COMPARISON OF ANIMAL PREFERENCE AND UTILIZATION AS INDICATORS OF QUALITY IN SUDANGRASS AND FORAGE SORGHUM TYPES

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CHAPTER I

INTRODUCTION

Livestock show distinct preference for certain forages. Indications are that animals can detect very distinct differences between varieties within a species. It is also well established that intake is one of the chief factors governing animal performance. The reasons for livestock preference are not well understood, yet grasses are of value only when fed to livestock and if animal production whether in the form of meat, milk, or wool, is to be increased to meet the demand in the future, animal performance as influenced by total intake must be improved.

Speculation, comments, and contradictions on palatability can be found in forage literature. Many report on the complexity and importance of the problem without offering satisfactory evidence on why known differences in palatability occur. Some researchers have attemted to explain livestock preference on the basis of nutritive value, while others relate preference to chemical composition (crude protein, amino acids, carbohydrates, etc.), others have implicated smell and aroma, and still others associate it with the phenotypic and physical characteristics of the plant.

If it were possible to increase animal intake through increased preference for the forage, a decided yield increase in animal production could be obtained. More objective forage breeding programs can be developed if the question of "what determines animal preference and why" can be defined and evaluated. Herbage yield, chemical composition, and productivity in terms of the animal are needed, for the animal is the ultimate judge of forage quality.

Two objectives have guided this research: (1) to determine animal grazing preferences for various sorghum types [*Sorghum sudanense* ('Piper') Stapf.] during the growing season and to associate this preferences with certain laboratory techniques which will measure quality and (2) to determine the value of certain forage sorghums [*Sorghum bicolor* (L.) Moench.] for animal utilization by grazing in late fall and winter to measure the quality of the forage by various techniques.

CHAPTER II

LITERATURE REVIEW

The response of the animal to the forage is considered by most investigators to be the most reliable measure of forage quality, if the physiological characteristics of the animal are constant. Quality is a nebulous term, but it refers to the aspects of forage as reflected in the yield of animal product. Mott (36) diagrammatically related the animal response to a given forage as a measure of quality *in toto*. Forages vary in their nutritive value, and in the rate at which they are consumed by the animal. He suggests that the nutritive value of a forage, as characterized by its chemical composition and digestibility, and the rate of intake are the two characteristics of greatest importance in evaluating forage crops. The rate of consumption of a forage is related to the readiness with which a forage is selected and eaten (palatability), the rate of passage during digestion, the quantity of forage available to the animal, and the environmental effects upon the grazing animal.

Quality is not easily defined or measured, but composition, physical appearance, digestibility, and palatability are key factors to consider in successful feeding operations. Plant composition, as determined by chemical analyses (crude fiber, ash, crude protein, carotene, and phosphorus) and digestibility (TDN), are the research workers' guides in estimating forage quality. The livestock feeder must base his quality judgments on experience and on the appearance of the forage (color, leafiness, and stage of maturity) to obtain economical production of milk, meat, and wool by ruminants.

A critique of the chemical analyses used to evaluate forage crops has been reported by Sullivan (43). He concluded that for the agronomist, lignin and crude protein content are good criteria of quality, with the moisture content of the standing crop also a factor. The major factor in determining the nutritive value in a forage is the amount of digestible energy provided by the forage consumed by the animal (39). The content of digestible energy, whether expressed as energy, digestible dry matter, or total digestible nutrients, is the classical index of forage quality (39). Blaxter et al. (6) suggested that the consumption level of forages by ruminants increases with the quality, i. e., the digestible energy or digestible dry matter content of forages.

Four groups of factors relating to animal preference have been recognized (14): (1) palatability, which includes attributes of the plant that the animal can recognize, (2) conditions surrounding available herbage such as microclimate, soil conditions, relative abundance, contamination, and mixture of species, (3) the previous history of the animal in both the sense of evolution of food habits and learning experience, and (4) the physiologic state of the animal.

Animal species differ markedly in their food habits, with each species showing innate preferences for certain plants, parts of plants, or plants in particular growth stages. Forage preference by domestic animals have also been shown to be related to pregnancy, fatness, lactation, and hunger. Sight, smell, touch, taste, instinct, and experience probably all bear on preference (25), but these are complex interacting mechanisms whose influences have been observed but not measured or explained.

The research relative to palatability is truly not conclusive with contradictions because of the array of forage species combined with different measurements of animal preference. Forages high in mineral content (particularly phosphorus and potassium), fats, soluble sugars, moisture, and crude protein are generally preferred by the animal, while those high in carbohydrates (NFE), crude fiber and silica are considered less palatable (5,16,19,20,30,32,41). These findings have led many researchers to agree that the succulent forage which is young, tender, and turgid will possess the desirable attributes and that older more mature tissue which is high in carbohydrates, silica and fiber will be less preferred.

The following research are examples which support these findings. Sorghum grasses high in potassium and phosphorus were positively preferred by the animals while carbohydrates (NFE) and crude fiber were negatively related with palatability (5,19,20,32,41). In a grazing study using sudangrass hybrids (Sorghum vulgare X Sorghum arundenaceum) crude protein and total sugar were positively related with grazing preference while crude fiber and dry matter yields were negatively related (20). In a study of a number of species, plants having the highest content of sugar and phosphate were the most palatable (38). Buckner et al. (7) were successful in demonstrating relationships between chemical compositon and palatability. Through a breeding program, they transmitted the palatable characteristics of Annual ryegrass (Lolium multiflorum Lam.) into a hybrid, by crossing Annual ryegrass with the unpalatable Tall fescue (Festuca arundinacea Schreb.) The chemical analysis of the hybrid resulted in a highly significant inverse relationship for the association of sugars and moisture with silica and a significant positive association of sugars with digestibility. These findings suggest a relationship of silica and lignin and their combined influence on digestibility. The hybrid was low in silica and the increase in palatability appeared to be the result of great succulence (high moisture), higher sugar content, and lower fiber content than the parents. They concluded that the close association of sugar, digestibility and palatability, suggests that sugar content would be a good indicator for the nutritional value of the grasses.

Sullivan (43) reported that moisture is a lesser known criterion of forage quality and that moisture content of the tissue, free from surface water, is therefore higher in forages of good quality than in those of poorer quality. Archibald (2) reported moisture to be positively correlated with acceptance in palatability trials. An increase in moisture content may make herbage more attractive, but it may also reduce the dry matter and energy which the animal consumed (14). Animal preferences are also related to water-soluble dry matter and the water-soluble carbohydrate fraction.

Silica, like lignin, is an integral part of the matrix of plant cell walls, and it may similarly reduce the accessibility of the cell wall carbohydrates to be attacked by the digestive microorganisms (1). Van Soest (46) reported that silica interfered with the digestibility of other grass components. For every additional unit of silica contained in a grass, digestibility decreases three-fold.

Statistical studies (1) show that the indigestibility of grasses unexplained by known factors, such as lignin content, was closely related to silica content. Studies with artificial rumens revealed that when silica was chemically removed, the digestibility of grasses improves (46).

There is so little understanding of silica in plant feeds that it is overlooked in chemical analysis aimed at accessing the nutritive value of feeds. If one considers that the composition of the fiber fraction determines its digestibility, then analytical procedures should be devised to retain the silica in this fraction rather than exclude it (29).

Perhaps more significant than the amount of any chemical compound is the combination of components (25). Although protein shows the best correlation of all chemical ingredients with preference of forages by livestock, several investigators believe that total nutritive value of the plant is a better indicator of palatability. Also, Heady (25) found that in most grazing studies, preference has been correlated with groups of compounds rather than with single items because of the difficulty in having one variable fluctuating and all others remain constant. Stapledon (42) suggested that animals have, more or less, an instinctive drive to satisfy all their nutritional needs, while others (34,35) reported that animals may deliberately select certain plants for their salts and calorie contents.

Certain external physical factors of plants may influence animal preference. Jung and Ried (31) found that Piper was an outstanding variety with high yielding capacity, resistance to foliar diseases, and higher animal preference than some of the present hybrids, which are more robust types, with higher yields, wider leaves, and coarser stems.

However, the dry-matter content of the sudangrass varieties was generally higher than that of the hybrids. When strip grazing Piper, Haygrazer, and Hi-dan-37 at moderate stocking rates, Piper was grazed to the soil surface, while approximately 12 inches of stem stubble remained on Grazer and Hi-dan-37. The preference for the variety Piper was associated with the physical characteristics of growth.

Palatability in grass sorghum was reported by Gangstad (19) to be generally related to factors of leafiness, succulence, and tenderness. Leafiness, as measured by the percent leaf weight, as found to be more highly correlated with palatability than any other factor of physical composition. This is in agreement with the report of Johnstone-Wallace (28) in which the palatability preference of animals for leaves was much greater than for stems. Burton (9) found that leaf blades from the top of heading culms of Gahi-1 pearl millet [Pennisetum glaucum (L.)] and Georgia 337 sudangrass contained more crude protein, more true protein, and less lignin than older bottom leaves taken from the same culms. Young leaves of three late-maturing pearl millet genotypes gave an in vitro dry-matter digestibility of 75.3% whereas old leaves were only 61.4% digestible. Young and old leaves did not differ in cellulose or total available carbohydrate content, but the young leaves were unquestionably more palatable to cattle than were old leaves.

Animal preference is probably influenced by the presence of awns, spines, hairiness, position of leaves, stickiness, and texture (25). The hairs and other trichomes of the leaf can be highly impregnated with silica and the leaf surfaces become rough to the touch. The grass then becomes less palatability to the grazing animal (29). Jones (29) reported that variation in palatability may in part be due to differences in silica content of the plant. Negative correlations have been shown between silica and animal preference in native grasses (16).

The relationship of color to animal preference has been observed, but usually plant color is associated with physiological changes within a species, and only limited color variations within genotypes. Fontenot and Blaser (18), reported that color would be of little importance in selection of herbage by sheep since they appear to be color blind. However, Dwyer et al, (17) reported there were times and conditions when a species, normally considered unpalatable, was selectively grazed by cattle. The relative preferences of yearling steers for 18 species of native and introduced forage plants was closely associated with maturity and plant color.

Another possible explanation of preference and/or palatability of forages might be found through research with animal rejection for particular plants. Aroma and odor have been shown to be implicated in acceptance or rejection of forage by the animals. Some of the early research on forage selection by animals offered no common explanation for the acceptance or refusal of a plant, except that plants characterized as "aromatic" were not relished and sheep did not discriminate between poisonous and nonpoisonous plants (24). Fontenot et al. (18) reported that the sense of smell was of no importance in selection of herbage species by sheep, although it appeared important in initial stimulation of appetite. However Roe et al. (40) suggested that selection or rejection of certain strains of Phalaris arundinacea by sheep was made through smell rather than taste. In a review of the palatability, Heady (25), stated that there was little understanding in the relationship of odor to animal preference. He reported that odor-producing glands were found external to the plant but odors may also originate internally and become released only with mastication of the plant tissues.

A number of theories have been advanced to explain the rejection by cattle of forage growing over the near dung-contaminated areas. Norman and Green (37) reported that the initial neglect of herbage around animal droppings was due to the dung itself, and that the resultant ungrazed herbage then became mature and unpalatable. Gardner (24) expressed the idea that the lush growth around dung spots could be unpalatable, but that some rejection could be due to smell alone. However, Tribe (45) reported that when red clover [<u>Trifolium pratense</u> (L.)] was given a smell of fresh sheep feces (but not directly contaminated) it was avoided by sheep with a normal sense of smell, but readily consumed by sheep which had no sense of smell due to removal of the olfactory bulbs.

After a given time period, odor may be of minimal importance near dung contaminated areas, however the chemical components of the plant may become altered. Plice (38) found that the manure affected plants were always higher in protein, calcium, potassium, iron, fat, nitrates, and vitamins. The normal or unaffected plants were always higher in silica, aluminum, phosphorous, tannin, chloride, and sugars. When sugar was added to manure-affected plants, they become palatable and were readily eaten. He hypothesized that high nitrogen and low phosphorous content in fresh cow dung provided a source of plant nutrients having a P/N imbalance, which prevented normal sugar formation in the forage and thus decreased its palatability. Plice (38) speculated that application of large amounts of N fertilizer would result in pasture forage that was unpalatable to livestock because it affected plant composition in a similar manner to dung. However, Burton (10) reported that the percentage of bermudagrass [Cynodon dactylon (L.) Pers.] consumed by cattle increased as fertilization increased to 1,500 pounds per acre. Heavy applications of phosphorous would not overcome the unpalatability of dung-affected brome (Bromus inermis Leyss.) and that heavy applications of nitrogen fertilizer would not cause brome to become unpalatable (33). While a dilute mixture of feces, urine, and water, did not cause a significant change in crude protein, phosphorous, or sugar concentration, it did result in a significant refusal of the forage by the animals, which provided evidence that the aroma of the excreta, rather than the quantities of these substances in brome, was the major determinants of forage rejection.

Research shows that selective grazing will affect animal output (14). Cattle allowed to graze the top half of the grazeable herbage under rotational grazing produced at a higher level than those which grazed the remainder. Rate of production for whole-plant grazers was intermediate. The top grazers selected herbage that was more nutritious and higher in digestibility, and the animals consumed more (18).

Animals prefer certain grasses which are not always the highest beef producers. A study (31) over a three-year period showed that the highest beef yields were obtained from Piper and Tift Sudan, although Johnson grass [Sorghum halepense (L.) Pers.] and Sweet Sudan were considered to be more nutritious and palatable. In a study using five forage types, Crampton (15) found that the total digestibility of a forage was not necessarily related to acceptability or to animal gain. These findings agree with those of Corbett (12) in which cattle consumed more of one grass than another but their weight gains were the same for both forages.

Research investigators agree that the hand-plucked herbage for sample analyses is an unreliable index of the composition of the herbage actually grazed (24). With the aid of esophageal fistula animals, samples can be taken of the herbage actually grazed by the animal. In most all instances the materials selected by the animals were significantly higher in the plant components: protein, carbohydrates, minerals, and ether extract, and lower in lignin and crude fiber, than hand harvested samples.

The development of reliable laboratory methods for estimating forage quality is one of the most challenging problems in agricultural research today. Barnes (4) reported that the in vivo digestibility trial has been the standard procedure for estimating forage quality, but such trials are expensive and time consuming. Also that the method was not applicable to small quantities of forage that were usually available from the plant breeder's nursery or from small-plot agronomic experiments. Considerable interest has developed recently in the use of the in vitro rumen fermentation technique for the evaluation of forage quality. The in vitro rumen fermentation technique, to a degree, simulates the digestive process in the rumen by which structural carbohydrates are digested and converted into soluble products by enzymes of the rumen microorganisms. This value is then used as a predictor of in vivo digestibility or intake by the animal. The artificial rumen has been used with considerable success in the prediction of the energy or dry-matter digestibility of forages (17). Attempts to relate the level of forage intake to the rate of fermentation of forage components in an *in vitro* system have, in general, indicated a lesser accuracy of prediction (39). This may be explained by such factors as forage palatibility and the high variability of animal response in intake trials. Ried et al. (39) found a positive correlation between *in vitro* and *in vivo* dry matter digestion of Piper sudangrass and concluded that as the physiological age of sudangrass increased, there was a concomitant fall in voluntary intake, and a highly significant correlation between consumption and dry matter digestion. A highly significant correlation between ad libitum intake and percent digestible dry matter was found for sudangrass varieties and hybrids (39).

Any influence of digestibility on intake declines when digestibility is above 65% (34). Dry matter intake of a forage increases with increasing concentration of digestible nutrients in the feed of dairy cows (11) and high correlations are found between milk production and nutrient intake. Variations in digestible dry matter were associated with variations in milk, energy, and body weight, and at low digestibilities the level of milk production was determined by the animal's capacity and the rate at which undigested feed could be moved through the alimentary canal (6). At high levels of digestibility the physiologic state of the cow was the primary determinant of feed intake (6).

EXPERIMENT II

Livestock producers would value an extension of the grazing period in the fall and winter to reduce labor and other costs and to shorten the winter feeding period. The possibility of extending grazing into the fall and early winter would be advantageous to many producers.

The utilization of forage saved for fall use has been studied more extensively in Great Britain (12,13,21) than the United States. Systems tested in Britain involved perennial species, such as orchardgrass, ryegrass, alfalfa, and lovegrass, where a surplus of material was accumulated prior to frost and utilized *in situ* with livestock. Burns and Wedin (8) reported that conditions of snow, rainfall, and temperatures in Great Britain are not as severe as in midwestern United States and are thus, more conducive to an *in situ* grazing system in winter.

Corbett (12) and Gardner and Hunt (21) reported nutrient losses with winter *in situ* forage utilization in Scotland. These losses, however, did not exceed those encountered under the conventional method of harvesting hay in Scotland. Organic matter and crude protein losses of forage increased as the winter progressed. The protein content was considered relatively high and approximately equivalent to stored hay. Dry matter yields of *in situ* forage were high in all years and were directly related to the length of the regrowth period prior to frost.

Morphological characteristics of the species involved and the date when pastures were grazed after frost were suggested by the British workers as important factors for obtaining high utilization of the forage (12,13,21). In all studies, livestock were able to maintain body weight while utilizing *in situ* forage, except during periods of snow cover.

Improved animal management was of greater importance in winter than in summer grazing because the forage was subjected to many factors which caused rejection by the animal (13,21).

Research on sorghum production in late-season has been reported by Webster and Davies (47). They indicated that maximum dry matter yields of forage sorghum occurred during early September. Dry matter losses increased constantly after frost, with 50% of the total forage lost by December. Percent crude protein was highest (10%) at the immature stages of growth and decreased to 3.5% at the seed-set stage. After frost, crude protein values ranged from 1.7 percent in October to 1.9 percent in December. Percent curde fiber increased gradually after frost to 30 percent in December. Frosted and weathered forage were considerably lower in feeding value than forage harvested at frost.

Burns and Wedin (8) found that "stockpiled" forage sorghum offers a real possibility for obtaining large quantities of forage low in crude fiber and prussic acid content for maintenance of ruminant animals. They found that sudangrass increased progressively in percent crude fiber from the pasture to the hay and to the stockpiled management system. Forage sorghum reacted differently with a drastic decrease from 27.5% crude fiber under hay management to 20.9% under the stockpiled management system.

Forage sorghum saved for fall use following one summer cutting as hay would be more efficiently utilized when grazed for reasons of availability alone, allowing the animal access to the forage without pulling it down (8). They suggested a possible increase in the feeding value of forage sorghum if harvesting was delayed until approximately frost time as compared with early cutting.

Although protein content is not as critical for ruminants as for nonruminants, Burns et al. (8) suggested that protein warrants consideration since higher quality forage reduces or eliminates needs for protein supplements. They reported a uniform percentage of crude protein was maintained essentially from the time of killing frost through the final fall cutting for both sudangrass and forage sorghum.

Hobbs et al. (26) reported losses in the native grasses from late summer to late winter. The apparent digestibility of dry matter, protein content, and NFE decreased from about 58%, 7.5%, and 60% respectively in September to about 41%, 4.3%, and 45% in November, to 40%, 2.5% and 45% in February. Also, when compared to the cured native grass hay, the late winter grasses had a lower dry matter digestibility.

To consider the economics of winter cured forages versus baling cured hay, Hodgson (27) found that the mowing and post-mowing operations account for one half the cost of producing the hay. In addition, the harvesting, storage and feeding processes still require considerable hard labor and offer resistance to maximum mechanization and transport.

CHAPTER III

METHODS AND MATERIALS

EXPERIMENT I

Eight sorghum grasses were selected representing different types of sudangrass and forage sorghum varieties and hybrids used in live-stock feeding.

The types used in the 1967 and 1968 trials were: Piper and Sweet Sudan, Sudangrass varieties; Sudax and Haygrazer, sorghum X sudangrass hybrids; Sweet Sioux and Horizon Sp-110, sorgo X sudangrass hybrids; Trudan II, sudangrass X sudangrass hybrid; and Sugar Drip, the forage sorghum variety.

These eight selected types of sorghum grasses were planted in a randomized complete block design on a Norge loam soil on the Agronomy Research Station, Stillwater, Oklahoma. The experiment was replicated four times. The planting dates were May 30, 1967, and June 5, 1968. The forages were planted at a rate of 20-25 pounds per acre with a six-hole drop Planet Jr. planter. Tiller and stand counts were determined for 2 rows 18 inches long. In 1967 the plots consisted of six 25 foot rows spaced 12 inches apart. Plot length was increased to 50 feet in 1968 to allow more accurate sampling for each treatment. The six row plots provided two center rows for the harvest and four guard rows for border.

The experimental site was fertilized in May, 1967 with 300 pounds per acre of a 10-20-10 fertilizer which was incorporated with a grain drill. After the second and third grazing trials, an additional 30 pounds of nitrogen per acre as ammonium nitrate were applied by a Gandy spreader. In 1968, 300 pounds per acre of a 10-20-10 fertilizer was applied preplant and followed by 30 pounds nitrogen after each successive grazing trial.

Supplemental irrigation was applied to achieve maximum yields for each variety and hybrid. Applications were made on August 1, 1967, June 19, August 5, and September 9, 1968. Approximately 3 acre-inches of water were applied with a sprinkler irrigation system on each date.

Animal response was determined for two growth stages of the selected forage types. The early growth stage was 24-30 inches average height, while the latter stage of growth was 40-45 inches average height. There were differences in height between the different types as a result of seedling vigor and speed of recovery after clipping.

Three clippings from each plot were used to determine animal preference and utilization of the available forage for each grazing trial. The initial clipping yielded the total quantity of forage available to the animal. After which, six Hereford heifers were allowed to graze selectively, cafeteria style, until indications of preference and palatability were obvious over all replications. Visual ratings of the preferred types were recorded and the second clipping taken from each plot. The animals were allowed to continue grazing to give indication of preference for the less palatable types. When the forage became limiting, the final clipping of unconsumed residual forage was recorded for each plot. After each grazing trial the plots were clipped to a uniform average height of 3 inches with a Jari mower.

A varying number of grazing trials were performed depending upon the stage of maturity and the growing season. In 1967, four grazing trials were conducted on the early growth stage (24-30 inches in height) while the latter stage of maturity (40-45 inches in height) supported only three grazing trials. Three grazing trials were performed on each growth stage in 1968. The early growth stage was clipped to three inches the third week after planting to correct irregularity of germination and early plant growth.

From the initial clipping of each grazing trial, plot yields expressed as pounds per acre oven dry forage and calculations of percent dry matter were recorded. Whole plant samples were ground to pass the 2 mm sieve of a Wiley Mill. Aliquots were taken from the ground samples for laboratory analyses.

Percent nitrogen was determined by the Micro-Kjeldahl apparatus using 0.2 grams oven dry forage (3).

A modified Tilly and Terry (44) in vitro forage digestion technique was used to determine dry matter digestibility. Duplicate one gram oven dry samples from each treatment with two standards, consisting of high (alfalfa) and a low digestible (bermuda grass) forage, along with prepared blanks, were subjected to digestion. The standards were used to evaluate the rumen innoculum and for relative comparison for each treatment.

Digestion samples contained 80 milliliters of McDougall's (35) buffered solution, 20 ml. of rumen liquor from a fistulated steer on a bermudagrass-alfalfa hay diet, and were incubated under anerobic conditions, at 38 degrees C. for 48 hours. After which time micro-flora activity ceased by placing the samples into a 5° C. refrigerator. The rumen innoculum was removed after centrifugation and the 100 ml. acid pepsin solution (2 g. 1:10,000 pepsin in 1,000 ml. of 0.1 N HCl) was added and the sample then placed in the incubator at 38° C. for 48 hours. Gentle agitation for all samples at frequent intervals assured a uniform mix of the contents throughout the digestion procedures. The indigestible residue was quantitatively determined by drying at 70° C. Percent digestible dry matter was calculated by subtracting the indigestible residue (less the blank) from the total weight of the sample, multiplied times 100.

Silicon content was determined by modifying the method described by Gieseking et al. (23) for comparative purposes with in vitro dry matter digestion. At the time of sampling, a thorough washing of all plant material with distilled and deionized water was necessary for removing surface silicon. Wet ashing of plant materials was performed by the complete digestion of a two gram aliquot for each treatment using a 3:1 nitric-perchloric acid mixture. Quantitatively, the plant residue from the digestion flask was transfered to the pre-weighed fritted glass disc filter and washing with 150 ml of hot deionized water, will yield internal plant silica.

Attempts were made to determine alcohol soluble carbohydrates for green frozen plant material. Difficulties were encountered in obtaining representative samples because of the extremely large plants and small sample size that was analyzed. In view of this difficulty, samples for alcohol soluble carbohydrates were taken from the oven dried materials. Alcohol soluble sugar content was determined by the anthrone method of Yemm and Willis (49). A representative sample of 2 grams of grass material (leaves and stems) was selected from each treatment, put in 15 ml. of 80-percent ETOH, and stored in a cool place. Each sample was ground, boiled gently for 20 minutes, and filtered through No. 40 Whatman paper. All alcohol extract samples were made up to a standard volume with 80-percent ETOH, and the alcohol soluble sugar content determined.

EXPERIMENT II

The eight forage sorghums were selected to represent different types of varieties and hybrids used in livestock feeding. These types represented a cross-section of the quantitative and qualitative characters found in forage sorghum genotypes. The purpose of this study was to evaluate forage sorghums cured in the field for animal utilization during the winter months.

The grazing trials were conducted on a Norge loam soil in 1967-68 and 1968-69 at the Agronomy Research Station, Stillwater, Oklahoma. Each plot consisted of six rows, 50 feet long spaced 12 inches apart. The two center rows of each plot were considered the test plot rows and the four remaining rows were used as borders.

The forage sorghums were seeded with a six-hole drop Planet Jr. planter at a rate of 20-25 pounds per acre. The varieties and hybrids were planted on July 6, 1967 and July 22, 1968. A 500 pound per acre application of a 10-20-10 fertilizer, was applied preplant to the experimental area. On August 7, 1968, a supplemental irrigation was applied to achieve a uniform germination for all plots. Approximately 2 acre-inches of water were applied with a sprinkler irrigation system on this date.

The field design consisted of a randomized complete block using the eight varieties as treatments. The experimental unit consisted of eight replications using two replications for each grazing trial. Thus four dates were arbitrarily set for grazing trials through the winter months, namely: November, December, January, and February.

Forage utilization was determined by initial clipping before grazing followed by a clipping of the residue forage left after the grazing period. The percent dry forage and dry matter production per acre were determined by oven drying the initial clipping and converting to pounds per acre. From this dried sample of forage material, protein was determined by the Micro-Kjeldahl technique (3) and percent digestible dry matter was determined by modified Tilly and Terry method (44) for each grazing trial.

Animal preference was determined by close visual observation of the plots throughout the grazing trials. These observations were expressed as a comparison of the forage types ranked 1 through 8, consecutively.

CHAPTER IV

RESULTS AND DISCUSSION

EXPERIMENT I

Stands were not uniform for all varieties and hybrids. The 20-25 pound seeding rate had differences in stand counts since the seeds were of different size and dimensions. Average stand counts for the intitial, regrowth after the first grazing, and regrowth after the third grazing trial, are shown in Table I. Stand counts increased and essentially doubled in the regrowth after the first grazing trial as a result of tillering for all forages except Sugar Drip.

Grazing pressures reduced plant stands for some types. The stands following the third grazing were reduced about 50 percent for Sweet Sudangrass, one of the most preferred types, while Piper, Trudan II, and Horizon SP-110 had only slight reductions in plant numbers. The variety Piper and the true sudangrass hybrid Trudan II, were also preferred by the animals but could withstand the grazing pressure. The sorgo X sudangrass hybrids, Sweet Sioux and Horizon SP-110, and the sorghum sudangrass hybrids, Haygrazer and Sudax, were less palatable types while a reduction in plant numbers was not apparent with grazing pressure.

Yields for each sorghum type from the grazing trials at each stage of growth were totaled for the entire growing season. The mean of 1967-68 yields for each growth stage are given in Tables III and IV. The hay

TABLE I

STAND COUNTS FOR SORGHUM TYPES AT THE PASTURE STAGE IN 1967

Sorghum Type	Plants/Sq.Ft.	Tillers/Sq.Ft.	
	Initial Stand	Regrowth after First Grazing Trial	Regrowth after Third Grazing Trial
Piper	22	48	40
Sweet Sudan	17	37	18
Sweet Sioux	10	24	22
Haygrazer	11	25	25
Sudax	10	24	22
Trudan	13	43	35
Horizon	14	24	20
Sugar Drip	18	17	1

TABLE II

ANIMAL PREFERENCE AS EVIDENCED BY PERCENT
FORAGE UTILIZATION AT TWO STAGES
Means of 1967-68

Sorghum Type	Pasture Stage	Hay Stage
Piper	41	32
Sweet Sudan	42	42
Sweet Sioux	31	27
Haygrazer	32	11
Sudax	39	12
Trudan	41	32
Horizon SP110	24	18
Sugar Drip	32	10

TABLE III

ANIMAL PREFERENCE, AVERAGE YIELD, AND OTHER DATA
OF SORGHUM TYPES IN THE PASTURE STAGE
1967-68

Type	Animal Preference	Yield Dry lbs./A.	Dry Matter Percent	Percent Digestion	Nitrogen Percent
Piper	1	7,062	15.7	54.53	2.62
Sweet Sudan	2	6,159	14.8	57.35	2.87
Sweet Sioux	7	9,296	14.5	56.10	2.64
Haygrazer	6	8,509	14.2	57.16	2.73
Sudax	5	8,300	14.0	57.67	2.69
Trudan II	3	8,211	14.3	55.94	2.68
Horizon SP-110	4	8,343	13.7	56.86	2.53
Sugar Drip	8	7,120	13.7	59.31	2.81

TABLE IV

ANIMAL PREFERENCE, AVERAGE YIELD, AND OTHER DATA
OF SORGHUM TYPES IN THE HAY STAGE
1967-68

Type	Animal Preference	Yield Dry lbs./A.	Dry Matter Percent	Percent Digestion	Nitrogen Percent
Piper	2	9,634	14.8	46.33	2.34
Sweet Sudan	1	7,643	13.3	48.74	2.67
Sweet Sioux	6	10,134	12.7	48.16	2.51
Haygrazer	7	10,530	12.6	47.96	2.43
Sudax	5	11,995	12.9	47.99	2.37
Trudan II	3	9,989	14.2	47.38	2.30
Horizon SP-110	4	10,276	13.0	48.13	2.27
Sugar Drip	8	7,850	11.6	50.17	2.58

stage of growth was highest in forage dry matter yield per acre. At both stages of growth hybrid vigor was indicated for the sorgo and sorghum X sudangrass hybrids by their higher production of dry matter per acre. These were followed in production by the true sudangrass hybrid. The forage sorghum and sudangrass varieties were the lowest yielding types for either stage of growth. Yields for each grazing trial within each growth stage are given in Appendix Tables VII, VIII, IX, and X.

The sudangrass varieties Piper and Sweet Sudan were the most preferred types for all grazing trials (Fig. 1). When Piper and Sweet Sudan were compared at different stages of maturity, Piper appeared superior at the early stage while Sweet Sudan was more preferred at the later stage. The true sudangrass hybrid, Trudan II, was very similar to the sudangrass varieties in physical and phenotypic characters and ranked third in animal preference. The hybrids, Sudax, Horizon SP-110, Sweet Sioux, and Haygrazer were intermediate, while Sugar Drip was the least preferred type.

As the season progressed, preferences for the specific types were more difficult to rank and ratings became high, medium, or low in acceptance (Appendix Tables VII, VIII, IX, and X). The trend toward uniform grazing or reduced preference for particular types in the regrowth forage indicated either a lower quality forage for the preferred types as the season progressed or a higher quality forage for the less preferred types.

Taste did not appear to be a criteria of selection in the sorghum grasses. Until animal adjustment to the new grazing area was attained, the animals grazed casually across replications and meandered about until preferences were established. Once preferences were made the

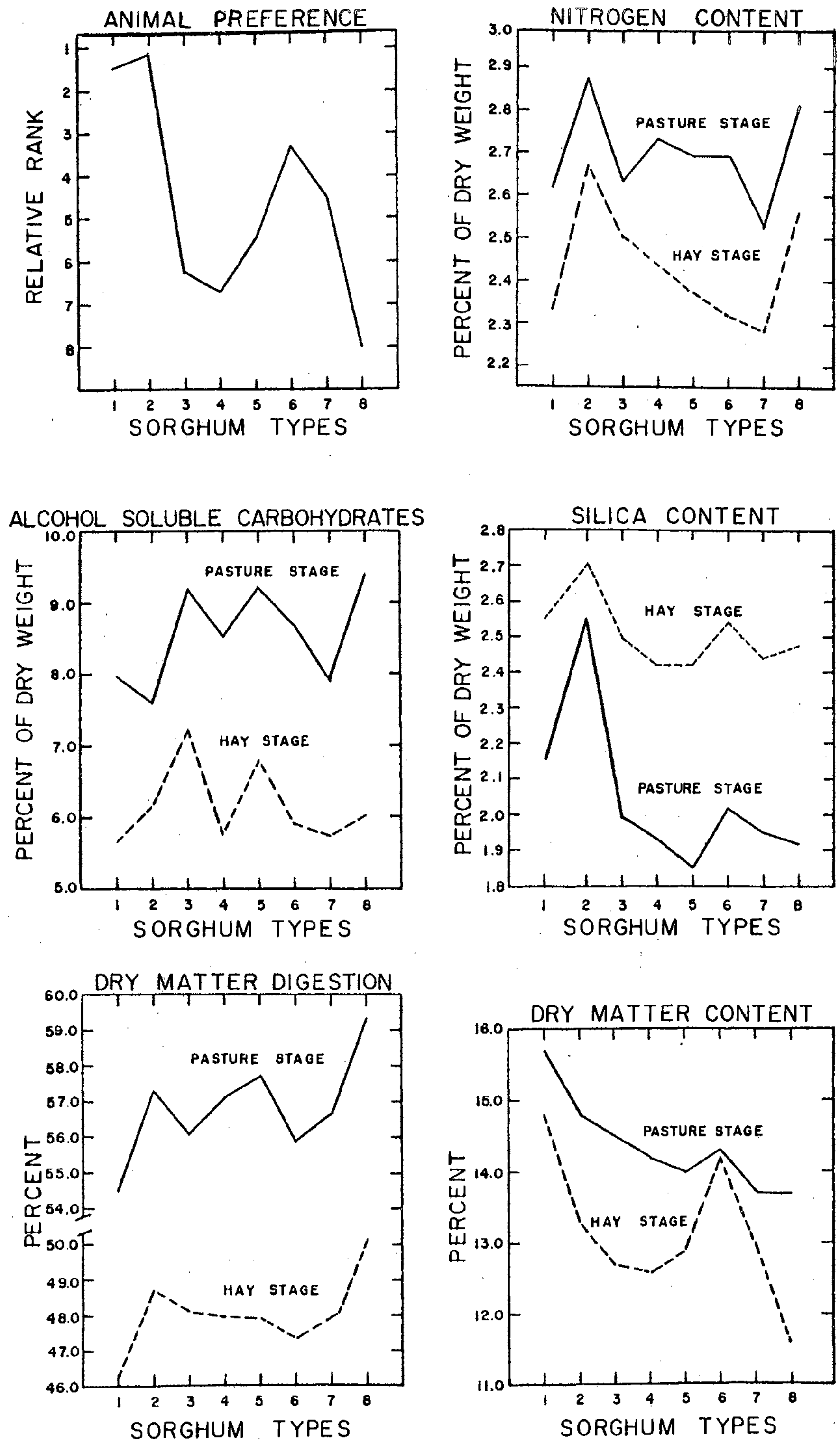

Figure 1. Analyses for the Sorghum Types: 1-Piper, 2-Sweet Sudan, 3-Sweet Sioux, 4-Haygrazer, 5-Sudax, 6-Trudan II, 7-Horizon Sp-110, 8-Sugar Drip

animals could identify other replications of the preferred types without actual tasting of the preferred plots. Animals apparently detected this pattern by smelling, or browsing (touch, feel) across all plots and confined their grazing to the preferred types.

To obtain a quantitative estimate of animal preference and forage quality, the following calculation was performed for all replications and grazing trials:

$$\frac{\text{Clipping 1} - \text{Clipping 2}}{\text{Clipping 1}} \times 100 = \text{Percent Forage Utilization}$$

Table II shows the percentage figures which illustrate animal preference and resemble very closely the visual ratings especially at the hay stage. These values are not truly conclusive because clippings were not always harvested at the appropriate times when visual preferences were well established. The accuracy of harvesting clipping 2 immediately when animal preference was shown, was not consistent across grazing trials. As a result, some types which were lower in preference (Sudax), had about the same percent utilization in the pasture stage as the preferred types, (Piper and Trudan II).

Animal preference and trends between the two stages of growth, are very similar for all laboratory analyses for each sorghum type.

Nitrogen content indicating plant protein has been the most highly correlated chemical component with animal selection (25). Figure 1 represents the percent nitrogen for the sorghum types (1-8) at two stages of growth. Varieties 1 and 2 were found to be the most preferred types and exhibited the extremes in percent nitrogen. Also the least preferred type, No. 8, was very high in percent nitrogen. All types were considered very high quality forages at both growth stages, while the pasture stage was significantly higher in percent nitrogen.

The highest percent dry matter digestion was for the forage sorghum Sugar Drip (Fig. 1). This response probably occurred because Sugar Drip was in an earlier physiologic maturity stage in comparison to the sudangrass types at all harvests. This variety was very high in succulence, low in structural components, and was least preferred by the animals. One of the more highly preferred types, variety 1, was the lowest in dry matter digestion. The pasture stage was earlier in maturity with less structural components and had the highest percent digestible dry matter.

The carbohydrate content as shown in Figure 1 indicated that within sorghum grasses, sugars did not appear as selective components. The less preferred types had higher amounts of soluble sugars while the highly preferred types were low in sugars. The early stage was found to have significantly higher amounts of sugars than the hay stage.

At the hay stage of maturity larger quantities of silica were accumulated in the plant when compared to the pasture stage (Fig. 1). The preferred types, 1, 2, and 6, had relatively higher levels of plant silica which indicated a relationship of preference with silica. These data conflict with data of previous workers (16,29) in which a negative correlation existed. However, these are in agreement with earlier results reported on the association of dry matter digestion with silica (46) where a negative correlation existed.

The types 1, 2, and 6, which were the true sudangrass varieties and hybrid (highly preferred), contained the highest amounts of dry matter (Fig. 1). A possible explanation for the animals preference for dry matter, silica and low digestible forage would be to satisfy their nutritional needs for body maintenance. This high amount of moisture may make the herbage more attractive, but it may be difficult for the animal to consume enough volume to meet energy requirements (15). For example, a 600 pound steer would have difficulty consuming 200 pounds of green forage of variety 8 (11.6% dry matter). In general, animals encounter forages having high dry matter content but will chose forage with lower dry matter and high moisture if available. Most research situations compare forages with wide differences in moisture content, i. e., high dry matter content versus one with a relative lower dry matter content, the herbage highest in moisture would generally be selected (2). The condition was reversed in this research, in that the forage types had very high moisture and low dry matter content. It is conceivable that animals grazing these forages might select types high in structural components (fiber and dry matter) in order to regulate the extremely fast rate of passage through the digestive tract.

The physical factors would be of minimal importance as palatability factors in sorghum grasses. The presence of hairs or other trichomes on the leaves, serrated margins, and color of the plant were considered uniform for all types.

The leaf to stem ratio was determined for each of the sorghum types and preference appears to be related to the size of the leaf (Fig. 2). The more preferred types, 1, 2, and 6, (true sudangrass varieties and hybrid) have narrow leaves, while the less preferred types, 3, 4, 5, and 7 (sorgo and sorghum sudangrass hybrids) are intermediate in leaf to stem ratio and had dry, pithy midribs in the leaves. The highest ratio obtained was for Sugar Drip, the forage sorghum with broad, heavy leaves, and no true stem in the very immature stages.

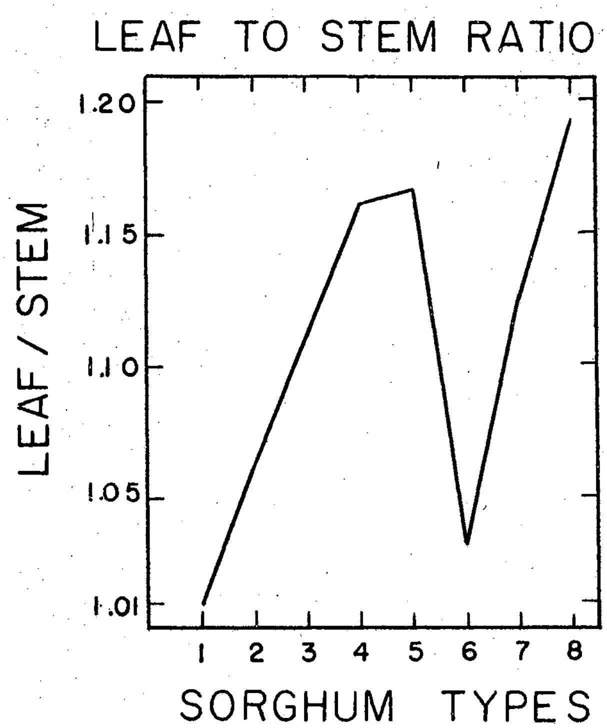

Figure 2. Leaf to Stem Ratio for 8 Sorghum Types

The various laboratory analyses which others have shown to be related to animal preference and forage quality were not in agreement with these findings. No single factor, which has been reported by other researchers, was found to explain animal preference in sorghum grasses. A combination of these components offers little evidence for the selection by the animals, however the energy content of the forage (percent dry matter) cannot be neglected in terms of maintenance requirements and also in terms of regulation of the rate of feed passage through the animal.

EXPERIMENT II

The need for a high quality forage which can be utilized *in situ* for wintering livestock is of great concern in the livestock industry.

There were marked differences in yields among the 8 forage types. Pioneer 931 had the highest total forage yield at all dates. (Appendix Tables X and XII). Yieldmaker, Sugar Drip, and Leafmaster 43 were intermediate in total forage production followed by Hegari, 3 Little Indians, Dekalb FS 1a and OK 632, respectively.

The average dry matter yields for all varieties are presented in Figure 3 and indicate that the varieties had about the same rate of loss through weathering as evidenced by an insignificant variety X date interaction. This 20 percent loss of dry matter for the dates Dec. 5 to Jan. 1, followed by an additional loss of 13 percent by Jan 24, represents the physical and chemical action of weathering in the winters of 1967-68 and 1968-69. The loss of dry forage could be explained by the degradative influence of weathering.

Forage quality (11) and animal preference (2) have been related to the amount of moisture in the standing forage. Figure 3 shows the mean percent dry matter of the eight forage types across the grazing seasons. The percent dry matter indicated moisture in the forage at the time of grazing. The variety Sugar Drip, the most palatable forage, retained significantly higher moisture within the forage throughout the grazing season. The increase in dry matter percent was best explained by continual freezing, thawing, and lodging of plants which resulted in a forage of lower quality as the season progressed. When the dry matter content approached 80 percent the forage became a dry-fiberous material

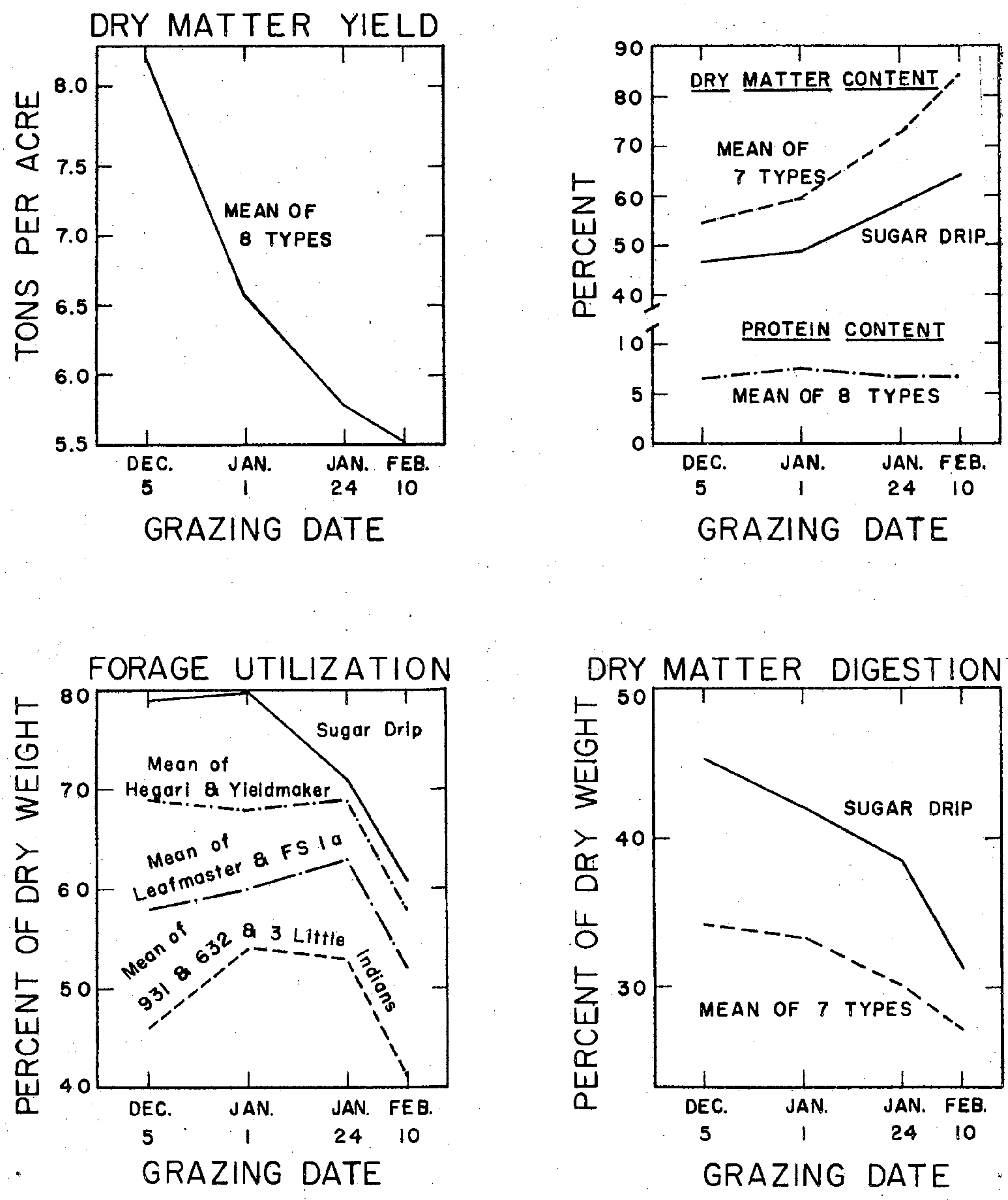

Figure 3. Dry Matter Yield, Dry Matter Content, Protein Content, Forage Utilization, and Dry Matter Digestion for 8 Forage Types.

and was objectionable to the animals because it was harsh and rough.

A forage of high quality must not only be a high yielding forage but also contain the properties desirable to livestock. Figure 3 and Appendix Tables XI and XII illustrates the animals grazing response to eight forage sorghums during the winters of 1967-68 and 1968-69. Sugar Drip had the highest percent utilization followed by Hegari, Yieldmaker and Leafmaster. Dekalb FS 1a, 3 Little Indians, Pioneer 931, and OK 632 were consecutively lower in percent utilization. However, this rank in percent utilization coincides with the visual preference ratings made for each grazing trial and would presumably be a valid test for forage quality in winter grazing.

As a result of the decline in available dry matter as winter progressed and animal grazing days remained constant, the percent utilization increased for the less desirable types, i. e., the animals were forced to eat types which they would not eat if other choices had been available. Since the choice of forage was limited, a rapid decline in forage utilization was observed for all forage types on the last grazing date.

Utilization in pounds of dry forage per acre is recorded in Table V. Again, Sugar Drip had the highest utilization followed by Yieldmaker. Pioneer 931 had a remarkably high dry forage yields per acre and a low preference rating. If the animals were forced to consume it, it would out-perform the lower yielding types and provide more grazing days.

The protein content of any feed is of major concern to the livestock producer. The protein content as determined by Kjeldahl nitrogen X 6.25 was relatively consistent for all sorghum types, at all dates

TABLE V

TWO YEAR AVERAGES FOR WINTER GRAZING FORAGE SORGHUMS

FORAGE SORGHUM TYPE	Yield Dry lbs./A.	Percent Dry Matter	Percent Utilization	Utilization lbs./A.	Percent Digestion	Digestible lbs./A	Percent Protein	Digestible Protein lbs./A.
Sugar Drip	15,331	51.7	75.7	11,606	39.6	6,071	6.3	382
Hegari	10,618	63.3	65.4	6,944	32.6	3,461	7.1	245
Pioneer 931	19,452	62.7	50.9	9,901	31.3	6,088	6.4	389
Yieldmaker	15,763	58.8	64.0	10,088	31.8	5,013	6.7	336
OK 632	9,375	71.4	50.0	4,688	26.9	2,521	6.7	169
Leafmaster 43	13,540	63.0	61.8	8,368	32.2	4,360	7.4	323
3 Little Indians	11,601	60.7	51.2	5,940	32.0	3,712	6.3	238
Dekalb FS 1a	11,099	66.6	56.8	6,304	31.6	3,507	7.7	270

throughout the testing period (Fig. 3 and Appendix Tables XI). This indicated that percent nitrogen of a plant becomes "fixed" and is relatively insoluble and resistant to the chemical and physical actions of weathering. For the ruminant animal maintenance ration, the quantity of protein found in cured forage sorghums was considered adequate until late January or early February.

The digestible dry matter of a forage is a true indication of forage quality and significantly correlated with animal consumption and production (46). The highest digestible forage for all dates was Sugar Drip, the variety most preferred by the animals. Although Pioneer 931 had a lower digestion, the production of digestible pounds of dry matter per acre was highest because of its extremely large forage production. A significant decline in percent digestible dry matter is represented in Figure 3. The severity of the winter on cured forage sorghums was truly represented in the decrease of digestible nutrients in the plants. As dry matter yields declined, the highly digestible portions of the plant (leaves, soluble constituents, i. e., starch, sugar, etc.) were lost and the indigestible fractions (dry stems, sheath, and heads, which were high in crude fiber and lignin) were proportionally greater.

The livestock producer in the cow-calf operation is primarily interested in maintaining the body weight of the brood cows in the winter months. The economics of wintering these animals at the lowest cost, also is of primary importance. Winter grazing cured forage sorghums might contribute greatly to such operations since the cost per acre or animal units is reasonably low when compared to feeding costs of the baled material (Table VI). The assumed grazing cost of $22.01/A. and $1.50/A. for labor and management cost gives a total operating cost of

TABLE VI

ESTIMATED FORAGE SORGHUM PRODUCTION COSTS AND RETURNS PER ACRE, ON A LOAMY SOIL IN NORTH CENTRAL OKLAHOMA*

Category	Kind	Unit Price	Feeding Hay Quantity	Feeding Hay Value	Grazing Quantity	Grazing Value
Production	Dry matter forage	ton 18.00	8.0	144.00	8.0	144.00
Total Receipts				144.00		144.00
Operating Costs						
Preharvest Cost:						
Seed		lb .20	20.00	4.00	20.00	4.00
Fertilizer	N	lb .10	50.00	5.00	50.00	5.00
	P	lb .08	100.00	8.00	100.00	8.00
	K	lb .05	50.00	2.50	50.00	2.50
Tractor	Repairs	hr .72	1.27	0.92	1.27	0.92
	Fuel & lube	hr .72	1.27	0.92	1.27	0.92
Equipment	Repairs & lube	acre .52	1.00	0.52	1.00	0.52
Custom hire	Rent fertilizer spreader	acre .15	1.00	0.15	1.00	0.15
Total Preharvest Cost				22.01		22.01
Harvest Cost:						
Custom hire	Swathing & Baling	bale .30	240.00	72.00		
	Hauling	bale .15	240.00	36.00		
Total Harvest Cost				108.00		
Total Operating Cost				130.01		22.01

*Strickland, P. L. and T. Dunn, Alternate Crop Enterprise Budgets for Dryland Production, Southwestern, Oklahoma. Processed Series P-599 January, 1969.

$23.51/A. for 8 AUM of grazing. While feeding the baled forage to the animals would involve a cost of production and putting in the barn of $130.01/A. plus an assumed cost of feeding in the winter $36.00/A., which gives total operating cost of $166.01/A. for feeding 8 tons of hay. Since the baled forage has a higher percent utilization the cost per AUM needs consideration. The total grazing cost was $16.99 for 8 AUM or $2.94/AUM. While the total operating cost for feeding baled forage was $159.49 and 19 AUM would be possible, assuming 25 pounds daily consumption to maintain 1 AUM, the cost of feeding would be $8.74/AUM. Thus, forage grazing costs for sorghums would be economically more favorable than a sorghum haying system for wintering cattle.

Important factors which must be considered when utilizing _in situ_ winter cured forage sorghums are:

1. Depending upon the severity of the winter, forage quality appears to terminate cured forage grazing sometime in late January or February as indicated by large declines in dry matter production, forage utilization, and dry matter digestibility.
2. Adverse weather conditions prohibit proper grazing and additional pastures or holding pens where bogging and trampling are not of major concern, will be required. Any precipitation in sufficient quantity will reduce forage utilization and impair soil structure when grazed.
3. The planting date will depend upon the average maturity of the forage type. To attain maximum production of dry matter and high quality forage, the killing frost date should occur at the booting stage when the stalks contain maximum quantities of

soluble constitutents.

4. A strip grazing scheme will offer the highest utilization of the available forage. By confining the animals to a small grazing area which will supply 10-12 grazing days, high forage quality and percent utilization are attained. Stocking rates may vary depending upon the conditions but approximately 8-10 AUM per acre are not uncommon.

5. Lodging of the forage will occur sometime after frost which causes trampling, waste, and decay of the material. However, when lodging occurred uniformly and the forage was not compacted to the soil surface, decay was minimal and accessibility of the forage was high. In 1968-69, a slow and heavy snow in November lodged the forage material uniformly onto a blanket of snow. The snow layer underneath and the one above compressed this massive layer of forage material and curing occurred in a compact bundle above the soil surface. In late December, the only effect of weathering observed was to the outermost portion of the forage, while the interior forage retained some color indicating good protection from the winter elements. Due to this unusual curing condition in 1968-69, the forage retained a higher quality over a longer period than normally would be expected.

CHAPTER V

SUMMARY AND CONCLUSIONS

EXPERIMENT I

High forage quality was produced at two stages of growth. The highest production in pounds of dry forage was produced in the latter stage of maturity (hay). When compared to the early stage (pasture) it contained significantly lower amounts of nitrogen, dry matter digestion, and percent dry matter.

Animal preference for certain sorghum types was the same at both stages of maturity. The true sudangrass types, Piper, Sweet Sudan, and Trudan II, were the most preferred types for all grazing trials in 1967 and 1968. The sorgo and sorghum sudangrass hybrids, Horizon SP-110, Sweet Sioux, Sudax, and Haygrazer, were intermediate to low in preference while the forage sorghum, Sugar Drip, was the least preferred type.

No conclusive evidence was found to associate animal preference to the laboratory analyses. One of the two most preferred types was very high in percent nitrogen and percent digestible dry matter while the other preferred type was considered very low and the least preferred type contained the largest amounts. The percent alcohol soluble carbohydrates and leaf to stem ratio were highest in the intermediate or less preferred types, while the preferred types contained the least amounts, indicating a negative relationship of preference with sugar in the sorghum grasses. Dry matter percent and silica content were positively related with animal preference.

A combination of components may be necessary to explain animal preference for a preferred type. Odor appeared to be the selection sense and future research might pursue the aromatic compounds relating to smell.

EXPERIMENT II

The effects of weathering on the cured forage sorghum resulted in a decline in the available forage, percent digested, and percent utilized for all types as the elements of winter increased.

The protein content for the various types was not affected by the adverse environmental conditions but the percent of dry matter increased with time.

Sugar Drip was consistently higher in forage quality, as evidenced by the higher percent dry matter digested, forage utilized, and retention of moisture throughout the winter. More pounds per acre of Pioneer 931 was utilized than any other type, although it was not used as efficiently as some of the other types. Pioneer 931 has a very high production capacity, which offsets its low use efficiency.

The research indicates that it is quite feasible to graze cured forage sorghums for maintenance rations with reasonably low costs in the areas that have rather mild winters.

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APPENDIX

TABLE VII

ANIMAL PREFERENCE, YIELD, AND OTHER DATA
FOR SORGHUM TYPES AT THE PASTURE STAGE IN 1967

Type	Grazing Trial	Animal Preference	Yield Dry lbs./A	Dry Matter Percent	Percent Digestion	Nitrogen Percent
Piper	First	1	1,003	11.7	60.73	3.70
	Second	1	1,463	13.8	55.00	3.01
	Third	2	1,247	10.7	59.69	3.04
	Fourth	High	3,048	18.7	57.15	2.55
Sweet Sudan	First	2	1,039	11.1	64.63	3.76
	Second	2	1,880	12.7	58.64	3.30
	Third	1	864	12.5	63.39	3.48
	Fourth	High	2,145	17.8	60.04	3.12
Sweet Sioux	First	7	1,155	10.5	63.83	3.53
	Second	6	1,293	12.0	52.51	3.37
	Third	7	2,398	14.9	63.02	3.07
	Fourth	Low	4,578	14.2	58.52	2.66
Haygazer	First	6	1,311	11.5	63.73	3.67
	Second	7	1,183	11.2	60.67	3.36
	Third	6	1.353	13.7	62.90	3.11
	Fourth	Low	4,094	14.1	57.92	2.73
Sudax	First	5	1,167	11.5	62.92	3.57
	Second	4	1,293	11.9	60.48	3.27
	Third	5	1,537	14.7	63.46	3.00
	Fourth	Medium	4,743	12.7	58.58	2.79
Trudan II	First	3	969	10.9	63.88	3.75
	Second	3	1,517	11.8	56.05	3.10
	Third	3	1,702	13.1	64.60	3.06
	Fourth	High	4,123	16.4	54.85	2.69
Horizon SP-110	First	4	1,444	11.2	62.00	3.38
	Second	5	1,189	11.8	57.87	2.69
	Third	4	1,431	13.8	66.01	2.97
	Fourth	Medium	4,602	12.7	56.75	2.50
Sugar Drip	First	8	1,190	10.6	62.49	3.50
	Second	8	680	11.3	61.80	3.63
	Third	8	1,340	16.4	67.00	2.23
	Fourth	Low	3,941	12.8	58.44	2.75

TABLE VIII

ANIMAL PREFERENCE, YIELD, AND OTHER DATA FOR SORGHUM TYPES AT THE HAY STAGE IN 1967

Type	Grazing Trial	Animal Preference	Yield Dry lbs./A.	Dry Matter Percent	Percent Digestion	Nitrogen Percent
Piper	First	2	2,051	10.4	48.52	2.99
	Second	2	1,672	12.1	39.27	2.01
	Third	High	3,193	15.8	36.86	2.35
Sweet Sudan	First	1	1,655	9.0	44.35	3.22
	Second	1	1,408	11.8	46.47	2.68
	Third	High	2,454	12.4	40.30	2.90
Sweet Sioux	First	6	2,522	9.2	48.62	2.72
	Second	7	1,793	9.8	46.48	2.30
	Third	Medium	4,019	12.7	36.09	2.34
Haygrazer	First	7	2,828	9.5	44.19	2.56
	Second	6	1,668	11.5	46.33	2.44
	Third	Low	4,406	12.4	42.66	2.34
Sudax	First	5	2,252	8.7	46.53	2.94
	Second	5	2,291	11.1	44.54	2.46
	Third	Medium	5,442	13.4	38.23	2.34
Trudan II	First	3	2,273	9.6	49.03	2.88
	Second	3	1,876	11.7	34.93	2.07
	Third	High	3,773	14.3	39.57	2.33
Horizon SP-110	First	4	2,369	9.6	48.93	2.58
	Second	4	1,427	11.9	41.70	1.93
	Third	Medium	3,831	12.8	39.94	2.44
Sugar Drip	First	8	1,910	7.3	44.40	2.99
	Second	8	591	8.6	41.52	3.12
	Third	Low	2,973	11.5	39.77	2.64

TABLE IX

YIELD OF SORGHUM TYPES AT THE PASTURE STAGE IN 1968

Type	Grazing Trial	Yield Dry lbs./A.	Dry Matter Percent	Percent Digestion	Nitrogen Percent
Piper	First	2,635	19.2	54.63	1.97
	Second	4,215	15.2	58.33	2.19
	Third	403	18.3	60.14	2.32
Sweet Sudan	First	2,516	18.7	57.22	2.31
	Second	2,995	13.6	58.26	2.55
	Third	345	16.0	61.30	2.43
Sweet Sioux	First	3,049	17.6	55.20	1.99
	Second	5,238	12.8	55.33	2.20
	Third	575	15.3	62.13	2.13
Haygrazer	First	3,681	18.2	54.58	2.08
	Second	4,432	14.1	55.72	2.28
	Third	506	15.1	60.28	2.35
Sudax	First	4,248	17.5	56.77	1.94
	Second	5,086	13.3	57.48	2.29
	Third	638	14.9	59.13	2.40
Trudan II	First	3,169	17.4	59.10	2.11
	Second	4,628	14.4	56.64	2.18
	Third	521	14.9	57.42	2.32
Horizon SP-110	First	3,877	17.8	59.68	1.91
	Second	3,503	11.9	56.95	2.23
	Third	422	14.9	59.72	2.37
Sugar Drip	First	3,670	15.9	55.14	2.10
	Second	3,137	12.9	62.65	2.39
	Third	248	14.6	67.09	2.50

TABLE X

YIELD OF SORGHUM TYPES AT THE HAY STAGE IN 1968

Type	Grazing Trial	Yield Dry lbs./A.	Dry Matter Percent	Percent Digestion	Nitrogen Percent
Piper	First	3,585	18.0	52.67	2.05
	Second	2,919	14.3	51.76	2.32
	Third	5,848	17.8	48.90	2.28
Sweet Sudan	First	3,594	18.8	55.45	2.24
	Second	2,320	12.8	54.46	2.67
	Third	3,855	14.9	51.38	2.32
Sweet Sioux	First	3,418	18.2	53.42	2.22
	Second	3,518	11.8	53.51	2.26
	Third	4,931	14.4	50.85	2.18
Haygrazer	First	3,703	16.8	53.45	2.26
	Second	2,755	11.6	52.10	2.52
	Third	5,565	13.6	49.14	2.43
Sudax	First	3,812	17.9	53.09	1.98
	Second	4,138	12.2	53.51	2.40
	Third	6,055	13.6	52.03	2.09
Trudan II	First	3,267	20.2	57.22	2.04
	Second	3,246	13.2	52.71	2.39
	Third	5,543	16.1	50.82	2.09
Horizon SP-110	First	3,703	17.7	53.14	2.23
	Second	4,018	11.7	53.41	2.27
	Third	5,205	14.0	51.63	2.13
Sugar Drip	First	4,138	17.6	57.39	2.19
	Second	2,026	12.0	58.04	2.50
	Third	4,062	12.7	59.86	2.02

TABLE XI

WINTER GRAZING FORAGE SORGHUM 1967-68

Forage Sorghum Type	Date of Harvest	Yield Dry lbs./A.	Percent Dry Matter	Percent Utilization	Percent Digestion	Percent Nitrogen
Sugar Drip	Dec. 10	19,820	48.0	81	39.5	0.86
	Jan. 10	15,030	35.5	87	34.9	0.84
	Jan. 24	12,850	55.9	72	30.2	0.95
	Feb. 10				27.2	0.86
Hegari	Dec. 10	14,108	50.1	70	30.0	0.94
	Jan. 10	8,276	48.8	53	21.9	0.99
	Jan. 24	9,801	63.5	64	19.4	1.05
	Feb. 10				19.4	0.82
Pioneer 931	Dec. 10	22,869	52.8	53	28.6	0.99
	Jan. 10	21,998	42.2	71	21.5	0.72
	Jan. 24	19,820	71.9	70	23.6	0.69
	Feb. 10				20.0	0.60
Yield-maker	Dec. 10	23,523	44.3	68	23.8	0.98
	Jan. 10	15,682	34.8	74	22.3	0.86
	Jan. 24	13,504	61.5	58	19.2	1.01
	Feb. 10				16.3	0.89
OK 632	Dec. 10	12,415	50.6	66	21.1	1.12
	Jan. 10	6,970	41.6	47	27.5	1.42
	Jan. 24	8,277	77.6	40	23.1	0.86
	Feb. 10				21.7	0.97
Leaf-master 43	Dec. 10	15,246	47.3	62	29.3	1.19
	Jan. 10	13,939	40.9	66	25.2	1.15
	Jan. 24	11,543	66.3	56	25.1	1.04
	Feb. 10				22.5	1.18
3 Little Indians	Dec. 10	13,286	48.9	56	27.9	0.82
	Jan. 10	15,029	40.2	73	27.5	1.14
	Jan. 24	11,544	70.6	57	24.6	0.95
	Feb. 10				23.2	0.96
Dekalb FS 1a	Dec. 10	16,771	50.5	69	25.8	0.89
	Jan. 10	9,365	46.9	61	22.2	1.03
	Jan. 24	8,277	69.3	63	23.1	1.19
	Feb. 10				22.4	0.83

TABLE XII

WINTER GRAZING FORAGE SORGHUMS 1968-69

Forage Sorghum Type	Date of Harvest	Yield Dry lbs./A.	Percent Dry Matter	Percent Utilization	Percent Digestion	Percent Nitrogen
Sugar Drip	Dec. 10	20,473	44.8	77	45.9	0.92
	Jan. 10	15,029	60.9	72	42.4	1.12
	Jan. 24	11,108	59.1	71	47.8	1.12
	Feb. 10	12,415	66.2	61	35.1	1.31
Hegari	Dec. 10	12,415	57.8	70	50.8	0.73
	Jan. 10	11,326	74.1	69	45.2	1.51
	Jan. 24	8,930	73.3	61	40.5	1.49
	Feb. 10	9,364	84.3	60	36.2	1.49
Pioneer 931	Dec. 10	22,216	51.9	21	38.6	1.11
	Jan. 10	15,482	72.0	41	40.4	1.18
	Jan. 24	14,375	74.7	47	38.9	1.38
	Feb. 10	17,207	80.6	49	39.2	1.45
Yield-maker	Dec. 10	20.691	55.7	68	49.4	1.17
	Jan. 10	14,593	71.4	66	45.3	1.22
	Jan. 24	11,326	73.7	62	41.2	1.15
	Feb. 10	11,534	81.4	55	36.6	1.24
OK 632	Dec. 10	9,801	76.0	42	31.8	1.14
	Jan. 10	10,282	89.6	47	34.3	1.05
	Jan. 24	9,148	87.3	55	31.8	0.98
	Feb. 10	8,930	91.6	44	24.3	1.04
Leaf-master 43	Dec. 10	15,682	57.7	56	37.4	1.02
	Jan. 10	15,682	76.0	64	43.9	1.18
	Jan. 24	11,979	80.7	65	40.4	1.18
	Feb. 10	10,672	83.2	63	33.6	1.26
3 Little Indians	Dec. 10	11,979	53.8	35	34.3	0.78
	Jan. 10	10.237	72.3	43	42.9	1.11
	Jan. 24	9,366	70.2	49	37.8	1.06
	Feb. 10	8,059	76.1	30	37.5	1.18
Dekalb FS 1a	Dec. 10	11,544	65.0	43	40.8	1.44
	Jan. 10	11,326	82.2	46	42.2	1.52
	Jan. 24	10,237	76.6	64	35.9	1.27
	Feb. 10	9,801	86.1	40	40.9	1.55

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