The impact of soil fertility and legumes on the yield and persistence of buffel grass

P.C. Kerridge, R.W. McLean and R.M. Jones

Division of Tropical Crops and Pastures, CSIRO, St Lucia QLD 4067

Summary. The impact of soil fertility on the persistence of Biloela buffel grass *Cenchrus ciliaris,* sown with either Fitzroy stylo *Stylosanthes scabra,* or Siratro *Macroptilium atropurpureum, was* studied under conditions of heavy grazing pressure. Buffel yield decreased with lower soil P, S, and N, the decrease being greater with Fitzroy stylo than with Siratro. This suggests that the stylos compete strongly with grasses for available nutrients.

Introduction

Legumes of the genus *Stylosanthes* often become the dominant component when sown into native grassland or with introduced grasses. This has been observed under conditions of low soil P and heavy grazing pressure during the wet season when animals preferentially select the grass (3). Other legumes such as Siratro do not become dominant on P deficient soils (6).

There is strong advocacy for sowing legumes with nil or minimal input of fertilizer and supplying deficient minerals as a direct supplement to cattle in order to reduce costs (4). But, as with temperate legumes, the contribution of tropical legumes to soil N is limited under conditions of low soil nutrient status (2). The extent to which lower N input influences long term productivity and persistence of native and sown grasses grown in association with legumes needs closer examination.

The aim of this study was to compare the contribution of two legumes, Fitzroy stylo, *Stylosanthes scabra* and Siratro, *Macroptilium atropurpureum,* to soil N and the consequence of this on persistence and productivity of buffel grass, *Cenchrus ciliaris,* when grown under low and moderate levels of P and S.

Methods

The study site was at the CSIRO Narayen Research Station (25? 41'S, 150? 52'E, rainfall 716 mm). The experimental area was a complex of red (Dr5.61) and yellow podzolic (Dy5.61) soils with mean surface (0-10 cm) pH - 6.0, total N - 0.065 %, bicarbonate extractable P - 4 ppm, phosphate extractable SO_4^{2-} - 3 ppm. In January 1981 two replications of an experiment were sown comprising Biloela buffel grass, sown with either Siratro or Fitzroy stylo together with various fertiliser treatments. The treatments were the two legumes combined in factorial combination with four levels of maintenance fertilizer (kg/ha) *viz:*

- P_5S_0 applied annually;
- P_0S_5 applied annually;
- P_5S_5 applied annually;
- $P_{20}S_5$, the P applied in 1982 and 1986, and the S annually.

The fertilizers used were monoammonium phosphate at sowing and triple superphosphate and gypsum for maintenance. Basal K, Cu, Zn and Mo were also applied at sowing. Plot size was 0.25 ha. The plots were grazed during the growing season (January to May) at the rate of two yearling steers/ha. Steers were rotated between replications every two weeks.

Botanical composition and yield were estimated before and after each grazing season. The experiment was finally destocked in early April 1990 at the end of a drought period. Following rain, yield and botanical composition were estimated after 6-weeks regrowth in May 1990. The density and basal cover of buffel grass were estimated in December 1990.

One hundred 5 cm diameter soil cores (0-10 cm) were collected from each paddock in September 1989. Determinations were made of bicarbonate extractable P, total soil N, NO3-N (released after 3-week incubation) and N uptake by buffel grown in pots (supplied with P and S).

Results and discussion

The changes in yield and botanical composition are shown for two of the fertilizer treatments in Figure 1. Buffel was the main component in all treatments at the commencement of grazing but declined with time in the treatments not receiving both P and S. Buffel yield was higher in the `Siratro' than 'Fitzroy stylo' treatments and while it declined with time in treatments not receiving P and S, the decline was more rapid when grown with Fitzroy stylo than Siratro.

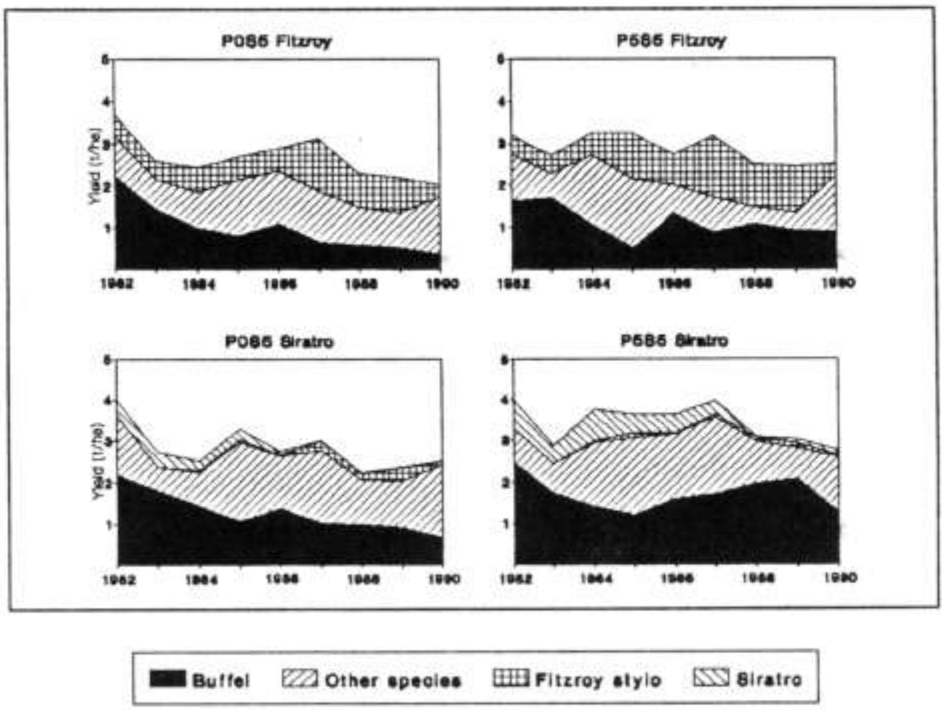

Figure 1. Changes in yield and botanical composition with time.

Siratro responded more strongly to fertilization than Fitzroy stylo but almost disappeared with time due to poor seed set and failure of seedlings to survive. On the other hand the increase in Fitzroy yield up to 1990 was associated with a large increase in the population of the legume. The reduction in the Fitzroy yield in January 1990 was due to death of most old Fitzroy plants during the preceding wet winter.

Buffel yield, being the mean of the estimations in January and May 1990, is shown in Table 1. The 'fertilizer x legume' interaction was significant for yield of buffel because there was a lower amount of buffel in the low P and S treatments when Fitzroy stylo was the companion legume rather than Siratro. The reduction in buffel yield was because of fewer and smaller plants in the low fertility treatments, in particular, with Fitzroy stylo (Table 2).

Table 1. Buffel grass yield when grown with either Siratro or Fitzroy (mean of January and May 1990 estimations) and the mean bicarbonate P, total N, NO_3-N produced on incubation, and N uptake by buffel grown in pots from soil sampled in September 1989.

Treatment	Yield		Soil			N uptake in pots
	Fitzroy	Siratro	P	Total N	NO_3-N	
	(kg/ha)		(ppm)	(%)	(ppm)	(mg/pot)
P_0S_5	410	870	3.3	0.077	25	1750
P_5S_0	350	950	10.0	0.082	26	2070
P_5S_5	1400	1530	10.3	0.094	35	2210
$P_{20}S_5$*	1180	1030	8.3	0.101	38	2820
l.s.d. (P=0.05)	510		2.6	0.015	5	35

20 kg/ha P as triple superphosphate every fourth year.

Table 2. Mean density and basal area of buffel grass in December 1990.

	Density (plants/m^2)		Basal Area (%)	
	Siratro	Fitzroy	Siratro	Fitzroy
Low fertility	10	9	5	3
High fertility	15	16	8	9
l.s.d. (P=0.05)	6		5	

Total presentation yields at the time steers were removed from the trial each year varied from 400 - 1000 kg/ha over the various treatments. The bulk of this remaining yield consisted of unpalatable plants such as *Aristida.*

There was no legume x fertilizer interaction for total soil N, NO_3-N, N uptake or soil P and thus only the fertilizer main effect is shown in Table 1. For the legume main effect, there was higher mean NO_3-N (33 *vs* 29 ppm N) and N uptake (2400 *vs* 2000 mg/pot N) for Fitzroy than Siratro but no effect of legume species on total soil N or soil P. Thus there was little effect of legume on the N status of the soil even though higher yields were obtained with Fitzroy stylo (Fig. 1). The mean increase in soil N attributable to the legumes fertilized with P and S was estimated to be 24 kg/ha/yr.

The buffel yield in the field (Table 1) was more strongly correlated with total soil N (R^2 = 0.64) than with NO_3-N or N uptake by buffel grown in pots. But it can be seen from Table 1 that there is also a strong relation between buffel yield and soil P when the S deficient treatment (P5So) is excluded.

What then is the relative importance of soil fertility, the companion legume and grazing pressure on persistence of grasses? There are no studies where the three factors have been examined together and so their relative importance can only be assessed by inference. In another long-term study at the Narayen Research Station, Biloela buffel, grown on a podzolic soil heavily fertilized with P and grazed at moderate pressure, was persistent and productive with Siratro as the companion legume but gradually declined in the absence of the legume (5). The decline in the yield of buffel at lower soil fertility, that is, lower N, P and S, with both legumes in this study (Fig. 1) confirms the importance of adequate N for persistence of Biloela buffel. Moreover, the presence of a high yielding legume, Fitzroy stylo, when soil P and S were limiting, did not result in sufficient input of N to maintain a productive buffel grass pasture. Further, the more rapid decline with Fitzroy than Siratro suggests that the stylo competed strongly with the buffel grass for the limited nutrients. Heavy grazing pressure on the buffel would have enhanced this competition.

This decline in buffel due to soil fertility and the companion legume may be moderated by other soil factors and grazing pressure. At Narayen, persistence of buffel sown with Siratro was higher on a gradational red earth than a duplex podzolic soil but its decline was accelerated on both soils by heavy grazing pressure (PC Kerridge, unpublished data). At Katherine, buffel sown with stylos on a red earth soil persisted over time under moderate grazing pressure (7). *Urochloa mosambicensis* persisted and increased with time in a stylo dominant pasture under conditions of low soil P and moderate grazing pressure (1). *Bothriochloa pertusa* has been observed to increase and then dominate in stylo pastures under heavy grazing pressure at moderate soil P levels (7-9 ppm; R.J. Jones, pers. comm., 1991). Detailed competition studies will be required to achieve a better understanding of the processes and interactions involved in persistence.

From this study we can conclude, that though the vigour of buffel decreases at low soil N, P and S levels, persistence is strongly influenced by the companion legume. This points to the need to select grasses for their ability to compete with the stylos for nutrients as well as forpersistence under heavy grazing. Alternatively, maintenance of higher soil P, S and N will enhance persistence of grasses sensitive to competition from the stylos.

References

8. Coates, D.B. 1991. Trop. Grassi. 25, 229-230.

9. Crack, B.J. 1972. Aust. J. Exp. Agric. Anim. Husb. 12, 274-280.

10. Gardener, C.J. 1984. In: The Biology and Agronomy of Stylosanthes. pp. 333-337.

11. Partridge, J.G. and Miller, C.P. 1991. Sown Pastures for the Seasonally Dry Tropics. QDPI Conference and Workshop Series QC91002.

12. Mannetje, L. 't and R.M. Jones. 1990. Trop. Grassi. 24, 269-281.

13. Rayment, G.E., Bruce, R.C. and Robbins, G.B. 1977. Trop. Grassl. 11, 67-77.

14. Winter, W.H., Mott, J.J. and McLean, R.W. 1989. Aust. J. Exp. Agr. 29, 613-622.