AN EVALUATION OF THE PROTEIN, DIGESTIBILITY, AND YIELD OF SELECTED FORAGE SORGHUMS

By

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AN EVALUATION OF THE PROTEIN, DIGESTIBILITY,

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CHAPTER I

INTRODUCTION

The interest in forage sorghums, Sorghum bicolor (L.) Moench, for silage has raised questions dealing not only with their agronomic characteristics, but also with their nutritional value. The questions being asked are concerned with the relative value of hybrids and sorgo varieties for protein, digestibility, and total nutrients.

Hybrid forage sorghums and sweet sorghum varieties are the types that are usually considered for ensiling purposes. Previous work has indicated that the sweet sorghums may be more efficient for livestock feeding than the hybrid sorghums which usually contain more grain.

This study was designed to compare these two types on the basis of their crude protein, digestibility, and yield. Twenty-four sorghums, all available to Oklahoma farmers, were examined to compare the forage quality of hybrids and varieties.

CHAPTER II

LITERATURE REVIEW

Nutritive Value

Research has been reported in many articles about the value of feeds for animal nutrition. Van Soest (30) proposed that digestibility, consumption, and energy efficiency for productive purposes are the three main components of a feed's nutritional value. Others such as Barnes (4) suggested the percentage of nonnutritive constituents of the feed or forage as another quality component. However, nearly all agree that the important factors influencing the feeding value of forages are intake, nutrient content, and digestibility.

Intake or consumption of a feed is a difficult factor to measure unless it is done in feeding trials, and even then the desire to eat varies among animals. Palatability is another term used in intake determination, which is defined as the animal's preference when given a choice of feeds (30).

The nutritive content of forages has long been measured by the proximate analysis system which breaks the feed down into protein content, crude fiber, ether extract, nitrogen free extract, and ash. This system was used until the Van Soest method of fiber determination was developed (31). Van Soest reasoned that the cell content of forages (starches, sugars, and proteins) were easily digested and the cell walls were the least digestible material. Van Soest further broke the cell walls down into hemicellulose, cellulose, and ligin for a measure of the digestible fiber termed acid detergent fiber. According to Cummins (5), this fiber measure is more precise and definitive for the nutritive value of forages.

The three measures of digestibility which are used in a forage quality examination (30) are: (1) apparent digestibility, (2) digestible energy, and (3) true digestibility. Apparent digestibility refers to the balance of feed ingested less the matter lost in the feces (30). Digestible energy is measured by multiplying the amount of digestible nutrients by the digestion coefficient. True digestibility of a feed is measured by the difference between intake and fecal loss. The measure used in this study was true digestibility.

The method used in our evaluation for dry matter digestibility was Tilley and Terry (29) in vitro technique. This method simulates the digestive process of ruminant animals by using digestive liquor and micro-organisms collected from an active rumen (28). This allows for an analysis of many varieties and treatments with less expense and time than the in vivo systems (5).

In comparisons of several chemical methods on corn and sorghum silage, Marten et al. (14) reported that the modified Tilley and Terry in vitro technique was the best for predicting in vivo dry matter digestibilities. The closest agreement between in vivo and in vitro dry matter digestibility found by Tilley et al. (28) was in a low digestible and low protein herbage.

Silage

The forage sorghums under evaluation in this study were primarily developed for silage production. Therefore, the purpose and process of silage making should be reviewed.

Silage making preserves forage plants for their nutrient content and energy availability to animals. Silage making is an old art which was introduced into the United States in 1880 by John M. Bailey, who learned of its use in France (3). The ensilage process depends upon many factors: activity of plant enzymes, oxidation before ensiling, presence and production of organic acids, type of micro-organisms present and their development, attainment of proper acidity, level of moisture, temperature during fermentation, and the presence of additives. Due to the lack of control of most of these factors, silage making is still an art and not yet subject to scientific control (24).

Some of the advantages of using silage as a roughage are: (1) preserves the highest yield of nutrients for the land area, (2) can be harvested at different moisture levels, (3) allows flexibility in the cropping system, and (4) the complete process can be mechanized. However, along with these good factors, there are a few disadvantages of silage use which are: (1) there is no accessible market, (2) silage is often bulky to store and handle, (3) the mechanization is expensive in relation to its value, and (4) it must be fed soon after removing from storage or it will spoil (15).

The ensilage process is basically an anaerobic fermentation of carbohydrates. Micro-organisms convert the sugars into organic acids resulting in a low pH. At this low pH, the microbes cannot live so they literally kill themselves. At pH 4 silage will stay well preserved if the mass of it is not exposed (14).

Two characteristics of a good silage are (1) high nutritive value and (2) a nutritive value representative of the digestible nutrients in the forage at harvest (20). The first is estimated from the performance of the livestock to which the silage is fed, and the second is measured by the retention of nutrients from harvest until consumed.

Two factors used in judging silage preservation are color and odor (19). The desirable color is a natural green to olive-green color determined under natural light. An undesirable color is deep brown or black, which indicates excessive heating or putrification. Silage odor should be clean and sharp, which indicates correct acid levels for preservation. A burned or putrid odor indicates excessive heating and improper fermentation (19).

Crude Protein

According to Barnes (4), proteins compose approximately 80 percent of total nitrogen in forages. Stallcup and Davis (21) correlated laboratory testing with feeding trials and showed that crude protein and crude fiber were of great value in predicting the nutritive value of forages. Stallcup (22) also correlated data from the proximate analysis on 25 forage species and found that a high relationship existed between crude protein and digestible protein ($r = 0.95$).

Webster (26) found that the protein level decreased as the forage plant matured. He also noticed that forage sorghum hybrids had 1-2 percent higher protein content than the comparable varieties. Worker (27) reported that as dry matter yields increased, crude protein decreased. Webster and Davies (25) observed that sorghum forages grown during wet years had lower amounts of protein than those grown during dry years. However, there was no difference in the maximum protein yield during wet and dry years.

In a three-year study of Atlas forage sorghum, Elrich et al. (10) reported that the protein percentage decreased after blooming, but protein yield per plant and per acre continued to increase with dry matter production until frost. Conclusions from this experiment indicated that maximum dry matter yield would be obtained by a high plant population and a delayed harvest until the grain was fairly mature. In Oklahoma, maximum forage yield ordinarily comes in the late dough stage during September or late August according to Webster and Davies (25).

Digestibility

According to Cummins (5), animal intake and production correlates well with digestibility for most cases. This makes it an important measure of forage quality and the purpose for its use in this study.

The best means for measuring digestibility would be to conduct feeding trials; however, this was impractical for this experiment due to the number of varieties evaluated, the lack of facilities, and the lack of time. With the development of the in vitro laboratory procedure, the investigation of many treatments or genotypes can be conducted in a relatively short period of time (28).

Cummins and McCullough (7) reported considerable variation among different forage sorghums in dry matter, crude protein, crude fiber, and nitrogen free extract digestibility. Dry matter digestibility ranges from 52 to 65 percent. The results of Garrett and Worker's (11) investigation of sweet and hybrid sorghum silage indicated that the proportion of grain did not make any difference in the feeding value of the silage. They also suggested that some sweet forage varieties of sorghum may be as valuable for feeding growing beef cattle as a hybrid forage containing more grain. Owen et al. (17) reported that sterile silages were not inferior to other sorghum silages, which indicated that the seed content of these silages should not be used as a criterion for judging their quality.

Apparent digestibilities of Atlas sorghum silage decreased from 55 to 46 percent as the plants matured from the milk to hard-seed stages according to Owen and Kuhlman (16). However, they also reported that Rox sorghum silage was not affected by increased maturity. Elrich et al. (10) concluded that high plant population produced the greatest amount of crude fiber, which lowers the digestibility if the plants are mature. For increased digestibility at higher populations, they suggested that the harvest should be earlier than grain maturity.

One proposed method for increasing sorghum digestibility was the breeding for bloomless hybrids in areas where there is little danger of a drought. The thick cuticular wax present in the bloom has been proposed as lowering the digestibility. This bloom is recognized as being beneficial for drought tolerance. Cummins and Dobson (6) indicated that digestibilities were higher in the bloomless leaves than in isogenic bloomed sorghum leaves.

Schmid et al. (18) evaluated sorghum forage and found that high positive correlations existed for the in vitro dry matter digestibility of silage and dry fodder. They concluded that fodder would be a good predictor of silage digestibility. The results of tests with ten silages indicated that fresh undried silage and percent dry matter were statistically acceptable when predicting in vivo digestibility from in vitro digestibility data (1).

Many researchers at various locations have evaluated sorghum forages for digestibility and other nutritive characteristics. However, due to the different environmental conditions and different varieties available, a regional examination of the nutritional and agronomic aspects of forage sorghums was needed. The objectives of this study were designed to provide a basis for hybrid and variety comparisons using yield, crude protein, and the digestibilities of both silage and dry forage as the measures of nutritional and agronomic value.

CHAPTER III

MATERIALS AND METHODS

This study consisted of an evaluation of twenty-four forage sorghums for yield, crude protein, and digestibility. These hybrids and varieties were entered in the 1973 Performance Tests of Sorghums in Oklahoma (8). The hybrids and varieties compared in this study are listed in Table I and Table II.

TABLE I

FORAGE SORGHUM HYBRIDS

Hybrid	Company
FB-44 (Blend)*	ACCO Seed Company
FS-531*	ACCO Seed Company
Titan E	Asgrow Seed Company
SM 300	Browning Seed Company
DeKalb FS-1b.*	DeKalb AgResearch
DeKalb FS-25*	DeKalb AgResearch
Hi-Kane	Frontier Hybrids, Inc.
S-214	Frontier Hybrids, Inc.
Funks 93F	Funk Seeds International
Funks G 99F	Funk Seeds International
Growers 30F	Growers Seed Association
McNair 722	McNair Seed Company
McNair 744	McNair Seed Company
NC + 675F	NC + Hybrids
NK-326	Northrup King and Company
Bundle King II*	Richardson Seed Farms
Si-GRO 2	The J. C. Robinson Seed Company
Husky*	George Warner Seed Company

*Entered as (75-95 PCT Hybrid)

TABLE II

FORAGE SORGHUM VARIETIES

Variety	Seed Source
Sugar Drip	Oklahoma Agricultural Experiment Station
Brandies	Oklahoma Agricultural Experiment Station
Rio	Oklahoma Agricultural Experiment Station
Dale	Oklahoma Agricultural Experiment Station
Roma	Oklahoma Agricultural Experiment Station
Sart	Oklahoma Agricultural Experiment Station

Planting

The experiment was conducted at Perkins Agronomy Research Station near Stillwater on a vanoss fine, sandy loam soil. Fertilizer was uniformly applied at the rate of 296.8 kg. of 45-0-0 and 190.4 kg. of 0-0-60 per hectare preplant. This rate was determined by a soil test taken in the early spring of 1973. The plots were planted with a cone planter on June 9, 1973.

A randomized block design was used with four replications. The plots consisted of three rows which were 12.2 m. long. The rows were 101.6 cm. apart and the forage plants were hand thinned to 7.6 cm. spacings within the rows.

The rainfall for the growing season from April to August was 34.7 cm.

Harvest

All of the entries were harvested at the late dough stage for maximum production while maintaining a relatively high protein level and digestibility. The center sorghum row (7.9 linear meters) was harvested. The plants were cut at ground level and weighed to determine yield of green forage in metric tons per hectare. A sample weighing 9 kg. of green material was composited from the four replications and dried to determine dry matter yield.

Sampling

Five whole plants, selected randomly from each plot, were chopped into pieces that were 2.5 to 3.8 cm. long by a forage chopper. The plant material was thoroughly mixed to form a homogeneous sample. Samples were then taken for silage and dry forage.

Ensilage

The chopped plant material was placed in a half-gallon jar and packed tightly to eliminate as much air as possible. An air controlling lid was constructed and used to promote fermentation.

After filling the glass silos with the chopped plant material, the jars were wrapped with aluminum foil to prevent light from entering and interfering with the fermentation process. The samples were stored at room temperature for two months to allow completion of the fermentation process.

The air controlling lid was designed to allow a build-up of gas inside the jar to escape to avoid breaking the jar. It also prevented outside air from seeping into the silo jar. The air regulator was made by inserting a copper tube, approximately 5 cm. long and .6 cm. in diameter, through a hole drilled near the center of a home-canning type jar lid. The tube was carefully soldered air tight to the lid. Attached securely on the top of the copper tube was a piece of plastic surgical tubing. To restrict any air movement, a glass bead was inserted in the end of the surgical tubing. To allow for gas movement from the inside to the outside of the jar, a small slit was made in the side of the surgical tubing. This slit remained closed as long as the pressure was not too great inside the jar. When pressure would build up, the gas would force the slit open for its escape. After its escape, the slit would reseal due to the stiffness of the tubing.

Laboratory Preparation

The dry sorghum forage samples were ground through a one mm. screen in a Wiley mill and stored for future analyses.

The silage samples were frozen with dry ice, ground through a one mm. screen, and placed in a freezer to maintain their frozen condition.

The crude protein was determined for both forages and silages by the macro-kjeldhal method (2).

One measure of the preservation of silage is its pH (13). The pH was determined by squeezing the juice from the silage into a beaker. A Boeckman pH meter with a glass electrode was used to determine the hydrogen ion concentration.

The *in vitro* dry matter digestibility was determined by the Tilley and Terry technique (29). This part of the analysis was conducted at the Fort Reno laboratory by the USDA-ARS.

The yield of protein per hectare was calculated by multiplying the percent of the crude protein by the dry matter yield. Plant height was measured in centimeters.

Since there was a difference between types, the data were statistically analyzed by sorghum types for the observed variables. Duncan's New Multiple Range Test (23) was used among entries within types to determine the differences.

CHAPTER IV

RESULTS AND DISCUSSION

Entries in hybrids and in varieties were significantly different for most variables. Therefore, under each variable observed, the hybrids and varieties will be discussed separately.

Crude Protein

The average of the hybrid forage sorghums was significantly higher in crude protein than the average of the varieties for dry forage and silage. Average crude protein of the varieties was determined to be 3.91 percent (dry forage) and 4.11 percent (silage); whereas, that of the hybrids was 4.27 percent (dry forage) and 4.63 percent (silage) (Figures 1 and 2). Webster (24) reported similar results.

Crude protein was significantly different ($p<.01$) among the hybrid entries for both dry forage and silage (Figure 3 and Table III). Measurable differences in the crude protein may be attributed to the various types of hybrids studied. These types varied in plant height, maturity, and genetic composition. McNair 722 and Si Gro 2 had the highest crude protein percentage for dry forage with 5.88 percent and 5.80 percent, respectively. McNair 722, Funks 93F, and Bundle King II ranked highest in protein in the silage with 6.20 percent, 5.95 percent, and 5.89 percent, respectively (Table III).

Crude protein in hybrids was found to be significantly higher in

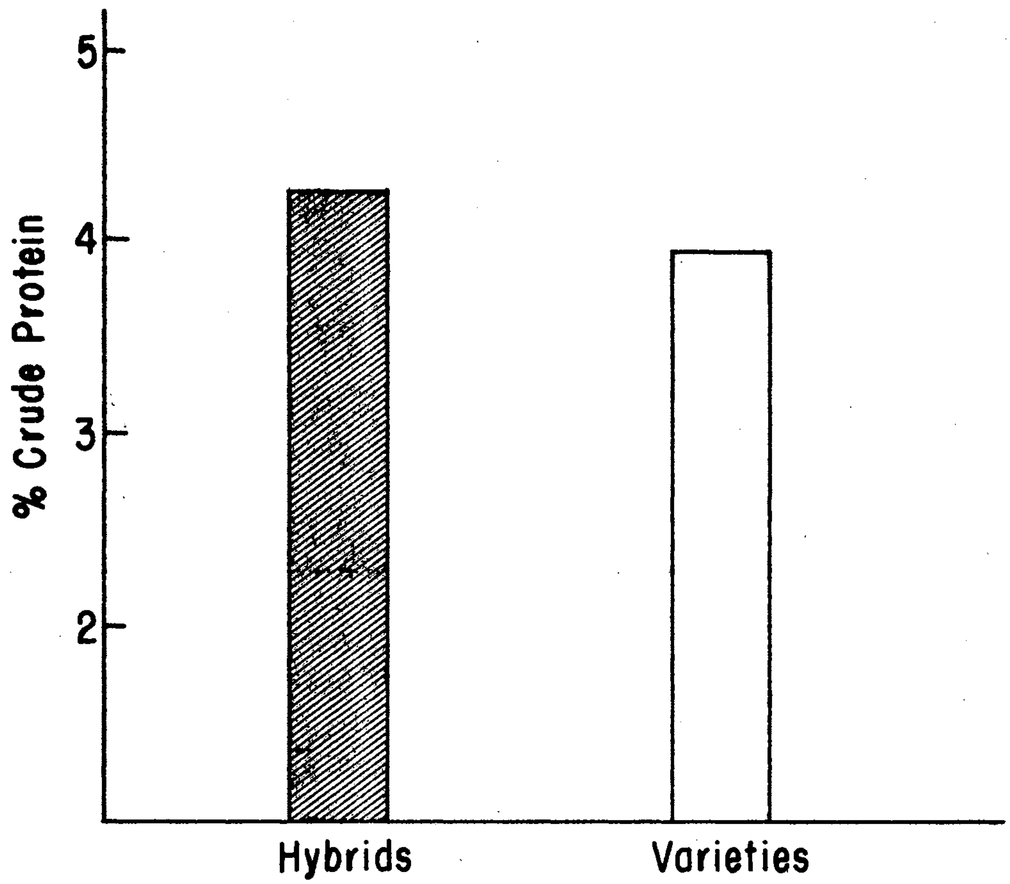

Figure 1. Comparison of Hybrids and Varieties for Percent Crude Protein in Dry Forage

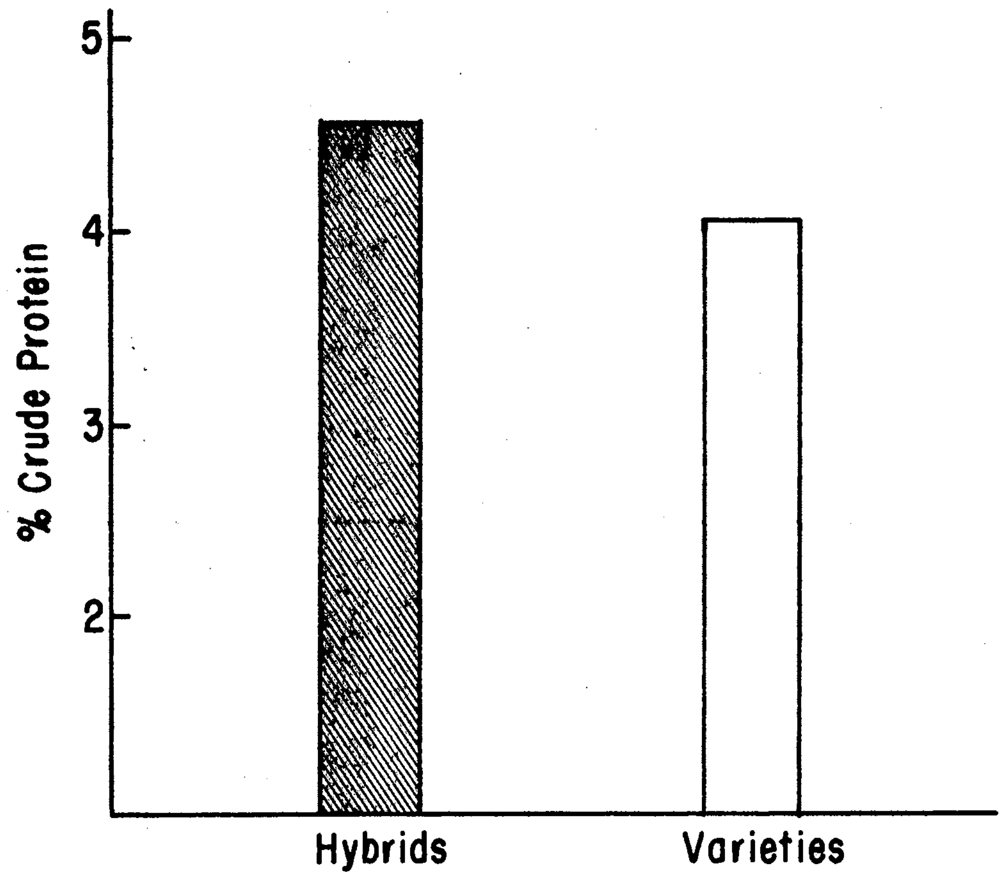

Figure 2. Comparison of Hybrids and Varieties for Percent Crude Protein in Silage

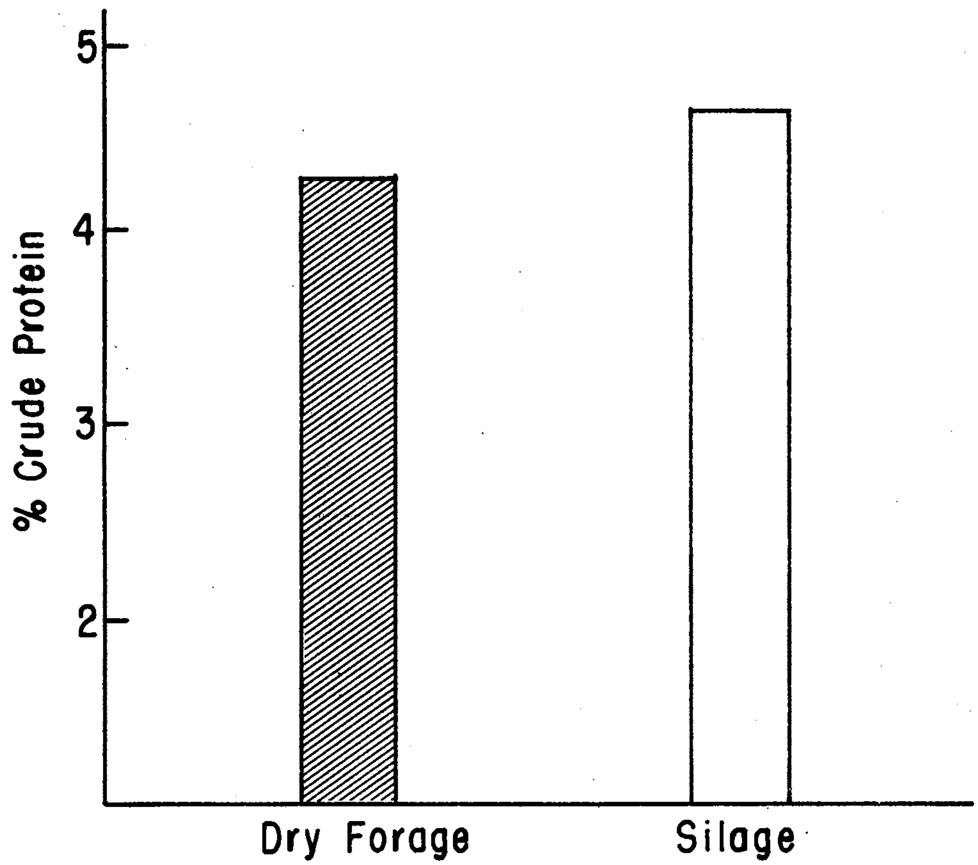

Figure 3. Comparison of the Percent Crude Protein in the Silage and Dry Forage of Hybrids

TABLE III

AVERAGE PERCENT OF CRUDE PROTEIN FOR HYBRIDS

Hybrid	Crude Protein Percent	
	Dry Forage	Silage
McNair 722	5.87 a[1]	6.20 a
Si Gro 2	5.80 a	4.52 bcd
Funks 93F	5.38 ab	5.95 a
F B 44	5.12 abc	5.33 ab
Hi-Kane	4.84 bcd	5.42 ab
Husky	4.67 bcd	4.58 bcd
Titan E	4.57 b-e	4.81 bc
NC + 675	4.43 c-f	4.48 bcd
SM 300	4.36 c-f	4.55 bcd
G-30F	4.04 d-g	4.54 bcd
Bundle King II	3.82 efg	5.89 a
McNair 744	3.73 fg	3.91 cde
NK-326	3.68 fg	4.29 cde
FS-25	3.48 fgh	3.93 cde
FS-1B	3.48 gh	4.13 cde
Funks 99F	3.24 gh	3.78 de
FS-53	3.85 h	3.26 e
Mean	4.27	4.63

[1]Values within the forage types followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

the silage than in the dry forage. A significant hybrid by source of crude protein interaction indicated that the hybrids did not respond in the same pattern in the dry forage as they did in the silage. These data indicate that crude protein may be preserved better in silage than dry forage.

Later maturing hybrids tend to have a lower crude protein content (Figure 4). A yield increase was also noticed as the time to maturity increased. This indicated that more dry matter was produced with less crude protein content. The sharp decline in crude protein during 100 to 120 days after planting may have been due to an infestation of the sorghum midge resulting in severe damage to the grain during that period of the maturing season.

All of the varieties in this study were sweet sorghums. Since they have a similar genetic background, the varieties performed rather uniformly for the characteristics of crude protein. The uniformness of the varieties was demonstrated by the lack of statistical differences among the variety entries (Table IV). Different times of maturity did not affect the protein content of the varieties as it did the hybrids (Figure 5). A difference in crude protein between silage and dry forage was not significant; however, there was a trend for the silage to preserve the protein better than the dry forage in the late maturing varieties.

Protein Yield

Protein yield measured in kilograms of crude protein per hectare was calculated by multiplying the percent protein by the dry matter yield. This variable combines two important factors, percent crude

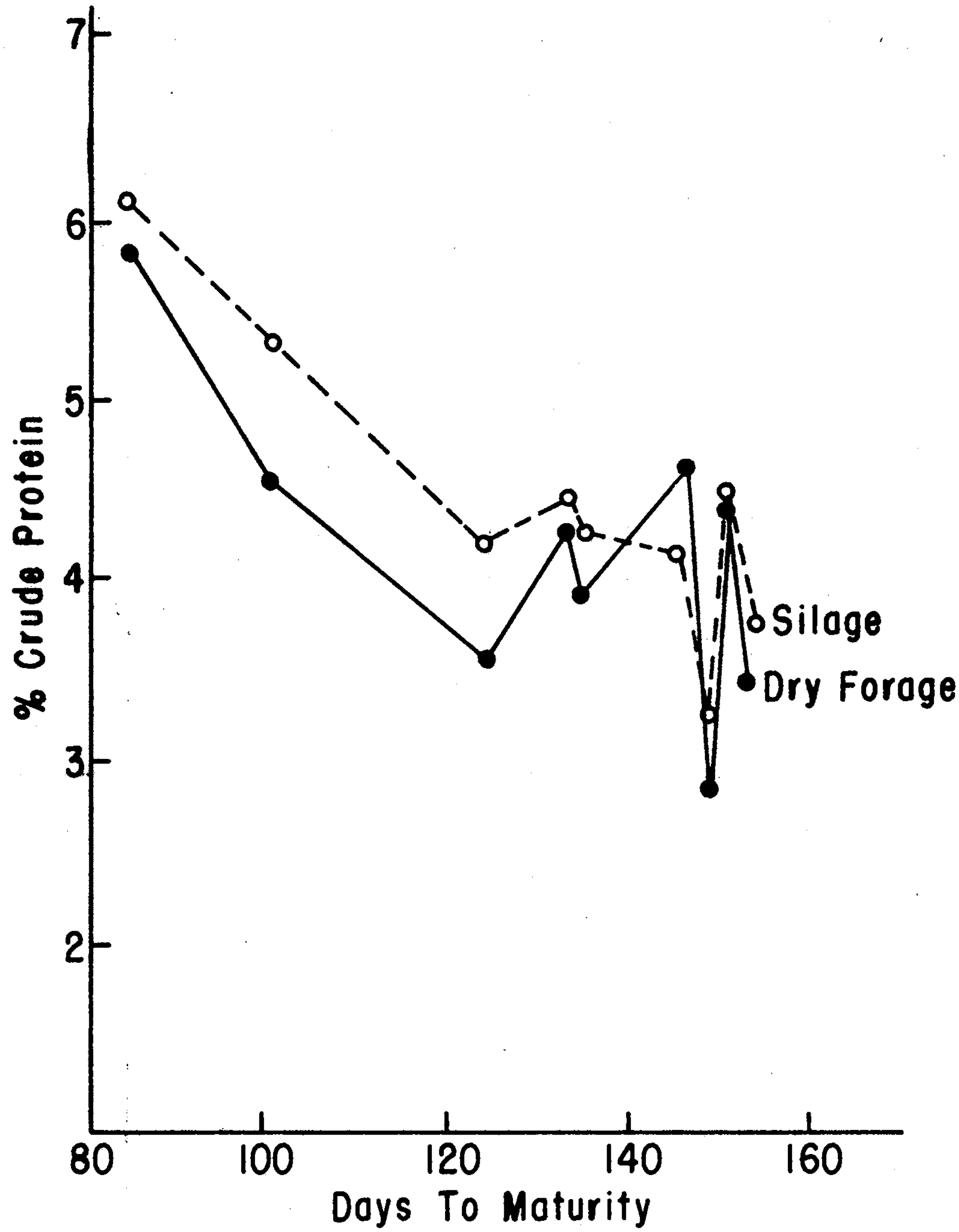

Figure 4. Relationship of Crude Protein to Days to Maturity in Hybrids

TABLE IV

AVERAGE PERCENT CRUDE PROTEIN FOR VARIETIES[1]

Variety	Crude Protein Percent	
	Dry Forage	Silage
Sugar Drip	4.56	4.30
Dale	4.30	3.69
Roma	3.89	4.80
Rio	3.85	4.02
Brandies	3.49	4.47
Sart	3.41	3.63
Mean	3.91	4.11

[1]Values within the forage types were not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

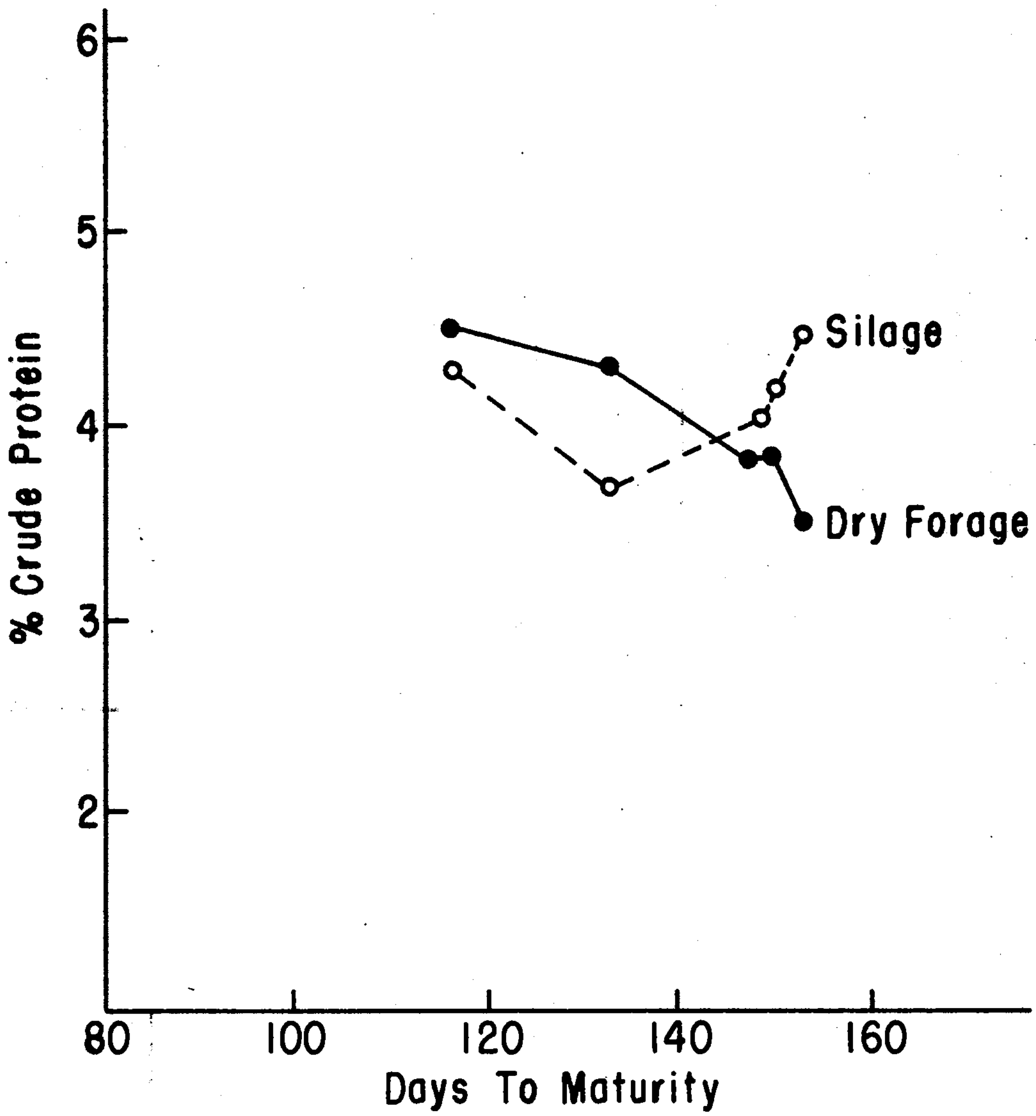

Figure 5. Relationship of Crude Protein to Length of Maturity in Varieties

protein and yield, into one measurement providing another estimation for the performance of hybrids and varieties.

There was no significant difference between average of hybrid and average of varieties in the protein yield for dry forage or silage (Figures 6 and 7). This is true because even though the hybrids were higher in crude protein than varieties, the varieties out-performed the hybrids in yield.

There were differences ($p<.01$) among the hybrids with respect to several variables. Husky had the highest yield of protein in dry forage with 741 kg/ha. Protein yield in silage was higher ($p<.02$) than dry forage (Figure 8). Growers 30F and Funks 99F ranked highest in protein in the silage with 769 and 768 kg/ha., respectively (Table V).

The slight differences in crude protein and in dry matter yield of the varieties proved to be significant when combined to form protein yield. Sugar Drip and Brandies were the top varieties in protein yield for silage with 762 and 772 kg/ha., respectively (Table VI). Sugar Drip alone was the leader in the protein yield of dry forage with 794 kg/ha.

Yield

Yield was recorded in two ways. Dry matter yield was determined by drying a composite sample weighing 9 kg. from the harvested green forage and reported in tons/ha. Green forage yield was determined by harvesting and weighing .0008 of a hectare. The green forage measurement was more accurate due to possible errors and drying differences encountered in obtaining the dry matter yield.

The varieties were higher ($p<.0002$) for both dry matter and green

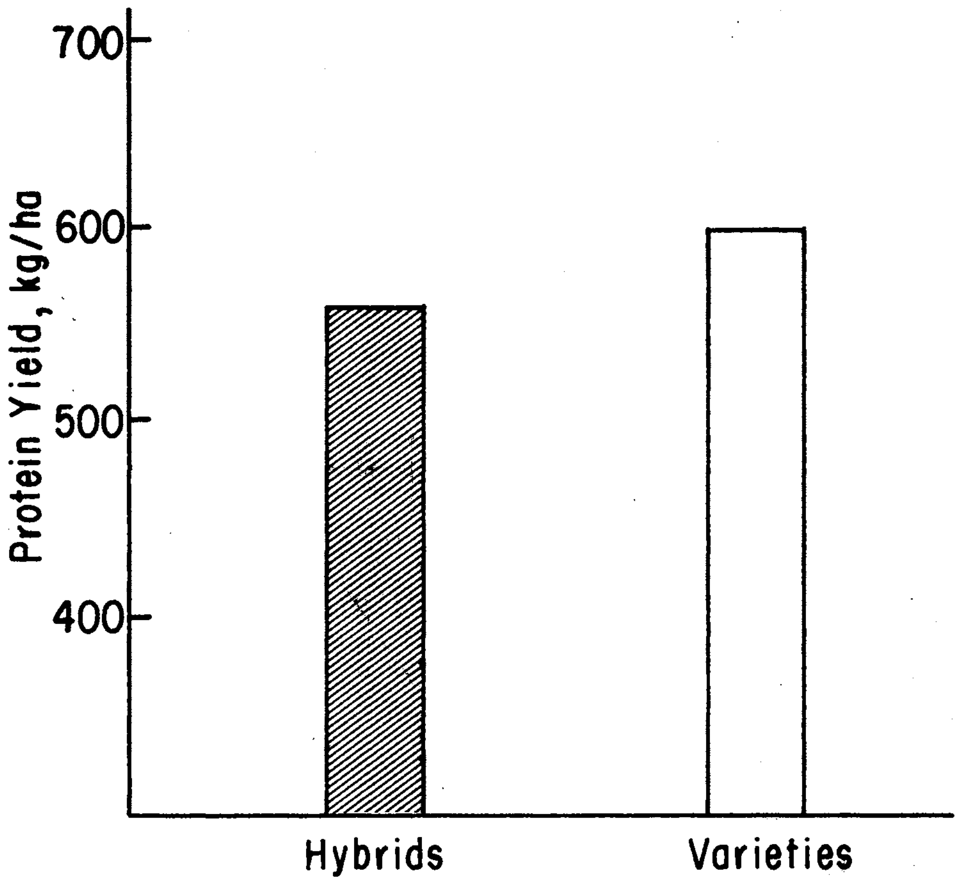

Figure 6. Comparison of Protein Yield in Dry Forage for Hybrids and Varieties

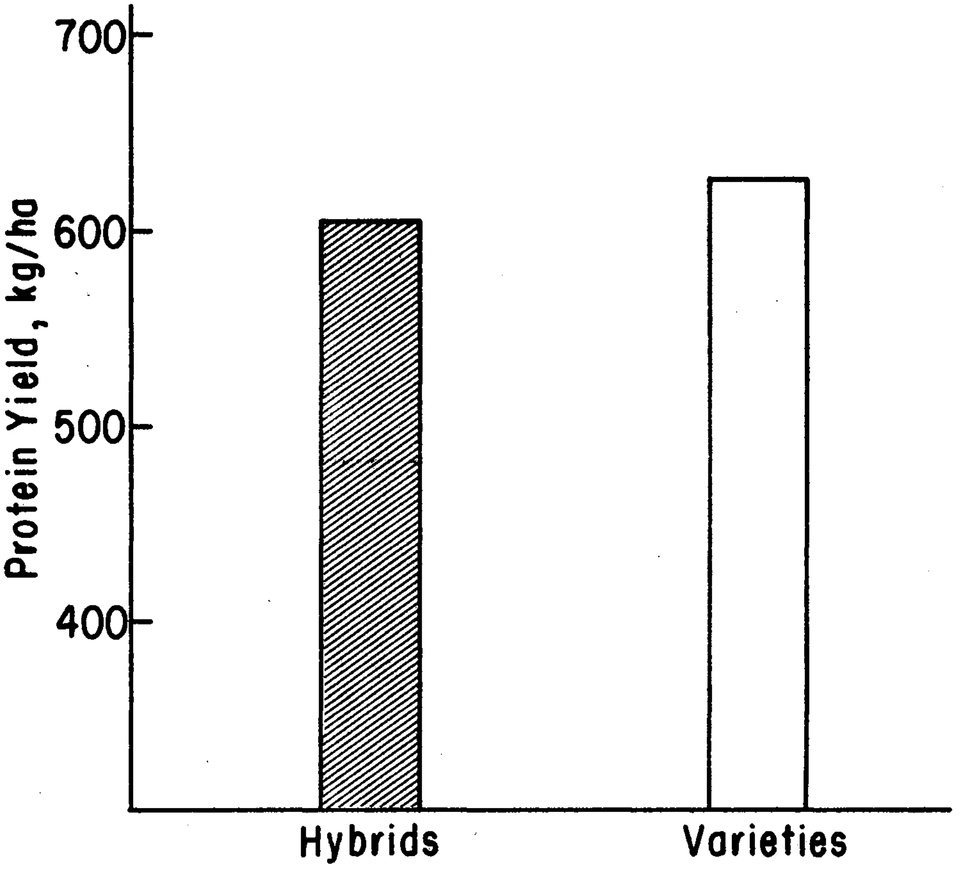

Figure 7. Comparison of Protein Yield in Silage for Hybrids and Varieties

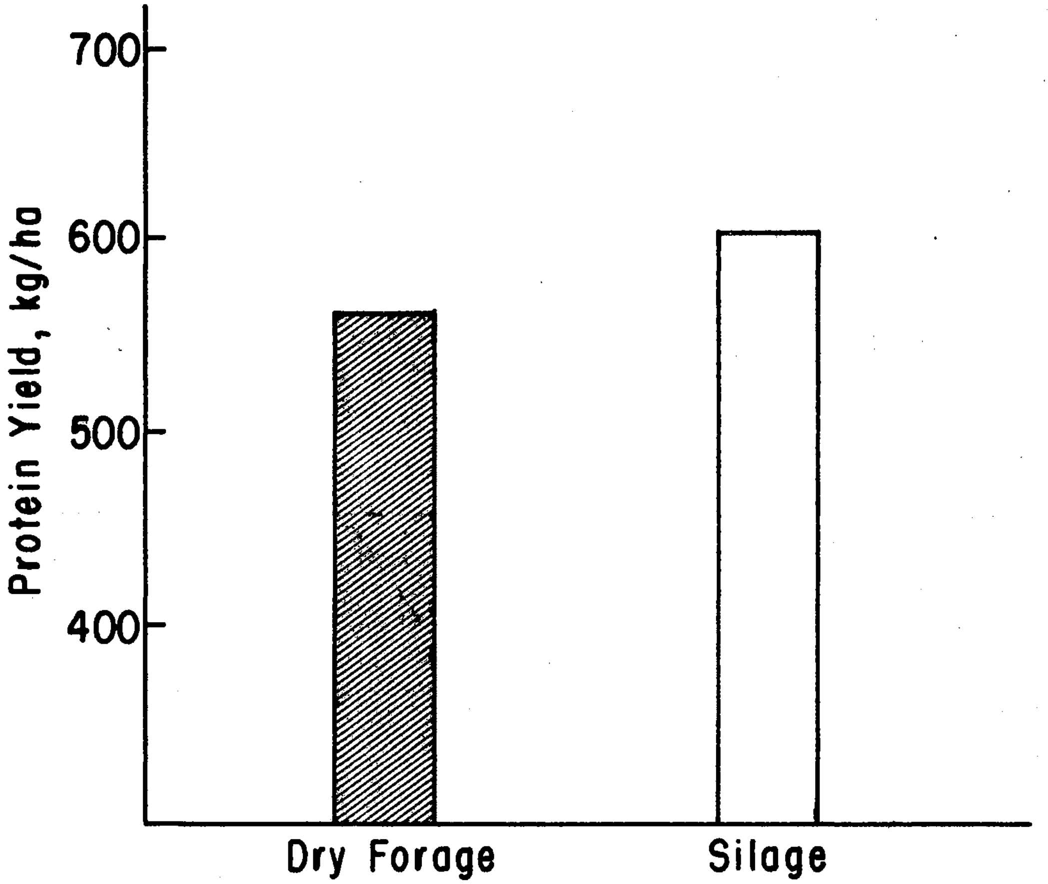

Figure 8. Comparison of Protein Yield in Hybrids for Silage and Dry Forage

TABLE V

AVERAGE PROTEIN YIELD FOR HYBRIDS

Hybrid	Protein Yield kg/ha	
	Dry Forage	Silage
Husky	741.0 a[1]	713.2 ab
SM-300	706.2 ab	731.7 ab
Si Gro 2	698.1 ab	543.4 bc
G-30F	690.3 ab	769.0 a
FB-44	666.7 ab	709.6 ab
FS-25	660.8 abc	734.0 ab
Hi-Kane	654.9 abc	730.1 ab
Funks 99F	653.0 abc	768.7 a
NC + 675F	550.4 a-d	553.2 abc
S-214	548.7 a-d	597.7 abc
McNair 744	528.0 bcd	552.6 abc
McNair 722	512.9 bcd	538.1 bc
Titan E	464.1 cd	480.1 c
Funks 93F	444.2 d	488.5 c
NK-326	432.1 d	526.3 bc
FS-53	424.6 d	484.3 c
Bundle King II	402.4 d	621.9 abc
FS-1B	359.0 d	426.8 c
Mean	563.2	609.4

[1]Values within forage types followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

TABLE VI

AVERAGE PROTEIN YIELD FOR VARIETIES

Variety	Protein Yield kg/ha Dry Forage	Silage
Sugar Drip	794.8 a[1]	762.0 a
Dale	627.2 b	533.3 c
Rio	606.5 b	633.3 b
Brandies	600.9 b	772.4 a
Roma	513.7 c	630.3 b
Sart	513.4 c	559.1 c
Mean	602.9	634.4

[1]Values within forage types followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

forage yield (Figures 9 and 10). The average yield for the varieties was 15.3 (dry matter) and 41.9 tons/ha. (green forage); whereas, the average yield of the hybrids only averages 13.4 tons/ha. (dry matter) and 36.7 tons/ha. (green forage). Varieties produced more forage than hybrids because the varieties were developed for syrup production which requires a large proportion of stalks. The varieties that matured later generally had a larger green forage yield (Figure 11). Stalks make up the major portion of plant material. Some hybrids were also low yielders. Yields among hybrids were significantly different at the $p = .05$ level. Green forage yields ranged from a high 20.6 to 10.9 tons/ha. (Table VII). This large variation can be accounted for by differences in plant height, percent stalks, and maturities. An equally wide range of values was obtained for dry matter yield. Funks 99F and DeKalb FS-25 were the leaders in both yield measurements. They had heavy stalks, were tall, and were late maturing. Figure 12 indicates that the later maturing hybrids produced more forage than the earlier maturing entries.

There were no significant differences observed for green forage or dry matter yield among the varieties. Sugar Drip produced one of the higher dry matter yields with 17.5 tons/ha. and Sart, a late maturing variety, produced 47.4 tons/ha. of green forage (Table VIII). Varied plant moisture levels among the varieties may have caused the unequal performance of green and dry forage yields.

In Vitro Dry Matter Digestibility

The average *in vitro* dry matter digestibility of the varieties was significantly higher than the average of the hybrids for both silage

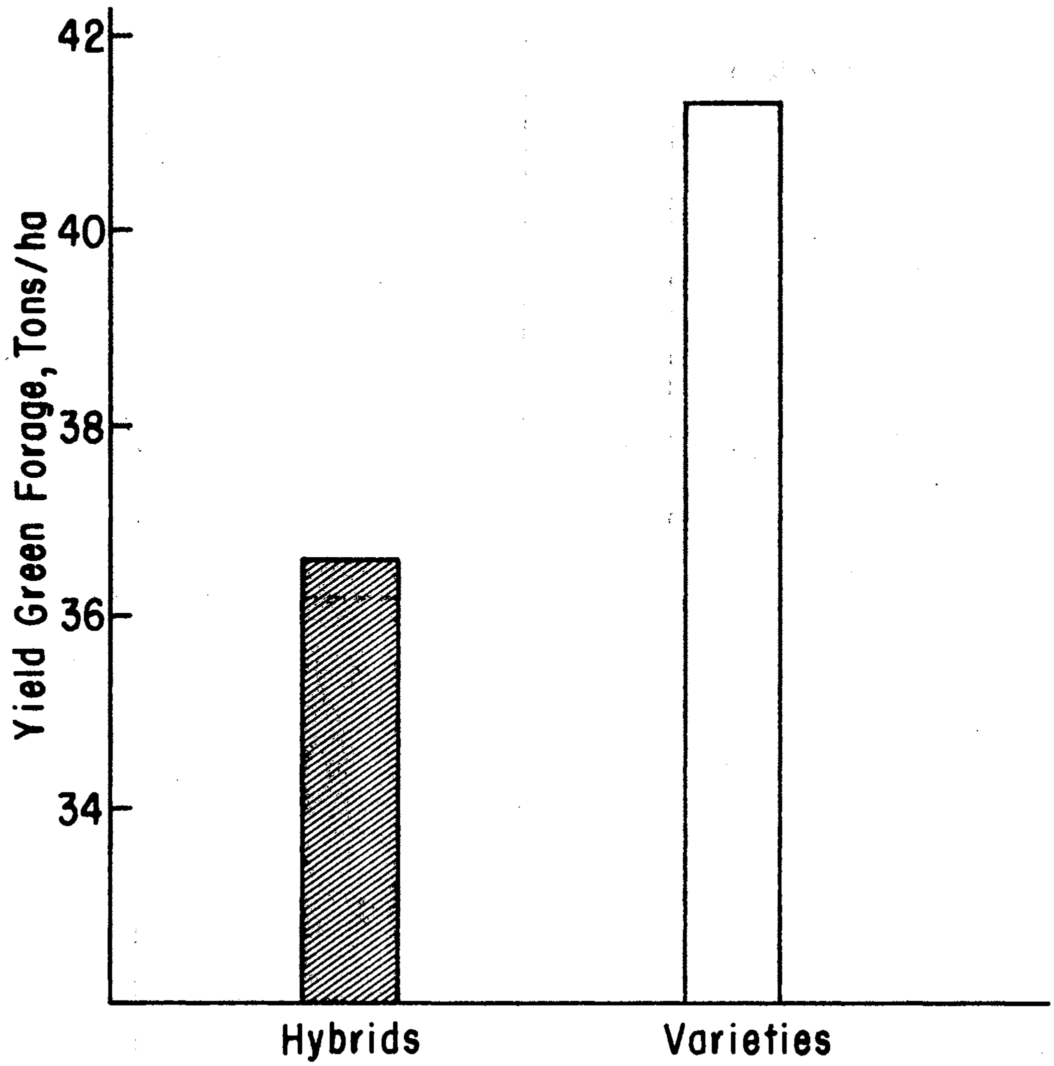

Figure 9. Comparison of Hybrids and Varieties for Green Forage Yield

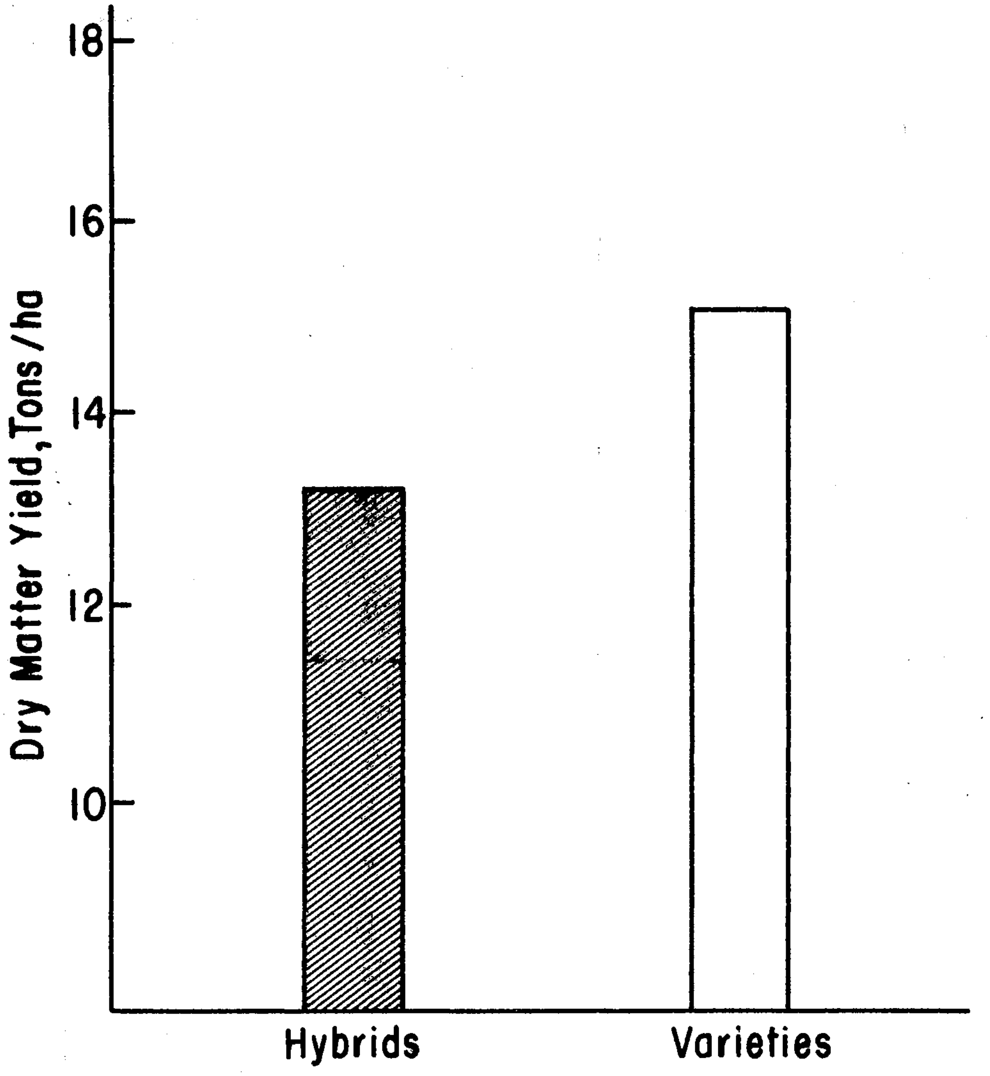

Figure 10. Comparison of Hybrids and Varieties for Dry Matter Yield

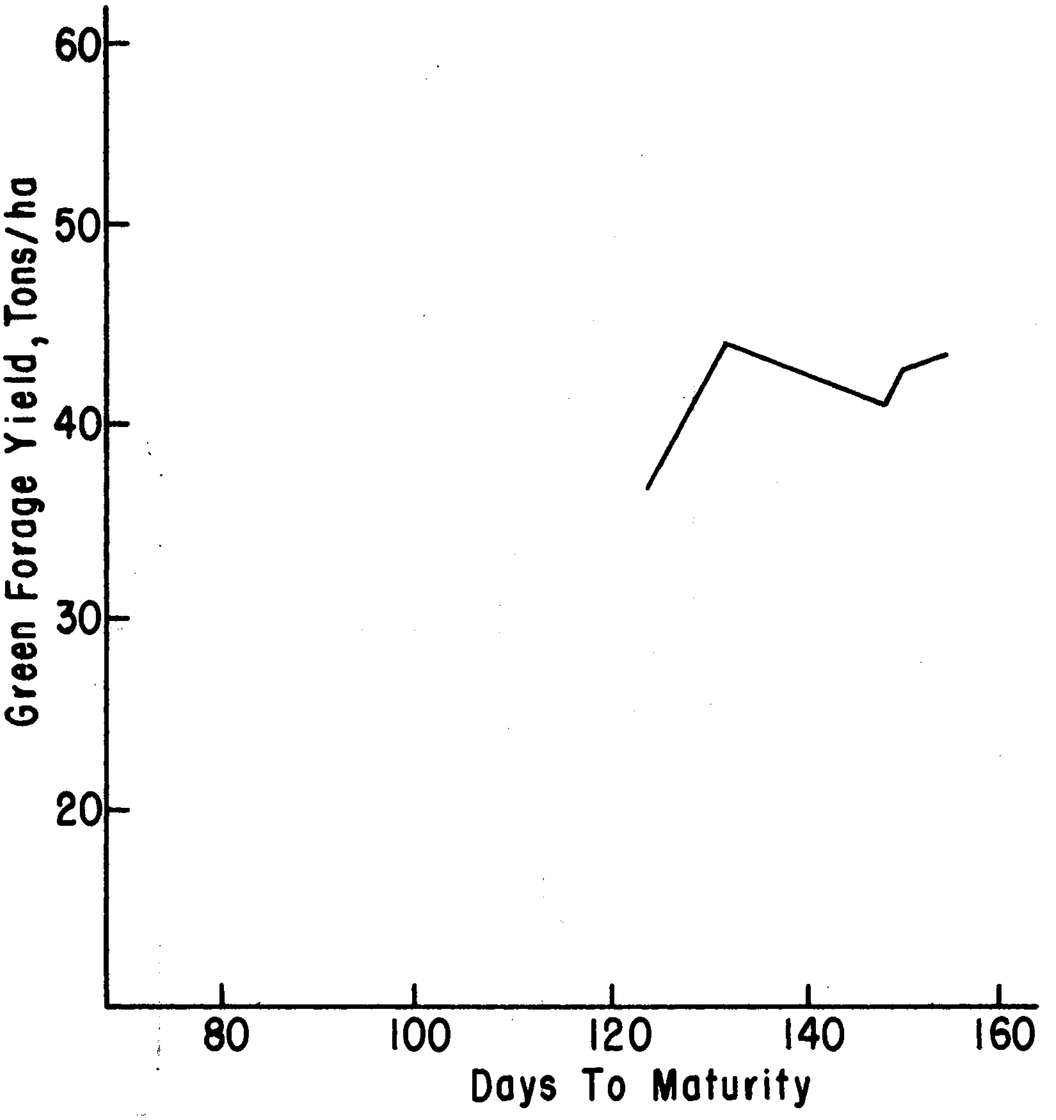

Figure 11. Relationship of Green Forage Yield and Days to Maturity of Varieties

TABLE VII

AVERAGE YIELD FOR HYBRIDS

Hybrid	Yield Tons/ha	
	Green Forage	Dry Matter
Funks 99F	50.9 a[1]	20.0 a
FS-25	50.6 a	18.8 a
FS-53	47.2 ab	14.9 c-f
S-214	44.3 abc	15.3 cde
McNair 744	42.1 bcd	14.2 c-g
NC + 675F	38.3 cde	12.2 e-j
NK-326	38.1 cde	11.7 g-k
Husky	36.5 c-f	15.2 c-f
G-30F	36.3 c-f	17.0 bc
Hi-Kane	34.2 d-g	13.5 d-h
SM-300	33.1 efg	15.9 cd
Bundle King II	33.0 efg	10.6 h-k
Titan E	31.8 efg	9.6 h-k
Si Gro 2	31.6 efg	12.2 f-j
FB-44	29.6 efg	13.2 d-i
Funks 93F	29.3 fg	8.2 k
FS-1B	27.1 g	10.3 ijk
McNair 722	26.9 g	8.8 k
Mean	36.7	13.4

[1]Values within forage types followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

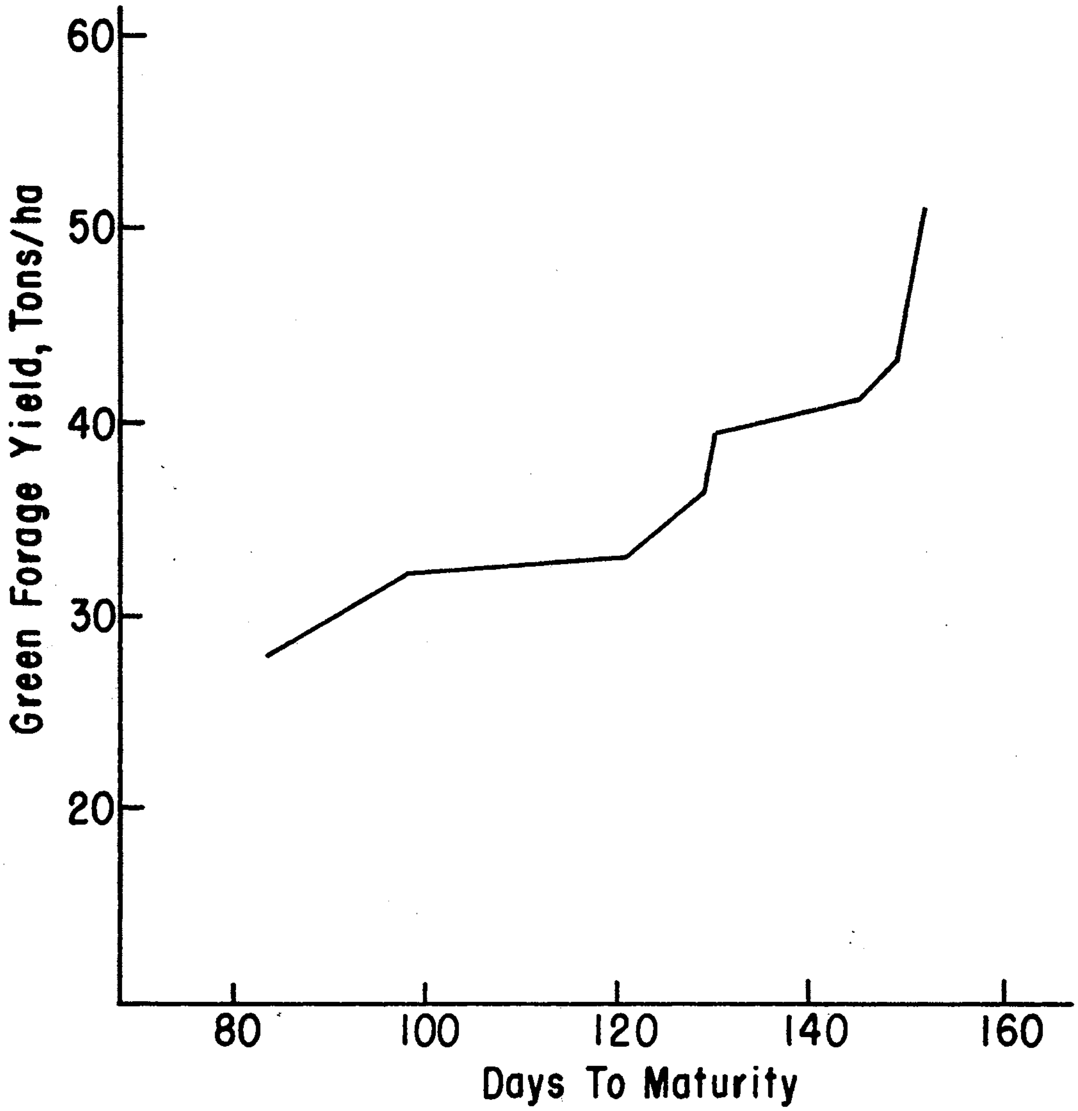

Figure 12. Relationship of Green Forage Yield and Days to Maturity of Hybrids

TABLE VIII

AVERAGE YIELD FOR VARIETIES[1]

Variety	Yield tons/ha	
	Green Forage	Dry Matter
Sart	41.1	15.1
Dale	44.3	14.5
Brandies	43.3	17.1
Rio	40.8	15.6
Roma	37.9	13.2
Sugar Drip	37.8	17.6
Mean	41.9	15.3

[1]There were no significant differences among values within forage types tested at 0.05 level according to Duncan's Multiple Range Test.

and dry forage (Figures 13 and 14). This is similar to Garrett and Worker's (11) conclusions concerning sweet forage sorghums.

Within the hybrids, differences were significant among the entries for dry forage and silage (Table IX). The silage had a slightly higher digestibility than the dry forage of the hybrid entries, although it was not significant. NK-326 was the top hybrid for both silage and dry forage with 74.49 and 68.25 percent digestibility, respectively (Table IX). Increased time to maturity had little effect on digestibility.

There were no significant differences among the varieties for digestibility of silage or dry forage (Table X). In most cases, the digestibility of the silage was slightly higher than that of the forages but the differences were not significant. The fermentation process could have reduced some of the plant tissues into more digestible forms.

Some of the varieties higher in digestibility were Brandies (71.15 percent for dry forage) and Sugar Drip (72.29 percent for silage) as shown in Table X.

Silage Quality

Silage quality was measured in three ways. PH is an indicator of silage preservation according to Marten et al. (14). The acid levels should be correct for good fermentation if the pH is between 3.5 to 4.0. The silage pH in this test was measured and the mean for the hybrids was 3.8 and the mean for the varieties was 3.7. Only one entry, McNair 722, had a pH above 4.0. This entry also had the highest protein level.

Moisture level is another indication of silage quality.

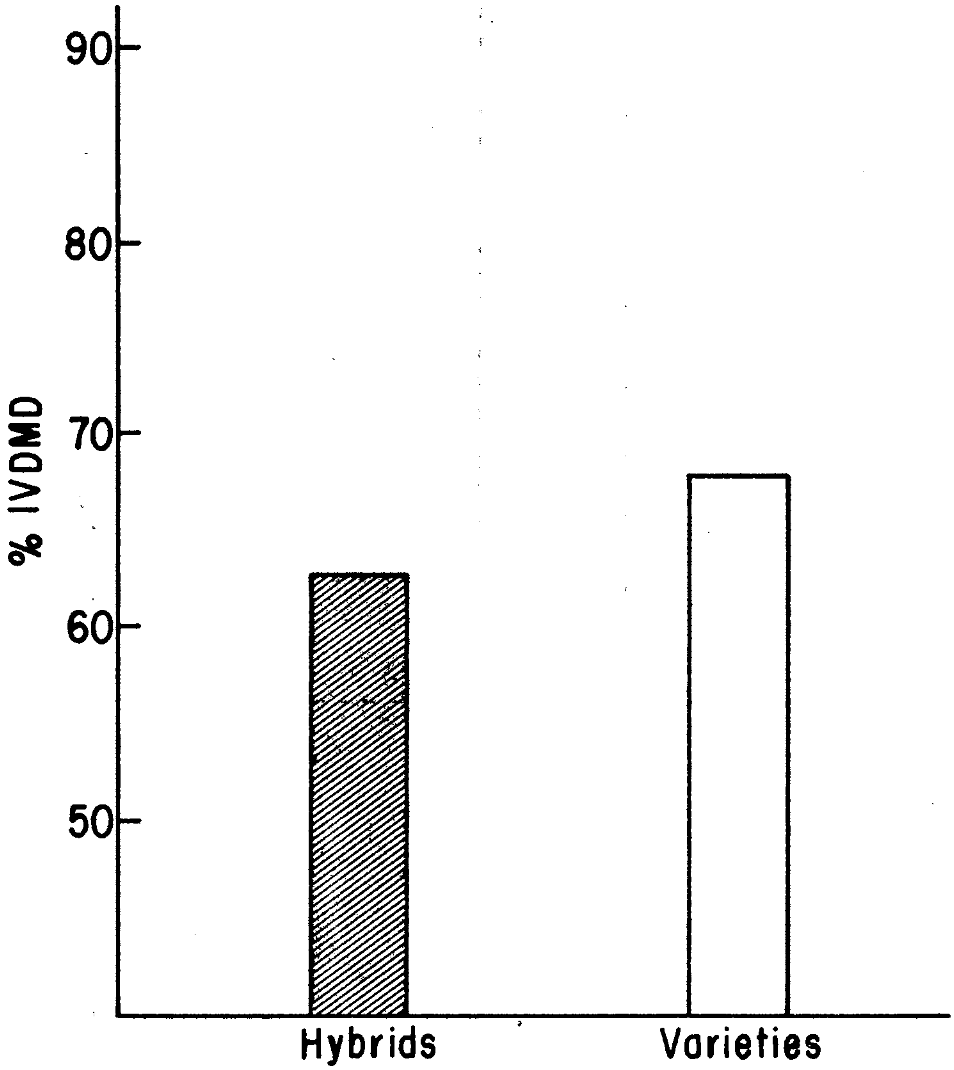

Figure 13. Comparison of Hybrids and Varieties for Dry Forage IVDMD

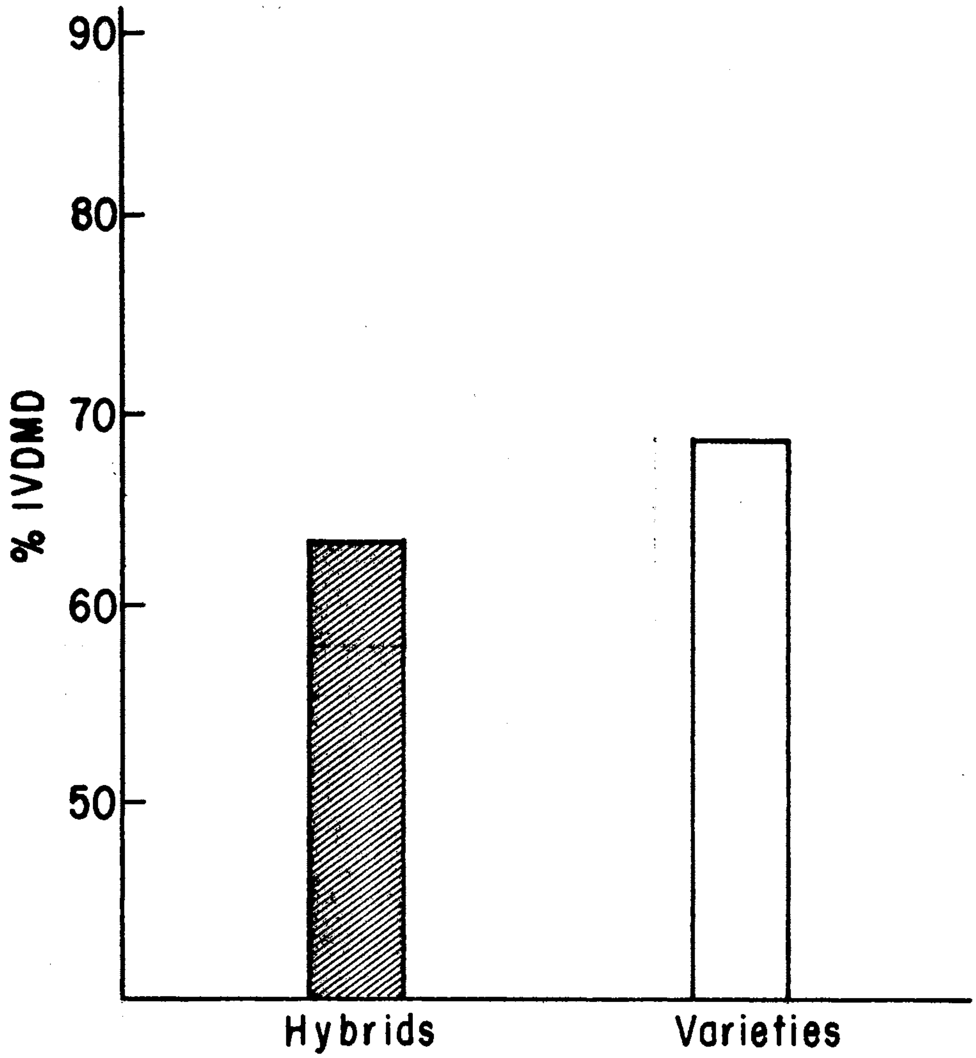

Figure 14. Comparison of Hybrids and Varieties for Silage IVDMD

TABLE IX

AVERAGE IN VITRO DRY MATTER DIGESTIBILITY FOR HYBRIDS

Hybrid	IVDMD%	
	Dry Forage	Silage
NK-326	68.25 a[1]	74.49 a
Titan E	66.81 ab	65.93 bc
McNair 722	66.34 abc	67.03 bc
Funks 93F	65.97 abc	62.39 bc
Bundle King II	65.55 a-d	64.21 bc
McNair 744	65.29 a-c	64.59 bc
Funks 99F	64.71 b-f	66.56 bc
S-214	63.69 b-g	61.78 bc
G-30F	63.30 c-h	62.51 bc
Husky	62.92 c-h	62.78 bc
FS-1B	62.49 d-h	66.04 bc
FS-25	62.16 d-h	61.67 bc
NC + 675F	62.00 e-h	62.19 bc
FB-44	61.94 e-h	62.40 bc
Si Gro 2	61.51 fgh	62.42 bc
FS-53	60.30 gh	61.05 c
SM-300	60.11 h	63.93 bc
Mean	63.80	64.46

[1]Values within forage types followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

TABLE X

AVERAGE *IN VITRO* DRY MATTER DIGESTIBILITY FOR VARIETIES[1]

Varieties	IVDMD %	
	Dry Forage	Silage
Brandies	71.16	68.25
Sugar Drip	69.61	72.29
Dale	68.83	71.53
Rio	68.04	68.52
Sart	66.92	67.65
Roma	66.67	65.83
Mean	68.37	68.83

[1]There were no significant differences among values within forage types tested at 0.05 level according to Duncan's Multiple Range Test.

Recommended moisture levels for forage sorghum silage is 70 to 75 percent. The moisture level for the silage of the hybrids and of the varieties was 77 percent and 76 percent, respectively. This higher than normal moisture level could be one factor that caused the erratic behavior of the entries when dry forage was compared to silage for the observed variables.

A rating for color and odor was taken when the silage was opened. The scale ranged from "good" to "poor." The "good" silage was rated as having a clean sharp odor and an olive green or natural color. The silages having a pungent or putrid odor and a dark color were classified as "poor." Both color and odor were rated "fair" for the hybrids and varieties.

CHAPTER V

SUMMARY AND CONCLUSIONS

Forage sorghums hybrids (18 entries) and varieties (6 entries) were examined for their nutritional and agronomic value by the measurement of percent crude protein, yield, and digestibility. Since these sorghums were developed for silage and dry fodder, they were examined for both types of forage.

For statistical purposes, the analysis and discussion were conducted by examining the hybrids and varieties separately.

Percent crude protein for both silage and dry forage was found to average higher in the hybrids than in the varieties. Also the early maturing hybrid entries were higher in percent crude protein than the later maturing hybrid entries. The days to maturity did not affect the crude protein content of the varieties. Hybrids were significantly different among themselves. Crude protein in the silage of hybrids was significantly higher than the crude protein content of the dry forage, indicating that silage preserves protein better than dry forage.

Varieties were more uniform in their crude protein content and were not significantly different from each other. The crude protein of the silage and dry forage from the varieties were essentially the same.

The protein yield, crude protein multiplied by dry matter production, was calculated as another method of evaluation. No differences were observed for protein yield between hybrids and varieties. Hybrid entries were statistically different for protein yield. The protein yield in the silage of the hybrids was significantly higher than in the dry forage. Variety entries were also different for protein yield. There was no difference in the silage and dry forage protein yield of the varieties.

Yield was measured by dry matter and by green forage tons/ha. Due to possible errors in drying, the green forage was considered a more precise yield indicator. The average of the varieties was significantly higher than the average of the hybrids for both dry matter and green forage yield. Hybrid entries were different for both measures of yield. Yield increased with increasing days to maturity. There were significant differences among varieties for both green and dry forage yields.

Varieties were also significantly higher than hybrids for the average in vitro dry matter digestibility. The digestibilities were different among the hybrid entries. The digestibilities of the silage and dry forage were essentially the same although the silage was slightly higher than hybrids for most entries. Varieties were not significantly different from each other in vitro dry matter digestibility of the dry forage or silage.

Silage quality was evaluated by pH, moisture level, color, and odor. Although the moisture level was slightly more than recommended, the silage was acceptable when the above measurements were used as the criteria.

In conclusion, the varieties performed better than the hybrids for the average digestibility and yield. The average of the hybrids was higher for crude protein content. Both hybrids and varieties were equal for protein yield.

While silage was not superior in digestibility, it could be safely concluded that ensiling does not cause a reduction of valuable nutrients and may preserve them better than dried forage.

Several varieties performed well in all of the aspects evaluated but no hybrid or variety was superior for all of the measured characteristics. However, the early hybrid entries, McNair 722 and Funks 93F, were superior for crude protein production. Funks 99F and Sart were the higher forage producing entries in this study. NK-326 was the leader in digestibility among the hybrids, whereas Sugar Drip was the top variety for digestibility.

The data collected during this study could be used to supplement recommendations concerning sorghum hybrids and varieties in the production of high quality forage.

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APPENDIX

TABLE XI

AVERAGE PLANT HEIGHT FOR HYBRIDS

Hybrids	Plant Height (cm.)
FS-53	315.60 a[1]
Funks 99F	310.52 a
McNair 744	275.80 b
FS-25	264.80 bc
S-214	246.38 cd
NK-326	232.41 de
Hi-Kane	232.41 de
Funks 93F	222.25 ef
FB-44	208.28 fg
G-30F	207.65 fg
Titan E	203.20 fg
NC + 675F	203.20 fg
Bundle King II	201.30 fg
SM-300	198.76 fg
Si Gro 2	197.95 g
Husky	194.95 g
McNair 722	188.60 g
FS-1B	137.16 h

[1]Values within plant height followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

TABLE XII

AVERAGE PLANT HEIGHT FOR VARIETIES

Variety	Plant Height (cm.)
Sart	299.09 a[1]
Rio	285.12 ab
Dale	265.43 bc
Brandies	256.54 bc
Roma	250.83 c
Sugar Drip	216.54 d
Mean	261.62

[1]Values within plant height followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

VITA 2

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