Sugarcane as a Cattle Feed: Production and Utilization [1]

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Beef production in south Florida and other subtropical and tropical regions has been disadvantaged by a deficiency of feed sources needed for the growing and finishing of young cattle. Most of the feeder calves weaned in south Florida are shipped to northern and western areas for feeding and finishing for slaughter. The tropical zone has 55% of the world's cattle, 80% of the buffalo, 67% of the goats and 36% of the sheep, yet produces less than 20% of the meat obtained from these species (15). Perennial pastures, the most abundant feed source in Florida and throughout the tropics, are limited by the relatively poor quality of the tropical grasses used, and by a highly seasonal forage production pattern.

Sugarcane may be a potential feed source for beef cattle in subtropical and tropical areas. Its advantages as a forage crop include: 1) adaptation to the tropical and subtropical environments, 2) less sensitivity than other crops to poor soil fertility, the hot-humid climate, and insect and disease problems, 3) existing technology for its production, 4) a high yield capability, and 5) the unique ability to maintain consistent quality as a standing crop in the field.

The purpose of this bulletin is to discuss the production and use of sugarcane as a feed source for beef cattle. The discussion will include information on the use of whole sugarcane feed products for various classes of cattle with emphasis on using fresh-chopped cane as a feed for growing-finishing beef cattle. Information will also be presented on agronomic practices or conditions specific to the production and harvesting of sugarcane as a feedstuff, and the economics of its utilization.

Growing Sugarcane for Feeding

Production Practices

Sugarcane grown for forage should be treated the same as cane for sugar production with regard to agronomic practices such as cultivation, fertilization, and pest control. Thus, recommendations already developed for an area should be used. Several publications are available for south Florida (2, 6, 8) , and other specific information can be obtained from county agricultural extension offices or the Agricultural Research and Education Center at Belle Glade (AREC-Belle Glade). Several agronomic

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practices specific to growing sugarcane for forage are discussed below.

Variety Selection

The most important decision when growing sugarcane for animal feeding is variety selection. Sugarcane has numerous varieties with widely varying characteristics. The three important items to consider are crop yield (plant and ratoon crops), nutritive quality (i.e., sugar and fiber contents) and ease of harvesting.

Yield information available on sugarcane varieties is presented as millable cane for sugar production. This includes only the processed stalk and not the top and other material that would be harvested for forage. Tops will average from 15 to 25% of the aerial cane plant, thus usable estimates of forage yield can be derived from millable cane data. The yield response of sugarcane varieties is sensitive to environmental conditions, and a variety for feeding purposes should be selected on information about its growth in the given area. For example, varieties that perform best on organic soils are different from those that perform best on mineral soils in south Florida. Average yields of millable cane in south Florida have been 35 to 40 tons/A (78 to 90 mt/ha) for organic soils and 30 tons/A (67 mt/ha) for sand soils.

In terms of nutritive quality, sugarcane varieties grown for sugar production are probably best for feeding purposes, because sucrose, the important part, is a highly digestible nutrient. However, in sugar production, less emphasis is placed on the quantity of fiber contained in a variety which could adversely and materially affect nutritive value to livestock. For example, a high-fiber, high-sucrose yielding variety may be acceptable for sugar production but could be less desirable as an animal feed because sugarcane fiber is poorly digestible. Sugarcane varieties grown in south Florida are lower in fiber content than those grown in other sugarcane production areas.

A laboratory investigation using forage evaluation methods was conducted to compare the nutritive quality of 66 commercial and breeding sugarcane varieties grown under south Florida conditions. A wide range in the percentage of fiber and *in vitro* digestibility of different varieties was observed (Table 1). The fiber content was found to be negatively related to *in vitro* digestibility (17). These data indicated that the feeding value of sugarcane varieties could be variable and emphasis should be placed on a lower fiber content when selecting a variety for feeding purposes. Crude protein content was low in all varieties tested; this result suggested little chance of finding a variety that would contain a moderate level of this nutrient.

In a steer feeding trial comparing two varieties that had a moderate difference in fiber content (44.8 vs 49.2% neutral detergent fiber), there was no difference in animal gains or feed efficiency (19). These animal performance results indicate that small to moderate differences in the fiber content of cane varieties are of little significance.

The most obvious differences between sugarcane varieties are their growth characteristics. Some varieties grow very erectly and do not tend to lodge severely under adverse climatic conditions. A variety should be selected for erectness throughout the growth and harvest periods if mechanical harvesting is planned, even if some sacrifices are made in yield and quality.

Maturity of Sugarcane

In a study at AREC-Belle Glade, five sugarcane varieties were harvested at different ages to determine the effect of maturity on potential nutritive value (18). Whole sugarcane plants were first harvested on April 9, when composed mostly of leaves with little stalk, and subsequently at 56-day intervals over the next 336 days. The results of laboratory analysis showed that during the early growth stages, dry matter (DM) content increased, crude protein content decreased to a low level, and fiber content decreased (Table 2). These trends continued, but at a slower rate, during the later growth stages. *In vitro* digestible organic matter, which approximately equals total digestible nutrients (TDN) , consistently increased over the entire 336-day growth period. The changes in fiber and digestibility of cane with increasing maturity is in sharp contrast to changes that occur in other forages because of progessive sucrose storage by the cane plant. These results have significant implications in terms of feeding sugarcane to cattle. A moderate level of crude protein exists in sugarcane only if harvested at a very young age. However, harvesting young cane would be counter-productive to the improved yield and digestibility obtained with increasing maturity. The ability of sugarcane to increase in digestibility with advancing maturity and to maintain this higher quality over an extended period as a standing field crop offers substantial advantages in its use as a cattle feed compared to other harvested forages.

The quality or maturity of sugarcane is also related to season. Sugarcane is usually planted at a time to allow growth during rainy and warm seasons of the year and be ready for harvest during the cool and dry seasons of the year. Such practice insures maximum sugar content in the stalks due to the stress of the cool and dry conditions. Of course, the cool and dry period of the year occurs when cattle would likely be fed sugarcane because pasture forage would be limited.

Row Spacing

An agronomic practice that can influence sugarcane yield is row width. Field data from Louisiana showed that rows spaced 36 inches (91 cm) apart produced 30 to 35% more millable cane than rows spaced at 65 inches (165 cm) (9). Different row spacings did not greatly affect the sucrose content of millable sugarcane (5, 10), thus indicating that spacing also would not affect the quality of cane as an animal feed.

With narrow row spacings, the sugarcane stalks tend to be longer and smaller in diameter (10, 21), which could be the cause of increased lodging. A Louisiana field study (11) showed that total millable sugarcane yields were 45 and 24 tons per acre (101 and 54 mt/ha) with row spacings of 24 and 72 inches (60 and 182 cm), respectively. However, ground losses with a whole-stalk harvester were 24 and 4 tons per acre (54 and 10 mt/ha), respectively. This difference in harvesting loss could possibly have been even greater if a conventional forage harvester had been used. Harvesting losses can be recovered with manual labor, but the cost may be prohibitive in many areas.

In general, it would be best to use the wider row spacing for sugarcane planted for feeding purposes if machine harvesting is planned. Of course, the selected row spacing should conform to both cultivation and harvesting equipment that will be used.

Harvesting and Chopping Sugarcane

Whole sugarcane can be harvested by hand or with machines. If hand harvested, the cane must then be chopped before feeding. Several commercial stationary choppers are available for processing hand-harvested cane, or it can be hand fed into a tractor drawn forage harvester.

Mechanical harvesting can be accomplished with some commercial forage harvesting equipment. Although this equipment was developed to harvest corn, sorghum, and other erect row crops, and was not designed for sugarcane, it can do an acceptable job in certain situations. Sugarcane is relatively difficult to harvest mechanically because of its high yield, tough stalks, tendency to lodge and rather broad stooling characteristics. The design of the header mechanism presents the greatest problem, because most units are fabricated with material that is less durable than needed for harvesting sugarcane. Also, the header intake is usually too narrow for the broad sugarcane stool and the often decumbent sugarcane stalk. For this reason, emphasis should be placed on selecting erect varieties if mechanical harvesting is planned. The chopping mechanism of most forage harvesters is generally satisfactory if care is taken not to overload the chopper and if the chopping knives are properly maintained.

When harvesting sugarcane, it is important to cut the stalk properly to insure good ratooning and regrowth of the stubble crop. Ideally, the stalk should be clean cut as obtained in hand cutting with a cane knife or machete. Because of the density of sugarcane, most forage harvesters are drawn too slowly and a poor cut is obtained. Also, a better cut is obtained with a rotating disc than with a cutter bar mechanism on the harvester header. The harvesting speed of a rotating disc cutter should be at least 500 feet (1500 m) per minute for best results. Stalks should be cut at ground level because regrowth will occur from each eye above ground level and this type of regrowth is less satisfactory than that which occurs below ground level. One procedure used in mechanical harvesting has been to cut the stalk about 6 inches (15 cm) above ground level, and then remove the stalk stump at the proper level with a cane knife. However, this practice is labor intensive and expensive.

A header mechanism adaptable to a commercial forage harvester has been designed and built by a sugarcane enterprise in south Florida which harvets a large acreage of sugarcane for silage. The header proved more durable than those commercially available and worked satisfactorily for the rapid harvesting of large tonnages of fairly erect sugarcane. A practical header mechanism should approach the gathering and base cutting system of a narrow-throat, single-row cane harvester. The throat width should be about 30 inches (76 cm) wide.

Feeding Sugar Cane

Fresh-Chopped Sugarcane in Feedlot Diets

Several trials were conducted at AREC-Belle Glade in which fresh-chopped sugarcane was fed at different levels in feedlot type diets. The quantity of sugarcane fed ranged from 20 to 77% of the diet dry matter (DM) with the remainder supplied by corn grain, citrus pulp and cottonseed meal (Table 3). Growing-finishing steers fed these diets exhibited a very predictable response in relation to the quantity of sugarcane fed (Table 4). As the percentage of sugarcane in the diet increased, rate of gain, feed utilization, and carcass quality decreased. These results would be expected since the energy value of sugarcane was lower than that of corn grain and citrus pulp which sugarcane replaced. Increasing levels of sugarcane in the diet also resulted in less DM intake which would limit rate of gain. This response is different from that obtained with corn silage where DM intake by steers fed high corn silage diets exceeded that by steers fed high corn grain diets (22). It is known that sugarcane fiber (bagasse) has a low digestibility and may have a depressing effect on feed intake.

Chapman and Peacock (3) reported that steers fed diets containing approximately 45, 60, and 75% corn silage on a DM basis gained 3.22, 2.96, and 2.68 lbs (1.46, 1.34 and 1.22 kg) per day and required 7.04, 6.62, and 6.49 units of feed per unit of gain, respectively. Although the comparison is indirect, steers fed a moderate level of sugarcane (30-39%) had a rate of gain and feed efficiency somewhat similar to those fed 45% corn silage. Steers fed high sugarcane diets (77%) gained 30% slower and 30% less efficiently than those fed 75% corn silage diets. This comparison indicated that fresh-chopped sugarcane may be equivalent to corn silage as a roughage source in high-concentrate diets, but has only 70% the value of corn silage when used as a major diet ingredient. Fresh-chopped sugarcane was reported to be approximate 70% the value of corn silage when used as the primary ingredient in feedlot diets fed to growing cattle in Kenya (4). This relationship supported the indirect comparison made between Florida feeding trials.

In a feedlot trial at AREC-Belle Glade, fresh-chopped sugarcane was compared with cottonseed hulls as roughage in high-concentrate growing-finishing diets fed to 12-month old steers. Diets were formulated such that sugarcane and cottonseed hulls supplied equal amounts of nitrogen detergent fiber (NDF) to the respective diets in which they were added (Table 5). Sugarcane and cottonseed hulls contained 52 and 85% NDF, respectively, on a DM basis. During the growing phase, steers fed the sugarcane diet gained 11% slower than steers fed the cottonseed hulls diet (Table 6). Most of this response was explained by a 8% lower DM intake by steers fed the sugarcane diet. This result supported the previous conclusion that sugarcane fiber limits DM intake. During the finishing phase, when the roughage source was reduced by one-half, rate of gain was similar for steers fed either sugarcane or cottonseed hulls. However, steers fed sugarcane consumed 12% more DM and were 12% less efficient in converting DM to gain than steers fed cottonseed hulls. Carcasses from steers fed sugarcane diets tended to be slightly lower in quality. They had a lower dressing percent, marbling score, and USDA grade; they also had less fat over the rib eye and a smaller rib eye area.

Value of Urea in Sugarcane Diets

Because of the low crude protein content of sugarcane, diets based on cane forage require a large quantity of supplemental nitrogen. Natural protein feeds are expensive, particularly in regions where sugarcane would be fed. The economics of feeding sugarcane might be improved by using a less expensive source of crude protein, like urea.

At AREC-Belle Glade, urea was evaluated as a replacement for cottonseed meal in sugarcane based diets. In three dietary treatments, urea and corn meal replaced cottonseed meal in a 71% (DM basis) sugarcane diet fed to 12-month old steers during a 93-day growing phase such that urea supplied either 0, 25, or 50% of the dietary nitrogen (Table 7). During a following 63-day finishing phase, urea supplied either 0, 20, or 40% of the dietary nitrogen in 40% sugarcane diets. During the growing phase, both rate of gain and feed efficiency by steers decreased as the urea level in the diet increased (Table 8). However, the adverse effect of urea on steer performance occurred mostly during the first 28 days of feeding. Over the next 65 days, rate of gain continued to be lower on diets containing urea, but urea had little effect on feed conversion. During the 63-day finishing phase steers performed as well when fed diets containing urea as when fed diets containing only cottonseed meal.

In a second trial, urea was again compared to cottonseed meal in 69% (DM basis) sugarcane diets, but with molasses as the supplemental energy feed (Table 9). In addition, corn meal was compared with molasses as a supplemental energy source in high urea (50% of dietary nitrogen) diets. During a 133-day feeding period, 12-month old steers fed the urea-molasses supplement had a much lower rate of gain and poorer feed utilization than steers fed either cottonseed meal-molasses or urea-corn meal (Table 10). However, the performance of steers fed urea-corn grain was almost equal to that of steers fed cottonseed meal-molasses.

It was concluded that urea can supply all of the supplemental crude protein required in sugarcane based diets without causing harmful effects, but with slower and less efficient gains than those obtained with natural proteins. When feeding high levels of urea, molasses is inferior to corn grain and possibly other starchy concentrate feeds as a supplemental energy source. The degree of improvement in urea utilization with corn grain would be related to the level of corn grain in the diet. Care should be taken to adapt animals slowly to urea in the diet. Possible procedures include the progressive replacement of a natural protein feed with urea over a 30-day period or even the feeding of liberal quantities of natural protein throughout an initial 30-day adaptation period while slowly increasing the level of urea in the diet.

The final decision on using urea in sugarcane based diets would be related to economics. For example, urea and molasses are less expensive than natural protein feeds and corn grain. Even if slower and less efficient gains are obtained by using urea and/or molasses, production cost may favor the use of these ingredients in some situations.

Sugarcane Silage

Sugarcane can be ensiled like other forage crops, but its nutritive value is significantly reduced. Florida data (16) showed a total digestible nutrient (TDN) value of 62.0% for fresh sugarcane fed to steers, and a value of only 45.5% for ensiled cane. Metabolism studies (14) with sheep confirmed the relatively low TDN value of sugarcane silage. It was shown that the TDN value of 51.6, 48.1, and 41.5%, respectively for 6, 12, and 24 month old cane was negatively related to the maturity of the cane when ensiled.

The large reduction in the TDN value of cane was attributed to the sugar which is fermented readily to ethanol by yeast, an inefficient fermentation pathway. Also, sugarcane has a high moisture content (70 to 80%), which is not ideal for making good silage and results in excessive seepage losses in most conventional silos.

Several Florida studies evaluated sugarcane silage as a roughage in growing-finishing steer diets. Shealy et al. (20) reported that when cane silage constituted around 30% of the DM in a ground snapped corn and cottonseed meal diet, it had approximately 70% the value as sorghum silage in a similar diet. Daily gains were 1. 7 9 and 2. 08 lb (0. 81 and 0. 94 kg) , respectively, f or steers fed sugarcane and sorghum silage diets, but feed efficiency was similar (8.6 vs 9.0 units of DM/unit of gain) because steers consumed less of the sugarcane silage diet. Kidder and Kirk (12) also fed steers ground snapped corn and cottonseed meal diets that contained either 25% ensiled or fresh-chopped sugarcane, resulting in daily gains of 1.84 and 1.93 pounds (0.83 and 0.88 kg), respectively.

The trials just described show that ensiled sugarcane can be used successfully at moderate levels in feedlot diets fed to cattle. This has been recently demonstrated in a commercial feedlot in south Florida. Feeding studies in which high levels of cane silage were fed to growing cattle have not been reported, but considering its relatively low TDN value it would probably not compare favorably with other ensiled or fresh-chopped forages.

Ensiled sugarcane was evaluated as a winter roughage for producing brood cows (13). Lactating cows fed 38 pounds (17 kg) of cane silage and 2.2 pounds (1 kg) of cottonseed meal per head daily during a 105-day winter period lost 44 pounds (20 kg) of liveweight per head compared to a loss of 78 pounds (35 kg) per head for cows grazed on carpet grass pasture and supplemented with 2.2 pounds (1 kg) of cottonseed meal. These results suggested that sugarcane silage would be an acceptable winter feed for brood cows which utilize poorer quality roughages more efficiently than growing cattle.

Shocked Sugarcane Stalks

Although the shocking of forages is not commonly practiced today, occasionally whole sugarcane stalks might be cut and temporarily stored for later feeding. Sugarcane stalks shocked during the winter months in Florida retain a relatively high percentage of their value (16). The TDN value of shocked sugarcane fed to steers was 57.5%, compared to 62.0 and 45.5% for fresh-chopped and ensiled sugarcane, respectively. Kirk and Crown (13) also demonstrated that shocked sugarcane was an acceptable winter roughage for producing brood cows in central Florida.

To better define changes in the nutritive value of whole sugarcane stalks with time after harvest, stalks cut and piled in late winter and early spring were sampled at various intervals and analyzed in the laboratory at AREC-Belle Glade. The moisture content decreased throughout the 42 day storage period (Table 11) . The neutral detergent soluble fraction and *in vitro* organic matter digestibility decreased immediately after the sugarcane was cut, suggesting a measureable loss of sugar during the first few days after harvest. Subsequently, these measurers remained relatively constant, and only after 30 to 40 days was there an indication of further deterioration. Average minimum and maximum daily temperatures during the study period were 60° and 80° F (16° and 24° C) respectively.

Sugarcane as a Supplement for Grazing Cattle

During three consecutive winters, 15 to 25 pounds (7 to 11 kg) per head of fresh-chopped sugarcane was fed daily to yearling steers grazing either paragrass, bahiagrass, or St. Augustine grass pasture at AREC-Belle Glade (7). In comparison to unsupplemented steers grazing these three pasture grasses, steers offered sugarcane gained an additional 52, 25, and 8 pounds (24, 11, and 4 kg) per steer, respectively, over a 10 to 12 week period. In addition to forage type, severity of the winter affected the degree of response to sugarcane supplementation. It was also pointed out that a higher stocking rate than the 2 head per acre (5 head per ha) rate used would have also shown a greater response to supplementation.

These trials showed that fresh-chopped sugarcane should be fed to grazing cattle only when pasture forage availability is very restricted. Such situations include a very severe winter or drought, the grazing of grasses that become dormant during cool or cold weather, or when using a very high stocking rate. The latter two situations would be relevant to grazing pasture forages in South Florida. Paragrass is the best quality forage grown in the Belle Glade area, but is very sensitive to cool weather, explaining the response noted in the aforementioned trials. Also, the use of heavy stocking rates on all pasture grasses during the winter period would allow more efficient use of the abundant quantity of forage available during the 8-month growing season.

Grazing Sugarcane

Grazing trials with standing mature sugarcane were conducted at AREC-Belle Glade, but usable animal production data were not obtained. It was recommended that sugarcane used in this manner be grazed clean within one week by using a very high stocking rate, and then grazed only once annually (2). The sugarcane stool can be destroyed by overgrazing or grazing for extended periods. Sugarcane does not appear to lend itself to grazing and should be so utilized only under emergency situations.

Feeding Previously-Frozen Sugarcane

Sugarcane grown in south Florida is occasionally frozen during the mid-winter months. When this occurs, the aerial stalk begins to deteriorate at a rate dependent upon the prevailing temperature. On January 12, 1982, a hard freeze occurred at AREC - Belle Glade on day 71 of a 134-day steer feeding trial in which fresh chopped sugarcane constituted 68% of the diet DM. Subsequent temperatures were unseasonably warm. Laboratory analyses of chopped sugarcane samples taken during the 64-day period after the freeze showed that DM content increased from 28 to 32%, neutral detergent fiber increased from 50 to 52% and crude protein increased from 4.0 to 5.0%.

In the feedlot, DM intake by steers fed diets containing previously frozen sugarcane increased over the 64 days it was offered (Table 12). This occurred even though the chopped sugarcane developed a distinct sour odor during the last several weeks of the feeding trial. Average daily gain of steers fed previously frozen cane during the last 50 days of the trial was higher than their gains during the first 84 days when mostly unfrozen cane was used.

Economic Considerations

This section presents a cost and return analysis of diets containing sugarcane using the results of feeding studies discussed in the previous section. Details of these analyses and their application to microcomputer programming were presented in an extension circular (1).

Value as a Feed in Florida

Diet and animal data from feedlot studies (Tables 3 and 4) were used to perform an economic analysis of chopped sugarcane in growing steer diets. Chopped sugarcane was priced at $10 and $20/ ton ($11 and $22/mt) to cover probable extremes of its production and harvesting costs in south Florida. Four concentrate prices were also entered into the analysis and are presented in Table 13 . Cane molasses, mineral mix, and salt were priced at $60, $250, and $120/ton ($66, $275, and $132/mt), respectively.

Results show that as the percentage of sugarcane in the diet increased, net returns above feed costs decreased, regardless of the price of sugarcane or concentrate ingredients (Table 14). These results indicated that with sugarcane and concentrate feed prices that would likely exist in south Florida, it is not advisable to feed chopped sugarcane, except possibly at low levels as a roughage ingredient.

Value as a Feed in the Tropics

Feed prices in most tropical areas are very different from Florida. The cost of producing sugarcane is usually much lower and the cost of concentrate feed is much higher. To determine the economic value of sugarcane in this situation, the performance and feeding data of steers fed diets containing 20 and 77% sugarcane dry matter (Table 3 and 4) were economically analyzed using feed and animal prices typical of the tropics. Rates of gain were changed to 3.5 lb (1.6 kg) and 1.89 lb (0.86 kg) per day for the 20 and 77% sugarcane diets, respectively.

For this analysis, purchase and selling prices of steers were set at $35 and $40/cwt ($0.77 and $0.99/kg), respectively. Chopped sugarcane was priced at $10/ton ($11/mt). Cane molasses, mineral mix, and salt were priced at $20, $250, and $120/ton ($22, $275 and $132/mt), respectively. Concentrate feeds were priced at a low and high level. Respective low and high levels were: corn, $4.84 and $6.72/bu ($0.19 and $0.26/kg); dried citrus pulp, $160 and $240/ton ($176 and $264/mt); and cottonseed meal, $120 and $200/ton ($132 and $220/mt).

The economic analysis showed that net returns above feed cost were highest for steers fed the highest level of sugarcane, irrespective of concentrate feed price (Table 15). These results demonstrated that the price structure of feeds in the tropics is very favorable to using chopped sugarcane in diets fed to cattle finished in the feedlot. It should be noted that the 77% sugarcane diet contained no corn, citrus pulp or molasses.

Comparing Sugarcane and Cottonseed Hulls in Growing-Finishing Diets

Because the apparent use of sugarcane in Florida is as a roughage ingredient in high concentrate growing and finishing diets, the study which compared sugarcane and cottonseed hulls (Table 5 and 6) was subjected to an economic analysis. In this comparison sugarcane and cottonseed hulls were priced at $20 and $100/ton ($22 and $110/mt) , respectively, on an as fed basis. Feed prices were: corn meal, $100/ton ($110/mt) ; shelled corn, $2.80/bu ($0.11/kg); dried citrus pulp, $135/ton ($149/mt); cottonseed meal, $167/ton ($184/mt); cane molasses, $60/ton ($66/mt) ; urea, $230/ton ($253/mt) ; biophos, $350/ton ($385/mt); mineral mix, $250/ton ($275/mt); and salt, $120/ton ($132/mt).

With the preceding cost structure, the economics of feeding either sugarcane or cottonseed hulls was similar. During the growing phase, feed cost per unit of gain was $0.35/lb ($0.77/kg) for steers fed sugarcane and $0.38/lb ($0.84/kg) for steers fed cottonseed hulls. During the finishing phase, cost of gain was $0.44/lb ($0.97/kg) and $0.41/lb ($0. 90/kg) , respectively, for steers fed sugarcane and cottonseed hulls. Dry roughage feeds, like cottonseed hulls, are usually expensive in Florida, and are often more expensive than the cost used in the above example. Therefore, sugarcane is an economically viable roughage source for feeding Florida cattle.

Urea in Sugarcane Diets

Supplementation of sugarcane diets with expensive natural protein ingredients could be prohibitive. To determine the economic value of substituting urea for cottonseed meal, performance data for the feeding study presented in Tables 7 and 8 were analyzed. Feed prices were the same as in the preceding section, and the citrus pulp used was priced at $135/ton ($149/mt).

Net returns above feed cost showed that it was uneconomical to feed urea during the growing phase, when urea had a negative effect on animal performance (Table 16). During the finishing phase, when urea feeding did not affect animal performance, increasing levels of urea resulted in higher returns above feed cost.

Summary

Sugarcane offers several unique advantages over other field crops as a forage for cattle in the tropical and subtropical areas. It is adapted to environmental conditions and a technology for its production exists in tropical and subtropical regions. Sugarcane maintains a consistent quality for long periods as a standing crop in the field.

For feeding purposes, a sugarcane variety should be selected on basis of erect growth characteristics, high yield, and good quality, if mechanical harvesting is planned. Agronomic practices for growing sugarcane for forage would be similar to those used when growing it for sugar production.

Feeding fresh chopped sugarcane to growing cattle will result in a very predictable response related to the level of sugarcane and concentrate in the diet. Chopped sugarcane is comparable to other roughage sources, like cottonseed hulls, when fed in steer fattening diets.

Urea can be used to supply crude protein in sugarcane diets, but animal performance will be below that obtained with natural protein ingredients. The performance of cattle fed sugarcane-based diets containing urea can be improved by adding a starchy concentrate ingredient, like cereal grains, to the diet.

When ensiled, sugarcane loses a significant percentage of its energy value. However, sugarcane silage can be effectively used as a roughage source in cattle fattening diets and as a winter supplement for producing brood cows. Stockpiled sugarcane stalks declined in *in vitro* organic matter digestiblity immediately after harvesting, but thereafter retain their nutritive value for relatively long periods, even when warm temperatures prevail.

Chopped sugarcane should be fed to grazing cattle only when the availability of forage is very limited. Sugarcane, itself, should be grazed only in emergency situations, and then only once annually and in a manner to completely clean the grazing area within one-week.

Current economics indicate that it is economically feasible to feed diets containing large quantities of chopped sugarcane to growing cattle in developing countries in the tropics. In Florida it is economical to feed chopped or ensiled sugarcane as a roughage source in high-concentrate diets fed to cattle.

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Table 1. Mean and range of laboratory analyses of 66 sugarcane varieties grown on organic soil plots in south Florida.

Analysis [a]	Mean	Range Low	Range High
	%		
Dry matter	25.8	17.0	30.5
Crude protein	2.3	1.1	3.1
Crude fiber	28.1	22.7	35.9
Neutral detergent fiber	52.7	42.6	67.7
Acid detergent fiber	35.4	28.3	41.5
Cellulose	27.0	21.9	32.0
Lignin	6.3	4.6	8.4
Ash	4.3	2.7	7.1
Calcium	0.20	0.06	0.35
Phosphorus	0.05	0.02	0.09
In vitro digestible organic matter	56.6	40.0	64.1

[a] All values except dry matter are presented as a percentage of the dry matter.

Table 2. Laboratory analyses of sugarcane at different stages of maturity.[a]

Harvest date	Dry matter	Crude protein	NDF [b]	ADF [b]	IVDOM [b]
April 9	12.9 [c]	9.2	67.4	39.3	50.1
June 4	14.0	5.8	61.7	37.0	53.1
July 30	21.1	3.6	52.7	33.0	54.1
September 24	25.2	3.1	53.5	34.4	51.2
November 19	27.4	3.2	51.8	33.1	54.7
January 14	28.7	2.8	47.3	30.3	56.1
March 10	28.8	2.6	46.4	30.5	59.1

[a] Values are an average of two samples from each of five sugarcane varieties harvested on each sampling date.
[b] NDF = neutral detergent fiber; ADF = acid detergent fiber; IVDOM = *in vitro* digestible organic matter.
[c] All values except dry matter are presented as a percentage of the dry matter.

Table 3. Composition of feedlot diets containing various levels of fresh-chopped sugarcane.

	Percent sugarcane dry matter in diet					
	Trial 1		**Trial 2**			
	30	60	20	39	58	77
Ingredient	**% on dry matter basis**					
Chopped sugarcane	30.1	60.1	20.3	39.4	58.4	77.3
Shelled corn, No. 2	37.5	13.3	45.7	30.5	15.2	--
Dried citrus pulp	14.0	5.0	17.3	11.5	5.7	--
Cottonseed meal, 41%	13.1	18.0	12.2	15.1	18.0	21.9
Cane molasses, 86¡ Brix	4.5	2.2	3.8	2.9	2.0	--
Mineral mix[ab]	0.5	1.1	0.5	0.5	0.5	0.5
Salt	0.3	0.3	0.2	0.2	0.2	0.2

[a] Mineral mix contained 11.5% P, 18.0% Ca, 0.3% Fe, 0.3% Cu, 0.02% Co, 0.2% Mn, 0.5% Mg, 0.2% Zn, and 12.5% NaCl.
[b] Vitamin A and D were added to each diet to supply 1,200 and 120 IU per Ib of dry matter, respectively.

Table 4. Performance of steers fed diets containing various levels of fresh-chopped sugarcane.

	Percent sugarcane dry matter in diets					
	Trial 1[a]		**Trial 2[a]**			
Item	30	60	20	39	58	77
No. of steers	20	20	8	8	8	8
Initial liveweight, Ib	733	735	558	570	562	564
Adjusted avg. Daily gain, Ib[b]	2.80	1.93	2.87	2.51	1.82	1.39
Dry matter intake, Ib/day	24.18	20.86	19.42	19.51	16.33	15.76
Dry matter to gain ratio	8.64	10.81	6.77	7.77	8.97	11.33
Hot carcass weight, Ib	599	551	564	542	483	450
Actual dressing %[c]	55.5	51.9	57.9	55.6	53.3	50.9
Carcass grade	Good +	Std +	Good	Good	Std +	Std
Fat over rib eye, in	0.40	0.18	0.30	0.38	0.21	0.21

Table 4. Performance of steers fed diets containing various levels of fresh-chopped sugarcane.

	Percent sugarcane dry matter in diets					
	Trial 1[a]		Trial 2[a]			
Rib eye area, sq in	10.82	10.56	10.90	11.21	9.70	9.80

[a] Steers used in trial 1 and 2 were 24 and 12 months old when placed in the feedlot, and were fed 95 and 133 days, respectively.
[b] Calculated from a final weight based on a 60% hot carcass dress (final weight = hot carcass weight x 0.60 and an initial weight taken after a 16-hour shrink without feed and water.
[c] Dressing percent calculated from actual live weight immediately out of feedlot and hot carcass weight.
Metric conversions: 1 Ib = 0.45 kg, 1in = 2.54 cm, and 1 sq in = 6.45 cm^2.

Table 5. Composition of feedlot diets containing either fresh-chopped sugarcane or cottonseed hulls as a roughage source.

	Roughage Source	
	Sugarcane	Cottonseed hulls
Item	**% on dry matter basis**	
Growing phase [a]		
Sugarcane	32.0	--
Cottonseed hulls	--	20.0
Shelled corn, No. 2	37.2	47.0
Corn meal	18.6	23.3
Cane molasses, 86¡ Brix	5.0	5.0
Cottonseed meal, 41%	4.8	2.3
Urea	1.0	1.0
Mineral mix[b]	1.0	1.0
Salt	.2	.2
Biophos[c]	.2	.2
Finishing phase [a]		
Sugarcane	17.1	--
Cottonseed hulls	--	10.0
Shelled corn, No. 2	48.9	54.3
Corn meal	24.4	27.2

Table 5. Composition of feedlot diets containing either fresh-chopped sugarcane or cottonseed hulls as a roughage source.

Item	Roughage Source	
	Sugarcane	Cottonseed hulls
	% on dry matter basis	
Cane molasses, 86¡ Brix	5.1	5.0
Cottonseed meal	2.1	1.1
Urea	1.0	1.0
Mineral mix[b]	1.0	1.0
Salt	.2	.2
Biophos[c]	.2	.2

[a] Vitamin A and D were added to each diet to supply 1,200 and 120 IU per Ib of dry matter, respectively.
[b] Mineral mix contained 11.5% P, 18.0% Ca, 0.3% Fe, 0.3% Cu, 0.2% Co, 0.2% Mn, 0.5% Mg, 0.2% Zn, and 12.5% NaCl.
[c]Biophos contained 21% P and 18% Ca.

Table 6. Performance of steers fed diets containing either sugarcane or cottonseed hulls as a roughage source.

Item	Roughage Source	
	Sugarcane	Cottonseed hulls
Number of steers	25	26
Initial weight, Ib	487	491
Growing phase		
Gain, Ib[a]	242	268
Avg. Daily gain, Ib	2.69	3.01
Dry matter intake, Ib/day	17.92	19.36
Dry matter to gain ratio	6.66	6.44
Finishing phase		
Gain, Ib[b]	247	247
Avg. Daily gain, Ib	2.72	2.72
Dry matter intake, Ib/day	21.43	19.09
Dry matter to gain ratio	7.87	7.04

Table 6. Performance of steers fed diets containing either sugarcane or cottonseed hulls as a roughage source.

Item	Roughage Source	
	Sugarcane	Cottonseed hulls
Carcass data		
Hot carcass weight, lb	582	605
Actual dressing %[c]	59.8	60.9
Carcass grade	Good	Good +
Fat over rib eye, in	0.43	0.54
Rib eye area, sq in	11.54	11.82

[a] Calculated from shrunk live weights.
[b] Calculated from beginning live weight with 4% pencil shrink and final weight based on a 60% hot carcass dress (final weight = hot carcass weight x 0.60).
[c] Calculated from actual live weight immediately out of feedlot and hot carcass weight.
Metric conversion: 1lb = 0.45kg, 1 in = 2.54 cm, and 1 sq in = 6.45 sq cm.

Table 7. Composition of fresh-chopped sugarcane diets containing different levels of urea.

Ingredient	Percent dietary nitrogen as urea					
	Growing Phase, 71% sugarcane			Finishing phase,40% sugarcane		
	0	25	50	0	20	40
	% on dry matter basis					
Chopped sugarcane	71.0	71.0	71.0	39.5	39.5	39.5
Shelled corn	--	--	--	27.3	27.3	27.3
Dried citrus pulp	--	--	--	13.2	13.2	13.2
Molasses	--	--	--	4.0	4.0	4.0
Corn meal	8.5	15.7	22.9	--	6.6	13.0
Cottonseed meal	19.2	10.5	1.9	15.3	7.6	--
Urea	--	1.2	2.3	--	0.9	1.9
Mineral mix [ab]	1.1	1.1	1.1	0.5	0.5	0.5
Biophos[c]	--	0.3	0.6	--	0.2	0.4
Salt	0.2	0.2	0.2	0.2	0.2	0.2

Table 8. Performance of growing and finishing yearling steers fed fresh-chopped sugarcane diets containing different levels of urea.

	% urea N growing/finishing diet		
	0/0	25/20	50/40
No. of steers fed	12	12	12
Growing phase			
Initial weight, lb	536	536	540
Days 1-28			
• Avg. daily gain, lb[b]	2.03	1.15	0.52
• Dry matter intake, lb/day	11.81	11.13	11.22
Days 29-93			
• Avg. daily gain, lb[b]	2.16	1.96	1.85
• Dry matter intake, lb/day	15.25	14.28	13.75
• Dry matter to gain ratio	7.06	7.29	7.46
Days 1-93			
• Avg. daily gain, lb[c]	2.01	1.60	1.38
• Dry matter intake, lb/day	14.23	13.27	13.00
• Dry matter to gain ratio	7.11	8.24	9.49
Finishing phase			
Initial weight, lb	723	685	668
Avg. daily gain, lb[d]	1.72	1.85	1.79
Dry matter intake, lb/day	19.62	19.02	18.27
Dry matter to gain ratio	11.40	10.28	10.21
Carcass data			
Hot carcass weight, lb	498	480	467
Dressing %[e]	54.2	54.1	53.5
Carcass grade	Good -	Std +	Std +
Fat over rib eye, in	0.21	0.19	0.17
Rib eye area, sq in	9.86	10.00	8.95

[a]Steers were fed 71% (dry matter basis) sugarcane diets during 93-day growing phase and 40% sugarcane diets during 62-day finishing phase.
[b]Calculated from unshrunk live weights.
[c]Calculated from shrunk live weights (16 hours without feed and water) at start and end of growing phase.
[d]Calculated from initial shrunk weight and a final weight based on a 60% hot carcass dress (final weight=hot carcass weight X 0.60).
[e]Dressing percent calculated from actual live weight immediately out of feedlot and hot carcass weight.
Metric conversion: 1 lb=0.45 kg, 1 in = 2.54 cm, and 1 sq in = 6.45 cm^2

Table 9. Composition of fesh-chopped sugarcane diets containing different crude protein and energy supplements.

Ingredient	Cottonseed meal and molasses	Urea and molasses	Urea and corn meal
	% on dry matter basis		
Chopped sugarcane	68.8	68.2	68.7
Cane molasses, 86¡ Brix	11.3	24.3	-
Corn meal	-	-	26.4
Cottonseed meal, 41%	18.8	3.8	1.4
Urea	-	2.1	2.0
Mineral mix[ab]	0.9	0.9	0.8
Biophos[c]	-	0.5	0.5
Salt	0.2	0.2	0.2

[a] Mineral mix contained 11.5% P, 18.0% Ca, 0.3% Fe, 0.3% Cu, 0.02% Co, 0.02% Mn, 0.5% Mg, 0.2% Zn, and 12.5% NaCl.
[b] Vitamin A and D were added to each diet to supply 1,200 and 120 IU per lb of dry matter, respectively.
[c] Biophos contained 21% P and 18% Ca.

Table 10. Performance of growing steers fed fresh-chopped sugarcane diets containing different crude protein and energy supplements[a].

Item	Cottonseed meal and molasses	Urea and molasses	Urea and corn meal
No. of steers fed	12	12	12
Initial weight, lb	527	527	531
Adjusted avg. daily gain, lb[b]	1.65	1.23	1.56
Dry matter intake, lb/day	14.68	14.04	13.86
Dry matter to gain ratio	8.88	11.38	8.86
Hot carcass weight, lb	410	379	406

[a] Steers were fed for 133 days.
[b] Gain calculated from an initial shrunk weight (16 hours without feed and water) and a final weight based on a 55% hot carcass dress (final weight = hot carcass weight x 0.55).

Table 11. Changes in the dry matter (DM) and neutral detergent fiber (NDF) content, and *in vitro* organic matter digestiblity (IVOMD) of whole sugarcane with time after cutting and stockpiling.

Days after cutting[a]	DM	NDF[b]	IVOMD
	%[c]		
0	28.2	48.7	57.1
4	30.3	54.8	51.2
7	30.9	53.7	53.1
11	33.9	53.8	53.5
14	34.1	53.2	51.0
17	34.7	54.7	55.0
21	33.8	54.0	53.0
24	36.4	54.9	51.2
28	36.2	56.5	49.4
31	37.7	56.4	51.0
35	37.8	55.9	49.5
39	35.3	57.6	46.7
42	38.4	57.3	47.4

[a]Two sets of stockpiled sugarcane stalks cut on March 9 and April 13, 1981.
[b]Percent of DM.
[c]Each value represents an average of the analyses of four samples. Two samples (3 stalks each) were obtained from each set of stockpiled sugarcane stalks.

Table 12. Chopped sugarcane dry matter (DM) intake and average daily gain of steers fed unfrozen and previously-frozen sugarcane.

Item	Unfrozen sugarcane	Previously-frozen sugarcane[a]
Chopped sugarcane DM intake, lb/day[b]		
Days 1-28	7.33	-
Days 29-56	8.81	-
Days 57-71	10.18	-
Days 72-84	-	10.52
Days 85-112	-	10.63

Table 12. Chopped sugarcane dry matter (DM) intake and average daily gain of steers fed unfrozen and previously-frozen sugarcane.

Item	Unfrozen sugarcane	Previously-frozen sugarcane[a]
Days 113-134	-	10.85
Average daily gain, lb/day		
Days 1-84[c]	1.68	-
Days 85-134	-	1.83

[a] Sugarcane was frozen on January 12, 1982, the 71st day of the feeding trial.
[b] Intake of sugarcane DM only; complete diet is presented in Table 9.
[c]Includes 15 days during which previously frozen sugarcane was fed.
Metric conversion: 1 lb = 0.45 kg

Table 13. Prices of concentrate ingredients used in economic analysis of sugarcane diets.

Concentrate feed	Relative price of feeds			
	Low	Medium-low	Medium-High	High
Shelled corn, $/bu[a]	1.50	2.33	3.16	4.00
Dried citrus pulp, $/ton[b]	80	113	146	180
Cottonseed meal, $/ton[b]	150	183	216	250

[a] Calculations assume standard bushel weighing 56 lb with 15.5% moisture. To convert to $/kg divide values by 25.4.
[b] Calculations assume as fed ingredient with 10% moisture. To convert to $/mt multiplyby 1.1.

Table 14. Sensitivity analysis of results from feeding diets containing varying levels of sugarcane and assuming two sugarcane costs and four levels of concentrate costs[a].

Percent sugarcane in diet	Sugarcane, $/ gross ton	
	10	20
	Net returns ($) above feed	
cost[b]	Low concentrate price	
20	168	159
39	139	120
58	94	71

Table 14. Sensitivity analysis of results from feeding diets containing varying levels of sugarcane and assuming two sugarcane costs and four levels of concentrate costs[a].

Percent sugarcane in diet	Sugarcane, $/ gross ton	
	10	**20**
	Net returns ($) above feed	
77	60	30
	Medium-low concentrate price	
20	134	124
39	113	94
58	79	55
77	51	21
	Medium-high concentrate price	
20	99	89
39	86	67
58	64	40
77	43	13
	High concentrate price	
20	64	54
39	59	40
58	48	25
77	34	4

[a] Production data taken from trial 2, Tables 5 and 6.
[b] Purchase and selling prices of steers were figured at $ 70/cwt ($1.54/kg.)

Table 15. Results of the economic analysis for two sugarcane diets and two concentrate feed cost levels that would likely occur in the tropics[a].

Percent sugarcane in diet	Concentrate feed cost[b]	
	Low	**High**
	--Net return ($) above feed cost--	
20	19.58	-61.18

Table 15. Results of the economic analysis for two sugarcane diets and two concentrate feed cost levels that would likely occur in the tropics[a].

Percent sugarcane in diet	Concentrate feed cost[b]	
	Low	High
	--Net return ($) above feed cost--	
77	66.43	46.02

[a] Production data taken from feedlot trial 2, Tables 5 and 6.
[b] Low concentrate costs were: corn, $ 4.84/bu ($ 0.19/kg); dried citrus pulp, $ 160/ton ($176/mt); and cottonseed meal, $120/ton ($132/mt). High concentrate costs were: corn $6.72/bu ($ 0.26 kg); dried citrus pulp, $ 240/ton ($ 264/mt); and cottonseed meal, $ 200/ton ($ 220/mt).

Table 16. Net returns from steers fed sugarcane based diets containing different levels of urea.

	Percent N as urea in growing/finishing		
Feeding diet phase	0/0	25/20	50/40
	----------Net returns ($) above feed cost----------		
Growing	64.29	44.86	34.02
Finishing	5.41	15.60	17.62