Tropical Grasslands (1995) Volume 29, 111–114

The effects of different light levels on the nutritive quality of four natural tropical grasses

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Abstract

Axonopus compressus, Imperata cylindrica, Cynodon dactylon and *Pennisetum polystachyon* were tested at 3 light levels (100%, 64%, and 28% of full sunlight) in field plots in a randomised complete block design with 3 replicates. *In vitro* dry matter digestibility (IVDMD), acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), hemicellulose and cellulose percentages were measured on whole tops cut on 3 occasions over 6 months.

Reduction in light transmission down to 64% had no effect on the nutritive quality of grasses. The lowest nutritive quality and the highest ADF and ADL were recorded in the grasses that received the lowest light level. High cell wall content was observed in the grasses grown in the shade. *A. compressus* showed the least sensitivity to amount of incident light and the highest IVDMD which indicated its potential as a shade-tolerant grass. As IVDMD of *I. cylindrica* and *C. dactylon* is increased by shade to 64% light transmission, they could also be considered as potential pasture grasses to be grown under coconut plantations.

Introduction

The population of developing countries is increasing rapidly, as is the demand for milk and meat (Blair 1991). Therefore, improving the nutrition of ruminants in these countries is of great importance. The shortage of arable land in many developing countries increases the need to integrate ruminants with extensive areas of tree crops and home gardens (Chen 1989). However, the successful exploitation of this resource requires the use of suitable shade-tolerant forage species.

The yield of shade-tolerant grasses often shows little depression or is even increased under moderate light levels (Samarakoon *et al.* 1990b). Norton *et al.* (1991) reported increased yield in *Paspalum notatum* under shade. However, the effects of shade on the quality of tropical grasses are less clear. Shading usually reduces the total non-structural carbohydrate of grasses (Wilson and Wong 1982) but its effect on the structural carbohydrate composition and dry matter digestibility appears variable. In a review, Wilson (1982) reported that the common shade response in forage species appeared to be an increase in cell wall content and lignification and a decrease in dry matter digestibility of forage. However, subsequent studies (Samarakoon *et al.* 1990a; Norton *et al.* 1991) with a number of tropical grasses have indicated that shade may have no effect on herbage digestibility or may even increase it. Responses in structural carbohydrate and lignin composition to shade were variable between species within these studies. Thus, it appears difficult to generalise about shade influences on forage quality, and the response of individual species needs to be examined. The present study was conducted to investigate the effect of different shade levels on the nutritive quality of 4 important natural pasture grass species found in the tropics.

Materials and methods

The experiment was conducted at the Research Farm, University of Ruhuna, Sri Lanka, during 1991–92. The average annual rainfall at the site was 3500 mm, evenly distributed except for a period of low rainfall (125–175 mm per month)

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from December–March. The soil was a red-yellow podzolic with a pH of 5.4–5.6.

Four natural grass species, *Axonopus compressus*, *Imperata cylindrica*, *Cynodon dactylon* and *Pennisetum polystachyon* were tested at 3 light levels in a randomised complete block design with 3 replications. The light levels were 100% (full sunlight), 64% (under a 35-year-old coconut plantation) and 28% (under a 24-year-old rubber plantation) of full sunlight. Light transmission was measured as photosynthetically active radiation (PAR) using 2 integrating PAR meters. One was used to measure the incoming radiation over 10 minute periods outside the plantations in full sun, while the second was moved through the coconut and rubber plantations to record the simultaneous measurements in the plantations. Measurements were done on reasonably clear days between 1000 h and 1400 h. Measurements were taken every 4 weeks.

Following land preparation, grass tillers of uniform size and age were hand-planted in 1 m × 1 m plots. The spacing between plants was 10 cm. At pasture establishment, 100 kg/ha urea, 50 kg/ha muriate of potash and 100 kg/ha rock phosphate were applied to all plots.

Three months after establishment, all plants were uniformly clipped to 5 cm height. Subsequently, 3 harvests were made at 8-weekly intervals. Whole plants were harvested at 5 cm height from 0.6 m × 0.6 m quadrats, which included 36 competitive plants in each plot. The harvested samples were dried in a forced-draught oven at 80 °C for 48 h. Dried samples were ground in a stainless steel mill to allow passage through a 1 mm sieve. Samples were analysed in duplicate from each replicate plot and the mean was used for statistical analysis.

The characters studied were *in vitro* dry matter digestibility (IVDMD), acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), hemicellulose and cellulose. IVDMD was estimated by the pepsin-cellulase assay (Goto and Minson 1977) method, ADF and NDF by the method of Goering and Van Soest (1970) and ADL by a modified method of Van Soest (1963) (Horii and Abe 1972). Hemicellulose and cellulose concentrations were estimated as the difference between NDF and ADF and, ADF and ADL, respectively. All readings were corrected to an oven dry matter basis and presented as a percentage of dry matter. The data were analysed by analysis of variance (nested design).

Results

Effects of harvests (H) × light levels (L), species (S) × H, and S × L × H on the parameters measured were generally not significant ($P > 0.05$), so data are presented as averages over the 3 harvests.

Light had a marked effect on feed quality (Table 1), but usually only at the highest level of shading. All species showed the lowest IVDMD and highest ADL at 28% light transmission. While the cell wall fraction (NDF) was significantly ($P < 0.05$) increased by shading, hemicellulose and cellulose concentrations were not significantly affected by light levels. The highest IVDMD and the lowest ADF were recorded in the pastures grown under coconut palms (64% light transmission).

A. compressus had the highest IVDMD and lowest ADF and cellulose concentrations of the 4 grasses tested, and *P. polystachyon* had the lowest IVDMD. Both of these species showed larger reductions in IVDMD and increases in ADL with shading than did *I. cylindrica* and *C. dactylon*.

Discussion

This study has shown that reducing light transmission to 64% had limited effect on IVDMD, ADF and ADL of the grasses tested, but further reduction to 28% light incidence caused a marked drop in quality. Since light transmission in coconut plantations does not appear to remain above 64% (Wilson and Ludlow 1991), shade tolerant pasture grass species may possibly be grown successfully under mature coconut trees without significant effects on their nutritional quality. Norton *et al.* (1991) and Samarakoon *et al.* (1990b) reported similar results after studying 6 tropical grasses. In most studies, the soluble carbohydrates of plants decrease under shading, and this decrease in cell contents leads to an apparent increase in the cell wall fraction (NDF) of the cell dry matter (Norton *et al.* 1991). This could explain the apparent increase in NDF of the grasses sampled, under shading. The low IVDMD and high cell wall content and ADL at 28% light transmission indicate the low

Table 1. The effects of different light levels on chemical composition of 4 tropical grass species.

Chemical composition	Light transmission (%)	Species				Mean
		A. compressus	*I. cylindrica*	*C. dactylon*	*P. polystachyon*	
IVDMD	100	62.5	50.8	51.6	52.7	54.4
	64	61.4	53.9	54.8	49.6	54.9
	28	58.4	49.4	50.2	48.2	51.6
	Mean	60.8	51.4	52.2	50.2	
ADF	100	42.3	45.3	44.2	46.3	44.5
	64	42.7	43.5	42.4	48.6	44.3
	28	43.4	46.8	44.1	50.1	46.1
	Mean	42.8	45.2	43.6	48.3	
NDF	100	72.1	71.4	76.3	75.8	73.9
	64	73.4	70.1	75.4	76.3	75.3
	28	71.6	72.8	77.2	78.8	75.1
	Mean	72.4	71.4	76.3	77.0	
ADL	100	9.6	8.9	9.8	9.4	9.4
	64	9.8	8.6	9.2	9.9	9.4
	28	11.3	9.2	10.2	11.2	10.5
	Mean	10.2	8.9	9.7	10.2	
Hemicellulose	100	29.4	26.1	32.6	29.3	29.4
	64	29.9	25.1	33.2	28.3	29.1
	28	29.8	25.7	32.5	28.0	29.0
	Mean	29.7	25.6	32.8	28.5	
Cellulose	100	31.4	34.9	33.8	37.9	34.5
	64	32.2	36.4	33.8	37.3	34.9
	28	32.6	36.1	34.2	38.1	35.3
	Mean	32.1	35.8	33.9	37.8	

LSD ($P < 0.05$) — Light levels: IVDMD 0.4; ADF 0.4; NDF 0.8; ADL 0.1; hemicellulose 0.4; cellulose 0.6.
— Species: IVDMD 0.5; ADF 0.4; NDF 0.9; ADL 0.2; hemicellulose 0.4; cellulose 0.7.
— Species × light: IVDMD 0.8; ADF 0.7; NDF 1.6; ADL 0.3; hemicellulose 0.7; cellulose 1.3.

nutritional quality of grasses grown under high shade levels. Norton *et al.* (1991) also reported the detrimental effects of heavy shade (30% light transmission) on the nutritional quality of tropical grasses.

The much higher IVDMD of *A. compressus* compared with the other grass species indicated its potential as a shade-tolerant natural tropical pasture grass for grazing. Kaligis and Mamonto (1991) reported the highest dry matter digestibility (74.9%) in *A. compressus* after studying 8 species of tropical grasses and Samarakoon *et al.* (1990b) have also mentioned the high digestibility of *A. compressus*. Although it was affected more by reduced light transmission than *I. cylindrica* and *C. dactylon*, it still maintained a higher nutrient quality than these species even at the lowest light intensity. After screening 46 grass species for shade tolerance, Stür (1991) reported that *A. compressus* was least sensitive to light in terms of yield. Reynolds (1988) considered *A. compressus* a valuable grass for heavily shaded conditions (even less than 30% light transmission) where sown grasses cannot survive regular grazing.

The increased nutritive quality of *I. cylindrica* and *C. dactylon* at 64% light transmission shows their potential to grow under coconut trees. Wong (1991) has ranked *I. cylindrica* as having medium shade tolerance. Consistently decreased nutritive quality of *P. polystachyon* under shade could be a function of the reduction in the level of young plant material caused by poorer growth under these conditions.

Conclusion

This study showed that there is potential to improve the quality of pastures grown in shade under coconut plantations by encouraging the introduction and spread of a shade-tolerant natural grass such as *A. compressus.* This grass shows promise because it has an interestingly higher IVDMD than the other common natural grasses under coconuts and its nutritive quality is little affected by light levels down to 64%. *I. cylindrica* and *C. dactylon* could be grown successfully under coconut plantations; their IVDMD is increased by shade to 64% light transmission but nevertheless still much lower than that of *A. compressus.*

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(Received for publication May 8, 1994; accepted November 23, 1994)