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(Accepted for publication June 27, 1986)

EFFECT OF FERTILIZER AND WEED CONTROL ON THE EMERGENCE AND EARLY GROWTH OF FIVE LEGUMINOUS FODDER SHRUBS

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ABSTRACT

A field experiment was conducted at Mt Cotton, southeast Queensland, to examine the effects of nitrogen and phosphorus fertilizers and weed control on the emergence and early growth of five leguminous shrubs. Under good nutrition and no weed competition, the shoot dry matter yield at 11 weeks was 294, 239, 66, 25 and 21 g m^{-1} of row for Sesbania sesban, S. formosa, Leucaena leucocephala, Acacia angustissima *and* Calliandra calothrysus, *respectively.*

The taller, faster growing Sesbania *species were less susceptible to weed competition than the other three species, their yields being reduced by* c. *65% as compared to* c. *80% for the others. The application at sowing of N (100 kg N ha^{-1}) and P (200 kg P ha^{-1}) fertilizer in a band near the seed increased the growth of the two* Sesbania *species but depressed yields in the other 3 species. Weed yield increased with fertilizer application in the presence of* C. calothrysus *and* L. leucocephala *and was unaffected in the presence of the others. Fertilizer adversely affected seedling emergence and nodulation in all species.*

INTRODUCTION

Increasing interest is being shown in the use of leguminous trees and shrubs as sources of fodder for livestock in tropical and sub-tropical regions (NAS 1979). In comparison to herbaceous legumes, shrub species offer advantages in terms of superior persistence (Jones and Jones 1982), higher yields, resistance to mismanagement and the ability to retain high quality forage under conditions of stress.

However, if these species are to be widely accepted they must propagate easily, preferably by seed. At present, the most serious limitation to their widespread use is their slow and difficult establishment phase. Jones and Bray (1983) point out that leucaena which offers great potential as a fodder species has been poorly accepted in Australia mainly because of its slow establishment.

This study was conducted to compare the emergence and early growth of five shrub species (*Acacia angustissima*, *Calliandra calothrysus*, *Leucaena leucocephala* cv. Cunningham, *Sesbania formosa* and *S. sesban*) which have shown potential as fodder plants.

MATERIALS AND METHODS

The experiment was conducted at the University of Queensland Research Farm at Mt Cotton (27°35'S, 153°E) on an infertile grey podzolic soil with a sandy clay loam surface horizon of pH 5.2.

The area had previously been cropped with sorghum and oats and had received 200 kg ha^{-1} single superphosphate and 100 kg ha^{-1} muriate of potash annually for 3 years. Total nitrogen content of the surface soil was 0.11%, available phosphorus was 7 ppm (sodium bicarbonate extract) and organic carbon 1.3%.

A split-split plot design was used with hand weeding or no weeding as the main plots, species (*Acacia angustissima*, *Calliandra calothrysus*, *Leucaena leucocephala* cv. Cunningham, *Sesbania formosa* and *S. sesban*) as the sub plots, and fertilizer (100 kg N ha^{-1} as urea and 200 kg P ha^{-1} as superphosphate) or no fertilizer as the sub-sub plots. Each sub-sub plot consisted of a 5 m length of row and rows were 2 m apart. There were four replications.

The area was twice cultivated with a rotary hoe to provide a seed bed of fine tilth. Scarified seed of the five species was sown by hand on November 1, 1985. Sufficient seed (based on previous germination tests) was sown of each species to achieve an establishment of 1 seedling 10 cm^{-1} row. Fertilizer was applied at planting in a 5 cm wide band 2 cm below the seed but not in direct contact with it.

Leucaena and the *Sesbania* species were inoculated with rhizobium strains CB81 and CB905, respectively, by applying a slurry of peat inoculum and water to the rows of newly emerged seedlings one week after planting. The other species were not inoculated because specific rhizobium strains were not available.

The success of emergence was determined by comparing the number of seedlings in each 5 m row at five weeks after planting with the estimated number of germinable seeds sown. Plant heights were recorded at 5, 8 and 11 weeks by measuring every fifth plant in a sub-sub plot. At 11 weeks after planting, all seedlings in the centre 3 m of each sub-sub plot were counted, harvested at ground level, oven dried at 70 °C for 48 hrs and weighed. In the non-weeded plots all weeds within an area 25 cm on either side of the row were harvested at the same time, separated into grass and broad-leaf (dicotyledonous) species, oven dried and weighed. Just prior to harvest there was an 18 day period without effective rain, so the effect of this moisture stress was assessed by visually ranking the degree of wilting, on individual plants within a sub-sub plot between noon and 1400 h. After harvest, the area was irrigated to soften the soil, and the roots of 3 whole plants remaining in each sub-sub plot excavated, examined for nodules and ranked on a scale of 0 to 5 where 0 = no nodules and 5 = very well nodulated.

RESULTS

Percentage emergence

Percentage emergence was most successful in *Leucanea leucocephala*, intermediate in *Calliandra calothrysus* and *Sesbania formosa*, and lowest in *S. sesban* and *Acacia angustissima* (Table 1).

The application of fertilizer significantly reduced seedling number (Table 1), whereas weed competition had no significant effect (data not shown).

TABLE 1

Percentage emergence of viable seed sown of five species of fodder shrub 5 weeks after planting

Species	Fertilized	Unfertilized	Mean
A. angustissima	41 (39*)	61 (54)	51 (46)
C. calothrysus	58 (50)	76 (61)	67 (55)
L. leucocephala	70 (58)	87 (74)	79 (66)
S. formosa	74 (60)	77 (63)	76 (61)
S. sesban	36 (37)	57 (49)	46 (43)
Mean	56 (49)	72 (60)	

*Angular transformed values (degrees) appear in parentheses. LSD ($p = 0.05$) angular transformed data: species mean, 8; fertilization mean, 6; species × fertilization, 12.

Plant height

S. sesban was the tallest species and at 11 weeks averaged 81 cm in height (Fig. 1). *S. formosa* also grew rapidly and averaged 55 cm at 11 weeks. The other species were

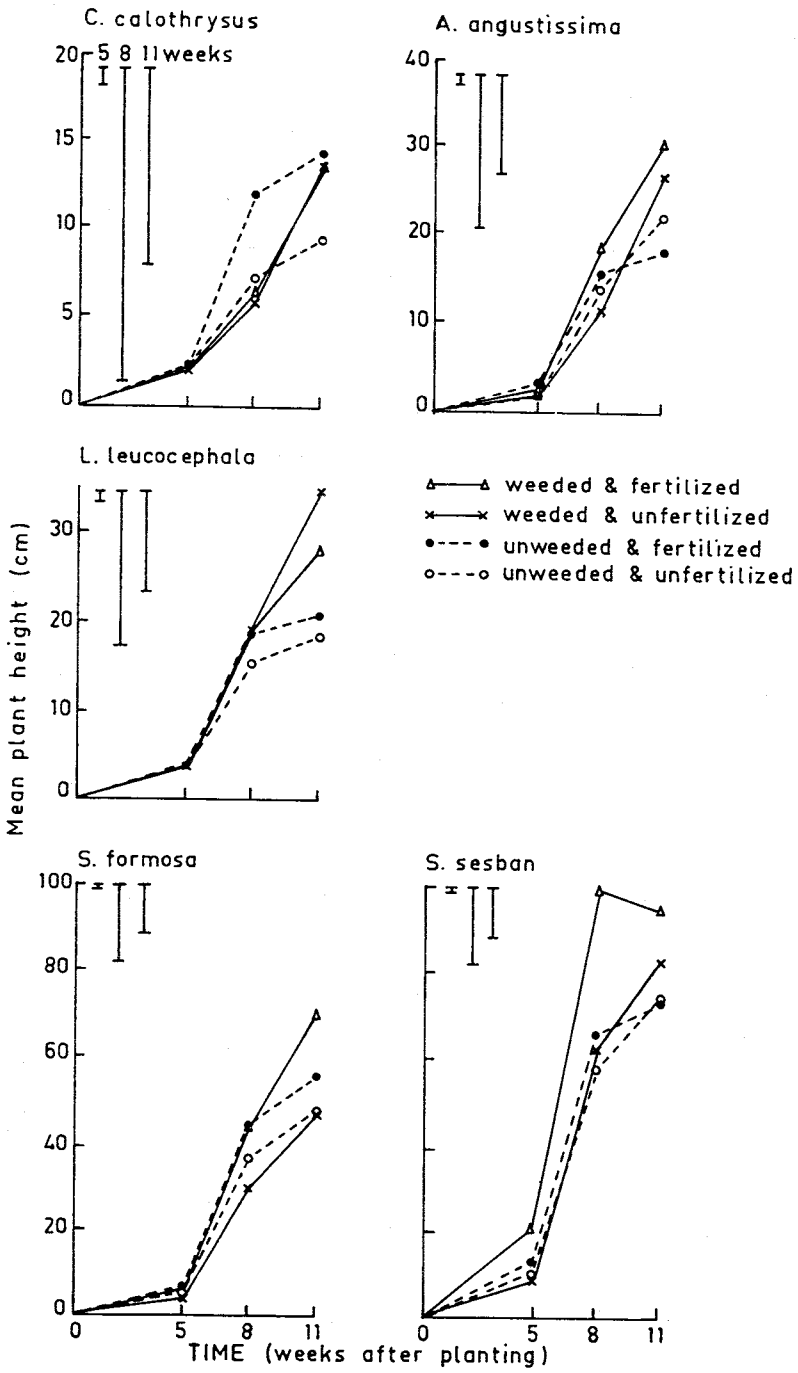

FIGURE 1
Effects of weeding and fertilization with nitrogen and phosphorus on the height of five fodder shrubs, 11 weeks after planting.

comparatively short with average heights of 25, 25 and 13 cm for *L. leucocephala*, *A. angustissima* and *C. calothrysus* respectively. At harvest, most of the weeds had set seed and had reached an average height of 60 cm.

Competition from weeds reduced the height of seedlings in all species except *C. calothrysus* (Fig. 1). The effect of fertilizer addition on height was not clear as species reacted differently to the different combinations of fertilizer and weeding treatments and at 11 weeks there were no significant differences (Fig. 1).

Shrub seedling dry matter yields

Overall, *S. sesban* and *S. formosa* were the most productive species in yield per metre of row (Fig. 2). *A. angustissima* was the least productive species and, on an average, yielded only 8% as much as *S. sesban*. *S. sesban* gave the highest individual plant yield at 13.9 g plant^{-1}, *S. formosa* (4.8 g plant^{-1}) was intermediate, while *L. leucocephala*, *C. callothrysus* and *A. angustissima* were lowest with mean yields of approximately 1.8 g plant^{-1} each.

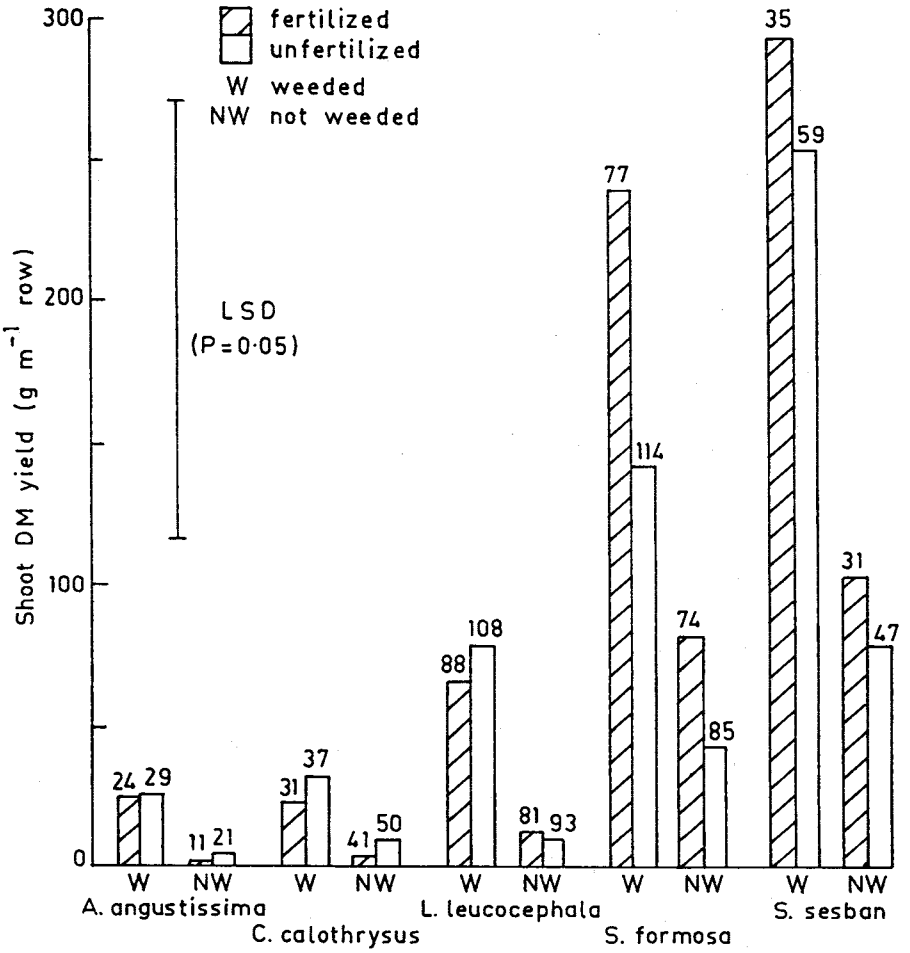

FIGURE 2

Shoot dry matter yield per metre of row of 11 week old fodder shrubs under weeded (w) and unweeded (nw) conditions, with and without N and P fertilizer at planting. (Numbers of seedlings present are shown).

Weed competition markedly suppressed tree seedling growth as yield per metre of row (Fig. 2) and per 11 week old plant. The mean reduction in yield for the taller *Sesbania* species, viz. *S. sesban* (63%) and *S. formosa* (68%) was significantly less ($P > 0.05$) than that of the shorter species *C. calothrysus* (78%), *L. leucocephala* (82%) and *A. angustissima* (83%). Fertilizer effects were not significant but there was a tendency towards stimulated shoot yield in the fertilized *Sesbania* species (Fig. 2).

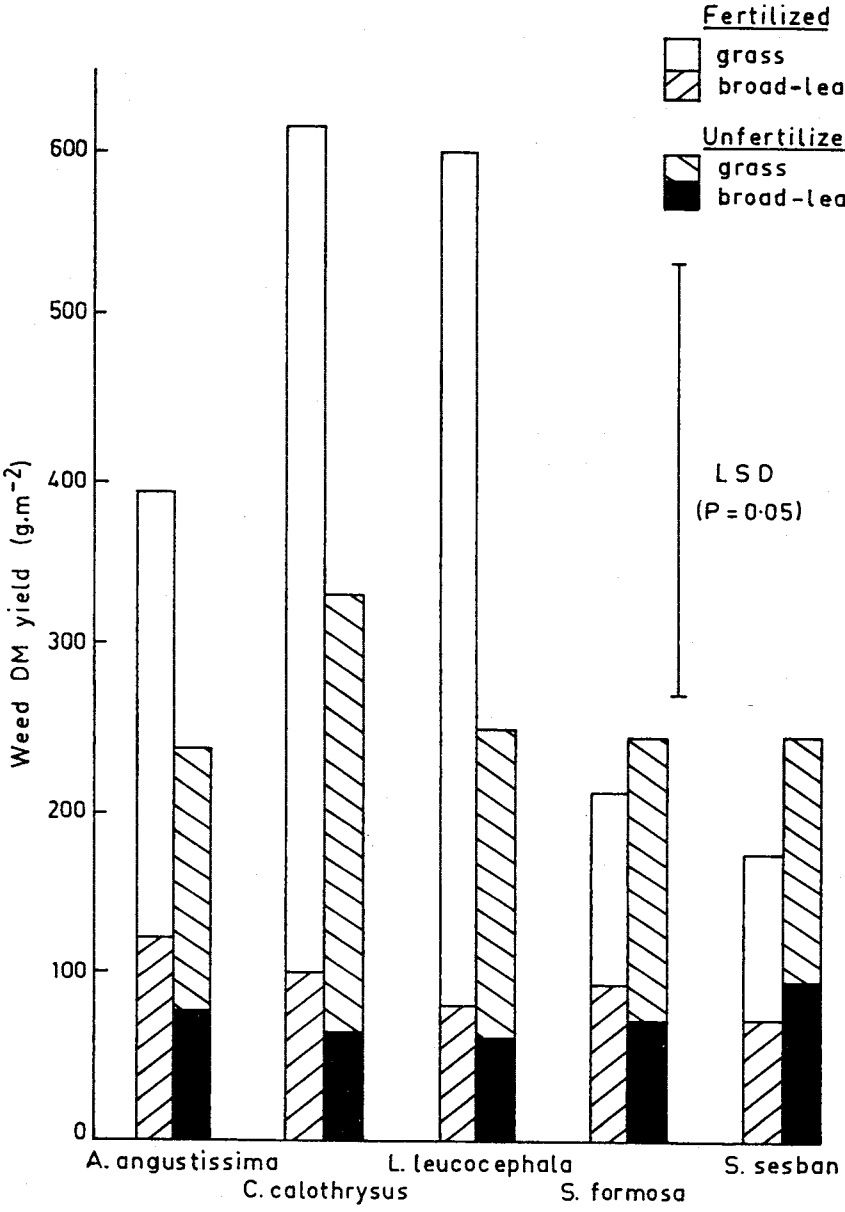

FIGURE 3

Mean dry matter yield of grass and broad-leaf weed species per m^2 at 11 weeks from planting in fertilized and unfertilized plots of five fodder shrubs.

Weed-shrub interactions

Weed yield was similar in all unfertilized treatments (Fig. 3). Where fertilizer was applied, weed yields in *C. calothrysus* and *L. leucocephala* plots were significantly increased, but in the *S. sesban* and *S. formosa* plots weed yield was suppressed although the differences were not significant (Fig. 3).

The dominant grass weeds were *Eleusine indica*, *Digitaria adscendens* and *Eragrostis* sp. while the main broad-leaf weeds were *Ageratum houstonianum*, *Galinsoga parviflora* and *Sida* spp. The contribution of grass weeds to total weed yield varied among plots from 20 to 98%. However, there was no relationship between percentage yield reduction and the yield of either grass or broad-leaf weeds except for *C. calothrysus* which was more susceptible (correlation coeff. 0.692*) to competition from the broad-leaf weeds than the grasses.

Water stess at harvest

Water stress in the tree seedlings at 11 weeks, as assessed by the degree of wilting and leaf drop, was significantly higher in unweeded treatments (Table 2). There were no significant differences between the species nor any effect of fertilizer on water stress symptoms (Table 2).

TABLE 2

Mean ranking for symptoms of water stress in weeded and unweeded 11 week old fodder shrubs

Species	Weeded	Unweeded
A. angustissima	0.75*	1.88
C. calothrysus	1.38	2.88
L. leucocephala	1.00	2.50
S. formosa	1.00	2.75
S. sesban	1.50	2.25
Mean	1.13	2.45

LSD (P = 0.05): weeding mean, 0.48; species × weeding, 1.51

*Ranking 0 = no visible symptoms, 1 = slight leaf folding, 2 = more severe leaf folding ± some leaf drop, 3 = moderate leaf drop.

Nodulation

Nodulation of all plants was very poor with most plants having only one or no nodules. Only *S. sesban* had a moderate number of nodules and in this species nodulation was suppressed significantly by fertilization, with the mean rank being 2.1 for the unfertilized treatment and 0.5 for the fertilized treatment.

DISCUSSION

The five species in this experiment showed marked differences in seedlng growth. Within 11 weeks after planting, a 10 fold difference in yield developed between the fastest and slowest growing species under weeded, fertilized conditions. Other work supports the species differences; Panjaitan and Blair (1985) reported that *C. calothrysus* and *L. leucocephala* were slow growing in comparison to *Sesbania grandiflora* (which is very similar to *S. formosa*) on a soil from Bali, Indonesia.

Success or failure of establishment can depend on the growth rate of the shrub species selected. In this experiment establishment of both *Sesbania* species was successful both in weeded and unweeded conditions. However *L. leucocephala*, *C.*

calothrysus and *A. angustissima* seedlings in the unweeded treatments would probably have succumbed to weed competition, and even in the weeded treatments, weeding would probably have needed to be continued for some time to ensure successful establishment.

Strong correlations have been found between seed size and early growth of several herbaceous legumes (Ludlow and Wilson 1972; Gardener 1978). However, in this study, the percentage emergence of the five species was not strictly in the order of seed size, although *A. angustissima* and *S. sesban* which had the lowest 100-seed weights (1.41 and 0.91 g respectively) had the lowest percentage emergence. The relatively poor emergence of the fast growing species *S. sesban* did not negatively effect final yield because individual plants were able to compensate for the lower plant density. However, for the slower growing species such as *A. angustissima*, the low yield at final harvest could in part be attributed to poor emergence. The negative effect of fertilizer on percentage emergence was also more important for the slower growing species compared to the faster growing *Sesbania* spp. In the latter species, the seedlings which did establish successfully appeared to benefit from fertilizer addition.

The use of fertilizers in the establishment of leguminous shrubs needs more study. Hill (1970) found that 65 kg N ha^{-1} applied to *L. leucocephala* substantially increased seedling yield, while Sivasupiramaniam *et al.* (1986) also obtained a response to 25 kg N ha^{-1}. However Cooksley (1974), Egara and Jones (1977) and S. Ruaysoongnern (*personal communication*) all reported that added nitrogen had no effect on the early growth of *L. leucocephala*. The fertilizer rates used in this experiment may have been slightly high but they were selected on the basis of a response in the growth of leucaena in pots on the Mt. Cotton soil to the equivalent of up to 400 kg P ha^{-1} without detrimental effects (S. Ruaysoongnern, *personal communication*). However in this experiment, either the urea or the superphosphate may have depressed emergence but their individual effects cannot be separated. The results do show, however, that for slower growing species such as *L. leucocephala*, *A. angustissima* and *C. calothrysus* the use of fertilizer, even when banded below the seed, does not improve the competitive ability of the seedlings in the presence of weeds and may even cause a negative effect.

Weed competition in this experiment was intense. The dominant weed was the vigorous annual grass *Eleusine indica* and total weed yields were equivalent to 2.6 tonnes dry matter ha^{-1} in unfertilized plots. The site is typical of the degree of weed competition from old cultivation areas. Weed competition might be expected to be less severe in previously uncultivated areas (Bray *et al.* 1985) and where perennial rather than annual grass weeds predominate (Falvey 1981). The results confirm many previous reports of the high susceptibility of *L. leucocephala* to weed competition (Hill 1970; Cooksley 1974; Jones and Aliyu 1976; Falvey 1981) and indicate that the other species are also susceptible to weed competition (although there were different effects). *Sesbania formosa* and *S. sesban* being tall were much less subject to competition for light than the other 3 species. The height:weight ratio at 11 weeks of seedlings in unweeded relative to weeded plots was increased by an average of 372, 337, and 247% in *A. angustissima*, *C. calothrysus* and *L. leucocephala* respectively as compared to 150% in *S. formosa* and 145% in *S. seban*. Egara and Jones (1977) hold the view that for *L. leucocephala*, competition for light is less influential than competition for nutrients and water. However in this study, although the degree of etiolation in *L. leucocephala* was less than that of *A. angustissima* and *C. calothrysus*, it was still considerable.

Competition for moisture was more intense in the unweeded plots. Although the five shrub species are adapted differently with respect to moisture requirements (NAS 1979; 1980; 1983), they showed similar degrees of moisture stress symptoms after a period of drought immediately before harvest.

In conclusion, it is evident that competition from weeds is an important factor in the establishment of leguminous shrubs and trees and the selection of fast growing types may be warranted where adequate weed control measures are not available. The use of fertilizers in the establishment phase requires further study but it appears that fertilizer may encourage weed growth to the detriment of the less vigorous species.

ACKNOWLEDGEMENTS

The technical assistance of Mr. W. Bean and the help of the Manager and staff of the University Farm Mt Cotton is gratefully acknowledged. We thank Mr. I. M. Wood and Dr. H. V. A. Bushby of CSIRO Division of Tropical Crops and Pastures for the kind provision of seed and inoculum respectively. The financial support of the Australian Centre for International Agricultural Research is also acknowledged.

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(Accepted for publication July 17, 1986)

STIMULATION OF GROWTH AND NITROGEN UPTAKE BY SHADING A RUNDOWN GREEN PANIC PASTURE ON BRIGALOW CLAY SOIL

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ABSTRACT

Shading a rundown green panic pasture stimulated greater growth and higher nitrogen (N) concentration of the green panic compared with adjacent plots in full sunlight. The pasture was 16 years-old and located on a grey, brown and red clay Brigalow soil in southern Queensland. The shades ("sarlon" cloth transmitting 37% light) were in place over two growing seasons.

Shade increased uptake of N by the rundown pasture by 5.3 g m^{-2} ($\equiv$ 53 kg N ha^{-1}) in the above-ground herbage over the two years; thus giving double the amount of N harvested from the full sun plots. Transfer of N from roots to tops did not appear to explain the result; at the end of the experiment shade roots had lost only 0.55 g N m^{-2} compared to the full sun plots. Soil microbial biomass carbon, and the nitrogen fixing activity of roots measured at the end of the experiment did not differ between treatments. The shade stimulation of N uptake by the grass needs further investigation to understand the mechanisms involved.

INTRODUCTION

Deterioration of old pastures on Brigalow soils is a serious problem in southern Queensland. As pastures age, grass yields and quality decline (Catchpoole 1980; Graham *et al.* 1981) and animal production is reduced (Rudder *et al.* 1982; Robbins *et*