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The Influence of Weather on the Quality of Tropical Legume Pasture During the Dry Season in Northern Australia. III Effects on Digestibility and Chemical Composition

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Abstract

In the semi-arid tropics, accumulated shed leaf of certain pasture legumes can provide highly nutritious feed for cattle in the dry season. Previous papers in this series have dealt with the fungal spoilage of leaf of Caribbean stylo in response to dew and unseasonal rainfall and the threat to acceptability by cattle. This paper focuses on the effects of varying degrees of moulding and leaching on dry matter digestibility of leaf of this legume. Uniform leaf material of high digestibility was exposed at six locations during the dry season and samples retrieved at 4-weekly intervals. From initial values of 75%, *in vitro* digestibility dropped to as low as 50%. Degree of moulding, as indicated by a quantitative index of discoloration, accounted for about 80% of loss. Moulding was much more important than leaching. This latter finding in the winter-dry tropics contrasts with previous findings in the summer-dry Mediterranean climate.

Introduction

The accumulated dry shed leaf of certain tropical legumes e.g. *Stylosanthes hamata* (Caribbean stylo) and *Stylosanthes humilis* (Townsville stylo) can provide highly nutritious feed for cattle during the dry season in the semi-arid tropics. The previous two papers in this series have dealt with the threat of fungal spoilage in response to dew and rainfall in this predominantly dry period. Mouldiness was related to cumulative wetness duration following a rainfall event > 2 mm and was observed to strongly affect acceptability to cattle. A Discoloration Index (D.I.) was devised which quantified this feed quality deterioration. In the present paper we pursue the implications of this deterioration on nutritive value, especially as it affects dry matter digestibility.

Locations, Materials and Methods

Leaf Samples and Exposure

In early April 1976, swards of Caribbean stylo were cut and the material air dried rapidly under cover. Leafy material was then stripped from plants to produce a mixture of leaf, petioles and fine stem. Aliquots of this simulated 'litter', equivalent to 10 g air-dry weight, were packaged in preparation for exposure at various sites.

Samples were exposed in the Northern Territory at sites along a transect inland from the coast. The sites (with their distance from the coast) were Berrimah Experiment Farm near Darwin (6 km), Coastal Plains Research Station (40 km), Upper Adelaide River Experiment Station (110 km), Douglas-Daly Experiment Station (130 km) and CSIRO's Research Station at Katherine (270 km). All except the last are experiment stations of the Northern Territory Department of Primary Industry and Fisheries. In Queensland, material was exposed at CSIRO's Davies Laboratory at Townsville (10 km from coast), CSIRO's Lansdown Research Station near Woodstock (50 km), and the Queensland Department of Primary Industries' Swan's Lagoon Beef Cattle Field Research Station near Millaroo (70 km) and at Wrotham Park (170 km).

In May 1976, 12 standard 'litter' samples were set out at each location. Each sample was spread evenly over bare soil, having a smooth, compact surface within a retaining ring of plastic mesh 20 cm in

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diameter and 3 cm high; leaf litter was equivalent to about 3 t/ha and was 5–7 mm deep. To discourage pests, the soil was previously treated with dieldrin, and both dieldrin-treated leaf material and a commercial rodent bait were scattered around each ring. The area was protected from large animals by a large poultry netting cage.

Two samples were retrieved at approximately monthly intervals to provide information on cumulative changes over the dry season. In addition, on each 'harvest' date, two fresh standard samples were set out; these were retrieved at the next harvest, thereby providing information on the effects of the weather in each monthly period.

Chemical Analysis

Duplicate Caribbean stylo leaf samples from the 49 location-periods were ground to provide single samples for *in vitro* digestibility, Kjeldahl digests for N and P analysis, and for ashing prior to cation analysis. Dry matter digestibility (DMD) was estimated by the *in vitro* digestibility procedure of McLeod and Minson (1978) and determinations were standardized with samples of known *in vivo* digestibility.

Quantification of Mouldiness of Litter

After harvest, each sample to be measured was mixed and a 1–2 g subsample taken. After removal of all stem and non-legume material, leaflets were sorted into one, two or three colour classes and the proportions calculated on an air-dry weight basis. The colour of each class was coded by using the Munsell Soil Colour Chart 10YR and transformed to a Discoloration Index (D.I.) as previously described (McCown *et al.* 1981), except that a limit of 6 rather than 7 was adopted. Observation that some loss of the most discoloured portion of leaflets (interveinal tissue) was occurring at about 6 indicates a natural limit to a discoloration parameter. A weighted mean D.I. for each sample was calculated by summing the products of the D.I. and the fraction of the total air-dry sample mass in each class. (Values of D.I. from measurements on ground bulk samples were similar to those using the above procedure.)

Results

The trends in DMD of dry leaf samples during the dry season of 1976 at six stations are shown in Fig. 1. The DMD of three unexposed aliquots of leaf was 74·3, 75·6 and 74·2. The mean of these is taken as the initial value at all locations.

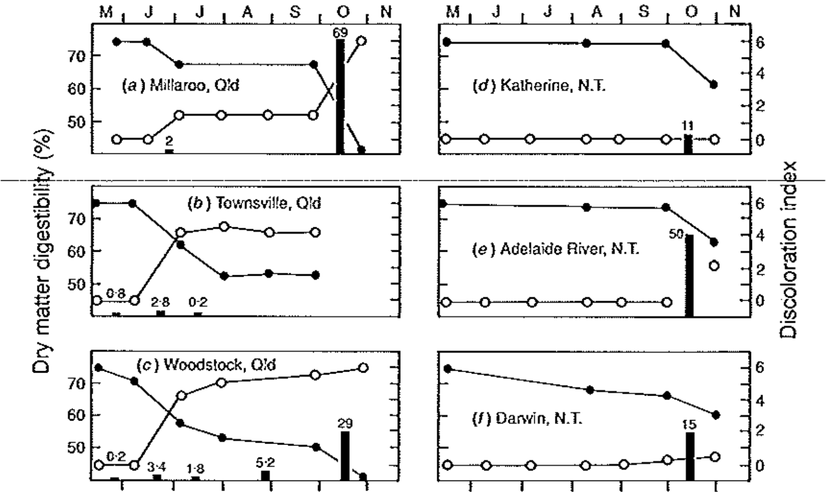

Fig. 1. Trends in Discoloration Index (○) and Dry Matter Digestibility (●) of Caribbean stylo leaf in relation to rain during the dry season of 1976 at six stations in northern Australia. (Histograms represent cumulative rain between leaf sampling times; amounts in mm are indicated.)

At Millaroo, 2 mm of rain in late June caused both a modest decline in DMD (to 68%) and a rise in the D.I. from 0 to 1·4. Without rain, neither changed further. Substantial rain in late October resulted in a fall in DMD to nearly 40% and a rise in the D.I. to its limit of 6·0. Much larger responses of DMD and D.I. to rain occurred at Woodstock and Townsville (Figs 1*b* and 1*c*). At Katherine and Adelaide River, DMD remained at initial high levels until rain at the end of the dry season reduced it to 62% and 64% respectively. Data from Douglas Daly and Coastal Plains (not shown) were very similar to Adelaide River, with DMD dropping from near-starting values to about 62% following 50 and 18 mm rain, respectively, in late October.

There was a gradual decline in DMD at Darwin before any rain was detected. This may have been related to the especially high dewfall (16 mm) at Darwin (McCown and Wall 1981, Table 1). This was the only station at which there was any rise in D.I. without any rainfall and the station with by far the highest dewfall. Rain in October dropped DMD to 61%, but with only a very small accompanying increase in D.I.

While rainfall is generally required for moulding to occur, the degree of the latter is more closely related to duration of wetness than to amount of rain (McCown and Wall 1981). In comparison with the Queensland stations, the increase in D.I. per unit rain was much smaller at the stations in the Northern Territory, where rain did not fall until the period of high evaporation prior to the onset of the next rainy season.

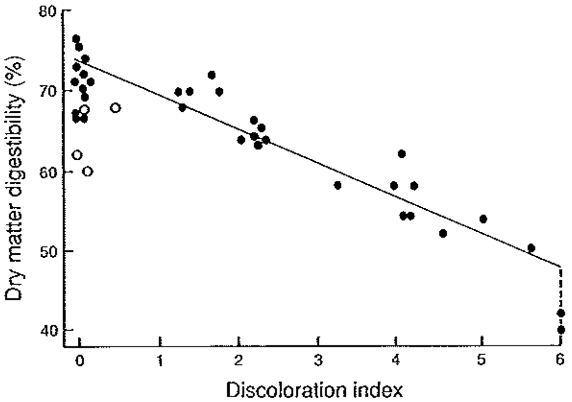

Fig. 2. The relationship between Dry Matter Digestibility of Caribbean stylo leaf and the Discoloration Index.

The inverse relationship between DMD and D.I. which is evident in Fig. 1 is quantified in Figure 2. The two samples in which D.I. had reached the limit of 6 were excluded from the regression calculation. The regression accounts for 77% of the variation in DMD. The outliers having low DMD and low D.I. include four samples (o) from Katherine and Darwin when rain in October did not increase D.I. Without these latter data, moulding, as indicated by D.I., accounts for 89% of variation in DMD. This regression,

$$Y = 73 \cdot 3 - 4 \cdot 0X,$$ is the line in Figure 2.

The drop in DMD following rain unaccompanied by increase in D.I. (which occurred at Katherine and Darwin) was presumably due to leaching of soluble substrates. The fact that leaching conditions occurred is apparent from changes in K concentration (Fig. 3). K declined steeply from over 2% without rain to about 0·4% after 10 mm. Beyond 15 mm there was negligible further effect. Data points below 15 mm were used to obtain the regression equation plotted in Fig. 3, which accounted for 76% of the variation in %K. These data points were drawn from the full range of discoloration, which indicates that moulding had little effect on K depletion. On the other hand, it was moulding rather than leaching which had the predominant effect in reducing DMD (Fig. 4). DMD did not drop

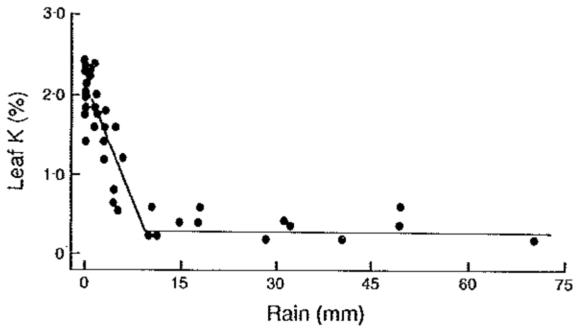

Fig. 3. The relationship between potassium concentration of Caribbean stylo leaf and cumulative rainfall.

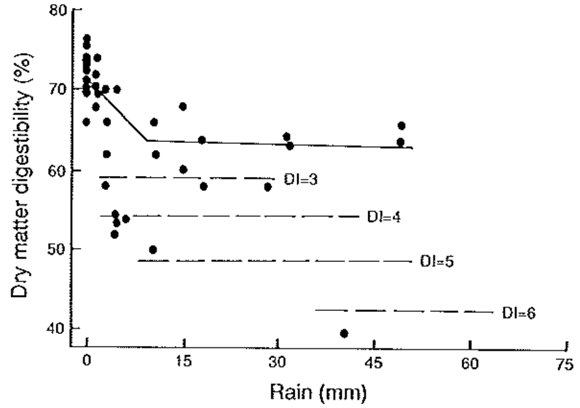

Fig. 4. The relationship between Dry Matter Digestibility (DMD) of Caribbean stylo leaf and cumulative rainfall. A curve has been fitted by eye where leaching was probably important (D.I. <3). Where DMD dropped below 60%, it was the result of rain occurring under low evaporative conditions which prompted moulding, as indicated by D.I.

below 60% unless moulding advanced past a D.I. of 3. In the region where the effect of moulding was slight (DMD $>$ 60%) a line with change of slope at 8 mm of rain was fitted by eye to provide a function for loss in DMD due largely to leaching, similar to that for K (Fig. 3). When D.I. >3, progressive depletion in DMD is related to degree of moulding as indicated by the dashed lines in Fig. 4. The regression on rain <15 mm in this case accounts for only 51% variation in DMD.

Concentrations of N and P did not change appreciably (Table 1). No regression of %N or %P on cumulative rainfall or on D.I. accounted for more than 1% of variance. Calcium concentration increased with moulding (Table 1); a linear regression on D.I. accounted for 77% of variance in Ca.

Discussion

Earlier papers in this series related degree of mould damage, as expressed by D.I., to acceptance of herbage by cattle. It was reported that cattle refused to eat leaf with a D.I. of 4 for the first day only, but when D.I. approached 6, refusal was indefinite and animals had to be removed. If a D.I. of 5 is taken as an approximation of a level of moulding which approaches 'spoilage', the information reported in this paper shows that important reduc-

Table 1. Chemical composition of leaf before and after exposure
Per cent of dry matter

	Original	After exposure						
		Millaroo	Woodstock	Townsville	Katherine	Adelaide R.	Darwin	Mean
N	2·70	2·50	2·65	2·10	2·50	2·75	—	2·50
P	0·15	0·10	0·19	0·11	0·05	0·14	—	0·12
K	2·40	0·24	0·24	0·64	0·21	0·35	0·32	0·33
Ca	2·00	2·63	3·10	2·70	2·10	2·17	2·27	2·50

tions in nutritive value have already occurred. Just how important this is for animal production can be estimated. From the relationship between liveweight change and intake of digestible dry matter (Holmes *et al.* 1966) and the effect of declining digestibility on intake (Minson 1982), rates of liveweight gains at 50% digestibility may be expected to be less than a tenth of those at 70%.

Digestibility is reduced by dry season rainfall via two distinct mechanisms: by leaching soluble (and the most highly digestible) substrates, and by providing the moisture to enable fungal growth which rapidly depletes the most digestible materials. Guilbert and Mead (1931) report that although moulding can occur in the summer-dry Mediterranean climate of California, the more normal result of rain on dry herbage of the naturalized legume, bur medic, is leaching of soluble carbohydrates with attendant decline in DMD (Table 2). In northern Australia, when the first rain on dry legume occurs during the hot, dry period just prior to the onset of the rainy season (e.g. Figs 1*d*–*f*), in common with most rain events in the Mediterranean dry season, wetness periods are generally too short for moulding. Daily pan evaporation rates following the October rain at Katherine (Fig. 1*d*) were > 10 mm/day (McCown and Wall 1981). Under these conditions our reductions in DMD were similar to those of Guilbert and Mead (1931), taking into account that our samples had higher initial digestibility.

Table 2. Effects of rain on dry bur medic
(Guilbert & Mead 1931)

Rainfall (mm)	% DMD	% Total carbohydrates	%N
0	64	45·1	2·83
8	59	42·4	2·78
26	56	41·2	2·85

In the winter-dry tropics, by the time rain occurs in the high evaporative conditions near the end of the dry period, dry legume leaf is very largely consumed and a new rainy season is imminent. The much more important phenomenon is rain in the previous cooler period when evaporation is relatively low, resulting in wetness periods long enough to cause moulding. Leaching often occurs, but as shown in Fig. 4, moulding is far more deleterious.

Dry matter changes were not monitored in our study. Changes in Ca concentration appear, however, to provide an estimate of losses. The increase in Ca concentration with increase in degree of moulding can be explained by conservation of initial tissue Ca as other dry matter components were leached or metabolized. If increase in Ca concentration is assumed proportional to loss of dry matter, then dry matter losses ranged from 5% at Katherine to 55% at Woodstock. The small effects of weather indicated in Fig. 1*d* lend plausibility to the former estimate. High values for percent loss are probably underestimated. Fragility of leaflets increased with decomposition; some leaf particles (and Ca) would have been unrecovered, making estimates of loss based on conservation of Ca conservative.

In neither our study (Table 1) nor the Californian study (Table 2) did N concentration decline. Presumably there is little N in solubles, and with moulding, N is conserved in microbial biomass. The most serious consequence is the decline in N intake with moulding, proportional to decline in dry matter intake. Following moulding, legume leaf remains the dry season herbage component with the highest protein content. However, in spite of severe dietary N deficiencies, acceptability to cattle declines with progressive moulding until at D.I. between 5 and 6, it appears to be virtually zero.

In the final paper in this series, the risks of spoilage of dry legume are simulated for 28 stations across northern Australia as a means of identifying areas most suited for this 'dry leaf strategy' for alleviating annual dry season protein deficiencies.

Acknowledgments

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