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THE INFLUENCE OF ACACIA SENEGAL ON THE FERTILITY OF A SAND SHEET ('GOZ') SOIL IN THE CENTRAL SUDAN *

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SUMMARY

Acacia senegal increased total nitrogen and organic carbon while it had no effect on the soil texture, pH, available phosphorus and available potassium of a Sand Sheet soil. The higher nitrogen content in the topsoil may have been partly caused by symbiotic fixation. To minimise soil variability when conducting field trials in areas cleared from *A. senegal* trees the uprooted tree patches must be avoided in plot layout and liberal amounts of nitrogen fertiliser and farmyard manure must be applied over the whole trial area when possible.

INTRODUCTION

Shifting cultivation is practiced in the tropics under conditions of extensive agriculture as the principal means of restoring soil fertility. In the Sand Sheet soils (known locally as 'goz') of the *Acacia senegal* zone of the Sudan, 12–20 years of *A. senegal* fallow is followed by 3–10 years cropping period during which sorghum (*Sorghum vulgare*), penissetum (*Penissetum typhoides*), sesame (*Sesamum indicum*) and groundnuts (*Arachis hypogaea*) are grown. Preliminary field trials with sorghum conducted in 1962 in a soil cultivated for the first year after a 12-year fallow revealed that crop growth was strikingly

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better on the sites of the felled and uprooted *A. senegal* trees than at a distance from them [2].

This was the major source of soil variability and was hard to avoid due to the dense and irregular tree spacing. A precise explanation of this phenomenon would not only provide a means to lower the experimental error in future field trials but would also add to the understanding of the role of the *A. senegal* rotation in soil fertility restoration under the arid tropical conditions of the area. Nye and Greenland [5] have reported that shifting cultivation systems in the humid tropics are usually more dependent on phosphorus, potassium and calcium cycling than on nitrogen although dramatic changes in nitrogen content varying as the relative length of the fallow and cropping period changes have been observed. Booth [1] has mentioned the existence of nitrogen fixing bacteria in *A. senegal* in the Sudan.

As a first step towards the explanation of the problem, detailed soil sampling was carried out at, and around an uprooted *A. senegal* tree and the results of the analyses are presented in this paper.

PROCEDURE

This study was carried out at Umm Higlig Experiment Site, Kordofan Province, in December 1964. Composite soil samples were taken around a recently uprooted 12-year old *A. senegal* tree at radii of 0.25, 0.75, 1.25, 1.75, 2.25, 3.25, 4.25 and 5.25 m. The depths sampled were 0–0.20, 0.20–0.50, and 0.50–1.30 m corresponding to the three soil layers as distinguished by Huntings [3]. The maximum radius of 5.25 m coincided with the outer perimeter of the tree branches. For better comparison composite samples were also taken from a radius of 20.00 m. Each composite sample consisted of 20 sub-samples.

The determinations performed on the composite samples were mechanical analysis (pipette method), pH (with soil: water ratio 1:5), total nitrogen (macro-Kjeldahl) organic carbon (dry combustion by Fisher induction carbon apparatus) available phosphorus (extracted by 0.025 N HCl + 0.03 N NH_4F) and available potassium (extracted by 1 N NH_4Ac). Soil: extractant ratio and shaking time was for both phosphorus and potassium 1:8 and 1 minute respectively.

RESULTS AND DISCUSSION

The results are presented in Figures 1–6. Comparison of the clay content (Fig. 1) and pH values (Fig. 2) from samples taken from an increasing distance from the tree did not indicate any differences for any of the three soil layers. Similarly, no differences were evident for

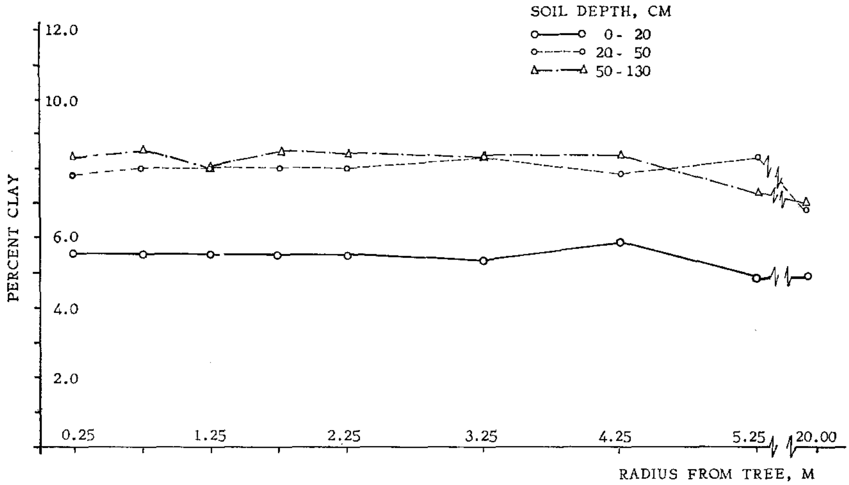

Fig. 1. The effect of *Acacia senegal* on the clay content of a Sand Sheet soil.

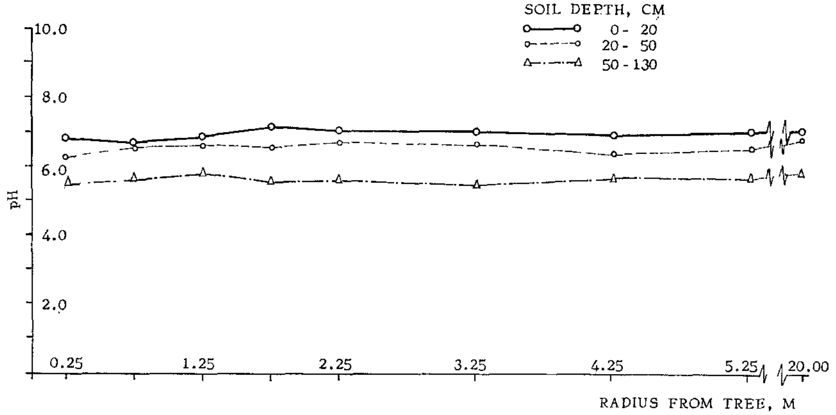

Fig. 2. The effect of *Acacia senegal* on the pH of a Sand Sheet soil.

available phosphorus (Fig. 3). Available potassium values did not differ for the second and third layers while for the first were slightly higher around the tree than away from it (Fig. 4). Total nitrogen was markedly higher around the tree and especially at the radius of 1.50–2.50 m for the first layer while for the second and third no appreciable differences were found (Fig. 5). Organic carbon was higher around the tree for all layers and particularly for the first (Fig. 6).

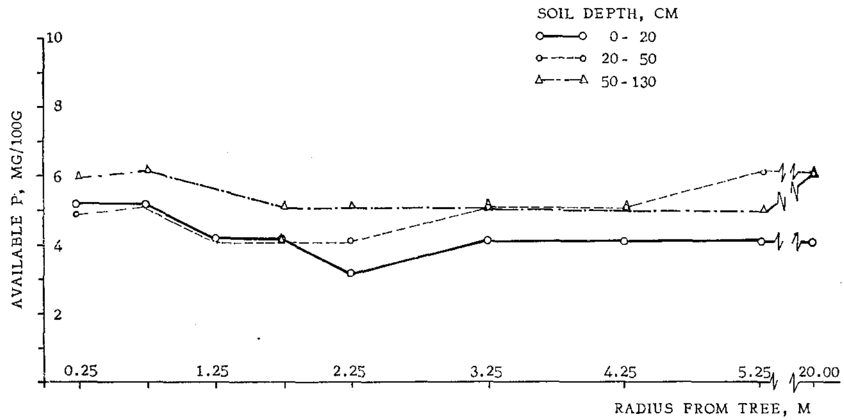

Fig. 3. The effect of *Acacia senegal* on the available phosphorus content of a Sand Sheet soil.

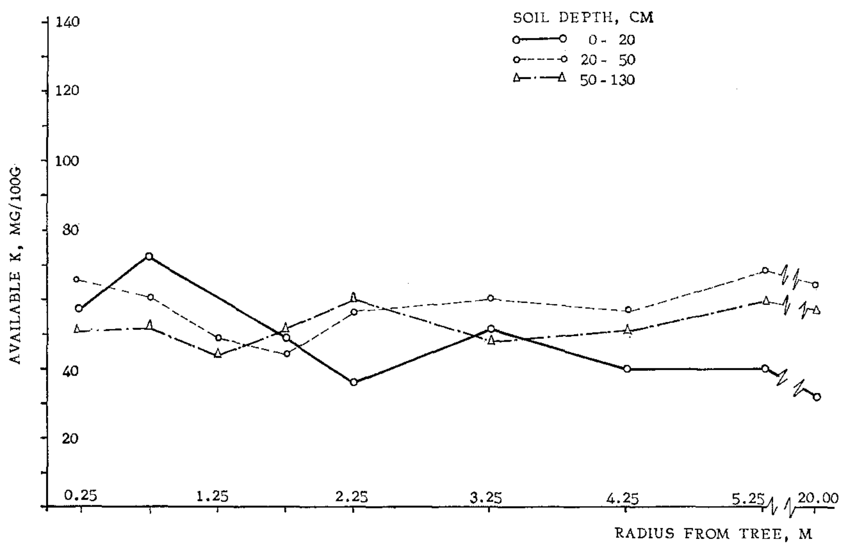

Fig. 4. The effect of *Acacia senegal* on the available potassium content of a Sand Sheet soil.

The higher content in organic carbon and nitrogen around the tree was probably the result of falling leaves, decaying tree roots and wind blown dry grasses and other plant debris accumulated around the tree during the dry seasons. It is probable that symbiotic

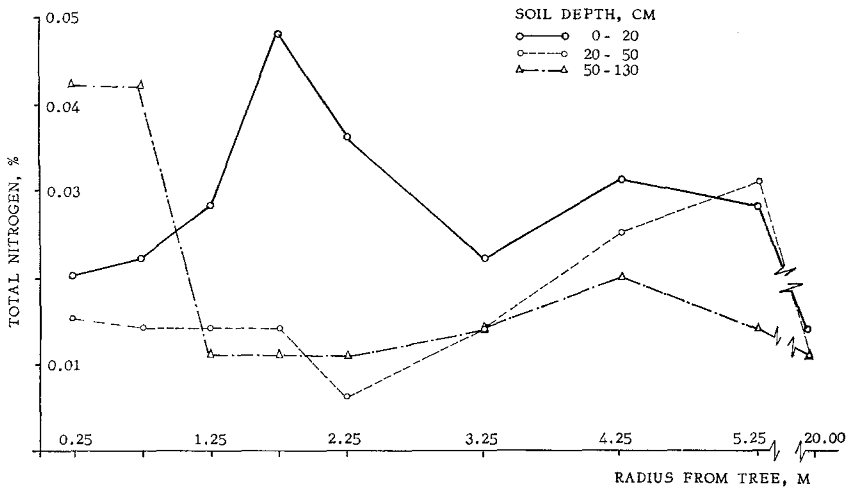

Fig. 5. The effect of *Acacia senegal* on the total nitrogen content of a Sand Sheet soil.

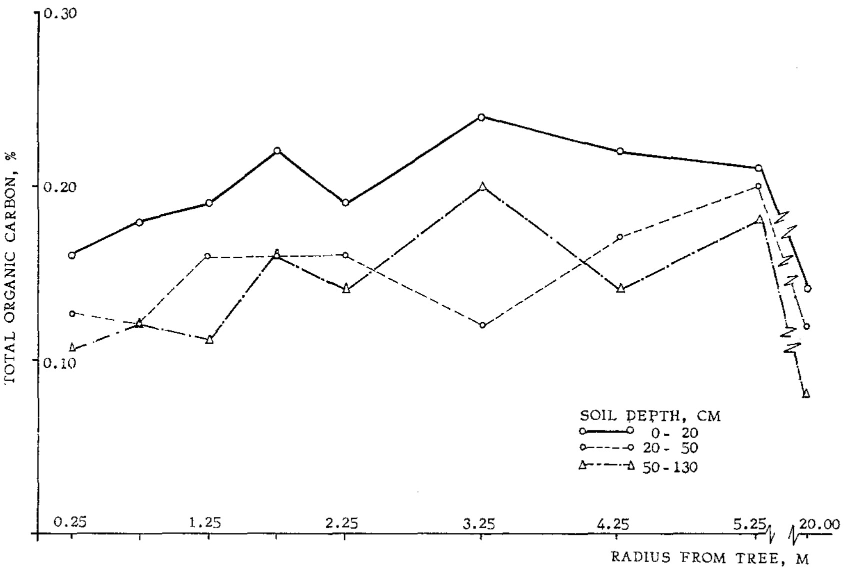

Fig. 6. The effect of *Acacia senegal* on the organic carbon content of a Sand Sheet soil.

nitrogen fixation in the leguminous *A. senegal* roots contributed to the nitrogen increase[1]. The fact that the difference pertained only to the first layer could be attributed to the acidity of the second and third layers. This may be supported by Mann [4] who reported inhibition of nitrogen fixation in groundnuts grown on acid soils.

The absence of any detectable difference in the response to drought between sorghum plants grown on uprooted tree patches and those at a further distance seems to exclude soil moisture as accounting even partly for sorghum growth differences. The small differences in potassium can hardly be a cause for the observed differential crop growth since in preliminary fertiliser trials sorghum did not respond to this nutrient [2].

To minimise soil variability in future fertiliser trials plots must not be laid out close to uprooted trees even if this will result in a very irregular layout. For trials not aiming at fertility investigations, *e.g.* variety trials, a liberal application of nitrogen fertiliser or farmyard manure may be sufficient. Growing a uniform and very dense crop of sorghum for 2–3 years prior to any trials may also be helpful.

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