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EFFECT OF CENTROSEMA PUBESCENS BENTH. ON SOIL FERTILITY IN THE HUMID TROPICS

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The advantageous effect of a leguminous pasture component on soil fertility in temperate climates is well known and there are ample quantitative data in the literature concerning the nitrogen-fixing ability of effectively nodulated temperate legumes such as white clover. In the tropics, soils under rain-forest cover are initially of high fertility because of the surface accumulation under the dense forest cover. However, under hot wet conditions the processes important to soil fertility—e.g. weathering of minerals, production and decay of organic matter, nitrification, and leaching of nutrients—proceed more rapidly. Hence fertility maintenance is a difficult task and the tropical legume has an important function to perform. There are few published data on the role of legumes in tropical pastures or on their nitrogen-fixing ability. In the wet belt of northern Queensland, the tropical legumes centro (*Centrosema pubescens* Benth.), stylo (*Stylosanthes gracilis* H.B.K.) and puero (*Pueraria phaseoloides* Benth.) have been recommended for use in improved pastures for cattle fattening for some 20 years. Although increased productivity has been widespread on these mixed pastures, there has been no publication of data relating to their long-term effects on soil fertility, though Schofield (1945) described an experiment using perennial tropical legumes as green manures after they had made 18 months' growth.

The present paper covers an investigation of soils under grazed guinea grass (*Panicum maximum* var. *typica*) and guinea grass/centro pastures of various ages. Comparisons of these soils with each other and with a soil under tropical rain-forest are reported.

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TABLE 1

CHEMICAL ANALYSES OF SOILS UNDER PURE GRASS AND GRASS/LEGUME PASTURES

Composition	Age (Years)	N (%)		C (%)		pH	
		0–3 in.	3–6 in.	0–3 in.	3–6 in.	0–3 in.	3–6 in.
A. Guinea grass	22	0·301	0·222	3·23	2·24	5·88	5·66
B. Guinea grass	16	0·306	0·238	3·66	2·73	5·78	5·56
C. Guinea grass/centro ..	16	0·406	0·286	4·40	3·14	5·92	5·72
D. Guinea grass/centro ..	11	0·432	0·308	4·58	3·01	6·06	5·92
E. Guinea grass	8	0·338	0·235	3·97	2·55	6·06	5·84
F. Rain-forest	—	0·423	0·327	4·66	3·60	5·60	5·50
Necessary differences for significance	5%	0·031	0·020	0·42	0·37	0·17	0·18
	1%	0·042	0·028	0·57	0·50	0·24	0·25
		C, D, F ≫ A, B, E E > A, B	D > C ≫ A, B, E F ≫ A, B, C, E	C, D, F ≫ B > A D, F ≫ E ≫ A C > E	C ≫ A, E F ≫ A, B, D, E D ≫ A D > E F > C > B > A	A, C — E ≫ F D, E ≫ B > F D, E > A	D ≫ A, B, F E ≫ B, F D > C > F E > A

The pastures are located at the Utchee Creek Sub-station of the Tropical Agriculture Research Station, South Johnstone. The latitude is 17½°S. and the average annual rainfall is 120 in., approximately 70 per cent. of which falls in the first four months of the year. The soil is a red loam similar to that described by Teakle (1950) as being found in areas of high rainfall and under rain-forest cover.

At Utchee Creek there are a number of 4-ac pasture paddocks of various ages. Those used in this investigation were:—16-year-old guinea grass/centro; 11-year-old guinea grass/centro; 8-year-old guinea grass; 16-year-old guinea grass; and 22-year-old guinea grass. All are unfertilized and are regularly grazed.

It is difficult to say whether or not the amount of grazing has been the same in each paddock, but none has had preferential treatment in any way. The legume in the grass/legume paddocks has been established over the entire period and is now evenly distributed through the pasture. Attempts were made to introduce legumes into the other paddocks but these were not successful, the legumes either not establishing well or persisting for only a few years at the most. Only an occasional leguminous plant may be found in these pastures. The whole area was originally under tropical rain-forest and the cleared areas are still surrounded on some sides by the virgin forest. The area of rain-forest sampled in this investigation was a strip running between two cleared blocks and centrally placed with respect to the experimental paddocks described above.

Each area was sampled at 20 sites, each site being sampled at two depths (0-3 in. and 3-6 in.). The 20 samples for each depth were bulked in groups of four to give five composite samples per paddock. In every case the soil surface was cleared of leaves, twigs, etc., before the sample was taken. The soils were examined for pH using a 1:2·5 suspension in water; for total nitrogen using a Kjeldahl method with copper catalyst; and for organic carbon using the method of Walkley (1947). Results (mean of five samples) are given in Table 1 and are shown graphically in Figures 1 and 2.

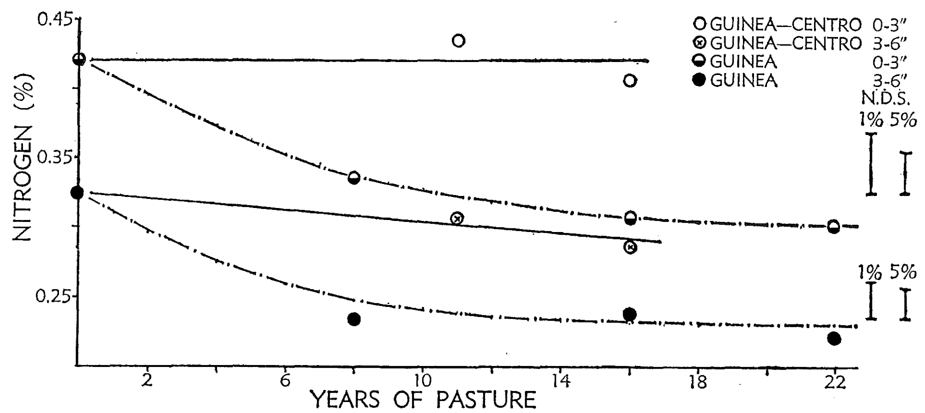

Fig. 1.—Changes in total soil nitrogen with years under pasture.

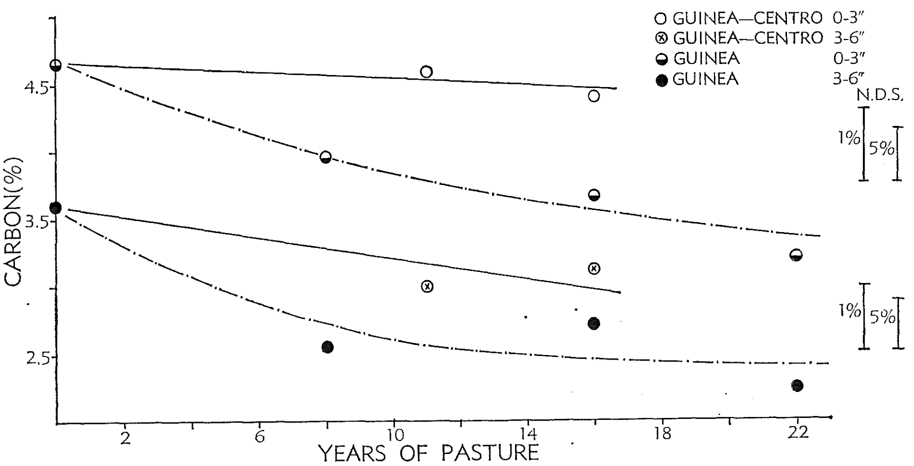

Fig. 2.—Changes in organic carbon in the soil with years under pasture.

The total nitrogen results are clear-cut. In the surface 3 in. of soil there are no differences between rain-forest and mixed pastures, while all three are higher (1 per cent. level, between sites) than the pure grass pastures. The 8-year-old pure guinea grass pasture is higher (5 per cent. level) than the 16 and 22-year-old pure guinea pastures. In the next 3 in., rain-forest is not different from the 11-year-old mixed pasture but is higher (5 per cent. level) than the 16-year-old mixed pasture. There are no differences between the pure guinea grass pastures but all are significantly lower (1 per cent. level) than the rain-forest and mixed pastures.

Organic carbon results show similar trends. There are no differences between rain-forest and mixed pastures in the surface 3 in. and all are higher (5 per cent. level at least) than the three pure grass pastures. In the next 3 in. the rain-forest is higher than both mixed pastures (5 per cent. level) but the mixed pastures are not different. Rain-forest and mixed pastures are all greater than the pure grass pastures (5 per cent. level at least). There are no marked effects on the C:N ratio of the soils.

The pH of the surface 3 in. for all pastures was higher (5 per cent. level) than that of the rain-forest. All but one—the 16-year-old pure grass—were higher at the 1 per cent. level of significance. In the 3–6-in. depth all had a higher value than the rain-forest but only three gained significance.

The two 16-year-old pastures—one of guinea grass/centro, the other of pure guinea grass—are situated side by side. The difference in nitrogen content of the soils may reasonably be attributed to nitrogen fixation by the legume, regardless of how this was achieved. Differential leaching and denitrification are unlikely to be significant. Assuming that an acre 6-in. of soil weighs 2 x 10^6

lb, the difference in total soil nitrogen under the two pastures amounts to 1480 lb nitrogen in the surface 6 in. Over 16 years this represents an average annual contribution of 92 lb nitrogen to an acre 6-in. of soil. Considering the vigorous growth made by guinea grass through the year, it appears that centro is efficient in fixing nitrogen and is comparable with, if not better than, temperate species of legumes.

Bryan (1961) drew attention to the lack of data on nitrogen production by tropical legumes. After reviewing the literature, he suggested that there seems reason to expect that under good management practices, and with suitable species, results can be obtained in low latitudes which are comparable with those obtained in temperate climates with temperate species. Working in the rain-forest region of Nigeria, Moore (1962) reported an average total soil nitrogen increase of 250 lb nitrogen per acre-foot per year under a grazed giant star grass (*Cynodon plectostachyum*)/centro pasture over a period of 2¼ years. This is of the same order of magnitude as values reported for nitrogen fixation by temperate legumes. There were also significant increases in organic matter. Changes in both nitrogen and organic matter were most marked in the surface 4 in. of soil.

Most work that has been published is concerned with comparatively young pastures, under five years old. Gethin Jones (1942) in Kenya reported changes in soil under an older ungrazed pure legume stand. He found average annual increases of 130 lb per acre 9-in. in soil nitrogen under *Glycine javanica* over a period of nine years.

Considering the present long-term results, it appears that grass/perennial legume pastures can play an important part in the humid tropics in maintaining soil nitrogen and organic matter levels on the better soils and in improving these levels on the poorer soils. Properly managed pastures should remain highly productive for long periods, provided other elements are not limiting.

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