DETERMINATION OF THE APPARENT DIGESTIBILITY OF DIETS CONTAINING COARSELY OR FINELY CHOPPED CANE TOPS

F J Salais[1], A Wilson[2] and R Elliott[2]

Centro de Investigación y Experimentacion Ganadera [3]
Chetumal, Q R, Mexico

Eight young bulls were used in two digestibility trials of 4 x 4 latin square design to measure the effect of fineness of chopping of sugar cane tops when these were given with a molasses/urea diet or with chopped sugar cane stem, with or without a supplement of rice polishings. The intake of cane tops was set at 3% of live-weight, while that of molasses/urea or chopped cane stem was not controlled (voluntary consumption of these was measured). In all cases the digestibility of the dry matter of the diets was greater when the cane tops were given in the longer form (5-20 cm) than when finely chopped by machine. When combined with the food intake data, the overall effect was that when the animals were given the coarsely chopped cane tops, they had greater intakes of digestible dry-matter. The molasses/urea basal diet was associated with greater digestibility and greater dry-matter intakes than the cane stem basal diet. Supplementation with rice polishings was without effect on digestibility, but it tended to increase voluntary intake of both molasses/urea, and cane stem. The effect of coarse chopping the cane tops on digestible DM intakes is in agreement with a previous growth trial.

Previous work at this Centre (Ferreiro and Preston 1976) showed that growth rate on sugar cane tops was superior to that on whole sugar cane, due mainly to greater voluntary intake of DM, An increase in intake, when chopped cane tops were added to derinded cane stem was reported by James (1973) and Ferreiro and Preston (1977), The former also reported an associated increase in growth rate.

In experiments carried out by Salais et al (1977), there was evidence that the particle size of the forage component in a molasses-based diet was important. Thus, when cane tops were used as a forage source, growth was better when these were chopped in large pieces with a machete, than when they were ground finely by machine.

The objectives of the experiment described here were to obtain further information on the effect of fineness of chopping of cane tops on voluntary intake and digestibility of diets based on molasses or cane stalk, with and without supplements of rice polishings.

Materials and Methods

Animals, Treatments and Design: Eight young Zebu bulls with an initial weight of about 170 kg were used in two 4 x 4 latin squares. The two squares were allocated identical treatments, but with the difference that all the animals in one square received a supplement of 750 g rice polishings per day. The treatments were:

---

[1] In receipt of fellowship from IDRC, Canada

[2] Technical Officer Ministry of Overseas Development, London UK

[3] This unit is now reestablished as the Departmento de Investigación y Estudios Superiores, Esceula de Medecina Veterinaria y Zootecnia, Universidad de Yucatan, Merida

A) Cane tops, chopped with a machete to a length of 5-20 cm, given at 3% of live weight daily with molasses/urea ad libitum
B) As A) above, but with the cane tops finely chopped by machine
C) Cane tops, chopped to a length of 5-20 cm, given at 3% of live weight, plus cane stem (finely chopped) ad libitum
D) As C) above, but with the cane tops finely chopped by machine.

The molasses/urea contained 3% urea and 1% ammonium sulphate. The cane stem was supplemented with a solution of urea/ammonium sulphate (10:1) at a rate defined by the sugar content (Brix°) of the stem (Ferreiro et al 1977). All animals received 60 g/day of a mineral supplement.

Housing and Management: The animals were kept in individual pens for 9 days adaptation and were then transferred to digestibility crates for a further 9 days. Faeces were collected, and food intake was measured for the last 7 days. The animals were fed once daily, receiving the chopped cane tops and rice polishings (when given) before being offered the cane stem (when given).

Results and Discussion

The results of the experiment are given in Table 1. The diets based on coarse chopped (5-20 cm) cane tops were more digestible in all cases than those with fine chopped tops, although the difference did not always reach statistical significance. There was a clear and significant ($P < 0.001$) difference in the dry matter digestibility between the diets with molasses/ urea, and those with the cane stem, in favour of the former. The addition of rice polishings was without effect (the average digestibilities in the two squares being 65 3 and 65.9%).

Table 1:
The effect of fineness of chopping of cane tops and supplementation with rice polishings on the digestibility and consumption of diets of cane tops with molasses/urea or cane stem.

Diet	Molasses/urea		Cane stem		Standard error of mean[3]
Form of cane tops	5-20 cm	Fine chop	5-20 cm	Fine chop	
DM Digestibility (%)					
With rice polishings	72.7[a]	71.0[b]	61.0[b]	56.4[c]	0.50
Without rice polishing	75.9[a]	71.6[b]	60.8[c]	55.5[d]	0.55
Voluntary intake (kg DM)					
With rice polishings	3.97[a]	4.12[a]	3.71[ab]	3.30[b]	0.17
Without rice polishings	3.49	3.15	2.94	2.84	0.23
Consumption index[1]					
With rice polishings	2.31[a]	2.34[a]	2.04[b]	1.83[c]	0.02
Without rice polishings	2.09[a]	1.87[b]	1.71[b]	1.47[c]	0.02
Digestible dry-matter consumption index[2]					
With rice polishings	1.67[a]	1.51[b]	1.24[c]	1.03[d]	0.03
Without rice polishings	1.58[a]	1.36[b]	1.04[c]	0.82[d]	0.01

[abcd] Means with different superscripts differ ($P<0.05$)
[1] Food intake, kg DM/100 kg live weight/day
[2] Digestible dry matter intake/100 kg live-weight/day
[3] Each value is the mean of 4 determinations

There were clear effects of supplementation with rice polishings and of the molasses diet on food intake, both of which increased food intake no matter how this was expressed (as total intake, or corrected to live weight). There was no obvious effect of processing the cane tops on food intake. although when this was corrected to a live-weight basis, there was a tendency (significant in the case of the cane stem diet) for intakes to be higher with the longer material. However, when the effect on digestibility was also introduced, the 5-20 cm material was associated with greater ($P < 0.05$ to $P < 0.001$) intakes of digestible dry-matter per unit body weight.

Table 2: Mean values for main treatment effects

	Digestibility of DM, %		Intake of DM, kg/d	
	Without rice polishings	With rice polishings	Without rice polishings	With rice polishings
Effect of chopping				
Coarse (machete)	68.3	66.8	3.21	3.84
Fine (machine)	63.5	63.7	2.95	3.71
Effect of basal diet				
Molasses	73.7	71.9	3.32	4.05
Cane stalk	58.1	58.7	2.84	3.51
SEx	±1.94	±1.76	±.81	±.59

The greater intake of digestible dry matter brought about by coarsely chopping the cane tops, explains the better growth rate for this treatment (compared with fine grinding) reported by Salais et al (1977). Presumably, the effect of coarse chopping of the tops is to stimulate rumen contractions which in turn would lead to reduced residence time in the rumen and, therefore, greater intakes of fermentable organic matter. As a consequence, there would be an increased supply of microbial protein at the duodenum, resulting partly from the greater intake of fermentable organic matter and the associated increase in efficiency of synthesis of microbial protein. The overall lower intake of dry matter on the cane stalk diets than on the molasses-based diets presumably is a reflection of the lower nutrient density of the former; and emphasises the fact that voluntary intake cipal factor limiting rate of animal productivity on sugar cane.

References

Ferreiro H M and Preston T R 1976 Fattening cattle with sugar cane : The effect of different proportions of stalk and tops Trop Anim Prod 1: 178-185

Ferreiro H M and Preston T R 1977 Digestibility and voluntary intake of derinded sugar cane stalk with and without addition of cane tops Trop Anim Prod 2:90-00

Ferreiro HM, Sutherland T M & Preston T R 1977 Brix and dry matter content as indices of urea requirements in diets based on sugar cane Trop Anim Prod 2:213-218

James L A 1973 Confith in rations for livestock. Proc CIDA Seminar on sugar cane as livestock feed, Barbados, January 1973 pp 30-31

Montpellier F A and Preston T R 1977 Digestibility of tops, rind, derinded stalk and the entire plant of sugar cane Trop Anim Prod 2:13-17

Salais F J, Sutherland T M and Wilson A 1977 Effect on animal performance of different sources of forage in diets based on molasses and urea Trop Anim Prod 2:158-162

Received 12 August 1977

FATTENING CATTLE WITH SUGAR CANE: A COMPARISON OF DIFFERENT SUPPLEMENTS

H M Ferreiro[1], T M Sutherland[2], A Wilson[3] and T R Preston[4]

Centro de Investigación y Experimentacion Ganadera[5]
Chetumal, Q R Mexico

A total of 64 Zebu bulls was used to study 8 combinations of supplements (combinations of protein, starch and oil) according to a completely randomised design with two replications (4 animals per treatment group). The basal diet was chopped whole sugar cane provided ad libitum in one feed trough, and a liquid mixture of molasses containing 10% urea and 1% ammonium sulphate given ad libitum in a separate feed trough. Addition of 500 g/d of ground maize grain gave no improvement over the unsupplemented control (51 vs 77 g/d) and both of these treatments were markedly inferior to the remainder. Growth was significantly improved (333 g/d) by 500 g/d of a fish meal/ soybean meal mixture (ratio 1:3) and there was a further increment in live weight gain when either 30 ml/d of maize oil (517 g/d gain) or 500 g/d of ground maize (555 g/d) were given. Providing 750 g/d of the fish meal/soybean combination appeared to increase growth rate by a further 100 g/d (to 669 g/d), the performance on this treatment being similar to that achieved on the positive control of 1 kg/d of rice polishings (728 g/d). Supplementation with 1.5 kg/d of rice polishings was no better (651 g/d) than the 1 kg/d level of this supplement. Voluntary intake was higher and feed conversion was better for the treatments which were superior for live weight gain. The increase in voluntary intake was mostly attributable to increases in the amount of sugar cane consumed; the relative intake on the molasses/ urea mixture was relatively constant (1 to 1.4 kg/d) and not related with live weight gain. When the data for the two treatments with rice polishings were omitted, there was a highly significant positive relationship (r = .57) between the amount of true protein provided by the supplements and the growth rate of the animals receiving them.

Key words: Sugar cane, cattle, supplementation

Rice polishings have always produced a growth response in cattle fed diets based on sugar cane and urea (Preston 1977). In contrast, the response to more traditional protein supplements and concentrates has been variable and nearly always less per unit of added protein than when rice polishings is used (Silvestre et al 1977 a,b, Lopez et al 1977). On the basis of these and other findings, it has been postulated that diets of sugar cane/urea are limited by the supply of essential amino acids and glucose precursors at the metabolic level (Leng and Preston 1976),

---

[1] In receipt of fellowship from IDRC, Canada

[2] On leave of absence from University of New England, Armidale NSW 2531, Australia

[3] Technical Officer, Ministry of Overseas Development, London UK

[4] Scientific adviser, EDVZ, Universidad de Yucatan

[5] This unit now reestablished as the Departamento de Investigación y Estudios. Superiores, Escuela de Medecina Veterinaria y Zootecnia, Universidad de Yucatan, Merida

As well as having an excellent balance of amino acids, particularly methionine, rice polishings is relatively rich in starch (30%) and unsaturated oil (13%). Sugar cane has less than 1% of total lipid material (Anon 1974), and as most of this is present as saturated waxes, it seems possible that there might be a deficiency of the essential long chain fatty acids. This could be also a factor associated with degree of response to different supplements.

The object of this experiment was to test a variety of supplements providing different combinations of essential amino acids, starch and unsaturated lipids, comparing them with rice polishings as the control treatment.

Materials and Methods

Treatments and Design: Eight different combinations of supplements were fed according to a completely randomized design with two replications. Details of the supplements are given in Table 1.
Animals: A total of 64 Zebu bulls was used with average initial weight 257 kg and slightly more than 2 years of age. There were 4 animals per treatment group. Housing was in open-sided pens with concrete floors.
Diets: In all cases, the supplement was given as the first feed in the morning(7:00 am) before feeding the sugar cane. The maize was ground coarsely in a hand grinder. In treatment D, the oil was mixed with fishmeal and soybean meal prior to feeding. The sugar cane was the mature whole plant including stalk and tops and was chopped in a forage harvester (Gehl CB600). It was fed twice daily, freshly chopped on each occasion at 08:00 and at 12:00 am. The cattle also had free access to a mixture of molasses containing 10% urea and 1% ammonium sulphate (w/w), and to a mineral mixture containing: salt 500 g, rock phosphate 570 g, and trace minerals 30 g. The animals were adapted gradually to the molasses/urea mixture giving increasing concentrations of 4,6,8 and finally 10% urea at 5 day intervals.
Measurements: The animals were weighed individually every 14 days and the gain in live weight was determined by regression of live weight on time. Feed intakes were recorded daily, as was the brix content of the sugar cane while every three days the cane was analysed for DM.

Table 1:
Composition and amounts of supplement fed (g/animal/day)

	A	B	C	D	E	F	G	H
Rice polishings	-	-	-	-	-	-	1000	1500
Maize grain	-	500	-	-	500	-	-	-
Fishmeal	-	-	125	125	125	187	-	-
Soybean meal	-	-	375	375	375	563	-	-
Maize oil	-	-		30	-	-	-	-
Total	-	500	500	530	1000	750	1000	1500

Results

Mean values of animal performance on the different supplements are summarised in table 2. There were highly significant differences in average live weight gain between the different treatments. Addition of 500 g daily of ground maize conferred no benefit over the unsupplemented control (51 vs 77 g/d) and both of these treatments were markedly inferior to the remainder. Growth was significantly improved by 500 g/d of a fishmeal/soybean meal mixture and there was a further increment in live weight gain when either 30 ml/d of maize oil, or 500 g/d of ground maize were given.

Table 2:
Mean values for performance characteristics (2 groups of 4 bulls/treatment: 98 days trail).

			Fishmeal/soybean .5kg/d		Fishmeal/soybean .75kg/d		Rice polishings			
	No Supp	Maize 0.5 kg	-	oil 30 ml/d	Maize 0.5 kg/d		1kg/d	1.5 kg/d.	SEx	Prob.
	A	B	C	D	E	F	G	H		
Live weight										
Initial	210	271	266	260	268	266	267	267		
Final	218	282	302	318	310	338	333	334		
Daily gain[2]	.037	.051	.333	.517	.555	.669	.728	.651	±.06	0.001
Feed intake,kg/d										
Sugar cane	10.6	12	14.8	15.7	15.0	16.6	16.6	15.8		
Molasses	1.19	.97	1.28	1.25	1.42	1.15	1.25	1.15		
Urea		.106	.140	.137	.154	.125	.136	.126		
Total DM intake kg/d	4.16	4.66	5.73	6.00	6.40	6.30	6.64	6.73		
Consumption index[2]	1.89	1.73	1.93	1.99	2.27	1.97	2.14	2.17	±.15	.05
Conversion[3]	111	88	15.4	10.3	10.6	9.10	8.66	10.0	±1.43	001

[1] Determined from linear regression of live weight on time.
[2] Daily intake of DM/100 kg live weight
[3] Determined from linear regression of cumulative DM intake (kg) on live weight (kg).

Supplying 750 g/d of the fishmeal/soybean combination appeared to raise growth rate by a further 100 g daily and performance on this treatment was very similar to that achieved on 1 kg daily of rice polishings which supported a growth rate of 728 g/d. Surprisingly, the treatment with 1,5 kg/d of rice polishings was slightly lower than the 1 kg/d level of this supplement.

There was a close relationship between the effects of the different treatments on live weight gain and on feed conversion, and a tendency for the best treatments to be associated with a higher voluntary consumption index. The increase in voluntary intake was mostly attributable to changes in the amount of sugar cane consumed (figure 1). In contrast, intake of the molasses/urea mixture remained relatively constant and was not related with live weight gain.

This latter finding is at variance with the report of Lopez et al (1976) where both molasses (also containing 10% urea) and sugar cane intakes increased in parallel fashion with the increase in rate of live weight gain, caused by addition of rice polishings to the diet. There is no obvious explanation for this difference in response between the two experiments.

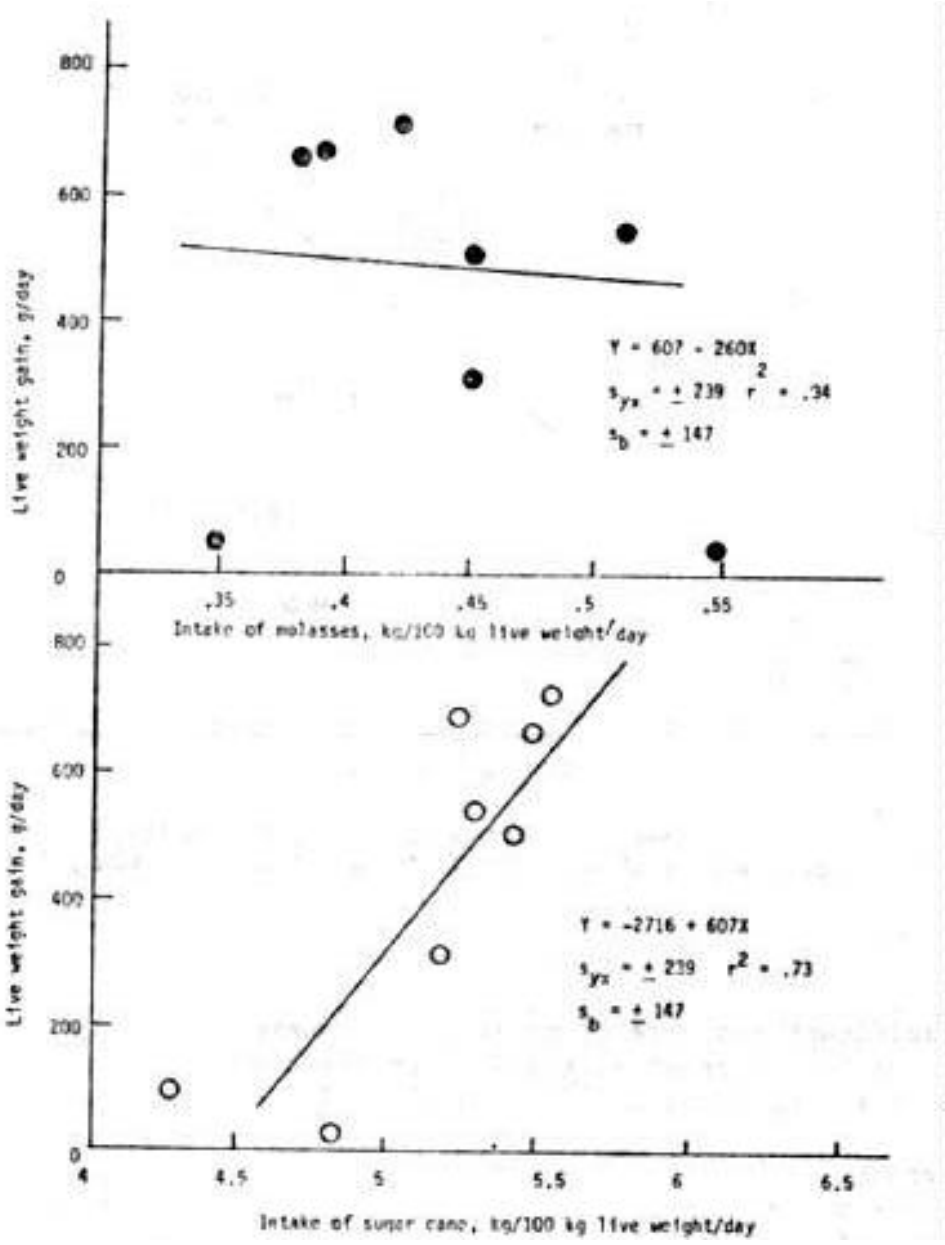

Figure 1:
Relationship between rate of live weight gain and (1) intake of molasses (•) (2) intake of sugar cane (○)

In figure 2, the data for daily live weight gain are plotted against the amount of true protein supplied by the supplements. If the information from the two rice polishings treatments is excluded from the analysis, there is a highly significant relationship (r = 0.97) between the amount of true protein given in the supplement and growth rate.

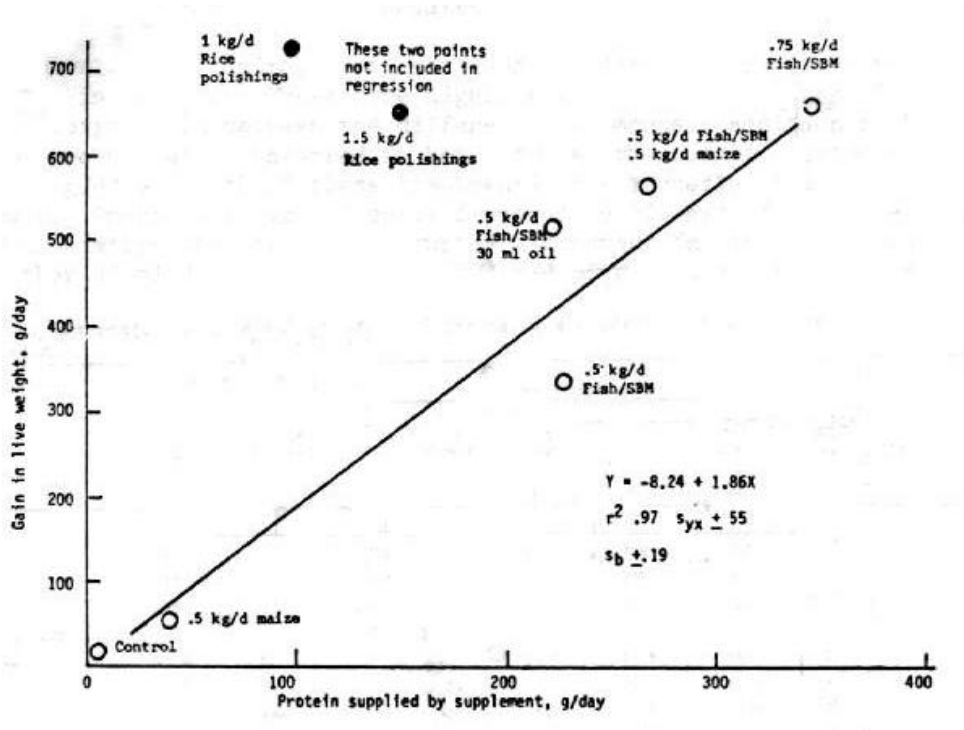

Figure 2:
Relationship between amount of protein supplied by the supplement and the of live weight gain (excluding data for the two groups given rice polishings)

Discussion

The significant response to maize oil is surprising and contrary to the findings of Silvestre et al (1977) when there was no response to supplementation with groundnut oil in a basal ration of sugar cane/urea and meat meal.

Maize grain can be considered as a good source of "by-pass" glucose precursor since maize starch is known to be incompletely fermented in the rumen, and therefore likely to pass through in some degree to the duodenum for gastric enzymic digestion to glucose. The fact that there was no response to 500 g/d of maize (about 350 g starch) implies that glucose precursors may not always improve performance on a sugar cane/urea diet, unless by-pass protein is also supplied. Ferreiro et al (1977) came to a similar conclusion when they obtained no benefit from adding 130 ml daily of propionic acid to a sugar cane/urea basal diet, And similar findings were obtained by Kempton et al (1978) when glucose supplementation of lambs fed a sugar /urea based diet, had no effect unless by-pass protein in the form of fishmeal was also given, That there can be, however, a response to glucose precursors, when by-pass protein is also supplied, is indicated by: (1) the significant growth response from adding 500 g/d maize to a diet which was already supplemented with 500 g of fishmeal/soybean, and (2) superior performance on rice polishings than with mixed proteins from fishmeal and soybean meal, even when the amount of protein provided by the rice polishings was less than half that in the fishmeal/soybean combination,

The only other interpretation for the superiority of rice polishings is on the basis of its higher content of sulphur amino acids, compared with any of the other sources tested in the experiment. However, it seems unlikely that this could account for all of the differences in response per unit of protein, between the rice polishings and the mixture of fishmeal and soybean meal. It is more likely that the superiority of rice polishings is due to a combination of three factors: namely, high quality protein rich in sulphur amino acids; starch which appears to lend itself to rumen by-pass (Elliott R, 1977 unpublished data), and the possible effect of the oil content retarding rumen microbial attack of both the protein and the starch and thus contributing to a more efficient by-pass of these nutrients.

References

Anon 1974 Unpublished data Chemistry Department Ministry of Agriculture Mauritius

Ferreiro H M, Preston T R & Sutherland T M 1977 Investigation of dietary limitations on sugar cane based diets Trop Anim Prod 2: 56-61

Kempton T J, Hill M K & Leng R A 1978 The effects of varying bypass amino acid and glucose availability on lamb growth and wool growth Austral Soc Anim Prod 12: (abs)

Leng R A & Preston T R 1976 Sugar Cane for Cattle Production: Present constraints Perspectives and Research Priorities Trop Anim Prod 1: 1-22

Lopez J N,Preston T R, Sutherland T M & Wilson A 1976 Rice polishings as a supplement in sugar cane diets: effects of level of rice polishings in wet and dry season conditions Trop Anim Prod 1: 164-171

Silvestre R, MacLeod N A & Preston T R 1977a Supplementation of sugar cane urea for growing cattle: effect of maize grain and different levels and sources of protein Trop Anim Prod 2 81-89

Silvestre R, MacLeod N A & Preston T R 1977b Effect of meat meal, dried cassava root and groundnut sugar cane/urea, or molasses/urea Trop Anim Prod 2: 151-157

Preston T R 19 77 b Nutritive value of sugar cane for ruminants Trop Anim Prod 2: 125-142

Received 10 October 1977