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ZERO-GRAZED PASTURE UNDER IMMATURE *HEVEA* RUBBER: IMPROVED PRODUCTIVITY OF *PANICUM MAXIMUM* AND *P. MAXIMUM* + *PUERARIA PHASEOLOIDES* AND THEIR COMPETITION WITH *HEVEA*

By

U. P. de S. WAIDYANATHA, D. S. WIJESINGHE AND R. STAUSS**

ABSTRACT

Much higher yields of pasture than in a previous study were obtained when *Panicum maximum* (cultivar Guinea B), or this grass in association with *Pueraria phaseoloides* was interplanted with rubber. The yields, however, declined over the 4-year experimental period. The mixture yielded substantially more than the pure grass, but the legume component was productive only in the first 2 years, The grass component of the mixture yielded as high, or, in one year, higher than the pure grass, and also contained higher concentrations of N, P, Mg and Ca.

Pasture competition on tree growth appeared to increase as trees grew, and girth differences between trees in the pastures and in a legume cover were highest at 3.5 and 4.5 years. At 4.5 years, the trees in the cover were of tappable girth (50cm) whereas those in the pastures were, on average, 16% less. The final girth of trees was not significantly affected whether the pasture was 1.0 or 1.5 m away from the rubber trees.

INTRODUCTION

In a previous study on zero-grazed pasture production under immature rubber (*Hevea brasiliensis*) by Waidyanatha, Wijesinghe and Stauss (1983) *Panicum maximum* (Guinea B) and *P. maximum-Pueraria phaseoloides* pastures were found to be reasonably productive and of tolerable competitiveness on rubber. It appeared, however, that the legume component of the mixed pasture was slow to establish, and its improved early establishment could have increased the productivity of the pasture. It was also observed that pasture competitiveness was more severe in the early years of the immaturity period; and mitigation of early competition should hasten trees to tappable maturity.

This experiment examined productivity of *P. maximum* and *P. maximum-Pueraria phaseoloides* pastures (with early establishment of the legume), and their competitiveness on *H. brasiliensis* as affected by the distance between pasture and tree.

** University of Hohenheim, Institute for Phytomedicine, 7000 Stuttgart 70, Federal Republic of Germany.

MATERIALS AND METHODS

The location of the experiment, soil and climate are the same as that described before for another experiment, which was located adjacent to this one (Waidyanatha *et al*, 1983). The experiment occupied the bottom of a slope, and therefore, the soil fertility (not measured) should be somewhat higher than that already described.

The experimental treatments consisted of *Panicum maximum* by itself and in combination with *Pueraria phaseoloides*, which were planted, leaving a circular space of radius 1.0 or 1.5 m around trees. An uncut *Pueraria* cover which was established leaving a bare circle of 1.0 m radius around trees was the control. The resulting five treatments were replicated fourteen times in a randomised block design. Each plot consisted of a circular area of radius 3.5 m with a single rubber tree in the centre and pasture or cover around it except in the bare space around trees as described already. The pastures and the cover were established in concentric circular rows, 0.5m apart.

The rubber trees (clone RRIC 105) were equidistantly spaced (in corners of equilateral triangles) at 7.0m apart. Six months old plants raised in polybags from budded stumps and selected for extreme uniformity were planted in the field in May 1977.

Acid-scarified and Rhizobium (CB 756)-inoculated *Pueraria* (5kg of seed/ha) was row-seeded at the same time as the rubber was planted, in all plots that were to contain the legume. The grass was planted 4 weeks later, two tillers per point and spaced 0.5m apart in the row. By this time, the legume seedlings were well established in the mixed and cover plots.

All plots received 300kg of a mixture (1 : 2 : 1) of urea, rock phosphate and muriate of potash at pasture and cover establishement. The cover did not receive any further fertilizer. Subsequently, all pasture plots received a basal dressing of 150kg of muriate of potash, 100kg of magnesium sulphate (Epsom salts) /ha/yr. In addition, the pure grass plots received 100kg of rock phosphate and 225kg of urea, and the mixed plots, 300kg of rock phosphate/ha/yr. The fertilizers were applied in four split-dozes per year.

Weeding and harvesting of the pastures and manuring of the rubber trees were as described previously (Waidyanatha *et al*, 1983). Oven-dried forage was analysed for N,P, K,Mg, and Ca using a Technicon Autoanalyser, except for the last year (1980/81).

RESULTS

Dry matter yield of forage

The harvestable forage yields (yield per hactare after correction for the vacant spaces around trees) are given in Tables 1 and 2. The correction for pasture-free spaces makes statistical comparison of yields only between pure grass and grass-legume pastures within each spacing treatment relevant. This is quite satisfactory because there was no interaction between the dry matter yield per unit area and the area of pasture-free space around trees, as is also indicated by the uncorrected yield data in Table 2.

Table 1. *Dry matter yield + (kg/ha) of forage*

	1977/78			1978/79			1979/80			1980/81	
	Grass	Legume	Total	Grass	Legume	Total	Grass	Legume	Total	Grass	Legume
Pasture 1.0m away from tree											
Grass pasture	17635	–	17635	13960	–	13960	9562	–	9562	6664	–
			***	**		***			*		
Grass + legume pasture	16568	10496	27064	17478	5733	23211	10889	704	11593	7720	0
Pasture 1.5m away from tree											
Grass pasture	14187	–	14187	11688	–	11688	8326	–	8326	6626	–
			***	*		***					
Grass + legume pasture	14558	8298	22856	14205	4822	19027	7973	605	8578	7044	0

+ After correction for pasture-free space around tree

Comparable treatment pairs significantly different (*$p < 0.05$, **$p < 0.01$, *** $p < 0.001$) by the t-test

Table. 2. *Mean dry matter yield of forage (kg/ha/yr) for total period*

	Per unit area+			Per harvestable area++		
	Grass	Legume	Total	Grass	Legume	Total
Pasture 1.0m away from tree						
Grass pasture	12814 ab	–	12814 b	11878	–	11878
						***
Grass + legume pasture	14201 b	4567	18768 a	13164	4233	17397
Pasture 1.5m away from tree						
Grass pasture	12224 a	–	12224 b	10207	–	10207
						***
Grass + legume pasture	13108 ab	4111	17219 a	10945	3432	14377

Values not corrected (+) and corrected (++) for pasture–free space around tree.
*** = Comparable pairs of values differ significantly ($p < 0.001$) by the t-test.
Values in the same column not followed by the same letter differ significantly ($p < 0.05$) by the multiple t-test.

The overall yield of the pastures was high but it decreased over the years, the average yield in the fourth year being only a third of the first year. Howeve , the yield of 7 t/ha corrected value) in the fourth year justifies maintenance of the pasturein that year. The decline in yield was more pronounced in the legume component of the mixed pasture which (disappeared completely at the end of the third year (Table 1). However, during the first two years, the legume-grass mixture strikingly outyielded ($p<0.001$) the pure grass. It is also notewrothy that the grass component yield of the mixture was comparable with that of the pure grass in the first year, and significantly higher in the next. At least in one comparison (at 1.0m bare space), the beneficial effect of the legume on the companion grass was indicated in the subsequent years also.

Nutrient and crude protein contents in pasture

Tables 3 and 4 compare the concentrations and total contents of nutrients, respectively, in pure grass and grass-legume pastures. N,P, Mg and Ca concentrations, but not K, were significantly higher in the grass component of the mixed pasture than in the pure grass. As normally observed, the concentration of nutrients in the *Pueraria* was higher than in the grass. The higher nutrient concentrations and the higher total dry matter yield of the mixed pasture have resulted in very highly significant total nutrient and crude protein conten ts in it than in the pure grass (Table 4).

Table. 3. *Nutrients in forage*

	N	P	K	Mg	Ca
		In grass			
Grass pasture	1. 35	0. 1C4	0. 691	0. 221	0. 105
	*	*		**	**
Grass + legume pasture	1. 44	0. 134	0. 745	0. 262	0. 145
		In legume			
Grass + legume pasture	2. 91	0. 154	0. 817	0. 259	0. .54

Comparable pairs of values differ significantly ($p < 0.05$ = *, $p < 0.01$ - **)

Table. 4. *Mean total nutrient contents (kg/ha/yr) in forage*

	Crude protein	N	P	K	*Mg*	Ca
Grass pasture	1056	132. 2	10. 2	67. 6	21. 6	10. 2
Grass + legume pasture	2018	253. 8	19. 5	107. 8	36. 8	20. 8

All comparable pairs of values differs significantly ($p < 0.001$) by the t-test.

Growth of Rubber

Pasture effects on growth of the rubber trees have been monitored using annual tree girth measurements. The girth data have been subjected to standard variance analysis as well as to repeated measures analysis (Dixon, 1979) for effects over the total period.

The girth of trees in the uncut legume cover plots was significantly superior to that of the pastures (Fig 1). The differences between the treatments were small and not significant at 1.5 years, but, thereafter, trees in the cover plots grew significantly faster than those in the pastures. Averaged over all the pasture treatments, the girth was 6.4, 12.7, 16.5 and 16.3% less under pasture than under cover at 1.5, 2.5, 3.5 and 4.5 years, respectively. The trees in the cover plots had reached the standard tappable girth of 50cm at 4.5 years. The final girth differences between pasture treatments were small, but there was some indication, especially at 2.5 and 3.5 years, that trees grew marginally better when pasture was 1.5.m away than when it was 1.0m. This difference however decreased eventually. There was also some indication (supported by the repeated measures analysis) that the mixed pasture at 1.5 m away from trees was probably the least competitive (Fig. 1).

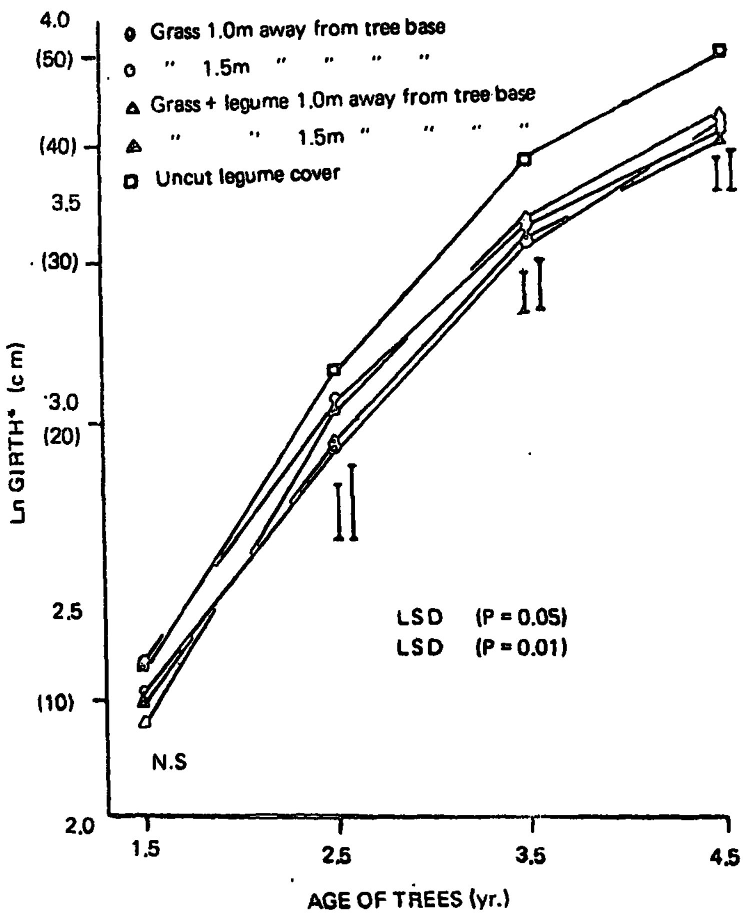

Fig. 1. Increase in girth with age

DISCUSSION

A single tree-plot design for a study of pasture-rubber interaction has certain deficiencies but was chosen in order to curtail size of the experiment to reduce management costs. The design is, however, permissable within the confines of the experimental objectives as stated in the Introduction. Interaction (border effects) between adjacent trees, which is the main drawback in the design, was greatly alleviated by reduced tree density and equidistant planting (see Mainstone, 1970) . Adjacent tree canopies did not touch each other until the end of the experimental period. Also, according to lateral root spread estimates (Soong, 1970), competition among root systems of adjacent trees should have been minimal. The low tree density should have, however, if at all, favoured better tree and pasture growth than is to be excepted at standard tree densities recommended for rubber (Mainstone, 1970).

Apart from presumably less competition from trees in comparison with the first experiment (Waidyanatha *et al*, 1983), higher soil fertility (see Materials and Methods) at this location may also have contributed to the higher forage yields recorded in thls experiment. Although the yields decreased relatively sharply after the second year, the level of pasture productivity even in the fourth year was satisfactory, considering the limitations to productivity imposed by increasing competition from growing trees for light, nutrients and water. Besides tree competition, pasture senescence, which is perhaps more rapid under zero-grazing, may be a factor for decreasing yields over time, as has been discussed previously (Waidyanatha *et al,* 1983).

Establishment of the legume a few weeks before the grass in the mixed pasture had the desired result of good, early legume establishment and productivity. However, the legume component yield decreased sharply after the second year, and it disappeared completely by the end of the third year. This result concurs with that of others (Ng and Wong, 1976; Dissanayake, 1982) that tropical creeping legumes are sensitive to regimes of defoliation as imposed under zero-grazing; but is contrary to the earlier observation that the legume component increased with time (Waidyanatha *et al,* 1983). This increase was, however, following initial poor establishment of the legume, and consequently resting it; but the legume yield was still less than that obtained in this experiment.

The legume-based pasture yielded significantly higher dry matter yields than the pure grass; and it was of interest that the level of productivity of the grass component when in association with the legume was comparable with that of the pure grass which received more than 100kg N/ ha/yr. Besides other considerations, this may imply substantial nitrogen transfer from the legume to the companion grass. Moreover, the nitrogen content was significantly higher in the grass component of the mixed pasture, and, together with that in the legume, resulted in a two-fold increase in the crude protein content of the mixed pasture over the pure grass. This emphasises the great advantage of legume-based pastures for the situation.

Ths higher concentrations and total contents of P and Ca in the grass component of the mixture may in part be explained by the higher quantity of rock phosphate applied to this treatment. But this result, together with the higher Mg and marginally higher K concentrations are also indicative of a role for the legume for the better nutrient status of the companion grass.

It is of great significance that despite a much higher yield, the legume-based pasture was no more competitive with the rubber than the pure grass (Fig. 1) as has also been seen before (Waidyanatha, *et al*, 1983). This presumably argues for some benefit of the legume in the mixture on tree growth. The beneficial effect, although clearly smaller in magnitude, may be similar to that accruing from legume covers (Broughton, 1976).

The competitiveness of the pastures on *Hevea* in this investigation is of the same order as that observed in the previous study (Waidyanatha, *et al*, 1983). On average, tree growth in pasture plots was depressed by about 16% as compared to that in the cover plots. At the rate of girth increments observed in the last year, it appears that the trees in the pasture would reach the tappable girth of 50cm in less than one year behind the trees in the legume cover. The larger pasture-free space around trees appeared beneficial to tree growth during the mid immaturity period, but the advantage decreased later probably as tree roots spread well into the pasture zone. The resulting additional loss of space by this practice does not therefore warrant it.

In conclusion, the study confirms the feasibility of zero-grazed pasture production under rubber at economic levels for about 4 years, and the tremendous advantage of legume based pastures over pure grasses in terms of higher productivity, reduced competition on rubber trees and possible savings on N fertilizer. However, the need for a more persistent legume capable of withstanding intensities of defoliation prevailing under zero-grazing is urgent.

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