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SOIL FERTILITY REGENERATION USING SOME FALLOW LEGUMES

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ABSTRACT
A field experiment was conducted at the Eastern farm of Michael Okpara University of Agriculture, Umudike. The aim to determine the effects of some *Centrosema* species: *Centrosema brasilianum*, *Centresoma pascuorum*, *Centrosema pubescens* and natural fallow (as control) on available soil organic carbon, organic matter, total nitrogen and available phosphorus. The experiment was laid out in a randomized complete block design with three replications and terminated 14 weeks after planting. Results indicate that the *Centrosema* species showed significantly ($p<0.05$) higher percentage increase in organic carbon and organic matter compared to the natural fallow. However, *Centresoma pascuorum* gave highest significant values of organic carbon (0.98±0.01%), organic matter (1.69±0.01%), total nitrogen (0.11±0.00%) and phosphorus (11.60±0.31mg/kg). Plant total nitrogen varied among species with *Centrosema brasilianum* giving highest significant value of (2.82%). This study indicates that among the legumes studied, *Centresoma pascuorum* was superior and should be used to enhance soil fertility.

KEYWORDS: *Centrosema* species, nutrients availability, natural fallow, organic

INTRODUCTION

Soil is said to be fertile if the nutrients required by plants are adequately supplied (Lai, 2000). The soil is traditionally regenerated by fallow cycle where natural vegetation is allowed to grow for several years before the land is cleared and cropped. However, when land becomes limited and fallow periods are shortened, so much that adequate nutrients levels are not restored, the system deteriorates resulting to soil degradation (Padwick, 1983).

With increase in population, demand for land increases resulting to intensive cultivation of available land with little or no fallow (Lal, 2000).This reduces soil fertility, destroys soil organic matter, increases soil acidification and accelerates desertification (Stockwell and Fisher, 1996). Deforestation to make land available for farming adds to the problem by causing erosion which not only removes the top soil but hinders crop emergence and growth as a result of nutrient loss (Muhamman and Gungula, 2006).

In view of all theses constraints, strategies that improve soil condition, suppress weed and increase yield per unit area have to be employed. Although efficient use of nitrogen fertilizers is a quick and more reliable way of boosting crop production, it is realized that many farmers cannot afford to use fertilizers because of their unavailability at the right time and at a reasonable price (Polycarp *et al*., 2003). However, environmentally friendly systems based on the use of nitrogen fixing plants have been reported to bring about favourable changes in the soil. The enhancement of the natural vegetation by deliberate planting of fast growing nitrogen fixing plants is an attractive approach for shortening the fallow period (MacDicken, 1990). Legumes have various effects on soil nutrients availability. They fix atmospheric nitrogen and may amend soils and crops with nitrogen. When used as cover crops, erosion risk, soil nutrient and organic matter losses can be decreased thereby improving soil structure.

The objective of this study is to determine in the short term, the effects of some *Centrosema* species on soil nutrient availability.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Eastern Farm of Micheal Okpara University of Agriculture, Umudike, Nigeria. The site is located at latitude 05^0 29^1 N and longitude 07^0 33^1 E. Its altitude is approximately 122 m above sea level. The minimum and maximum daily temperatures fall within the range of 20^0- 26^0C and 27^0– 36^0C respectively. Its relative humidity is between 57-91%. It is found in the rainforest zone and the environment is characterized by annual rainfall of 2177mm.

Seed treatment

The seeds consisted of seeds of *Centrosema brasilianum*, *Centrosema pascuorum* and *Centrosema pubescens*. Two grams of the seeds of each *Centrosema* species were collected from International Institute for Tropical Agriculture, Ibadan, Nigeria. Treatment consisted of immersing the seeds in boiling water for 3 minutes before sowing to speed up germination.

Land preparation

The land was prepared by ploughing done by a tractor. The treated seeds of *Centrosema brasilianum*, *Centrosema pascuorum* and *Centrosema pubescens* were sown, drilled in the cultivated seed bed at a planting distance of 50cm in row. Weeds were continuously checked at the early stage of growth by slashing.

Experimental design

The experiment consisted of the seeds of three species of *Centrosema*: *Centrosema brasilianum*, *Centrosema pascuorum* and *Centrosema pubescens* and natural fallow (without *Centrosema*). The experiment was laid out in a randomized complete block design (RCBD) and replicated three times in a plot size of 23m x12m. The experiment lasted for 14 weeks.

Soil collection and Analyses

Soil samples were collected from the experimental site before and after the experiment. Before planting, soil samples were collected from different spots at 0-15cm depth and bulked together. After the experiment, soil samples were collected from the 4 plots containing three *Centrosema* species: *Centrosema brasilianum*, *Centrosema pascuorum* and *Centrosema pubescens* and natural fallow also at depth of 0-15cm using a soil auger. The samples were properly labeled and packed into polythene bags. The soil samples were air dried at room temperature, crushed, sieved with a 2mm sieve and taken to the laboratory for characterization of some physical and chemical properties (particle size distribution, pH, organic carbon, organic matter, total nitrogen and phosphorus).

Soil analysis

Parameters tested were particle size distribution pH, organic carbon, organic matter, total nitrogen and phosphorus. The particle size distribution was determined by methods of Gee and Bauder (1986) using sodium hetameta phosphate as dispersing agent. Soil pH was measured in water using glass electrode pH meter at a soil-liquid ratio of 1.2.5 (Thomas, 1996), organic carbon was determined by wet oxidation of Walkley and Black as modified by Nelson and Sommers (1996) while organic matter was estimated from organic carbon using a factor of 1.729. Total soil nitrogen was determined by a semi micro-kjeldahl digestion and titration after distillation into boric acid (Bremner1996) and available phosphorus by Bray-p-2 method of Bray and Kurtz (1945).

Plant Sampling and Analysis

The entire plant of each of the three species of *Centrosema* was collected from the experimental site. The plants were oven dried at temperature of 55^0C, milled and packed into envelopes. The total nitrogen of each plant was determined by semi micro-kjeldahl procedure (Bremner, 1996)

Data analysis
All data collected were subjected to analysis of variance using SPSS (2004). Significant means were separated using Duncan's New Multiple Range Test (DNMRT).

RESULTS AND DISCUSSION

Initial Soil Sample
Table1 gives the details of soil characteristics prior to planting of *Centrosema* species. Based on the result, the soil is acidic in nature (4.66)

Table 1: Physical and chemical properties of soil prior to planting

Parameters	Sand (%)	Silt (%)	Clay (%)	pH (%)	Organic carbon (%)	Organic matter (%)	Total nitrogen (%)	P (mg/k)
Value	77.1	11.7	11.2	4.66	0.76	1.311	0.07	4.00

Textural Class: Sandy loam
The fertility level is low as indicated by the following chemical characteristics organic carbon (0.76%), organic matter (1.31%), total nitrogen (0.07%) and available phosphorus was also low (4.00 mg/kg) compared to critical range of 7.0 – 20.0mg/kg (Sobulo and Adepetu, 1987).

Effect of legumes studied on some chemical properties of soil as compared with natural bush fallow

Table 2 shows the effects of *Centrosema* species on some chemical properties of soil as compared with natural bush fallow. Organic carbon and organic matter content improved considerably over time compared to natural fallow. Kone *et al.,* (2007) studying the impact of farming system on soil status using legumes such as *Mucuna pruriens, Pueraria phaseoloides, Lablab purpureus* and maize reported that soil organic carbon increased over time under all legume based system. Organic matter and organic carbon contents were significantly ($p<0.05$) higher in *Centrosema* plots than the natural fallow.

However, *C. pascuorum* showed highest significant increase of 0.98% and 1.69% in organic carbon and organic matter respectively. Tian *et al*. (2001) and Dinesh *et al*. (2004) reported that legumes continuously provide great amounts of litter to the soil. This may explain the increase in soil organic carbon and organic matter in all plots containing *Centrosema* species over the natural fallow. However, *Centrosema pascuorum* gave higher significant value of 0.11% whereas there was no significant difference between C. *brasilianum, C. pubescens* and natural fallow. Henzel and Vallis (1977) reported that a predictable consequence of the variable nitrogen concentration of different legume residues is that they will contribute varying amount of nitrogen to the soil.

Table 2: Effects of legumes studied on some chemical properties of soil as compared with natural fallow.

	Means			
Parameter	*Centrosema basilianum*	*Centrosema pascuorum*	*Centrosema pubescens*	Natural fallow
pH	4.70± 0.1	4.61±0.65	4.66±0.01	5.17±0.01
Organic matter (%)	1.40±0.01^{b}	1.69±0.01^{a}	1.40± 0.01^{b}	1.3±0.0^{c}
Organic carbon (%)	0.81±0.01^{b}	0.98±0.01^{a}	0.80±0.01^{b}	0.76±0.0^{c}
Total nitrogen (%)	0.07±0.01^{b}	0.11±0.00^{a}	0.06±0.00^{b}	0.07±0.00^{b}
Available Phosphorus (mg/kg)	3.50±0.01^{c}	11.60±0.31^{a}	4.00±0.01^{c}	8.00±0.01^{b}

$^{a-c}$ Means in the same row with different superscripts are significantly different ($p< 0.05$)

This difference in nitrogen concentration among legumes may be attributed to nitrogen mineralization from litter decomposition. This may have been affected by nitrogen fixation in these legumes resulting in lower proportion of fixed nitrogen but significantly higher amount of fixed nitrogen in *C. pascourum* plot. Gathumbi *et al*., (2004) observed higher soil nitrogen levels in fallows improved with legumes than natural bush fallow.

Lelei *et al*. (2009) observed that natural bush fixed low amounts of nitrogen in comparison to improved fallow legumes. Lelei *et al*. (2009) also comparing legumes versus natural fallow observed that soil available nitrogen content was significantly higher ($p<0.05$) after legumes compared to natural fallow. This may be attributed to superior mineralization of incorporated nitrogen rich legume residues.

Phosphorus also showed significant variation among the plots. Nonetheless *Centrosema pascuorum* gave significant higher increase of 11.60mg/kg phosphorus and exceeded the critical level of 7.0 mg/kg (Sobulo and Adepetu, 1987).Lelei *et al*. (2009) while comparing total nitrogen and phosphorus contents of *Crotalaria*, *Lablab* and Garden pea with natural bush fallow observed that total nitrogen and phosphorus contents of *Crotalaria,Lablab* and Garden pea were significantly higher than natural bush. Gathumbi *et al*. (2004) also reported that *Crotalaria* fallow recorded greatest total nitrogen and phosphorus yield due to fast establishment and higher total biomass production.

There was no significant variation in pH; however, the *Centrosema* plots were more acidic than the natural bush fallow. This may be attributed to the fact that growth of legumes fixing nitrogen involves excess uptake of nutrient cations over anions from soil solution. Loss of symbiotically fixed nitrogen through leaching may contribute to acidification under legume plots. *Centrosema pascuorum* gave highest significant values of organic carbon, organic matter, total nitrogen and available phosphorus, indicating that it may have higher potential to improve soil nutrients over the other species and natural bush fallow. Therefore, should be used to enhance soil fertility.

Total Plant Nitrogen

Table 3 shows that plant total nitrogen varied among species. *Centrosema brasilianum* gave the highest significant percentage total plant nitrogen while *Centrosema pascuorum* gave the least. However this is expected because *Centrosema pascuorum* gave the highest amount of fixed soil total nitrogen (Table 2). The lower percentage soil total nitrogen observed with *C. brasilianum* and *C. pubescens* plots (Table 2) is believed to be due to the higher amount of nitrogen held in their vegetation. As a result of nitrogen fixation, Legumes have nitrogen rich foliage MackDicken (1989). Although legumes, such as *Centrosema* species fix nitrogen biologically below the ground, it is their leaves that are more valued by farmers as source of nitrogen and other plant nutrients Mensah *et al*. (2007).

Table 3: Total Plant Nitrogen

Centrosema species	Total plant nitrogen (%)
Centrosema brasilianum	2.82 ± 0.14^{a}
Centrosema pascuorum	$2.24\pm0.0l^{c}$
Centrosema pubescens	2.53 ± 0.02^{b}

[a -c] Means in the same row with different superscripts are significantly different ($p<0.05$).

CONCLUSION AND RECOMMENDATION

The study confirmed that the presence of *Centrosema* species made more impact in enhancing soil nutrient status. They enriched soil with nitrogen, organic matter, organic carbon and phosphorus. *Centrosema pascuorum* undoubtedly impacted highest significant increase of nutrient elements in soil compared to other *Centrosema* species and natural bush fallow

studied. The improvement in soil chemical properties produced by natural fallow could be produced by CPA fallow in a much shorter time under proper management. Therefore, the integration of *Centrosema* species such as *C. pascuorum* in our farming system will contribute to improve soil quality that will lead to sustainable agriculture in Nigeria.

RECOMMENDATION

Centrosema pascuorum is therefore recommended for the improvement of soil nutrient. The role of extension in demonstrating the benefits of legumes in soil nutrient enhancement and occasional workshops at village level will definitely make this system an attractive alternative for farmers and decision makers in Nigeria.

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