A LEAF-STEM RATIO STUDY OF SIX ANNUAL FORAGE GRASSES

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INTRODUCTION

Livestock producers and dairymen are becoming more concerned about the quality of forage fed to their animals. Midsummer declines in both milk production and daily gain of beef cattle have been a problem confronting dairy and livestock producers for some time. Forage of low quality as well as quantity is a contributing factor to this decline in production. Supplemental pastures have long been used in an attempt to minimize losses in milk and beef production.

The production of large quantities of green succulent forage of high nutritive value would appear to be a possible solution for maintenance of production in midsummer. Sudangrasses, sorghum-sudan hybrids and millet forages can be grown as a supplemental pasture or hay crop successfully in Oklahoma through the hot dry months and have gained widespread acceptance. However, these forages differ in quality and it would be beneficial to dairy or livestock producers to know the feeding value of these types of forages.

This study was initiated with the objective of determining the relative leafiness and protein content of six annual forage grass varieties. These varieties include Lahoma Sweet sudangrass, Piper Common sudangrass, one Sorghum-Sudangrass hybrid, variety SX-11, and one Sorgo-Sudangrass hybrid, variety Sweet Sioux. One Piper Sudangrass x Sorghum propinquum cross, variety PXP, was included along with the improved Pearl millet, variety Gahi-1.

REVIEW OF LITERATURE

Although much research has been done on the management factors that affect quality of forages, relatively little research has been done concerning total digestible nutrients of individual plant parts and the heritability of these parts.

The stems of forages differ considerably from the leaves in amounts of total digestible nutrients. Bumpus (2) made a chemical analysis of alfalfa and presented the following results of leaf and stem respectively; crude protein 34.9 percent and 22.1 percent; crude fiber 13.1 percent and 31.4 percent; calcium 1.06 percent and 0.62 percent; phosphorous 0.38 percent and 0.36 percent. After analyzing the feeding value of leaves and stems in tropical grasses Dirven (8) found that crude protein and fats were considerably higher in leaves and crude fiber was usually higher in stems. Sotola (25) observed that 67 to 83 percent of the total protein of the alfalfa plant was contained in the leaves as well as 71 to 85 percent of the calcium and 46 to 79 percent of the phosphorous. Sotola concluded that a given weight of leaves was almost 3.57 times as effective as the same weight of stems in supplying digestible protein. Thurman and Staten (29) in research conducted in Arkansas have shown that the crude protein content of sorgo plants is highest in the leaf blades. It is next highest in the heads and is lowest in leaf sheaths and stalks.

Pigden (18) in a study of the relation of lignin, cellulose, protein, starch and ether extract of range grasses found that a very

high portion of the stem material of cultivated grasses is structural material most of which is heavily lignified.

Numerous studies show that forage plants contain relatively large amounts of lignin which increase with maturity, and changes in this constituent have been considered as a partial explanation of the lowered feeding value of matured forages. In general, studies (4, 5, 10, 11, 13, 14, 16, 18, 20, 26, 28) have shown that lignin in plants is not only practically indigestible but also decreases the availability of other constituents. Patton and Gieseker (17) claimed that lignin acts as a physical barrier to the microorganism activity of the rumen. Forbes and Garrigus (10) and several other investigators have shown a high negative correlation between lignin and dry matter digestibility, and lignin and total digestible nutrients. However, Richards et. al. (22) found a significant positive correlation between lignin and dry matter digestibility.

Lignin may be defined as that encrusting material of the plant which is built up mainly, if not entirely, of phenylpropane. Lignin gives rigidity to plants, and as reported by Pigden (18) it is found mainly in the stem.

An increase in leafiness in grasses increases forage quality. Several investigators have found that percentage of leaves can be increased by different management factors. Hoelscher (12) investigating the changes in the leaf-stem ratio and moisture content of alfalfa at different maturities and heights of cutting found that when alfalfa was cut at 4 inches above ground level instead of 2 inches there was a yield reduction of 5.8 percent but an increase of 5.8 percent in the percentage of total digestible nutrients.

The stage of maturity is correlated with leaf-stem ratio and

percent protein. Cragmiles et. al. (6) evaluating quality of sudangrass and millet forages found that as plants approach maturity the percent leafiness is less. The same investigators have shown as plants reach maturity the crude protein decreases but the percentages of lignin (17) and crude fiber (13, 16) increase. Rauzi and Lang (21) ran a preliminary study on annual pastures for Wyoming drylands. They found that sudangrass decreased from 8.66 percent in crude protein at the beginning of the season to 4.24 percent by mid September.

Different rates and kinds of fertilizer have an effect on crude protein, percent lignin and phosphorous concentration. Achacoso et. al. (1) applied rates of 0, 30, 60, 120 and 240 pounds of nitrogen per acre on sudangrass and millet. Increases from 0 to 120 pounds of nitrogen applied per acre increased the percentage of crude protein from 7.4 to 13.5 percent, decreased the percentage of crude fiber from 32 to 20.1 percent and had no significant effect on percentage of lignin. Sullivan (27) studying the effect of temperature and phosphate fertilization on yields and composition of Piper sudangrass found that crude protein percentages were less at concentrations of P_2O_5 above 25 ppm. The average differences in lignin percentages among levels of phosphorous fertilization were insignificant. Phosphorous concentration within the forages increased with increased rates of P_2O_5 fertilization at 70 degrees Fahrenheit.

Burger and Campbell (3) investigated the effects of rates and method of seeding on the original stand, tillering, stem diameter and leaf-stem ratio of sudangrass and found that the percent of leaves of broadcast sudangrass was greater than that of the drilled sudangrass in the first harvest. This difference was not sustained in either the second or third harvest.

The leaf-stem ratio and crude protein of stems and leaves vary with varieties. Pickett (19) found that in Kansas the degree of leafiness and tillering, as well as diameter of stems and width of leaves, varies with the variety of sudangrass. Mehrotra (15) studying inheritance of forage leaf number in maize found that heritability of leaf number was high, ranging from 44.9 to 70.38 percent. Denman (7) made a leaf-stem ratio comparison of Lahoma, Tift, and Piper sudangrasses. He found that Lahoma had a higher percent leafiness and concluded leafiness to be an improvement in quality since leaves are preferred to stems by grazing animals.

MATERIALS AND METHODS

In the summer of 1963 a leaf-stem ratio study was conducted using six annual forage grass varieties (Table I.) grown on a Vanoss silt loam soil at the Agronomy Research Station, Perkins, Oklahoma.

The purpose of this study was to determine the relative percentages of leaves and stems for each variety. Since the leaves are green and succulent and are high in protein and minerals as compared to the other plant parts, a high leaf ratio should improve feeding value. Crude protein determinations were made by the Kjeldahl method on stems and leaves of each variety. These were used as a guide for quality evaluations of leaves and stems.

The field layout consisted of a randomized block design with four replications. Each plot consisted of 5 rows, 12 inches apart and 20 feet long. A 3 by 5 foot rectangular area was selected at random from each plot for leaf-stem ratio determinations.

All varieties were seeded with a one-row hand-operated Planet Junior garden planter on June 5, 1963. Piper and Lahoma were seeded at the rate of 20 pounds per acre. SX-11, Sweet Sioux and PXP were seeded at the rate of 30 pounds per acre. Gahi-1 Pearl millet was seeded at the rate of 15 pounds per acre. Fertilization consisted of 100 pounds of 33.5-0-0 per acre applied on June 24 and 100 pounds of 33.5-0-0 applied on July 27, one week after the first harvest. All applications were made with a Gandy spreader.

TABLE I.

VARIETIES OF SIX ANNUAL FORAGE GRASSES
ENTERED IN A LEAF-STEM RATIO STUDY

Variety		Type
Piper	Sorghum sudanense, Hitchc.	Common Sudangrass
PXP	Sorghum sudanense, Hitchc. x Sorghum propinquum	Piper x Sorghum propinquum
Lahoma	Sorghum sudanense, Hitchc.	Sweet Sudangrass
SX-11	Sorghum vulgare, Pers. x Sorghum sudanense, Hitchc	Sorghum-Sudan hybrid
Sweet Sioux	Sorghum vulgare, Pers. x Sorghum sudanense, Hitchc.	Sorgo-Sudan hybrid
Gahi-1	Pennisetum glaucum, R. Br.	Hybrid Pearl millet

One inch of supplemental water was applied on July 11 and on August 28 with a sprinkler irrigation system. The time of application was determined by signs of moisture stress from the plant leaves.

The forage was harvested twice. The first harvest on July 19, 38 days after the varieties were planted, was cut in boot to early bloom stage. A second harvest on August 19, 37 days after the first harvest, was cut in the boot to full bloom stage. On each harvest date the forage was clipped with a Jari mower set to cut at a height of 4 inches. The harvested forage was separated into leaves and stems. Green weight measurements were taken of leaves and stems from each plot. A random sample was then selected for dry weight measurements. These samples were oven-dried in a forced air oven at 148 degrees Fahrenheit for 72 hours. After dry samples were weighed and recorded, a random sample of leaves and one of stems was then taken for protein determination from each treatment.

Statistical analyses of the data collected were conducted as outlined by Snedecor (24) and Duncan (9).

RESULTS AND DISCUSSION

The percentages of leaves and stems for six annual forage grass varieties are shown in Table II. In the first harvest, Gahi-1 had the highest percent leaves with 86.1 percent. Lahoma was next with 67.1 percent leaves. Next to Lahoma was PXP with 61.0 percent leaves. The rest of the varieties had less than 50 percent leaves. In the second harvest all varieties had less than 50 percent leaves. Lahoma had the highest yield of leaves with 48.6 percent. It was followed closely by PXP.

Optimum growing conditions prevailed prior to the first harvest. Results from the first harvest would support the assumption that the degree of leafiness was due to relative productive capacity of the genotypes for leafiness for the different varieties. In the second growth period lack of moisture and high temperature near the end of the growing period caused the plants to mature rapidly. The first harvest plants were in boot to early bloom stage when harvested. The second harvest plants were in boot to full bloom stage. Rusoff et. al. (23) observed that the advancement in maturity of sudangrass is characterized by rapid elongation of the stem during the period immediately preceding bloom. This would account for the increase in the percentage of stems which characterized the yield data for the second harvest.

Although all varieties had low leaf percentages in the second harvest, there was a variation among varieties. This could be

TABLE II.

LEAF AND STEM PERCENTAGES OF SIX ANNUAL FORAGE GRASS VARIETIES ON A WEIGHT BASIS, PERKINS, OKLAHOMA, 1963.

Varieties	First Harvest		Second Harvest		Both Harvests	
	% Leaves	% Stems	% Leaves	% Stems	% Leaves	% Stems
Lahoma	67.1	32.9	48.6	51.4	59.7	40.3
Gahi-1	86.1	13.9	38.0	62.0	57.8	42.2
Piper	48.5	51.5	30.4	69.6	46.2	53.8
PXP	61.0	39.0	40.6	59.4	45.3	54.7
SX-11	45.3	54.7	37.1	62.9	41.1	58.9
Sweet Sioux	48.2	51.8	33.8	66.2	39.5	60.5

attributed to stage of maturity of the varieties. It was observed that Piper, Sweet Sioux, SX-11 and Gahi-1 were in full bloom while Lahoma and PXP were in boot to mid bloom stage. Comparative yields of leaves and stems are presented in Figures 1, 2 and 3.

Multiple range tests are presented in Tables III, IV and V. Gahi-1 produced significantly more leaves than any other variety in the first harvest, but in the second harvest Sweet Sioux was highest. Total leaf yield from both harvests was the same for these two varieties, but each produced significantly more than the other varieties.

Sweet Sioux outyielded all other varieties in total forage per acre but produced significantly more stems per acre for each harvest and in total yield.

Table VI shows the percentages of protein for the six varieties. In the first harvest Gahi-1 was high with 14.7 percent. It was followed closely by PXP. In the second harvest the protein percentage of all varieties dropped as did the leaf percentage shown in Table II. Table VII shows the percentages of total protein produced in the leaves. The percentage of protein was apparently affected by the percentage of leaves. In the first harvest Gahi-1 had the highest percentage of leaves and the highest protein content. In the second harvest Lahoma had the highest percentage of leaves and the highest protein content.

Figures 4, 5 and 6 show the comparative yields of protein for both stems and leaves and total protein.

Multiple range tests are shown in Tables VIII, IX and X. Total leaf protein was significantly greater in Gahi-1 for the first harvest, but for the second harvest and total yield Sweet Sioux was significantly higher.

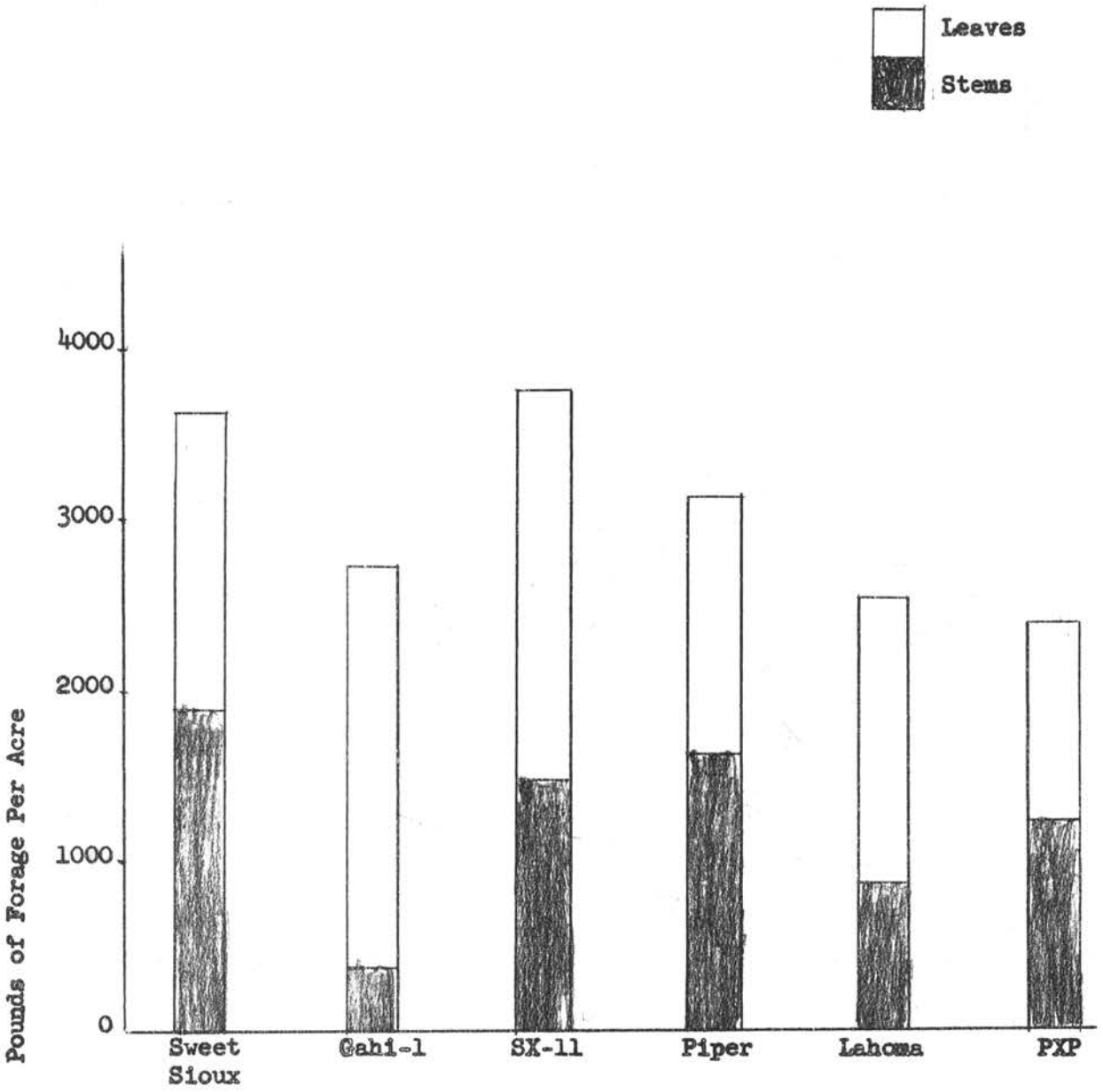

Figure 1. Leaf, Stem, and Total Yield for First Harvest of Six Annual Forage Grass Varieties, Perkins, Oklahoma, 1963.

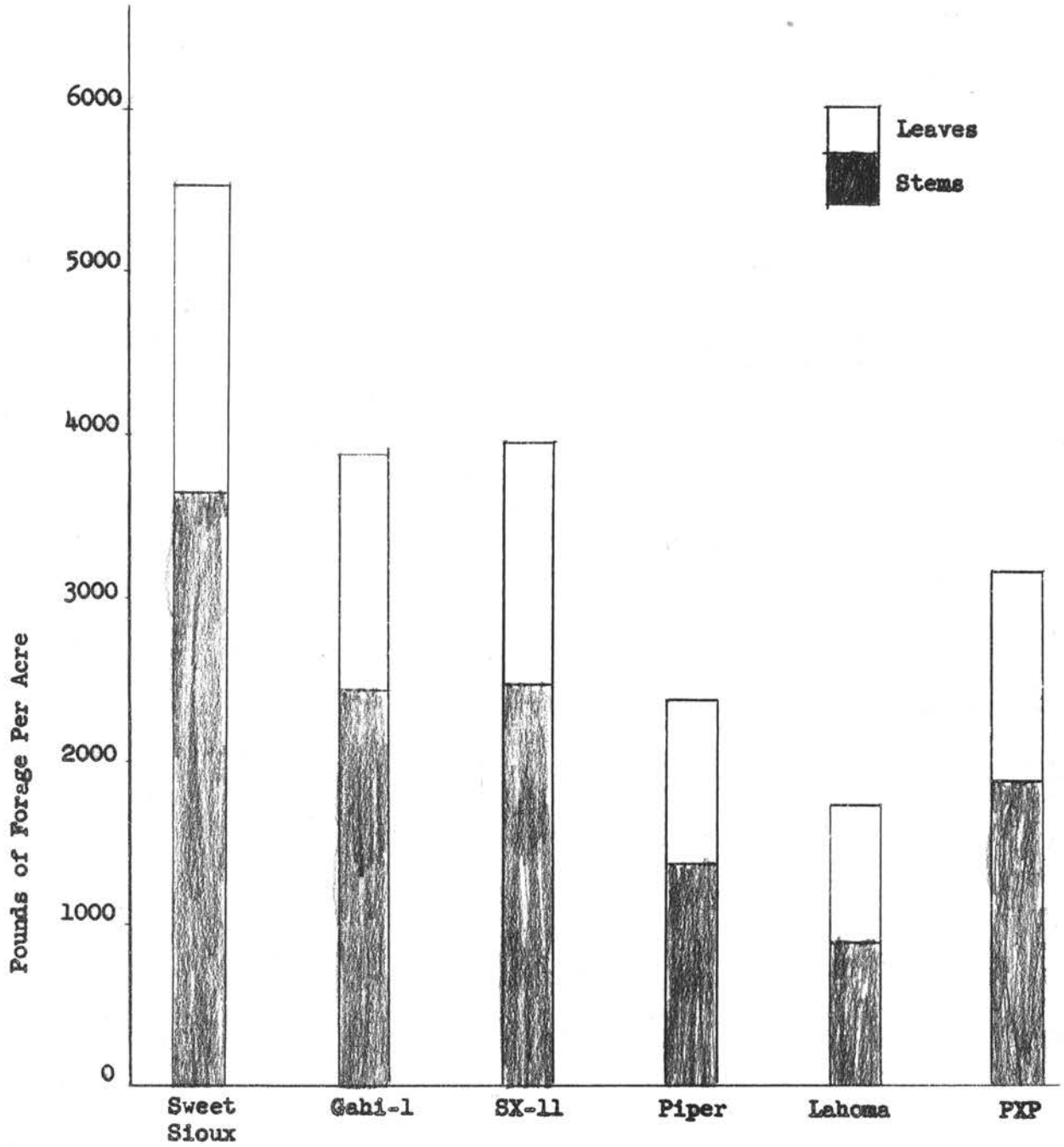

Figure 2. Leaf, Stem, and Total Yield for Second Harvest of Six Annual Forage Grass Varieties, Perkins, Oklahoma, 1963.

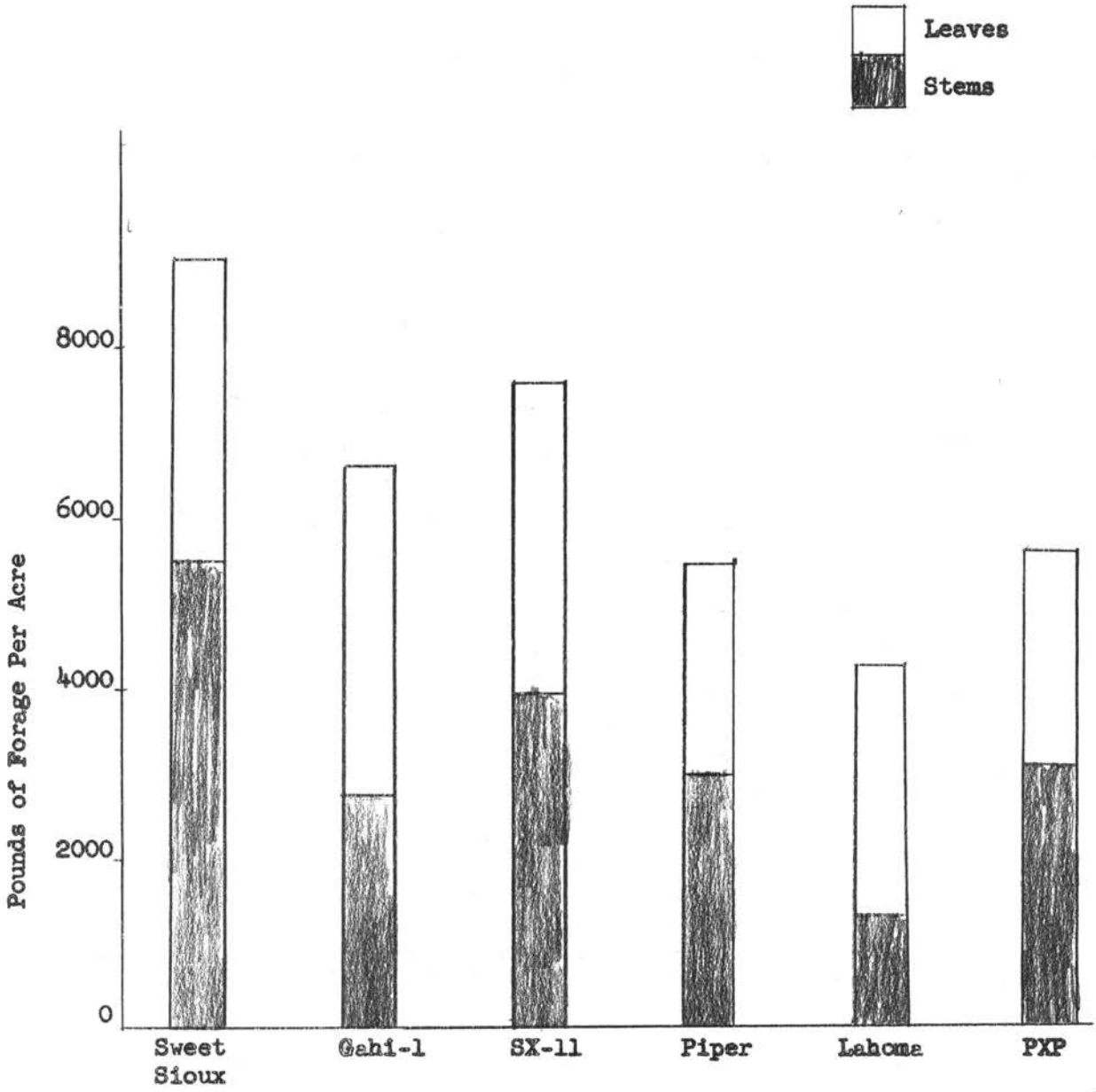

Figure 3. Leaf, Stem and Total Yield for Two Harvests of Six Annual Forage Grass Varieties, Perkins, Oklahoma, 1963.

TABLE III.

LEAF YIELD IN POUNDS OF FORAGE PER ACRE OF SIX ANNUAL FORAGE GRASS VARIETIES, PERKINS, OKLAHOMA. 1963. DUNCAN'S MULTIPLE RANGE TEST

Treatment	First Harvest	Second Harvest	Total
Gahi-1	2346 a[1]	1482 b	3828 a
Sweet Sioux	1749 b	1877 a	3626 a
SX-11	1699 b	1462 b	3161 b
PXP	1292 c	1284 b	2576 c
Lahoma	1720 b	839 c	2559 c
Piper	1524 c	1034 c	2558 c

[1] Numbers followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE IV.

STEM YIELD IN POUNDS OF FORAGE PER ACRE OF SIX ANNUAL FORAGE GRASS VARIETIES, PERKINS, OKLAHOMA. 1963. DUNCAN'S MULTIPLE RANGE TEST

Treatment	First Harvest	Second Harvest	Total
Sweet Sioux	1880 a[1]	3668 a	5548 a
SX-11	1466 c	2484 b	3950 b
PXP	1227 d	1878 c	3105 c
Piper	1619 b	1366 d	2985 c
Gahi-1	377 f	2419 b	2796 c
Lahoma	842 e	887 c	1729 d

[1] Numbers followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE V

TOTAL YIELD IN POUNDS OF FORAGE PER ACRE OF SIX ANNUAL FORAGE GRASS VARIETIES, PERKINS, OKLAHOMA. 1963
DUNCAN'S MULTIPLE RANGE TEST

Treatment	First Harvest	Second Harvest	Total
Sweet Sioux	3629 a[1]	5545 a	9174 a
SX-11	3753 a	3947 b	7690 b
Gahi-1	2722 c	3900 b	6622 c
PXP	2519 c	3162 c	5681 d
Piper	3143 b	2400 d	5543 d
Lahoma	2562 c	1726 e	4288 c

[1] Numbers followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE VI.

TOTAL PLANT PROTEIN PERCENTAGE OF SIX ANNUAL FORAGE GRASSES, PERKINS, OKLAHOMA. 1963.

Variety	First Harvest	Second Harvest	Both Harvests
Lahoma	13.3	8.6	11.4
Piper	11.5	7.7	9.8
Gahi-1	14.7	5.4	9.2
PXP	11.8	6.7	9.0
SX-11	10.5	5.6	8.0
Sweet Sioux	11.4	6.0	8.1

Percentage of protein was determined by the Kjeldahl method.

TABLE VII.

PERCENTAGE OF TOTAL PLANT PROTEIN FOUND IN LEAVES OF SIX ANNUAL FORAGE GRASSES, PERKINS, OKLAHOMA, 1963.

Variety	First Harvest	Second Harvest	Both Harvests
Gahi-1	90.4	65.4	81.8
Lahoma	83.1	73.2	80.1
Sweet Sioux	75.3	77.9	76.4
Piper	74.4	75.9	75.2
SX-11	74.1	72.7	73.6
PXP	74.7	66.7	71.4

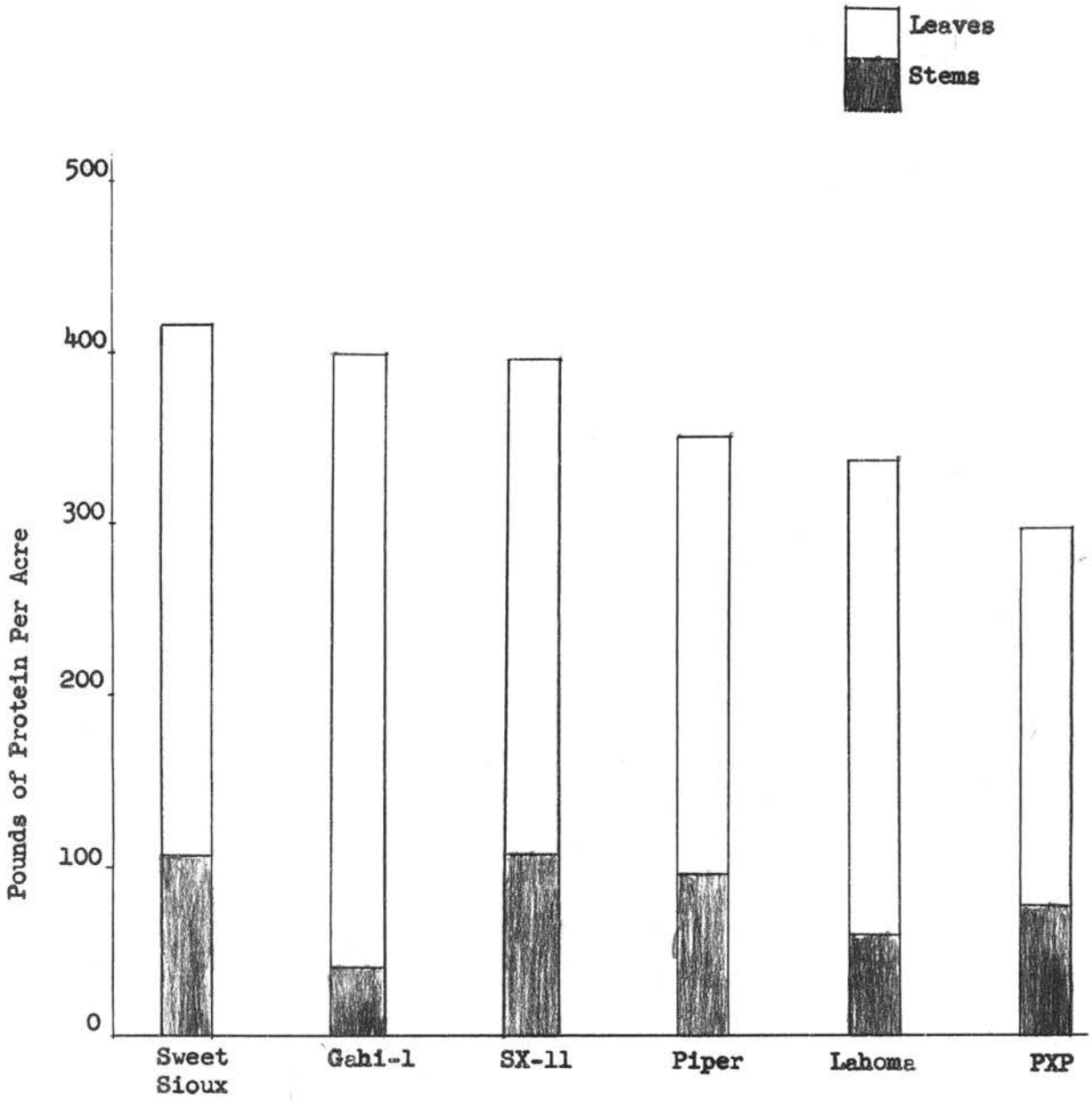

Figure 4. Protein Yield in Leaves and Stems for First Harvest of Six Annual Forage Grass Varieties. Perkins, Oklahoma, 1963.

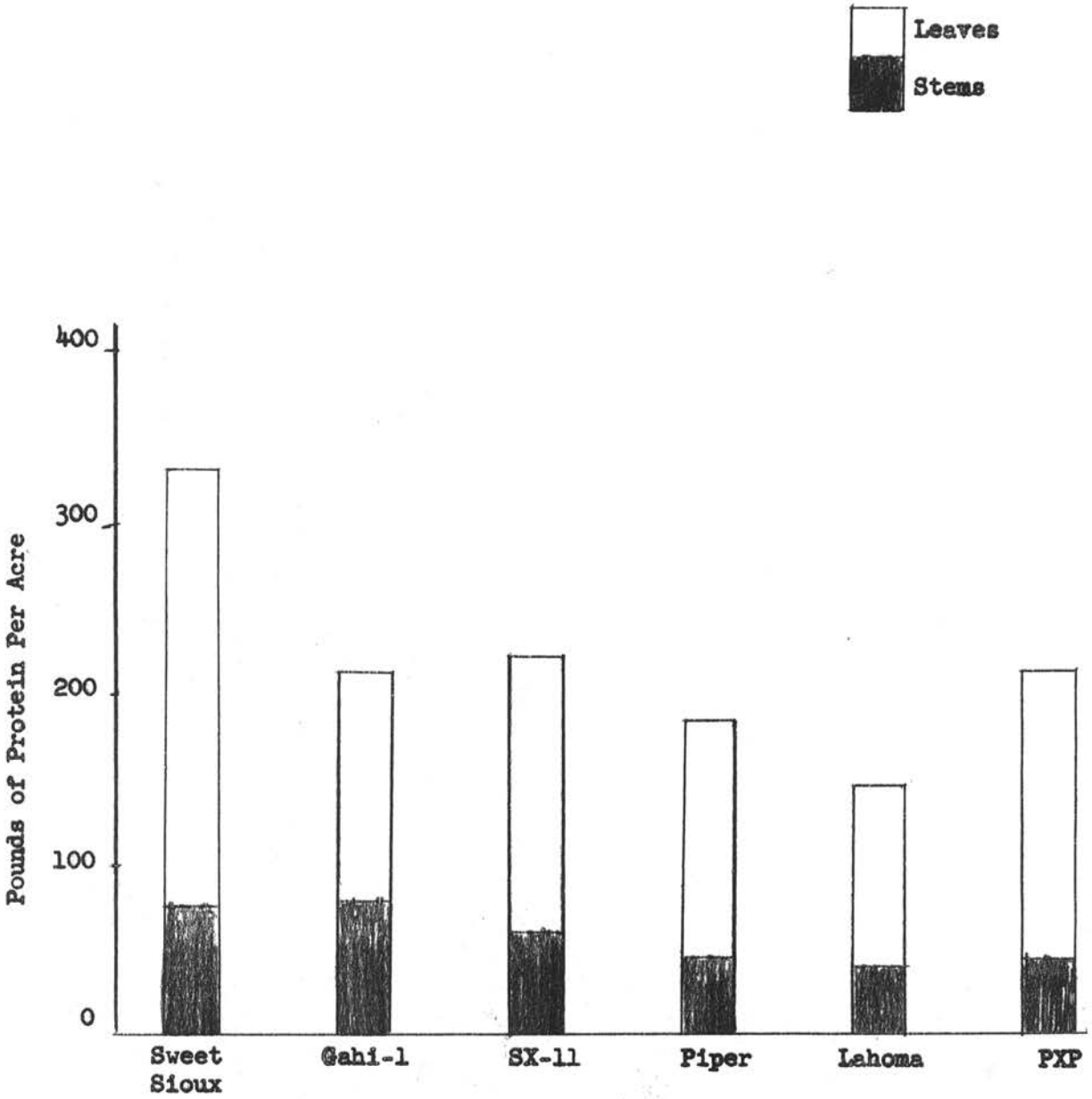

Figure 5. Protein Yield in Leaves and Stems for Second Harvest of Six Annual Forage Grass Varieties, Perkins, Oklahoma, 1963.

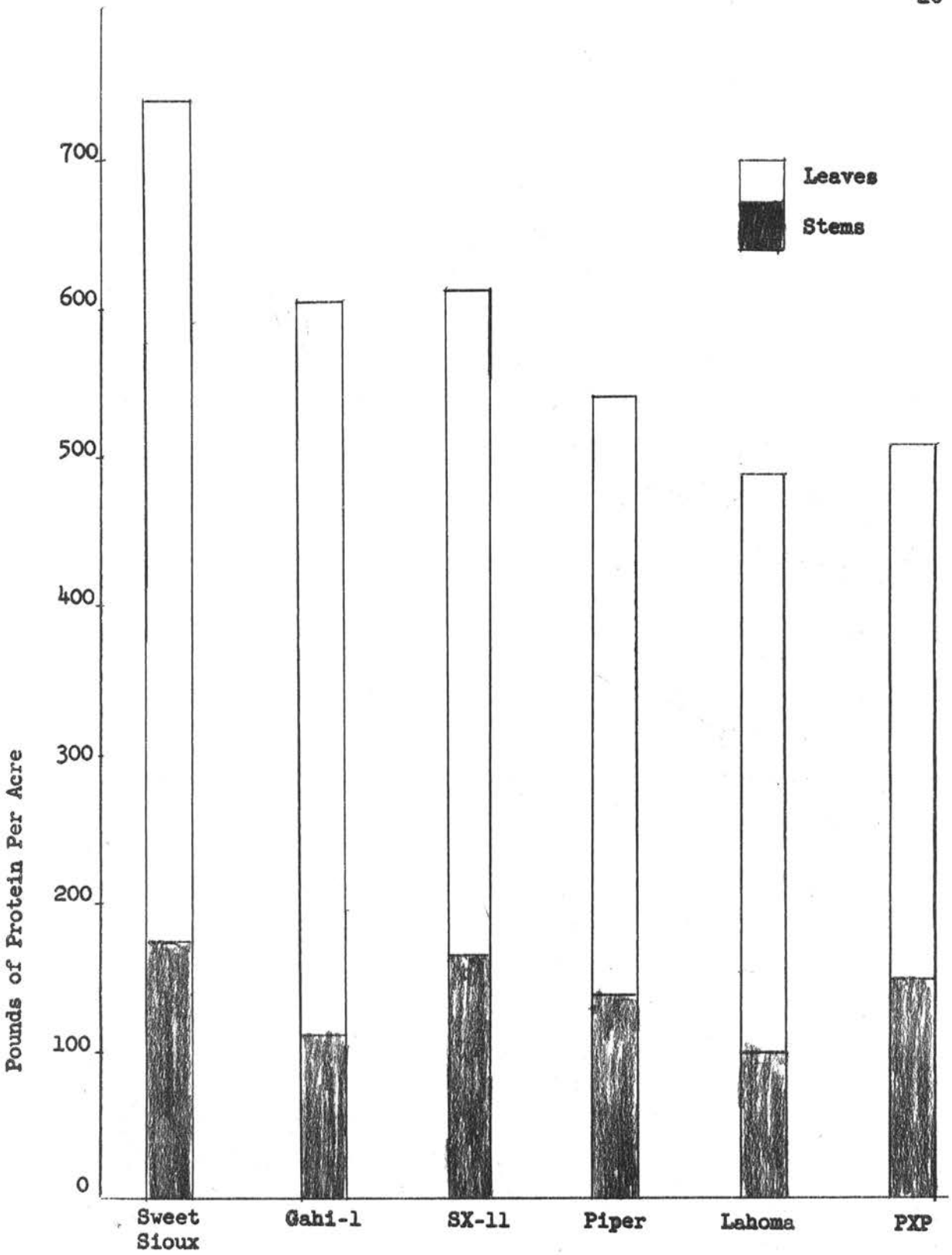

Figure 6. Protein Yield in Leaves and Stems for Two Harvests of Six Annual Forage Grass Varieties, Perkins, Oklahoma, 1963.

TABLE VIII.

PROTEIN YIELD IN LEAVES IN POUNDS PER ACRE OF SIX ANNUAL FORAGE GRASS VARIETIES, PERKINS, OKLAHOMA. 1963. DUNCAN'S MULTIPLE RANGE TEST

Treatment	First Harvest	Second Harvest	Total
Sweet Sioux	311 b[1]	258 a	569 a
Gahi-1	361 a	138 c	499 b
SX-11	293 bc	162 b	455 c
Piper	269 c	140 bc	409 d
Lahoma	283 bc	109 d	392 de
PXP	222 d	141 bc	363 e

[1] Numbers followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE IX.

PROTEIN YIELD IN STEMS IN POUNDS PER ACRE OF SIX ANNUAL FORAGE GRASS VARIETIES, PERKINS, OKLAHOMA. 1963. DUNCAN'S MULTIPLE RANGE TEST

Treatment	First Harvest	Second Harvest	Total
Sweet Sioux	102 a[1]	73 a	175 a
SX-11	104 a	61 b	165 b
PXP	75 c	71 ab	146 c
Piper	93 b	44 c	137 c
Gahi-1	35 e	77 a	112 d
Lahoma	57 d	40 c	97 e

[1] Numbers followed by the same letters are not significantly different at the 0.05 level of probability.

TABLE X.

TOTAL PROTEIN YIELD IN POUNDS PER ACRE OF SIX ANNUAL FORAGE GRASS VARIETIES, PERKINS, OKLAHOMA. 1963. DUNCAN'S MULTIPLE RANGE TEST

Treatment	First Harvest	Second Harvest	Total
Sweet Sioux	413 a[1]	331 a	744 a
SX-11	395 ab	223 b	618 b
Gahi-1	399 ab	211 bc	610 b
Piper	362 bc	184 c	546 c
PXP	297 d	212 bc	509 cd
Lahoma	340 c	149 d	489 d

[1] Numbers followed by the same letters are not significantly different at the 0.05 level of probability.

Sweet Sioux outyielded all other varieties in total stem protein for the first and second harvests and total yield. However, it was not significantly higher than SX-11 for the first harvest.

Total protein production per acre by Sweet Sioux was significantly greater than all other varieties except SX-11 and Gahi-1.

SUMMARY AND CONCLUSIONS

A leaf-stem ratio study was conducted using six annual forage grass varieties grown on a Vanoss silt loam soil at the Agronomy Research Station, Perkins, Oklahoma. The varieties were Lahoma Sweet sudangrass, Piper Common sudangrass, a Sorghum-Sudangrass hybrid, variety SX-11, and a Sorgo-Sudangrass hybrid, variety Sweet Sioux. Also included were a Piper Sudangrass x Sorghum propinquum cross, variety PXP, and an improved Pearl millet, variety Gahi-1. Crude protein determinations were made for leaves and stems of each variety. This was used as a guide for quality determinations of leaves and stems. Two harvests were made. The first harvest on July 19, 38 days after the varieties were planted, was cut in boot to early bloom stage. The second harvest on August 19, 37 days after the first harvest, was cut in the boot to full bloom stage.

Since leaves are usually high in protein and minerals as compared to stem material, a variety with a high percentage of leaves should then be superior in feeding value. In the first harvest Gahi-1 had the highest percentage of leaves with 86.1 percent. Lahoma and PXP were second and third highest with 67.1 and 61.0 percent leaves. Sweet Sioux, SX-11 and Piper were below 50 percent in percent leaves. In the second harvest all varieties were below 50 percent in leaves. This was attributed to a more advanced stage of maturity characteristic of the plants at the second harvest. Lahoma had the

highest leaf percentage with 48.6 percent. In the sum of both cuttings Lahoma again had the highest leaf percentage with 59.7 percent. Next to Lahoma was Gahi-1 with 57.8 percent leaves.

For the first harvest, multiple range tests showed Gahi-1 was significantly higher than all other varieties in yield of leaves per acre. In the second harvest Sweet Sioux was significantly high for leaves, stems and total yield. For the sum of both harvests Gahi-1 and Sweet Sioux were significantly high for leaves, Sweet Sioux for stems and total yield. It was observed from the data that a variety with high leaf percentage was medium to low in total yield and varieties with a low leaf percentage were high in total yield of forage.

In general percentage protein followed the same pattern as percentage of leaves. The percentage of protein was highly affected by the percentage of leaves. In the first harvest Gahi-1 had the highest percentage of protein along with the highest percentage of leaves. In the second harvest Lahoma had the highest percentage of protein along with the highest percentage of leaves. Also in the second harvest the percentage of leaves of all varieties dropped along with percent protein. Multiple range tests for the first harvest showed Gahi-1 was significantly high in protein. Sweet Sioux was significantly high for stems and total protein. In the second harvest and the sum of both harvests Sweet Sioux was significantly higher for leaves, stems and total protein.

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Master of Science

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