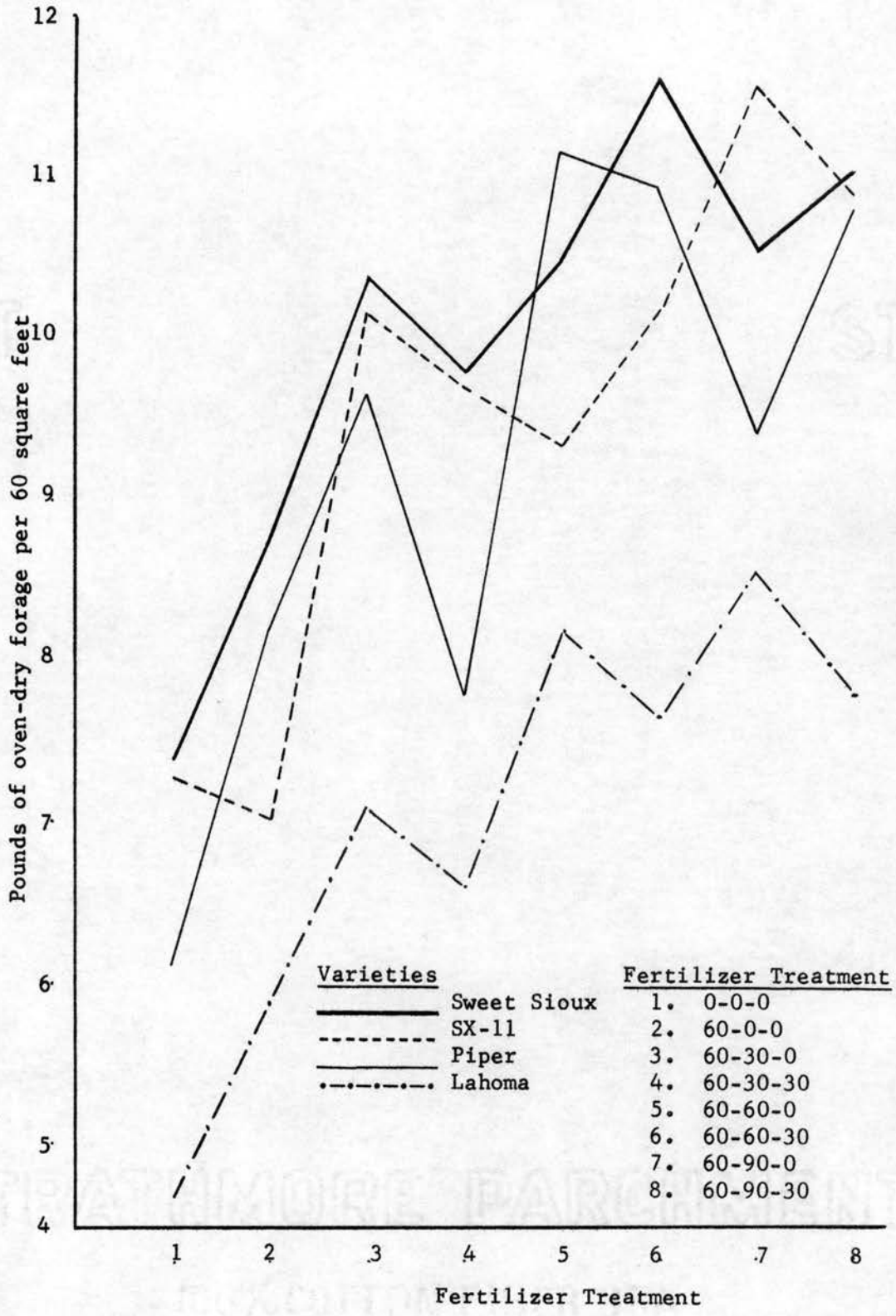

Figure 4. Forage Production for All Cuttings of Four Annual Sorghum Varieties in 1964 as Affected by Eight Fertilizer Treatments.

TABLE XII

STATISTICAL ANALYSES OF TOTAL FORAGE YIELDS FROM FOUR ANNUAL SORGHUM VARIETIES

Source of Variation	Degrees of Freedom	Mean Square	F.
Total	127		
Replication	3	2.0070	1.0058
Variety	3	55.9023	28.0158**
Fertilizer	7	32.0458	16.0599**
Phosphorus	2	13.6413	6.8364**
Potassium	1	0.6256	0.3135
P. x K.	2	3.2742	1.6409
Others	2	94.9318	47.5757**
/1 A	1	180.0180	90.2172**
/2 B	1	9.8461	4.9345*
Variety x Fertilizer	27	1.8638	0.9341
Error	93	1.9954	

*Denotes statistical significance at the 5 percent probability level.

**Denotes statistical significance at the 1 percent probability level.

/1 A = Treatments 0-0-0 and 60-0-0 vs. Other Treatments.

/2 B = Treatment 0-0-0 vs. Treatment 60-0-0.

TABLE XIII

TOTAL FORAGE YIELD OF FOUR ANNUAL SORGHUM VARIETIES

Variety	Yield Oven-dry Forage in pounds per 60 sq. ft. First Harvest	Second Harvest	Third Harvest	Total	*
Sweet Sioux	5.7216	3.8747	0.3788	9.9751	
SX-11	5.2865	3.8744	0.3325	9.4925	
Piper	4.4611	4.1103	0.6475	9.2189	
Lahoma	3.2856	3.5488	0.2341	7.0685	

*Any two means covered by the same line are not significantly different at the 5 percent level of probability.

L.S.D. 5% = 0.7013

L.S.D. 1% = 0.9286

TABLE XIV

AVERAGE TOTAL FORAGE YIELD OF FOUR ANNUAL SORGHUM VARIETIES AS AFFECTED BY EIGHT FERTILIZER TREATMENTS

Treatment	Yield Oven-dry Forage in pounds per 60 sq. ft. First Harvest	Second Harvest	Third Harvest	Total	*
60 - 90 - 30	5.6063	4.0713	0.4169	10.0945	
60 - 60 - 30	5.2931	4.3225	0.4519	10.0675	
60 - 90 - 00	5.4213	4.2213	0.3381	9.9807	
60 - 60 - 00	5.1763	4.1450	0.4425	9.7638	
60 - 30 - 00	4.6863	4.0788	0.5338	9.2989	
60 - 30 - 30	4.3956	3.6894	0.3219	8.4069	
60 - 00 - 00	3.7050	3.3019	0.4125	7.4194	
00 - 00 - 00	3.0756	2.9662	0.2681	6.3099	

*Any two means covered by the same line are not significantly different at the 5 percent level of probability.

L.S.D. 5% = 0.9918

L.S.D. 1% = 1.3134

60 pounds after each cutting produced a statistically higher yield then the unfertilized plots.

CHAPTER V

SUMMARY AND CONCLUSIONS

A field experiment was conducted to determine the effect of eight fertilizer treatments on forage yield of four annual sorghum varieties in the summer of 1964, on a Norge loam soil at the Agronomy Research Station, Stillwater, Oklahoma.

Results from the statistical analyses of the total data showed there were highly significant differences in forage yields among varieties and fertilizer treatments.

Sweet Sioux and SX-11 were not statistically different in forage production at the 5 percent level of probability, but they were significantly higher in yield than Piper. Though Piper was lower in yield than SX-11, it was not significantly different at the 5 percent level of probability. These three varieties were statistically different in yield than Lahoma at the 1 percent level of probability.

Fertilizer treatments showed that at least 30 pounds of phosphorus were required to obtain maximum yields of these annual forage sorghums with applications of nitrogen at the rate of 60 pounds initially and 60 pounds per acre after each cutting. The application of nitrogen alone at 60 pounds per acre at seeding time and 60 pounds after each cutting increased the forage production above that obtained from unfertilized plots.

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APPENDIX

APPENDIX TABLE I

MEAN YIELDS OF FORAGE IN POUNDS PER 60 SQURARE FEET AS INFLUENCED BY DIFFERENT VARIETIES AND DIFFERENT RATES OF FERTILIZERS AT THE TIME OF THE FIRST CUTTING

Variety	Treatment								Average
	00-00-00	60-00-00	60-30-00	60-30-30	60-60-00	60-60-30	60-90-00	60-90-30	
Piper	2.9450	3.2900	4.0900	3.5400	5.3750	5.1275	4.8850	6.4400	4.4611
Lahoma	1.8175	2.7000	3.2300	2.6950	3.9025	3.5150	4.2650	3.5625	3.2856
SX-11	3.6850	3.6375	5.6800	5.7225	5.6075	5.5200	6.3850	6.0475	5.2856
Sweet Sioux	3.8550	5.1925	5.7450	5.6250	5.8200	7.0100	6.1500	6.3750	5.7216
Average	3.0756	3.7050	4.6863	4.3956	5.1763	5.2931	5.4213	5.6063	

APPENDIX TABLE II

MEAN YIELDS OF FORAGE IN POUNDS PER 60 SQUARE FEET AS INFLUENCED BY DIFFERENT VARIETIES AND DIFFERENT RATES OF FERTILIZERS AT THE TIME OF SECOND CUTTING

Variety	Treatment								Average
	00-00-00	60-00-00	60-30-00	60-30-30	60-60-00	60-60-30	60-90-00	60-90-30	
Piper	2.8475	4.3125	4.6700	3.6000	5.0900	4.8100	3.8925	3.5800	4.1103
Lahoma	2.5700	2.9350	3.4575	3.6150	3.9675	3.8825	3.9800	3.9825	3.5488
SX-11	3.2400	2.9200	3.9375	3.6800	3.4000	4.3600	4.9400	4.5175	3.8744
Sweet Sioux	3.2075	3.0400	4.2500	3.8625	4.1225	4.2375	4.0725	4.2050	3.8747
Average	2.9662	3.3019	4.0788	3.6894	4.1450	4.3225	4.2213	4.0713	

APPENDIX TABLE III

MEAN YIELDS OF FORAGE IN POUNDS PER 60 SQUARE FEET AS INFLUENCED BY DIFFERENT VARIETIES AND DIFFERENT RATES OF FERTILIZERS AT THE TIME OF THE THIRD CUTTING

Variety	Treatment								Average
	00-00-00	60-00-00	60-30-00	60-30-30	60-60-00	60-60-30	60-90-00	60-90-30	
Piper	0.2825	0.5425	0.8525	0.5575	0.6625	0.9600	0.5850	0.7375	0.6475
Lahoma	0.2100	0.1725	0.3700	0.2200	0.2800	0.1925	0.2500	0.1775	0.2341
SX-11	0.3075	0.4125	0.5100	0.2475	0.3150	0.3025	0.2525	0.3125	0.3325
Sweet Sioux	0.2725	0.5225	0.4025	0.2625	0.5125	0.3525	0.2650	0.4400	0.3788
Average	0.2681	0.4125	0.5338	0.3219	0.4425	0.4519	0.3381	0.4169	

APPENDIX TABLE IV

MEAN OF TOTAL FORAGE YIELDS IN POUNDS PER 60 SQUARE FEET AS INFLUENCED BY DIFFERENT RATES OF FERTILIZERS ON FOUR VARIETIES OF ANNUAL FORAGE SORGHUMS

Variety	Treatment								Average
	00-00-00	60-00-00	60-30-00	60-30-30	60-60-00	60-60-30	60-90-00	60-90-30	
Piper	6.0750	8.1450	9.6125	7.6975	11.1450	10.8975	9.3625	10.7575	9.2189
Lahoma	4.5975	5.8075	7.0575	6.5300	8.1500	7.5900	8.4950	7.7225	7.0685
SX-11	7.2325	6.9700	10.1275	9.6500	9.3225	10.1825	11.5775	10.8775	9.4925
Sweet Sioux	7.3350	8.7550	10.3975	9.7500	10.4550	11.6000	10.5075	11.0175	9.9751
Average	6.3099	7.4194	9.2989	8.4069	9.7638	10.0675	9.9807	10.0945	

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