Forages for Plantation Crops

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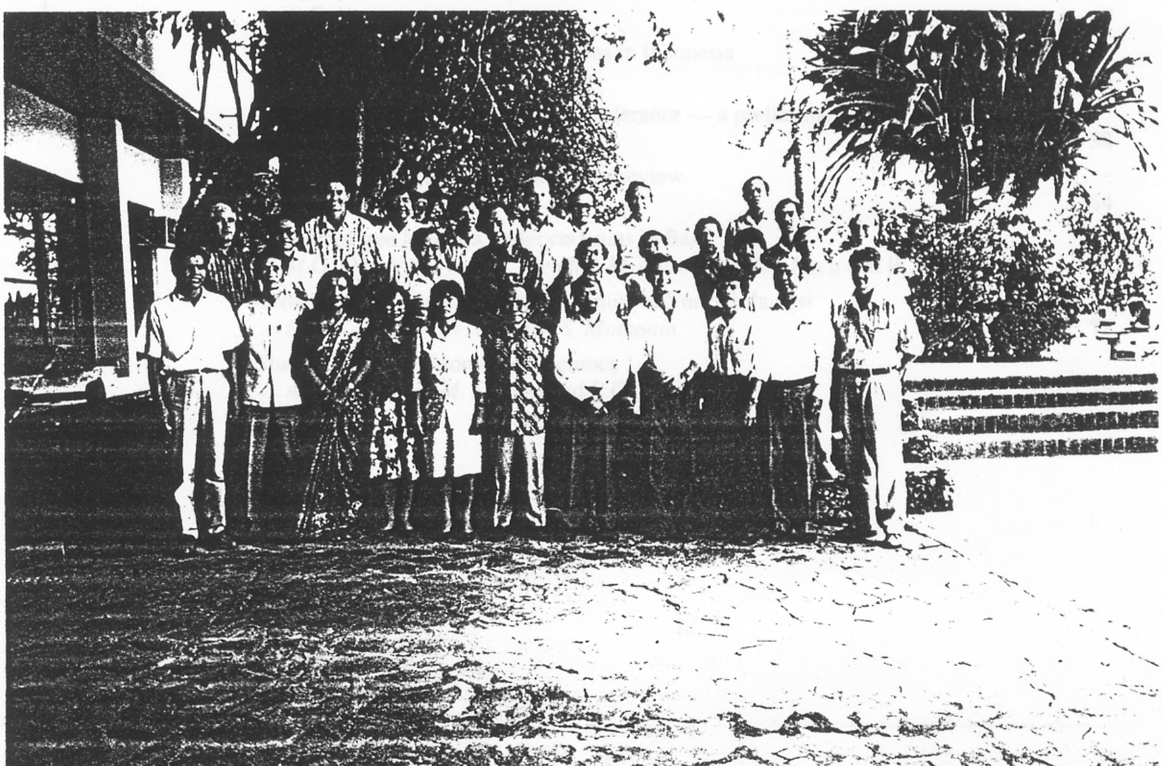

Contents

Compatibility of Grass–legume Swards under Shade

P. Sophanodora*

Abstract

Grass-legume swards form the basis of many productive pasture systems. Tropical pasture species grown under different levels of shade can exhibit both morphological and physiological changes in shoot to root ratio, leaf area ratio, specific leaf area and radiation use efficiency. These changes may affect the compatibility of grass-legume swards when grown in shaded environments.

Pure grass swards were compared to grass-legume swards under three light regimes. The proportion of legume yield was higher under shade than in full sun swards. The canopy extinction coefficient was lower in light shade than in full sun but was similar to full sun in dense shade. Generally, radiation use efficiency increased with shade. The implications of these results are discussed.

THE benefits of integration of pastures with plantations have been well documented (Shelton et al. 1987; Reynolds 1988; Chen 1989). However, few studies have examined the growth and compatibility of species mixtures (grass–legume) under shade. Mixed pasture swards commonly comprise two major plant groups, namely C4 grasses, which are fast-growing species, and C3 legumes, which are slower-growing species. Hence mixtures of grasses and legumes may be incompatible unless the legumes possess other mechanisms to improve their competitive vigour. Three mechanisms of response of species to shade are avoidance, tolerance and obligate shade requirement (Ludlow 1980). Only the latter two response mechanisms would be suitable for pastures under plantations, since the understorey species cannot avoid shade from the taller plantation crops. These strategies require that species are able to maximise radiation use efficiency, leaf area and light interception (Smith 1981).

It is clear that most improved tropical pastures are sun species (Ludlow 1978) with poor adaptation to dense shade. However, tropical pasture species when grown under shade can exhibit both morphological and physiological changes in shoot to root ratios, leaf area ratio, specific leaf area and radiation use efficiency (Sophanodora 1989).

This study was conducted to evaluate the effect of shade on the productivity of two tropical grasses grown in monoculture and the compatibility of mixture with a legume.

*Department of Plant Science, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Thailand.

Materials and Methods

Pure grasses swards of guinea (*Panicum maximum*) and signal (*Brachiaria decumbens*) and mixtures with centro (*Centrosema pubescens*) were established on a well-drained, fertile krasnozem soil at Redland Bay Farm, University of Queensland in January 1985. Grass seedlings about three weeks old were transplanted at spacings of 0.20 x 0.25 m into plots 2 x 3 m. For the mixed swards, legumes and grass seedlings were planted alternately along the row to give a 50:50 grass to legume mixture. Ten days after transplanting, structures covered with shade cloth were erected 1.5 m above the plots. The radiation regimes were 30, 70 and 100% of full sunlight. There were four replicates per treatment. Plots were irrigated regularly to avoid periods of water stress, no fertilizer was applied, and weeds were removed.

One month after commencing the shade treatments, all swards were cut to about 6 cm above ground level. This was designated day 0 for calculation of days after treatment (DAT) and at approximately weekly intervals, herbage was harvested from quadrats of 0.4 x 0.5 m at about 5 cm above ground level to determine dry weight and leaf area of the component species. Before each harvest, the percentage of midday photosynethically active radiation (PAR) interception by the canopy was measured by a linear probe (Muchow and Kerven 1977). The relative profile of intercepted PAR was measured in successive strata of 0.20 m depth from ground level.

The accumulated amount of PAR intercepted by the canopy was calculated from the sum of the product of mean relative percentage PAR interception by the canopy during two successive measurements and daily incoming PAR.

Extinction coefficient (K) of canopy was calculated from the equation (Charles-Edwards 1982)

$$K = -(\ln(I/I_0))/LAI$$

Where ln is the natural logarithm. I and I_0 are the light flux density below and above the canopy, and LAI is the leaf area index. The slope of the linear regression between accumulated intercepted PAR and herbage yield was regarded as mean radiation conversion efficiency (E_h) of the canopy.

Results

Herbage yields were markedly affected by shade treatments; the absolute reduction of herbage yield was greater in signal than in guinea (Fig. 1), although signal outyielded guinea. The proportion of legume yield in mixtures increased as level of radiation decreased. This was possibly due to the reduction in growth advantage of the grasses under shade and because legume growth was suppressed at 100% light by the initially strong growth of the grass. The yield of guinea grass in this experiment was lower than would normally be expected.

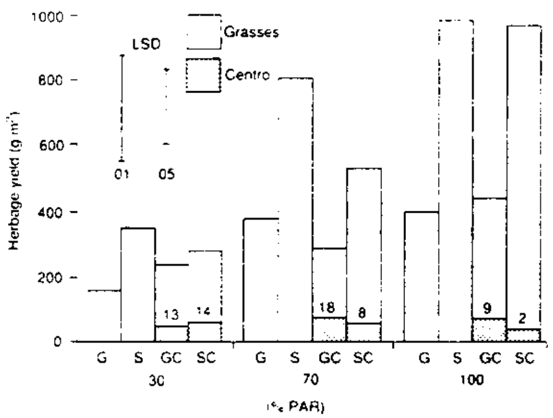

Fig 1. Herbage yield (g/m^2) of pure guinea (G), pure signal (S) and mixture of the grasses with centro swards (GC and SC) at 51 days regrowth under 30, 70 and 100% of full sunlight.

Generally, the lesser proportion of total LAI which occurred in the lowest stratum (0 – 40 cm) was lower at 30% and 70% light than in full sunlight (Table 1). Guinea was taller than signal. The lower stratum also contained less productive leaves due to shading by the upper leaves and the older age of leaves. A lower proportion of LAI in the top stratum suggested a better light penetration through to the lower stratum and hence centro would be able to intercept more radiation, since most centro leaves were in the lower stratum.

K value decreased in light shade (70% light) then increased at 30% light; however, there was not much difference in K value between pure and mixed swards, particularly under shade (Table 2).

Generally, radiation conversion efficiency (E_h) increased under low radiation, and centro swards had a lower E_h than pure grass swards. However, the increase in E_h under dense shade was greater in mixed swards than in pure grass swards. E_h of signal grass was higher than that of guinea grass.

Discussion

There was no growth advantage of the long erect-leaved guinea over the shorter, more prostrate-leaved signal in monoculture. This may have been associated with the low LAI and low solar radiation interception of the guinea grass which did not grow as well as was expected. Shading caused erect plants to lodge more readily.

Herbage productivity can be explained in terms of the amount of intercepted PAR and E_h. The increase in E_h under shade was not sufficiently large to compensate the reduction in amount of intercepted PAR. The percentage increase of E_h under dense shade was less in the pure grass swards than in the mixtures, hence the centro component was increased with shading. It might be expected therefore that centro would compete under conditions of greater equality in shade.

This study did not consider root dry matter, which provides a competitive sink demand for photosynthate and nitrogen. Under shade conditions, root demand

Table 2. Canopy extinction coefficient (K) and radiation conversion efficiency E (g/MJ) and relative increase, compared to full sun (in brackets), of the pure and mixed guinea and signal swards under 30, 70, and 100% of full sunlight.

Swards	Light transmission (%) 30 K	30 E_h	70 K	70 E_h	100 K	100 E_h
Guinea	0.55	1.47 (175)	0.44	1.21 (144)	0.51	0.84 (100)
Signal	0.52	2.69 (133)	0.32	2.27 (112)	0.41	2.02 (100)
Guinea centro	0.52	1.61 (185)	0.42	0.95 (109)	0.65	0.87 (100)
Signal/centro	0.52	2.65 (162)	0.40	1.64 (100)	0.48	1.67 (100)

was presumably less and thus leaf nitrogen content was higher, and this possibly helped to maintain leaf photosynthesis, and this together with the decrease in shoot to root ratio would lead to an increase in E_h. Under these conditions it seems that the benefit of nitrogen symbiosis is a less important strategy for promoting compatibility between shaded grass and legume mixtures. The route to maximise productivity of the shaded mixed swards is via maximum light interception and effective light distribution in the canopy, particularly to the lower profile where the legume LAI occurs.

However, grazing or cutting management would insert an interaction effect on the compatibility of grass–legume swards under shade, since cutting or grazing causes change of sward structure and K value. Preferential grazing may also be involved. Watson and Whiteman (1981) found that under coconuts in Solomon Islands signal virtually disappeared under grazing by the second year where centro comprised 14% of the mixture.

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