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EFFECT OF QUALITY OF CANE ON ITS VALUE AS LIVESTOCK FEED

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Experience has shown that although early indications were that chopped whole cane was a satisfactory feed for cattle, this was not always so. Experimental evidence was adduced showing that sugarcane fibre was only very slowly degraded in the rumen and that its accumulation led to low feed intake. It thus became apparent that minimal intake of sugarcane fibre associated with high total sugar intake was required. The relationship between Brix (approximate sugar content) and fibre content of cane have been examined and quantified for a range of levels of both Brix and fibre, and although Brix levels have an extremely important influence on the quantity of total sugars, on a DM basis the fibre content of the cane becomes the more important factor, and the necessity for keeping fibre:sugar levels low is clearly demonstrated. The effects of variety, maturity and weather on sugar and fibre levels in sugarcane are examined, and the desirability of selecting low fibre canes for animal feed emphasised.

Key words: Sugarcane, animal feed, Brix, fibre, fibre:sugar

PART 1 QUALITY OF CANE AS ANIMAL FEED

Background: Despite the reports of a number of highly encouraging experiments showing excellent growth rates and milk yields on diets based on sugar cane feeds, derinded cane (comfith) or chopped whole cane (CSC), James (1973), Pigden (1973), Preston et al (1976), Dixon (1978), Quintyne (1978) and several papers from Preston and his associates, other experiments have been disappointing, notably the results obtained at the Sugarcane Feeds Centre, Trinidad (SCF 1981), and various attempts at commercialisation.

Although the reference literature (e.g.University of Florida 1974) quotes whole cane as having Total Digestible Nutrients (TDN) of about 60% of total Dry Matter (DM), results compatible with such figures were simply not being achieved. The suspicion was growing that the "fibre " component (viz the insoluble solids) of the cane showed lower digestibility than had previously been believed, and a number of experiments at CEAGANA in the Dominican Republic (e.g. Valdez and Leng 1976; Bobadilla and Rowe 1979) showed that the rate of digestion of sugar cane fibre in the rumen was very slow, and that accumulation of undigested fibre in the rumen limited voluntary intake of sugarcane feeds.This was reported, though to a lesser degree, even in the case of comfith (Gill et al 1980). In recognition of this, Preston (1981) quotes Preston and Leng (1980) as saying "it has been shown in feeding trials with cattle that when whole sugarcane is fed, it is the soluble sugar fraction which contributes the greater part of the energy that the animal obtains from this feed. The fibrous component is digested only to a minor extent,but

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of greater concern is its detrimental effect on the overall nutritive status of the animal, because its slow rate of digestibility results in a very low rate of turnover of digesta within the digestive tract. Thus feed intake is low and so is the efficiency of rumen microbial synthesis".

In these circumstances it becomes a matter of some importance to examine the quality of the sugarcane being fed to animals - quality in this sense referring to sugar content, dry matter content and fibre content. This is attempted in the following sections.

Quantity of cane ingested: An animal presented with feed ad libitum can physically take in only a limited amount, and in the case of sugar cane the actual intake will be directly related to the sugar content of the cane: the higher the sugar content the higher the intake of sugars/kg of fresh cane eaten. Other things being equal the sugar content of the cane is proportional to the Brix* of the juice in the stalk, but there are two major variables in sugar cane, "fibre" and Brix. In sugar factory terminology - and suitable for the present discussion - "fibre" refers to the insoluble solids remaining after the juice has been expressed; for the total sugar content of the cane to be determined both fibre and Brix must be known. The calculation is simple:

% Juice = 100 - % fibre

Brix = total soluble solids in juice

Thus % soluble solids in cane $= \frac{(100 - \text{fibre}) \times \text{Brix}}{100}$

But total sugars are taken as 95% of Brix

Thus total sugars in cane (as % weight of cane) =

$$\frac{0.95 \times (100 - \text{fibre}) \times \text{Brix}}{100} \text{ as \% weight of cane}$$

By using this formula the total sugars in cane can be calculated for any combination of juice Brix and fibre; a range of figures is given in Table 1.

Table 1:

Effect of juice Brix and fibre on percentage of total sugars in cane stalk

°Brix of juice	Fibre (% of fresh weight of cane)						
	10	15	20	25	30	35	40
10	8.6	8.1	7.6	7.1	6.6	6.2	5.7
12	10.3	9.7	9.1	8.6	8.0	7.4	6.8
14	12.0	11.3	10.6	10.0	9.3	8.6	8.0
16	13.7	12.9	12.2	11.4	10.6	9.9	9.1
18	15.4	14.5	13.7	12.8	12.0	11.1	10.3
20	17.1	16.2	15.2	14.3	13.3	12.3	11.4
22	18.8	17.8	16.7	15.7	14.6	13.6	12.5

* In sugar technology a simple direct refractometric measurement of the percentage of total solids in the juice is possible and is expressed as degrees Brix. Total sugars represent about 95% of this value

The above relationship holds for stalk cane (as normally received by factories), but - mainly for economic reasons - whole cane, tops and trash included, are normally used for animal feed. The proportions of tops and trash are seldom, if ever, precisely known. Further, the tops may contain some sugars. For example, Purseglove (1968) states that "the leafy tops have a high percentage of reducing sugars". Dixon (1978) indicated approximately 16°juice Brix in cane tops. Canadian Cane Consultants (1973) used a ratio of tops to whole cane of 23% and from Pigden (1973) it can be calculated that the DM of the tops was 36% with 11% sugars and 25% fibre, representing Brix in the juice of the tops as approximately 15°(close to Dixon's figure), while the Brix of the juice in the comfith (viz the juice of the stalk cane) was 17.7°. Thus the sugar in the tops contributed significantly to the total sugars in the cane and should be included in calculations where tops are used. No figures are available for trash, though when whole cane is used for animal feeding the trash content may be as high as 10% of the fresh weight, contributing some 3% to the fibre of the whole cane (Humbert 1981). No extractable sugar is ascribed to the trash though there would presumably be small amounts.

However, in normal factory practice in Barbados it is estimated that 1.5 - 2% of the "fibre" attributed to the stalk cane is from adhering trash, so in the calculation below only 5% of fresh trash (1.5% of the DM) is attributed to the additional trash included in "animal cane".

Thus, for whole cane as fed to cattle, the figures in Table 1 would have to be modified. Using approximate figures for "average"cane as grown for sugar production in Barbados, we may assume, on a fresh weight basis, stalk making up 72% of the whole, tops 23% and trash 5%. Stalk fibre and juice Brix are taken at the 1980 Barbados averages of 15% and 19.5° respectively. Table 2 gives total sugars in cane based on these assumptions, and it may be seen that, for high quality cane, which as stalk cane would have given 50% of its DM as sugars, the inclusion

Table 2:
Total sugars in whole cane

Component and % of FW[1]	Brix of juice	Fibre: % FW in component	Fibre: % FW in whole cane	Total sugars[2]: In component (%)	Total sugars[2]: In whole cane (%)	DM[3]: In component (%)	DM[3]: In whole cane (%)	Total sugars as % of DM of cane	Sugar fibre ratio
Stalk 72%	19.5	15	10.8	16.6	12.0	31.6	22.8	35.0	
Tops 23%	15.00	25	5.8	11.0	2.5	36.0	8.3	7.3	
Trash 5%		30	1.5			30.0	1.5		
TOTALS			18.1		14.5		32.6	42.3	0.76

[1]FW=fresh weight

[2]As Brix

[3]DM=Dry matter

of tops and trash reduces the percentage of sugars in the DM to 42. The lower sugar content of the tops and virtually nil of the trash means that as the non-stalk components of the canefeed increase, the sugar:DM ratio decreases more rapidly than when sugars and fibre are calculated on the basis of stalk alone. For example, from Table 2 we have stalk cane at 19.5°Brix and 15% fibre, which would have total sugars as 15.75% of its fresh weight. However, with additional fibre added by tops and trash, making total fibre 18.1%, and including sugars in the tops, the total percentage of sugars as fresh weight comes to 14.5. If the fibre had been stalk fibre only, the percentage of sugars would have been 15.2. Admittedly this is not a very great difference from that based on stalk alone (15.75%), and for approximate calculations in this paper sugars and fibre content will be used as if stalk alone were being considered, except where otherwise stated, but it must be borne in mind that such figures can be very imprecise, especially where the proportion of non-stalk to stalk fibre is high, as, for example, in young canes with abundant tops and little stalk, or in old fields with a high proportion of rotten canes.

We may now consider how much sugar an animal requires per day. Quintyne (1978) feeding dairy cows weighing 500 - 550 kg was feeding almost 40 kg of cane supplying some 5 kg of sugars daily. James (1973) was feeding approximately 2.2 kg/d to steers between 150 and 300 kg. For the present model let us consider 3 kg total sugars as a daily requirement and see how the intake of cane to provide this quantity of sugars is affected by both Brix and fibre content of the cane. Table 3 shows the relationship.

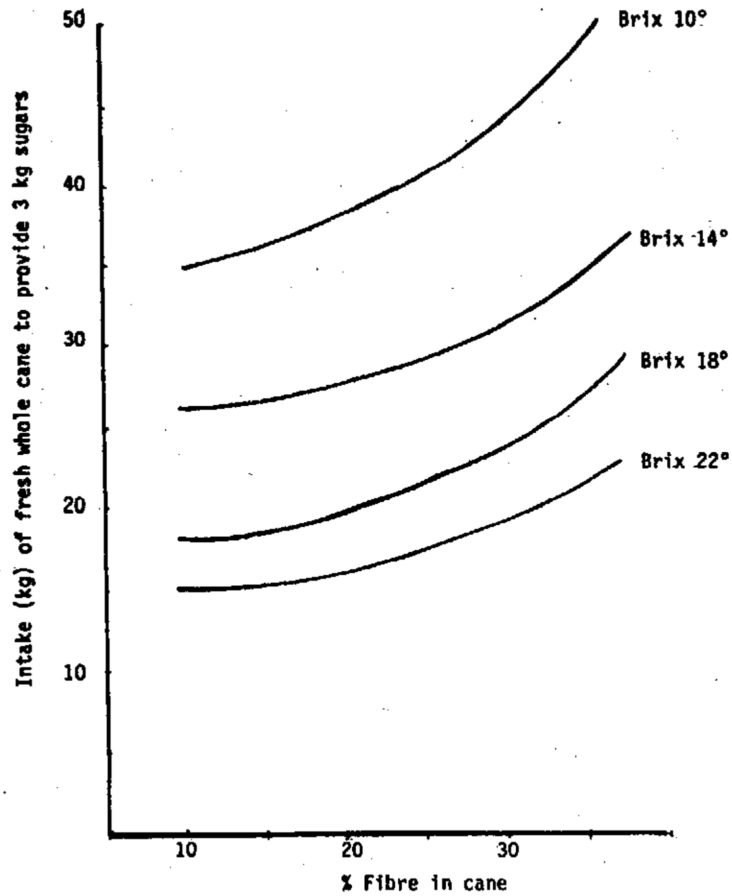
Table 3:
Weight (kg) of fresh stalk cane to give 3 kg total sugars

°Brix of juice	Fibre (% of fresh weight of cane)						
	10	15	20	25	30	35	40
10	35	37	39	42	45	48	53
12	29	31	33	35	38	41	44
14	25	27	28	30	32	35	38
16	22	23	25	26	28	30	33
18	19	21	22	23	25	27	26
20	18	19	20	21	23	24	26
22	16	17	18	19	20	22	24

Once again it must be emphasised that these figures are calculated as if all the sugars and fibre were associated with the stalk cane but, as noted above, as non-stalk fibre increases sugar content decreases to a relatively greater extent.

A graphical representation of some of the above figures is presented in Figure 1, which clearly shows that although increasing fibre content does substantially increase the weight of fresh cane required to provide a stated quantity of sugars, the effect of Brix is very much larger. For example a 100% increase in fibre at Brix 20°, from 15%

Figure 1:
Effect of fibre and juice Brix on fresh weight of cane needed to provide 3 kg total sugars



to 30%, would need an increase in consumption of fresh cane from 19 to 23 kg (25%) to provide 3 kg sugars; reducing Brix by 50% from 20° to 10° at 15% fibre would involve an increased consumption of cane from 19 kg to 37 kg (approximately 100%): indeed this relationship - halving the juice Brix and roughly doubling the total quantity of cane required holds for any level of Brix, but the converse is not true for fibre. Thus Brix is of critical importance if the animal's intake is limited by the total quantity of cane that can be consumed.

Dry matter intake: When the relationship between sugar intake and total DM of sugarcane is considered, a rather different picture appears. Again a simple calculation may be applied. As seen from p. 73

$$\% \text{ soluble solids in cane} = \frac{(100 - \text{fibre}) \times \text{Brix}}{100}$$

$$\% \text{ sugars} = \frac{0.95\ (100 - \text{fibre}) \times \text{Brix}}{100}$$

DM of cane = fibre + soluble solids

Thus sugars as % of DM

$$= 0.95\ (100 - \text{fibre}) \times \text{Brix} \div \left[\text{fibre} + \frac{(100 - \text{fibre}) \times \text{Brix}}{100}\right]$$

Table 4 shows the effect of Brix and fibre on sugars expressed as percentage of DM.

Table 4:

Effect of juice Brix and fibre content on sugars in cane stalk as percentages of DM

°Brix of juice	Fibre(% of fresh weight of cane)						
	10	15	20	25	30	35	40
10	45	34	27	22	18	15	12
12	49	38	31	25	21	17	14
14	53	42	34	28	23	20	16
16	56	45	37	31	26	22	18
18	59	48	40	33	28	24	20
20	61	50	42	36	30	26	22
22	63	53	44	38	32	28	24

Using these figures we may calculate the weight of DM to be ingested to provide 3 kg total sugars; this is expressed graphically in Figure 2.

Using the same comparison as for fresh cane (p 76) we now find the effect of fibre much greater, (Table 5).

Figure 2:

Effect of fibre and juice Brix on DM intake to provide 3 kg total sugars

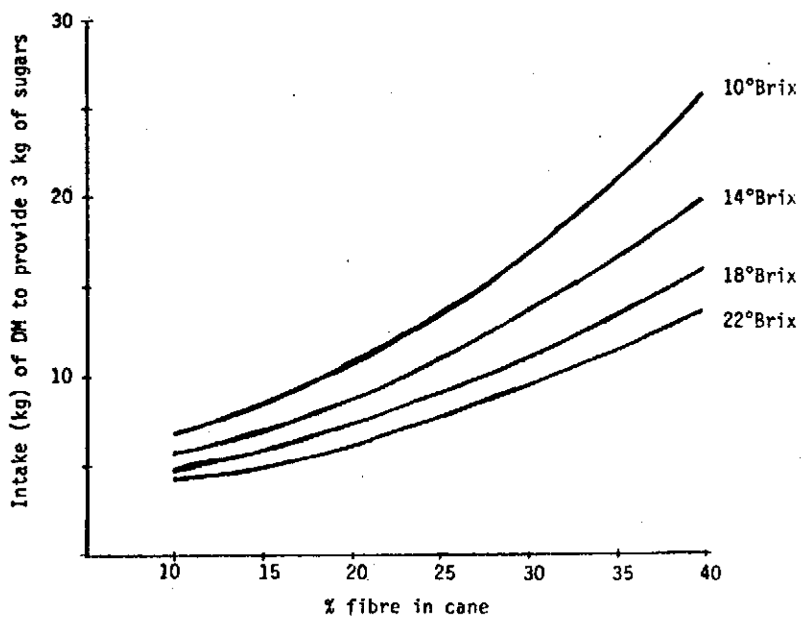


Table 5:
Intake necessary to provide 3 kg total sugars (to nearest round figure)

Fresh cane kg			Dry matter kg		
Fibre \ °Brix	10	20	Fibre \ °Brix	10	20
15	37	19	15	9	6
30	45	23	30	17	10

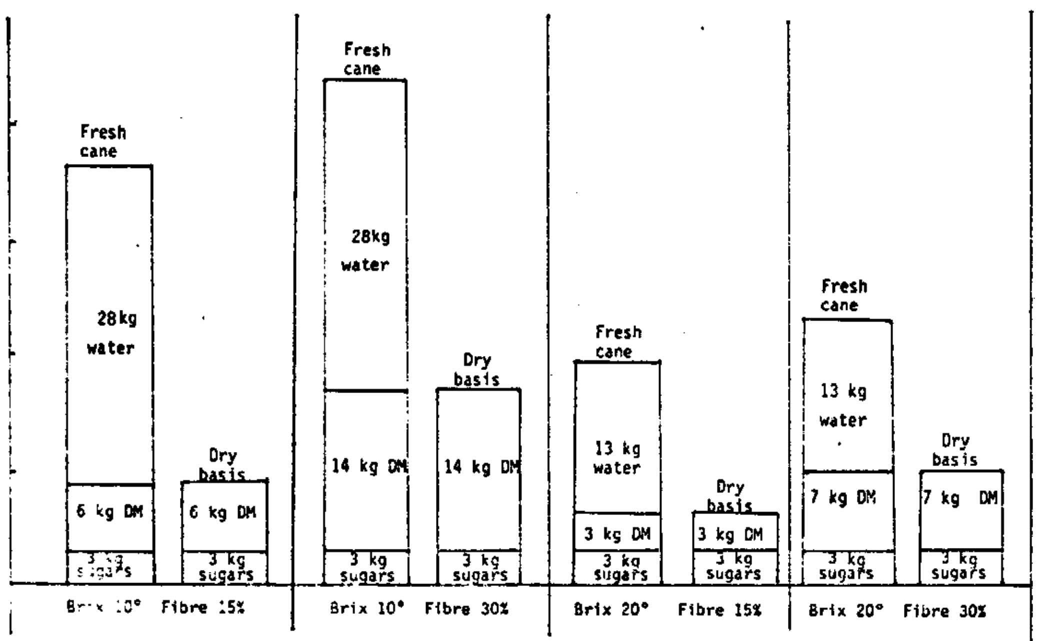
Thus to obtain 3 kg of total sugars:

Fresh cane: Doubling Brix reduces intake by about 50%
Halving fibre reduces intake by about 18%

DM basis : Doubling Brix reduces intake by about 45%
Halving fibre reduces intake by over 50% at the low Brix figure of 10°, by 40% at the higher Brix of 20°.

At first sight the difference in effect of Brix and fibre respectively on intake of fresh cane and DM appears anomalous, but a histogram makes the situation clear (Figure 3): the apparent anomaly is based on

Figure 3:
Relationship of sugars/other solids/water in sugar cane at Brix 10° and 20° and fibre 15% and 30% fresh weight

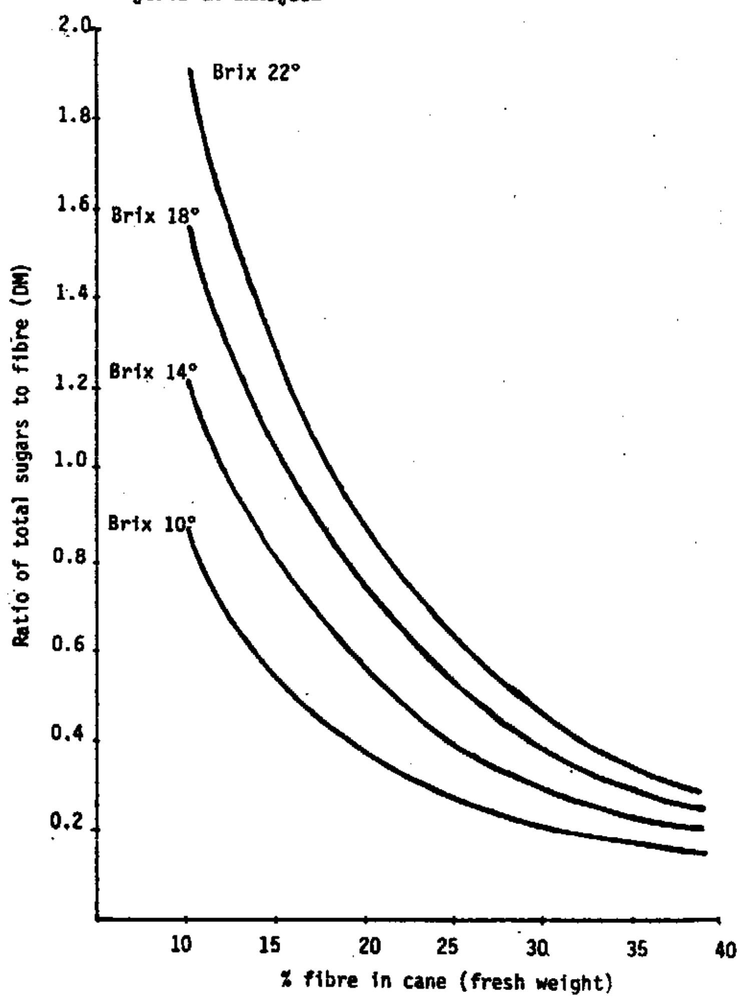


(DM in the histogram is dry matter other than sugars and is nearly all fibre) the fact that while fibre is expressed as percentage of whole cane, juice Brix is related to the juice component only; thus, in fresh cane the amount of water taken is in direct proportion to the Brix - note that the water intake is the same for each level of Brix, regardless of the total DM intake.

Thus, when DM intake is an important criterion - and normally it would be more important than fresh weight unless the latter were the overiding limiting factor on intake - fibre becomes more important than sugar content.

Sugars/fibre ratio: As fibre not only contributes greatly to the DM in sugarcane feed, but also is positively undesirable when fed in large quantites, the effect of Brix and fibre content of the cane on the sugars/fibre ratio may be considered. These are shown in Figure 4.

Figure 4:
Effect of fibre and juice Brix on ratio of total sugars to fibre in canefeed



In Barbados , as previously noted (Table 2), whole cane with tops and trash has a fibre content of about 18%; from Figure 4 a juice Brix of about 23° would be needed to provide a sugars/fibre ratio of 1.0(viz 50% of the DM as sugars). This also comes out in Table 4 where the percentage of total sugars to DM drops extremely sharply as fibre content increases. In practical terms a sugars/fibre ratio of 1.0 might be considered a target, and the quality of the cane as animal feed regarded in terms of how far it falls below this target. The obvious question now is, how can the quality of sugarcane be brought to and maintained at levels approaching the target.

PART II FACTORS AFFECTING THE QUALITY OF CANE

Many factors affect the quality of cane. Unfortunately the standard text books are apt to be inconsistent and confusing - partly because there has tended to be a concentration on Hawaii (e.g. Clements 1980) where a two year crop is grown, without ratooning, and sugar content is manipulated by irrigation processes, rather than the 12 - 16 month plant cane followed by ratoons, relying on seasonal rains as in many other parts of the world. The question of factors affecting quality is a vast one and can be treated only very briefly in this paper.

Variety: A very large number of cane varieties are commercially grown and have been selected for various qualities that suit particular conditions. The differences between varieties (or more accurately cultivars) can be large. Pate and Coleman (1975) examined 66 cultivars of commercial importance, all 10 months of age at harvest. Analyses were made of whole cane - viz stalk, tops and adhering leaves (trash), without separation into the different portions. The results are summarised in Table 6, and some of the differences are considerable e.g. a range in DM from 30-17%. In this paper we are primarily concerned with fibre (NDF) and total sugars (approximating to the NDS figures): these range from 68 - 43 and 57-32% of the DM respectively. Brix can be calculated from the detailed figures,and ranges from 18.1°to 10.6° on the juice of the whole cane.

In the previous section great emphasis was placed on the importance of high Brix. However this was, as stated at the time, related to the type of cane grown in Barbados, with about 30% DM in stalk cane, of which about 55% is sugars (Brix 19°). In general Pate's canes had relatively low total DM and the average fibre content of the whole cane at 13.57% was lower than that usually grown in Barbados, which averages about 18% (Table 2). The water content was higher, averaging 74.25% compared with Barbados' 67-70% for an average year, and consequently a 'good' sugars/fibre ratio could be obtained at lower levels of Brix. In fact 51 out of the 66 cultivars examined had NDS:NDF ratios (approximately sugars:fibre ratios) of over 0.9 , and 15 had ratios over 1.0.In the Barbados models with total fibre of 18%, a stalk Brix of about 23° would be required to achieve a ratio of 1.0. This is not to say that Brix is unimportant; it is very important for any given fibre level, but a low fibre cane with a lower Brix can provide a higher sugar intake per unit of DM than a high fibre cane with a similar or even higher Brix. On the

Table 6:

Summary of analyses of 66 cultivars of cane (Figures as % of DM)

	Mean	Range	
		High	Low
Dry matter [1]	25.75	30.5	17.0
Crude protein	2.32	3.06	1.06
Crude fibre	28.12	35.93	22.68
Ether extract	1.24	1.87	0.70
Ash	4.33	7.12	2.74
Calcium	0.20	0.35	0.06
Phosphorus	0.05	0.09	0.02
Lignin	6.31	8.43	4.60
Cellulose	26.99	31.97	21.89
NDF [2]	52.70	67.70	42.56
NDS [3]	47.29	57.44	32.30
IVDOM [4]	56.60	64.10	40.04

[1] Dry matter reported as % of fresh weight; all other data reported as % of dry matter

[2] Neutral detergent fibre [3] Neutral detergent solubles

[4] In vitro digestible organic matter

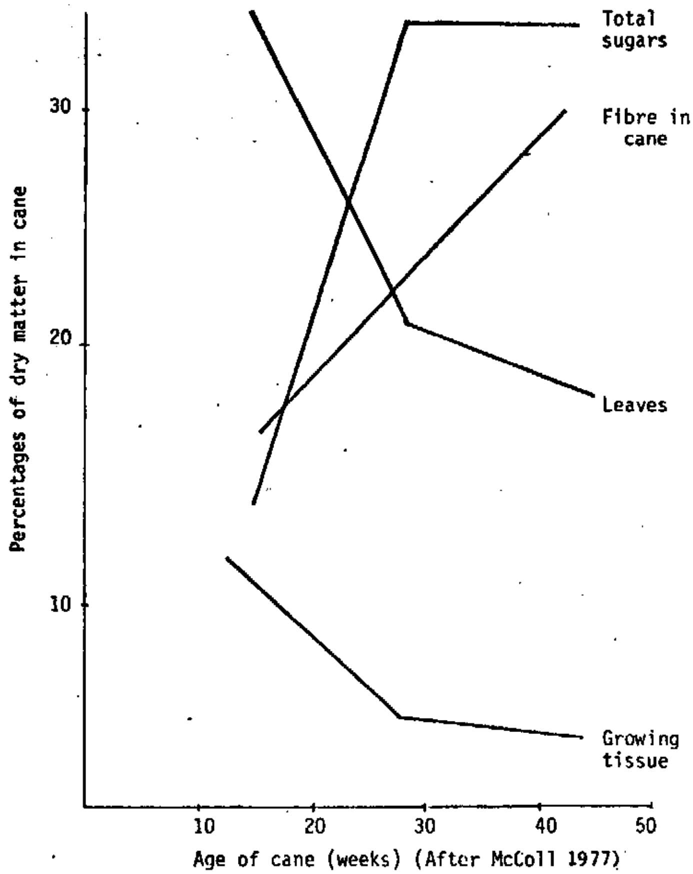
It is assumed that NDS approximates to percentages of total sugars from: Pate and Coleman (1975)

other hand, the actual volume of the low DM cane, to give a stated amount of sugar will be greater - though the increased volume is due to water.* There seems to be little information on whether the animal's appetite is limited by total volume, or by DM intake, or by the fibre component (though the latter is probably the most important consideration). Also, presumably the carrying capacity of any particular area of cane will be related to the sugar production per unit area, rather than to the absolute tonnage.

Maturity: Much of the information on the effect of maturity on the quality of sugarcane is derived from sugar factory measurements, which monitor the Brix and fibre continuously during the harvesting season. Relatively little has been published on the changes in components of sugarcane in the period before harvest. McColl (1977) made analyses of cane at 15, 28 and 42 weeks after planting (which was in August rather than the usual commercial date of October/November) and found a rapid increase in total sugars, attaining a maximum of about 34% of the dry weight of the whole cane by 28 weeks, and a linear increase in fibre. The proportion of leaves fell and so did the proportion of growing tissue (Figure 5). However these results are for only a portion of the usual life span

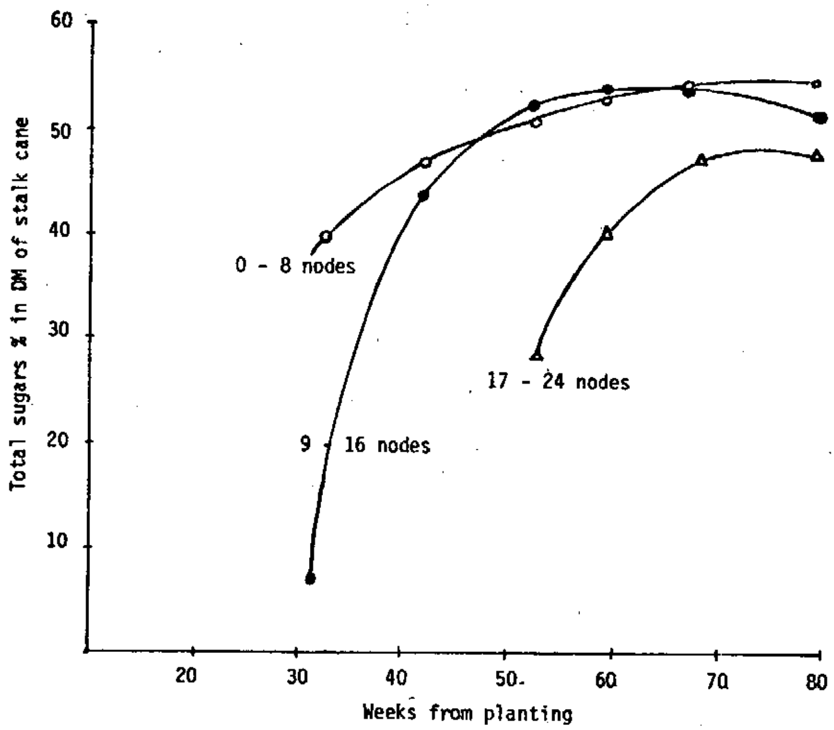
* It should be noted that for certain purposes, e.g where rindboard is a prime consideration, high fibre cane may be desirable, and there are high fibre canes with high total sugar contents; Walker (1981) quotes an example with 19.8% fibre and total sugar content of 16.2 (equivalent to juice Brix of 21.3); sugars as % of DM was 44, low for direct intake but probably satisfactory when the pith is separated from the high fibre rind.

Figure 5:
Changes in DM of cane components with time



of plant cane - usually 14 - 15 months before reaping. Preston (1977), quoting figures for Mauritius for cane up to 80 weeks of age, showed a sharp rise in sugar content from about 30 weeks from planting, and also separates the cane into three portions, 0 - 8 nodes, 9 - 16 nodes and 17 - 24 nodes from the base: the progress of sugar content with age is shown in Figure 6. Factory records, which though plentiful, are based on whole fields of cane of several cultivars and of various ages, show that at an average age of about 52 weeks (the canes being a mixture of plant canes and ratoons 45 - 55 weeks old), the total sugar content as measured by Brix is still rising at the start of harvest, reaches a peak

Figure 6:
Changes in sugar content of cane with time (from Preston 1977)



(in both Barbados and St Kitts about April), may remain at that peak for a while and then starts to decline. There is usually a tendency for a slight rise in fibre * content during the harvest season; McColl's (1977) suggests that part of this may be due to actual production of new fibre, and Walker (1981) states that secondary thickening of the vascular bundles does, in fact, occur even in canes 12 to 15 months old. Some of the increase in fibre observed in factory analyses towards the end of the crop are, however, undoubtedly due to rotten canes, which are of low moisture content and therefore of apparently higher fibre.

Figures 7, 8, 9 and 10 show changes in the juice Brix of cane stalks during the harvest season in Barbados, St Kitts, South Africa and Guyana, while Figure 12 shows changes in both Brix and fibre throughout a "normal" season in Barbados. At the SFC in Trinidad measurements were made on whole cane (viz stalk plus top plus trash); these are shown in Figure 11. Once again the seasonal rise in Brix of the juice is marked, peaking at 21° in May.

* Fibre in sugar factory terminology refers to all non-sugar solids entering the mill. With the recent increase in mechanisation of harvesting and loading, substantial quantities of extraneous matter such as rotten canes, trash, cane tops, earth and even stones have been included with canes delivered to the factories and have increased the apparent fibre content. Records of extraneous matter have been kept and a corrected figure for fibre has been used in Figures 13 and 14.

Figure 7:

Barbados sugar Industry Changes in juice Brix with time (Foursquare factory 1980)

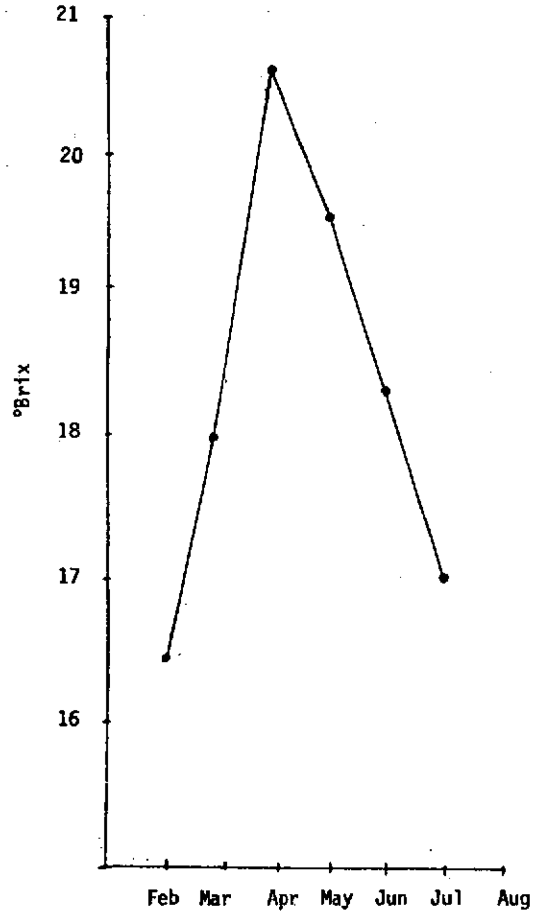
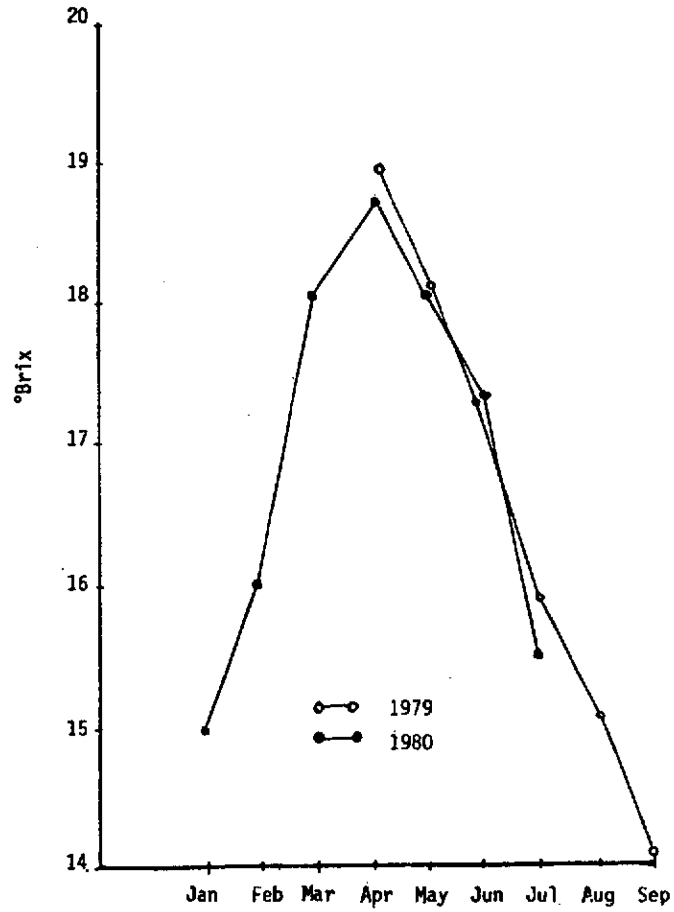


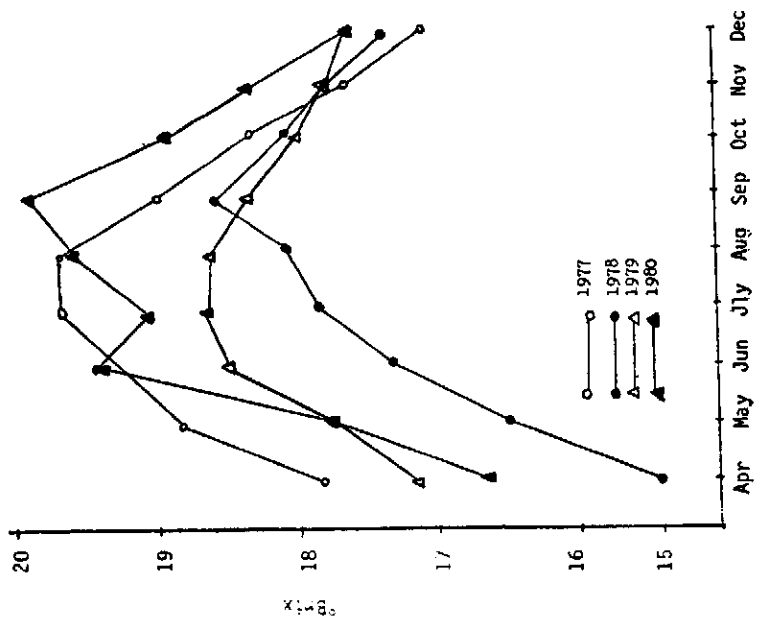
Figure 8:

St Kitts sugar Industry. Changes in juice Brix with time



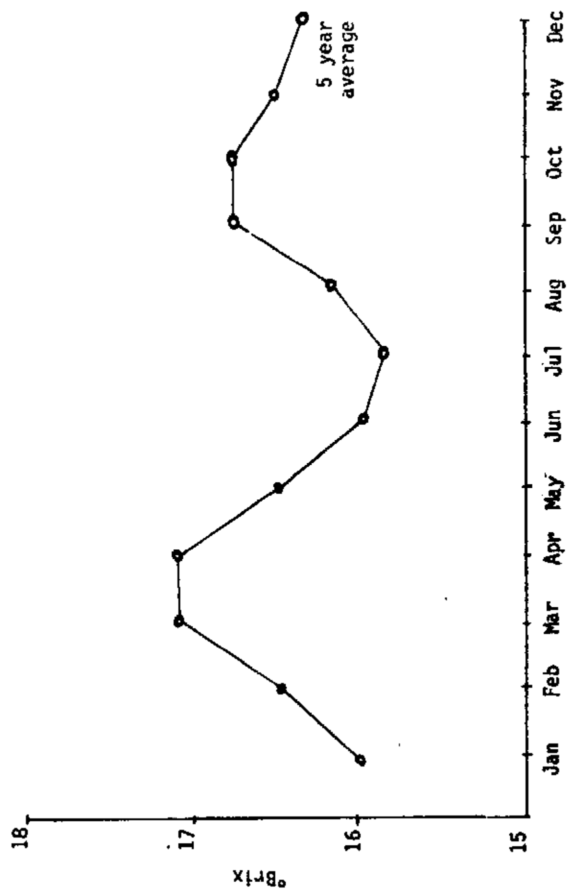
Source: St Kitts Sugar factory

Figure 9:
South African sugar Industry. Changes in juice Brix with time



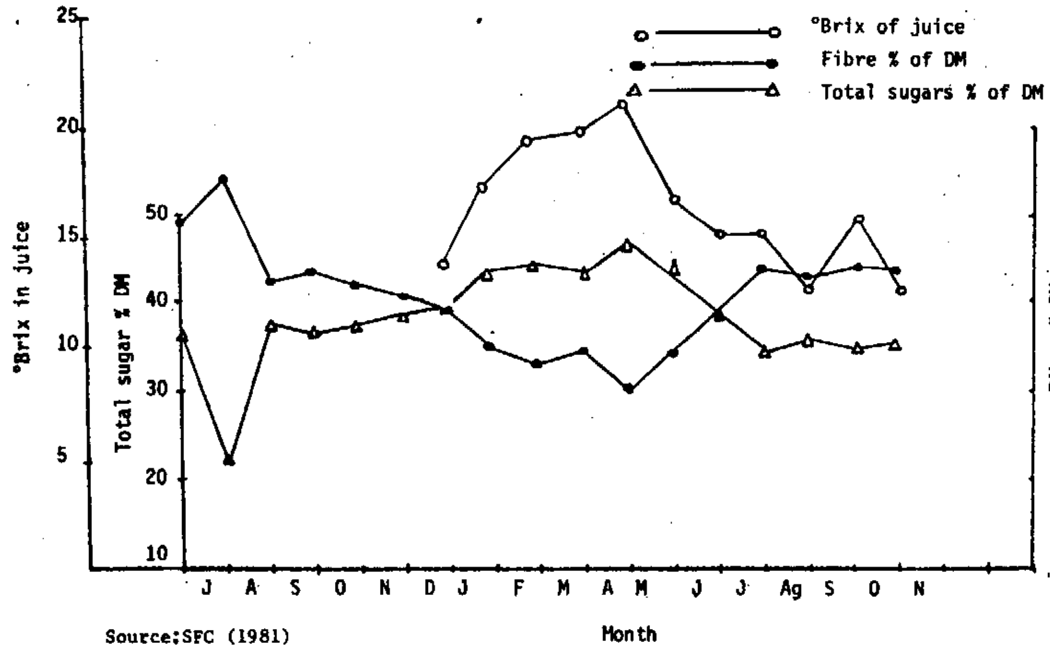
Source: South African Sugar Experiment Station

Figure 10:
Guyana sugar industry. Changes in juice Brix with time



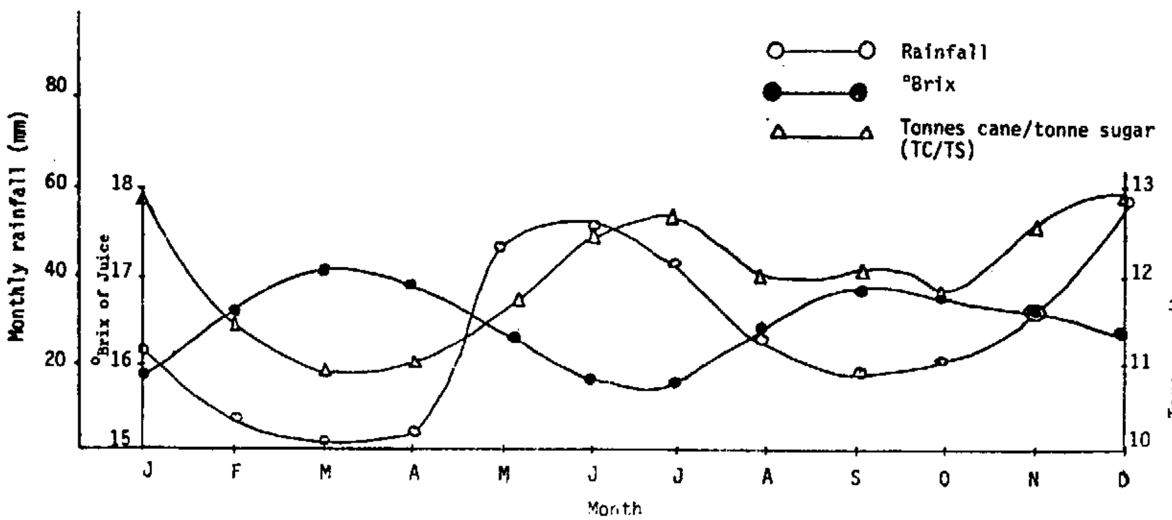
Source: Hudson (1981) from data from Jackson (1976)

Figure 11:
Changes in composition of sugarcane at SFC (whole plant)



Source:SFC (1981)

Figure 12:
Guyana sugar Industry: rainfall, Brix and TC/TS ratio. 5 years average for Brix and TC/TS 2 extremes of rainfall



Source: Derived from Jackson 1976 and Hudson 1981

Age of the cane (chronological maturity) is clearly one factor affecting the quality of sugarcane. Undoubtedly another is:

Rainfall: It is general experience that when the wet season starts the juice Brix falls. This has been dramatically shown for Guyana by Jackson (1976), where there are two wet seasons (Figure 12); this diagram also shows the important inverse relationship between juice Brix and the number of tonnes of cane required to produce a tonne of sugar (the TC/TS ratio). The decline in Brix in St Kitts and in South Africa coincide with the start of the rainy season. In Barbados every effort is made to finish the harvest before the early rains: Figures 13 and 14 show rainfall, Brix and fibre for one factory for 1980 and 1981. The former year was "normal", with rain starting in mid May - and a fall in Brix at the same time. In 1981 the early part of the year had more than average rain, and heavy rains were experienced in late April and early May, after which the juice Brix fell sharply from a peak of 19.42° in early April to 14.88° in August.

There is no precise knowledge as to why rainfall should cause a substantial fall in Brix. It would seem plausible to expect that it is a dilution effect. It is known that in dry weather the cane is under water stress (Gooding 1942; Hudson 1981) and it is also known that plants under water stress can take in water very rapidly, in a matter of minutes, when the stress is relieved (Gooding 1952). When the water contents of the cane received at the factory in 1980 and 1981 are compared (Figures 13 and 14), it is seen that the water contents of the cane throughout 1981 were substantially higher than those in 1980. Further, in 1981 there was a general downward trend in fibre as well as in Brix as the season progressed, which can only have been due to dilution - and indeed the steady rise in water content of the cane substantiates this interpretation.

That the low Brix levels of 1981 are associated with the higher water content of the cane therefore appears clear and with an approximate average fibre content of 13% and water content of 72%, the calculated juice Brix would be 17°; for 1980 with fibre at about 15% and water content 68%, the juice Brix would be 21° . However, while this can be taken as an explanation of the general low level of juice Brix in the very wet year of 1981, we still have to look further for reasons for the fall in juice Brix towards the end of the harvest season. If increasing dilution of the juice were the only cause, and if no additional fibre were being formed in the cane itself, the ratio of sugars to fibre should remain almost constant , with only a very slight fall in ratio because of the small amount of increased fibre to be expected as a result of secondary thickening. These ratios are shown in Figures 13 and 14 and are almost constant for 1980, but 1981 shows a definite tendency to decline. Thus in 1980 the actual amount of sugar per unit DM remained fairly constant, but in 1981 the quantity of sugar declined. A notable feature of the 1981 crop was that even by early July there was a high proportion of growing tillers, which by August were as tall as and more robust than the original cane, and there was also evidence of "top growth" on the old cane. As the stalk of the sugarcane is the storage organ for reserve food, it seems highly probable that sugars have been translocated from the stems to play a part in these two forms of new growth, both of which at the time of harvest are very immature and therefore of low total sugar content; indeed, at the end of August 1981, Brix measurements taken in

Figure 13;

Changes in cane : Crop season 1980 (Foursquare, Barbados)

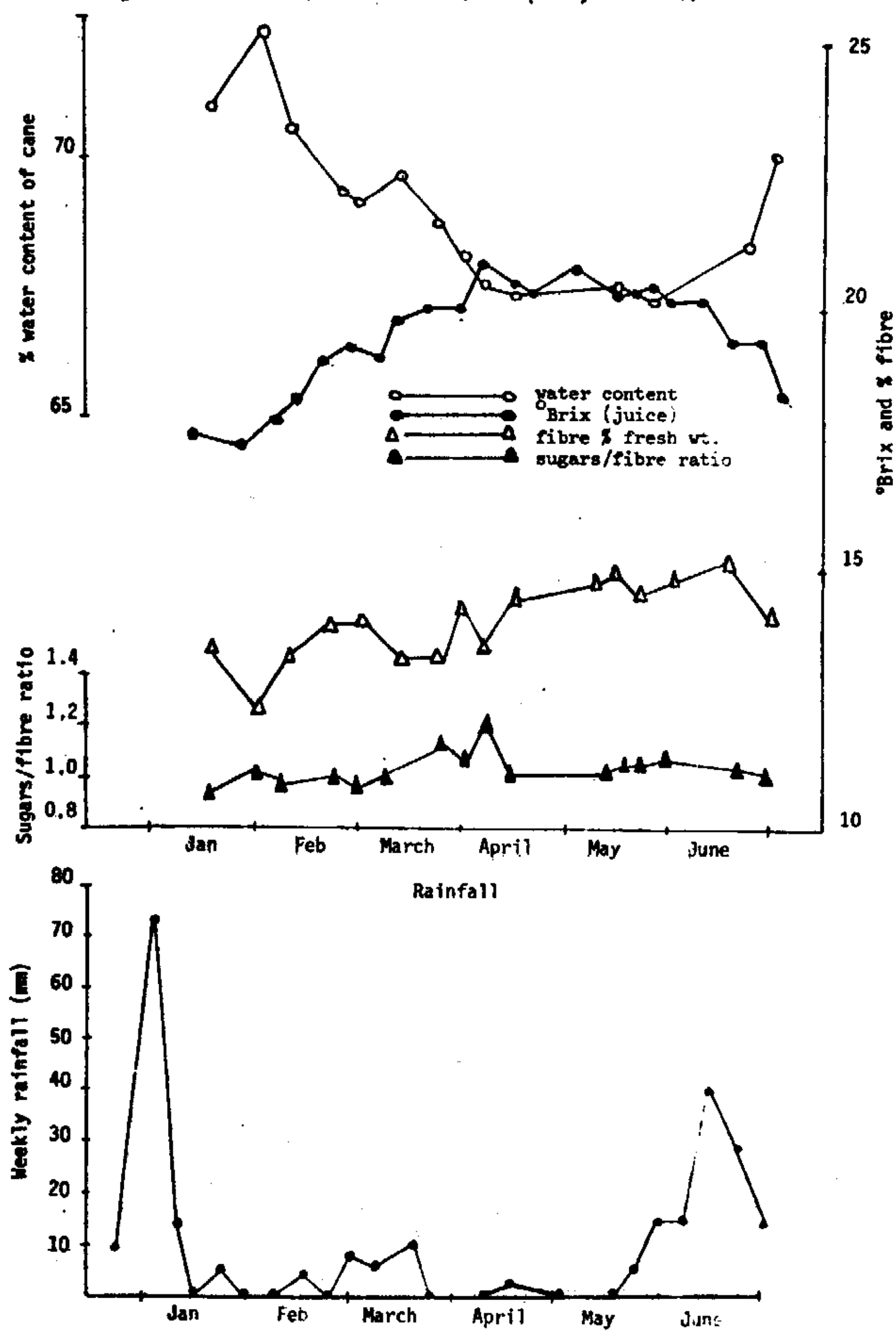
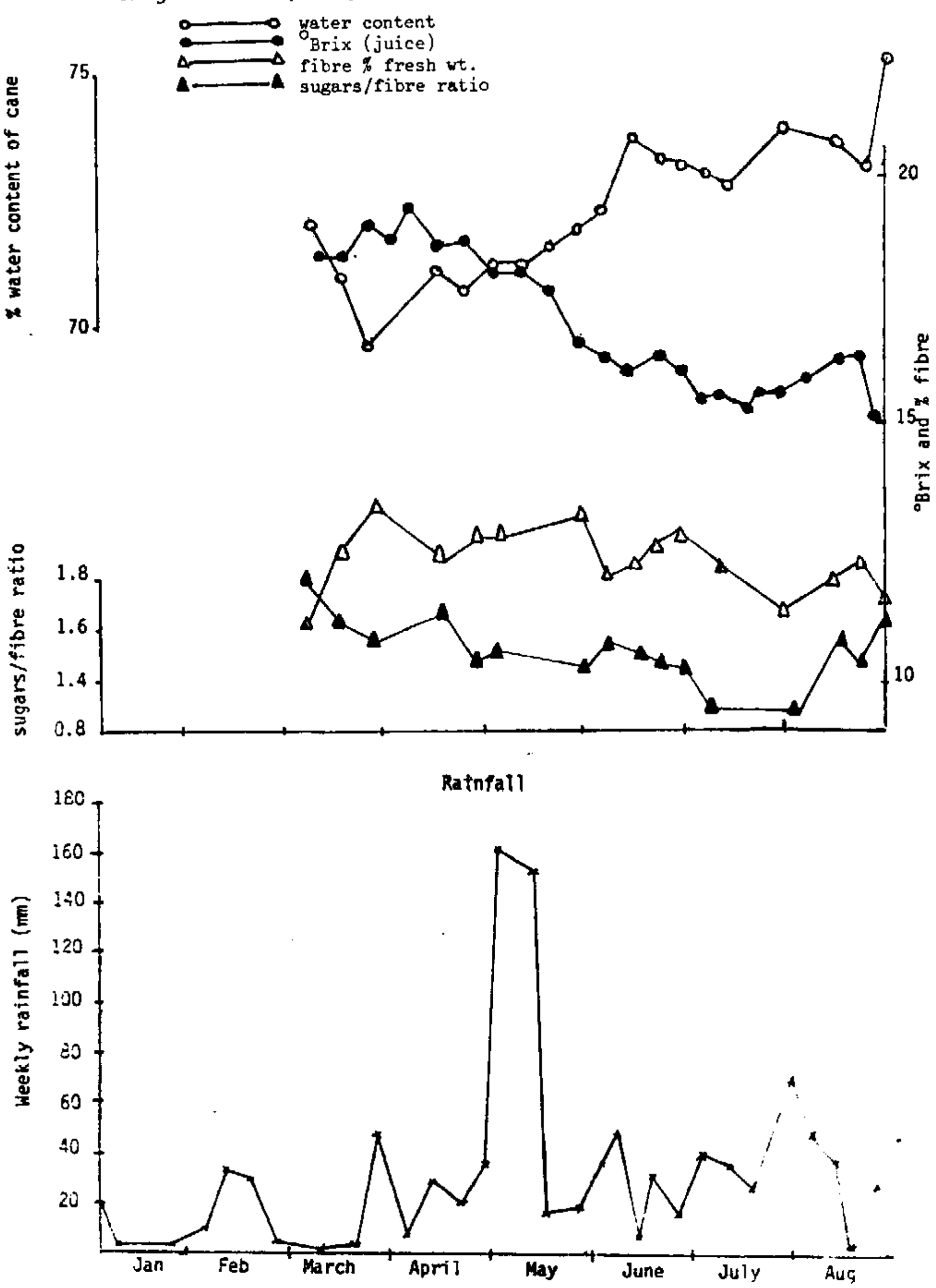


Figure 14:
Changes in cane quality : Crop season 1981 (Foursquare, Barbados)



the field showed the older canes ranging in Brix from 17° to 20°, but young though well grown and robust tillers, showed Brix of 12° - 13° . This new growth is a result of the stimulus of rainfall, which has two adverse effects on the quality of the cane - a simple dilution of the juice and diversion of the sugars to "low quality" new growth. The immature tillers also had very low fibre contents - reflected in the graph (Figure 14) - so the sugars:fibre ratio actually rose when a high proportion of tillers were being harvested .

Temperatures: Many West Indian growers believe that low night temperatures (which mean in the order of 20°C - 22°C rather than the usual 24°C) during December, January and February, (the latter period of maturation of the cane), lead to higher sugar contents, and this has been confirmed for Jamaica by Innes and Cowan (1960). The reason may possibly be that put forward by Seghal (1970) who, referring to maize, stated that high yields are not possible in the tropics because of high respiration during long warm nights consuming carbohydrates that would otherwise have been stored.

Extraneous matter: In the data shown in Figures 13 and 14 the fibre has been "corrected" for extraneous matter. The factory figures for 1981 showed weekly average fibres as high as 18% (compared with the corrected figure of about 13%); the extraneous matter varied with the method of harvesting and loading, being lowest with hand cutting and hand loading, highest (up to 18% of fresh weight) with mechanical cutting and loading by chopper harvesters, particularly in the wettest weather when substantial quantites of mud were included. The Sugarcane Feeds Centre in Trinidad has noted that there was a high proportion of ash in the canefeed in the wet season and attributes this to mud etc. picked up by mechanical loading (SFC 1981). Also towards the end of the season there is an increasing proportion of rotten cane, much of it due to rat damage.

Considering the Barbados models (Table 2) we have seen that with "typical" canes as grown for factory use, even at periods of high Brix - viz a normal crop season as in 1980 where the average Brix, island wide, from early February to mid July (5 1/2 months) was 19.5 - whole cane could provide only about 42 - 43% of its total DM as sugars. As Brix falls the ratio of sugars to fibre will fall . The animal nutritionist, bearing in mind that the sugars are the most valuable source of energy provided by the sugarcane ration, and the slow movement through the rumen of the fibre, will have to decide whether high energy supplementation by, for example, molasses will be necessary. The sugarcane agronomist will have to give more thought to ways of prolonging the period of highest Brix:fibre ratio; in places where cane is grown under irrigation this can to some extent be manipulated by irrigation practices (Clements 1980). The valuable analyses of different cultivars of cane carried out by Pate and Coleman (1975) show that there are canes offering very much higher sugar/fibre ratios than are currently being used for animal feed either in Barbados or Trinidad. If animal cane feeding using chopped sugarcane is to be taken seriously, screening for this quality and the development of cane specifically for animal feeds is essential. Self de-trashing cane can be useful: Table 2 indicates the way in which the presence of trash increases the ratio of fibre in the feed product. The effect of phased planting on sugar:fibre ratio is not known. The way is open for a considerable amount of experimentation, bearing in mind that total yield of sugar per hectare is not the end being sought; what is required is cane giving a higher sugar:fibre ratio even if the actual quantity of sugar is not extremely high.

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