Tropical Maize Silage in Central Brazil

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Introduction

The long (5-7 months) dry season of the savanna region (*Cerrados*) of Central Brazil makes imperative the conservation of forage for the continuous production of milk.

Surveys conducted in the late 1970's and early 1980's indicated that in the State of Minas Gerais the conservation of maize, sorghum, elephant grass and mixtures of any two of these species were extremely common among dairy producers. Analysis of on-farm silage samples (Paiva *et al*. 1978) showed that the resulting silages were always of low nutritive value, with a mean in vitro organic matter digestibility (IVOMD) of 60% and 5.6% crude protein (CP). A parallel survey (unpublished) also showed that the process of ensilage was slow and in small dairies it was frequently carried out manually.

It was therefore hypothesised that the low resulting nutritional value was due at least in part to the slow process of cutting, chopping and ensiling. A large number of experiments was carried out to determine maize growth curves, nutritional value throughout the vegetative period, various measurements of the efficiency (Pizarro and Vera 1980) with which field operations can be carried out, material losses during cutting, chopping and conservation, and the resulting nutritional value of maize silages. Lastly, a computer model of the whole process and various alternatives was developed (Pizarro and Vera 1979; Vera and Pizarro 1981).

What follows is a brief summary of results, with emphasis on the inherent nutritional value of maize, and of the resulting silage, when the crop is grown under tropical conditions and on low fertility oxisols.

Results and Discussion

Locally bred and widely available maize varieties were used in all of the trials, including Agroceres 259, Dentado Composto, BR103 and Maia 13. The last two were varieties released by the National Center for Maize and Sorghum Research of EMBRAPA.

The growth curve of the last two varieties was studied for three consecutive years, and regular samples were collected between days 23 and 170 post-planting. Total yields, and components of the biomass were quantified.

The maize crops were fertilised as per then current recommendations, including 100 kg N, 40 P and 40 K. A typical soil analysis (0-20 cm) is as follows: clay 65%, sand 13%, pH 5.2; P 2 ppm, OM 2.6%

Analysis of the growth curves showed that for all practical purposes, between years differences were accounted for by differences in accumulated temperature (ACCTEMP) and rainfall (ACCRAIN), and these two variables together with days since planting (AGE) provided a good prediction of dry matter (DM) yields:

$$\text{YIELD} = 8.22\ \text{ACCRAIN} + 0.00080\ \text{ACCRAIN}^2 + 4.803\ \text{ACCTEMP} - 52.402\ \text{AGE} - 0.2212\ \text{AGE}^2 - 2659\ (r=0.96)$$

DM percentage of the whole plant (DMPC) did not vary significantly between years, and was largely accounted for by AGE:

$$\text{DMPC} = 7.66\ \exp(0.0120\ \text{AGE})\ (r=0.95)$$

The most striking result in terms of nutritional value was the rapid decline in the CP content of the crop, regardless of year and variety. CP tended to stabilise at 4-5% after the 100th day of growth, as follows:

$$\text{CP} = 22.56\ \exp(-0.0285\ \text{AGE}) + 6.09\ \exp(-0.003085\ \text{AGE})$$

Dry matter digestibility (DMD) of the standing crop was evaluated in two sets of data. The first one determined the in vitro DMD of samples collected throughout the growth period as explained above. The second set of data was derived from a continuous digestibility trial carried out with penned sheep between days 49 and 177 of the growth period; it should be noted that over the period 140-77 days, the crop was fully matured and field-dried.

Up until 140 days of age, digestibility decreased linearly:

$$\text{DMD} = 73.98 - 0.172\ \text{AGE}\ (r= 0.84)$$

This implies that over the period of 100-120 days of age, which corresponds to approximately 30% DM (stage generally recommended for ensilage), DMD would be roughly 50-55% and CP 5%.

At approximately this stage of maturity, the contribution of grain to total yield was unexpectedly low despite being reasonably high in absolute terms, as shown in Table 1.

Table 1. Total dry matter and grain yields in two tropical maize varieties

	BR 105	Maia 13
Dry matter yield, kg/ha	11626	18078
Grain yield, kg/ha	3288	4237
Grain yield, % of total yield	28.3	23.4

As shown in Table 2, soluble carbohydrates and starch in particular, were low in the fresh forage. The low starch content in the fresh forage, relative to the ensiled material is almost certainly due to a laboratory artefact since later data determined in a different laboratory found that at a comparable stage of growth, starch in the DM of fresh forage ranged between 18 and 19% (Neto, *et al.* 1984). Nevertheless, soluble carbohydrates in the latter case were even lower than above.

It is worth noting that Neto *et al.* (1984) analysed samples using "definitive" methods (Bailey1967, 1973) and were able to account for 85-90% of the DM, the remaining being ash and possibly minor fractions unaccounted for.

Table 2. Chemical composition of the fresh material and the resulting silage of the variety BR 105

	Green forage	Silage
Dry matter, %	30.43	30.68
Ethanol soluble CHOs, % dm	12.37	1.81
Starch,% dm	5.93	16.28
Cellulose, % dm	22.37	22.12
Hemicellulose, % dm	20.01	22.12
Lignin, % dm	6.67	4.94
Crude protein, % dm	5.35	5.88

For purpose of comparison, it should be noted that the expected composition of temperate maize is generally as follows: water soluble CHOs 15%, starch 25%, hemicellulose 18%, cellulose 23%, lignin 5%, protein 9%, DMD 75% and grain as % of total yield 35-40%. A comparison with the data presented above shows that tropical maize in our conditions tends to be considerably higher in hemicellulose, somewhat higher in lignin and lower in protein and non-structural carbohydrates. It is hypothesised that this may be in part a plant adaptation to soil constraints, but mostly reflects the relatively low ratio of grain relative to the rest of the plant.

Numerous other results, particularly the partitioning of energy and nitrogen digestion in the gastro-intenstinal tract of the animal are available, but the above data should suffice to show the limitations of tropical maize silage, at least when grown on poor soils. In this environment, sorghum showed many of the same characteristics of maize (Pizarro *et al.* 1984), namely, high DM yields, moderate digestibility and marginal CP.

Not unexpectedly, the above tropical silages were unable to support weight gains in steers, unless supplemented with a protein supplement (Table 3)

Table 3. Liveweight gains of steers fed maize silage with different levels of cottonseed cake.

Cottonseed cake, kg/d.head	LWG, kg/d.head
Nil	-0.076
0.5	0.320
1.5	0.750

Contrary to our initial hypothesis, it is clear that the low nutritional value of farm silages cannot be attributed to the speed with which field operations are carried out, since the crop is of low quality throughout a relatively long vegetative period, including stages earlier than those most appropriate for ensilage.

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