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Growth and yield response of cowpea (*Vigna unguiculata* L. Walp.) to soils from different fallow physiognomies in the rainforest zone of Nigeria

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A study was conducted to evaluate the response of cowpea (*Vigna unguiculata*) seedlings to soil collected from four fallows of different physiognomy. Seedlings of cowpea were grown from seeds on soil samples collected from the four different fallow statuses (*Panicum maximum*-dominated fallow soil, *Chromolaena odorata*-dominated fallow soil, *Tithonia spp.*-dominated fallow soil and bush fallow soil that contains many herbaceous plant species) in plastic containers each having fifteen replicates. Among the growth characteristics assessed the number of nodules and stem dry weight being the most influenced. *Panicum maximum*-dominated fallow soil with greater organic matter content produced the most desirable growth characteristics during the growing period and at harvest. The results were used to deduce the best type of fallow soil for cowpea cultivation.

Key words: Growth, yield, fallow soil, *Vigna unguiculata*, physiognomy, rainforest, Nigeria

Introduction

Cowpea (*Vigna unguiculata* L. Walp.) is a legume grown under rain-fed conditions in the tropics (SANGAKKARA 1998). Although it occupies a smaller proportion of the crop area than cereals, it contributes significantly to household food security in West and Central Africa. Compared with many other crops, the cowpea has received little attention from plant breeders and a large efforts need to be made to break the yield barriers. If cowpea production is to keep pace with other crops, especially cereals, its yield potential must be improved.

In Nigeria, 80% of the cowpea production is mainly from the savanna zone of the country (FAO 1999). A wide range of seed yields have been recorded for cowpeas but they are generally low. Among the factors responsible for the low yields are low soil fertility, as most tropical soils are deficient in essential nutrients particularly nitrogen and phosphorus (JONES and WILD 1975). Traditionally, soil fertility in West Africa has been maintained

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through fallow. In Nigeria intensive cropping is gradually replacing the traditional shifting cultivation that is associated with long fallow and low crop yields are among the results of this practice. The steady decline in food production due to reduced length of fallow on land has prompted farmers to improve soils with different materials (organic and inorganic) in order to enhance plant growth and increase yield.

There is limited documentation on the effect of status of soil of different fallow physiognomies on cowpea growth and yield in Nigeria. Such information would be useful and important in agricultural extension delivery to farmers for increased crop productivity and poverty alleviation. An attempt to find out the growth and yield responses of cowpea to soils from different fallow status in the rainforest zone inform this study. Since fallows not only improve subsequent crop performance but also restore soil fertility and organic matter content over the long term, this experiment seeks to evaluate the effects of four fallow soils of different physiognomies on the growth characteristics and yield of the cowpea (*Vigna unguiculata* var. IFE BROWN) in the Ile-Ife area of southwestern Nigeria.

Materials and methods

Four fallow plots of different physiognomies were selected within the same area at Obafemi Awolowo University, Ile-Ife, southwestern Nigeria. These sites had to be in close proximity to one another to satisfy the conditions of the chronosequence approach of the study. Topsoil from the four fallow plots of different physiognomies (a *Panicum maximum* -dominated fallow plot, a *Chromolaena odorata* -dominated fallow plot, a fallow plot that contains many herbaceous plant species (mixed) and a *Tithonia spp* -dominated fallow plot) that are common in Ile-Ife area of southwestern Nigeria were collected. The soil was air dried and loosened before being put in 20cm wide plastic containers with holes at the bottom to facilitate effective drainage.

The four soil types were analyzed for pH; particle size distribution, organic matter content, sodium, potassium, calcium, magnesium and nitrogen contents. The soil particle size distribution was determined by Bouyoucos hydrometer and the pH electrometrically. Organic matter was determined by the chromic acid digestion method (BLACK 1965), the exchangeable cations and nitrogen by the semi-micro Kjeldahl method (TEL and RAO 1982).

Pure lines of cowpea seeds (Ife brown variety) were collected from the International Institute for Tropical Agriculture (I.I.T.A) Ibadan. The seeds were planted in each soil type in May 2008 and seedlings were established in each soil type at densities of 1, 2, and 3 per 5 litre pot. Each density had fifteen replicates, watering was with tap water every two days in the morning and in the evening to field capacity to give the best soil moistures regime for growth, thus there was no competition for water.

When the seedlings were nursed to full and equal establishment in the pots, measurement of some growth parameters such as leaf length, leaf breadth, leaf area, leaf number, shoot height were taken weekly. At harvest in August 2008 ten weeks after planting, the plants were removed and seedling mean dry matter yield (leaves, stems, roots, total), pod numbers and nodule numbers were measured after oven drying at 80 °C. The effects of soils from different fallow on the seedlings growth characteristics were determined using analysis of variance (ANOVA) with the aid of the software SAS Release 8.1. Significant means were separated by Duncan's multiple range test at the 5% probability level.

Results

Physical and chemical properties of soil

A chemical and mechanical analysis of the soils prior to cropping with cowpea is shown in table 1. The *Panicum maximum* -dominated fallow soil was found to have higher organic matter, organic carbon, pH and greater percentage of exchangeable cations than other fallow soils. The *Tithonia spp* -dominated fallow soil had higher nitrogen and phosphorus content, while *Chromolaena odorata* -dominated fallow soil had intermediate values for most of the soil properties determined.

Growth characteristics

The cowpea seedlings in *Panicum maximum* -dominated fallow soil had better growth characteristics such as greener leaves, higher number of leaves, bigger leaves, bigger stems, leaf area, shoot height and greater canopy than seedlings from other fallow soils. The cowpea seedlings growing in the *Chromolaena odorata* -dominated fallow soil were observed to have the slowest growth rate, the smallest number of leaves, the lowest leaf area, shoot height and the least canopy while the seedlings from the other two fallow soils had intermediate values (Figs. 1, 2, 3). The analysis of variance for the seedling growth parameters that were measured during the growing period revealed that the soils from the different fallows had a significant influence on leaf area ($p<0.05$).

Vigna unguiculata seedlings had the highest mean stem dry weight per plant in *Panicum maximum* -dominated fallow soil, the lowest in *Chromolaena odorata* -dominated fallow soil and intermediate values in the other two fallow soils (Tab. 2). The fallow soil types significantly affected the mean stem dry weight ($P \leq 0.05$). *Vigna unguiculata* seedlings had the highest mean root dry weight in mixed fallow soil, the least in *Chromolaena odorata* -dominated fallow soil and intermediate values in *Panicum maximum* and *Tithonia spp* fallow soils. The fallow soil types had no significant effects on the mean root dry weight.*Vigna unguiculata* seedlings had the highest mean leaf dry weight in *Panicum maximum* -dominated fallow soil, the least in *Chromolaena odorata* -dominated fallow soil and intermediate values in the other two fallow soils. The fallow soils had significant effects on the mean leaf dry weight ($p \leq 0.05$).

Vigna unguiculata seedlings had the highest mean dry weight of pods in *Tithonia spp* fallow soil, the lowest in *Chromolaena odorata* -dominated fallow soil and intermediate values in the other two fallow soils. The fallow soils had significant effects on the mean dry weight of pods ($p \leq 0.05$). *Vigna unguiculata* seedlings had the highest mean number of pods in *Panicum maximum* -dominated fallow soil, the lowest in *Chromolaena odorata* -dominated fallow soil and intermediate values in the other two fallow soils. The fallow soil types had significant effects on the mean number of pods ($p \leq 0.05$).

Vigna unguiculata seedlings had the highest mean total biomass in *Tithonia spp* fallow soil, the lowest in *Chromolaena odorata* fallow soil and intermediate values in *Panicum maximum* and mixed fallow soils. The fallow soil types had a significant effect on the mean total biomass ($p \leq 0.05$).*Vigna unguiculata* seedlings had the highest mean number of nodules in *Panicum maximum* -dominated fallow soil, the lowest in *Chomoleana odorata* -dominated fallow soil and intermediate values in the two other fallow soils. The fallow

Tab. 1. The chemical and mechanical analyses of the fallow soils prior to cropping with cowpea.

Fallow soil sample	% sand	% silt	% clay	% O.C	% O.M	Phosphorus mg kg^{-1}	% K	% Ca	% Na	Total N	PH	Electrical conductivity
Panicum	54	18	28	4.24	7.3	8.47	0.55	7.0	3.17	1.5	7.8 H_2O 7.5 $CaCI_2$	0.37
Chromokena	62	14	24	2.21	3.8	6.64	0.21	3.4	2.26	0.8	6.6 H_2O 6.2 $CaCI_2$	0.27
Mixed	36	26	38	3.66	6.3	7.13	1.03	6.2	3.04	1.3	6.9 H_2O 6.6 $CaCI_2$	0.55
Tithonia	72	14	14	2.04	3.5	9.86	0.36	5.1	2.48	2.48	8.1 H_2O 7.6 $CaCI_2$	0.30

Tab. 2. Some growth characteristics and yield of seedlings of the cowpea (*Vigna unguiculata*) grown in the four different fallow soil types at harvest.

Fallow soil types	Stem dry weight	Root dry weight	Leaf dry weight	Pod dry weight	Pod number	Total dry weight	No of Root nodules	Leaf number	Leaf area
Panicum dominated	1.41a	0.70ab	3.95a	2.81b	4.62a	8.26ab	15.24a	24.01a	35.49a
Tithonia dominated	1.31a	0.81ab	3.52b	3.67a	4.17ab	9.31a	15.12a	16.86b	31.85a
Chromolaena dominated	0.62b	0.59b	1.30c	1.48c	2.92b	4.04c	10.33b	17.23b	23.75b
Mixed	1.00c	1.10a	2.53b	2.13bc	3.51ab	6.77b	12.37b	18.47b	28.83ab

Mean within the same column and with the same letter are not significantly different according to DMRT

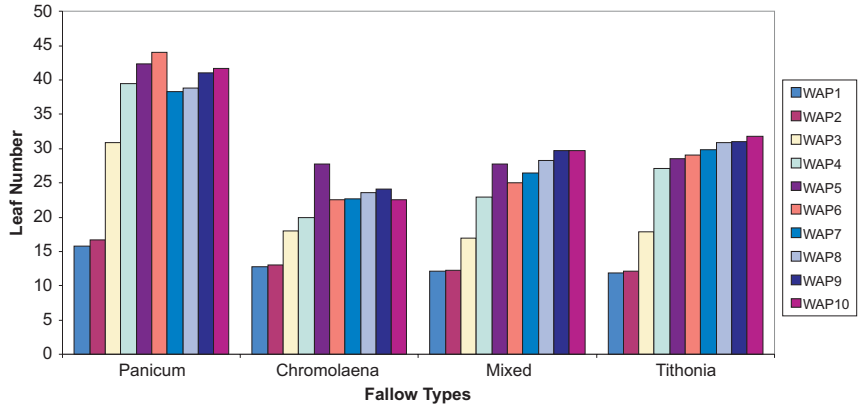

Fig. 1. Response of cowpea leaf number to various fallow soil types (WAP1–WAP10) during the growing period

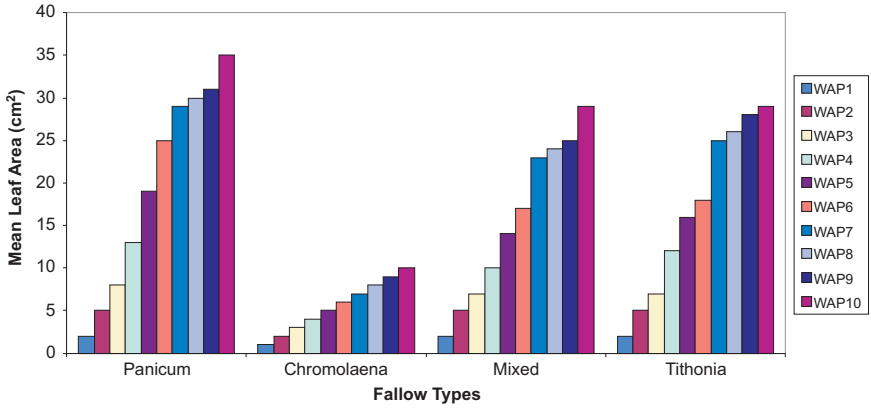

Fig. 2. Response of cowpea leaf area to various fallow soil types (WAP1–WAP10) during the growing period.

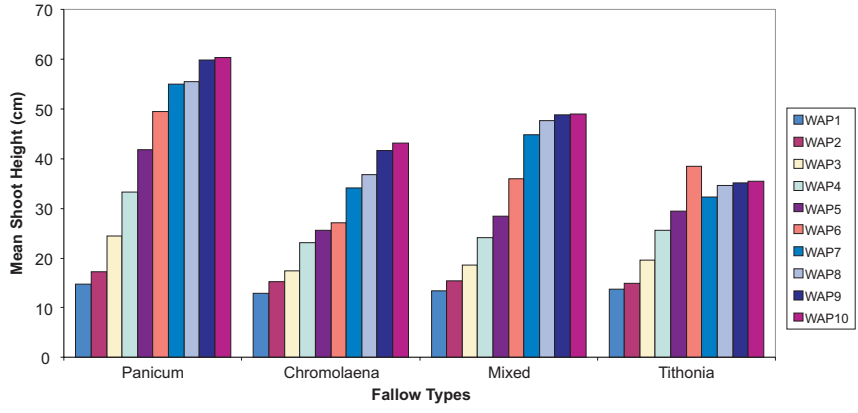

Fig. 3. Response of cowpea shoot height to various fallow soil types (WAP1–WAP10) during the growing period.

soil type had significant effects on the mean number of nodules ($p \leq 0.05$). *Vigna unguiculata* seedlings had the highest mean number of leaves in *Panicum maximum* fallow soil, the lowest in *Chromolaena odorata* fallow soil and intermediate values in mixed and *Tithonia spp.* fallow soils. The fallow soil types had significant effects on the mean number of leaves ($p \leq 0.05$).

Discussion

The study set out to highlight the response of the growth characteristics of cowpea (*Vigna unguiculata*) seedlings to soils from different fallow physiognomy. The analysis carried out on the performance of cowpea in relation to number of leaves, shoot height, leaf area and total biomass at harvest, showed a significantly higher value in *Panicum maximum* -dominated fallow soil than in the other fallow soils. The result showed clearly that fallow soil types are important factors in the cultivation of the cowpea.

The rapid growth rate observed in *Panicum maximum* fallow soil may be due to its richness in organic matter content, organic carbon content and in exchangeable cations. The binding influence of *Panicum maximum* roots on the soil is considered to be responsible for the ability of the grass to effectively check erosion (AMUSAN and OKE 2000). As a result the enriched soil will be able to retain its nutrients due to its better ability to check soil erosion. Enriched soils through proper management of organic amendments such as crop residues and manure can increase the yield of cowpea. Cowpea seedlings (*Vigna unguiculata)* growing in *Panicum maximum* -dominated fallow soil were observed to have the highest number of leaves and leaf area and so when considering growing cowpea as a fodder or vegetable, *Panicum maximum* fallow soil is highly recommended.

Comparison of the biomass of different parts of cowpea seedlings indicated that leaves had the highest yield. This could be attributable to the fact that the leaf is the site of food manufacture through photosynthesis and hence is expected to have a greater biomass accumulation compared to the stem and root. HEUVELINK (1995) while monitoring the growth, development and yield of a tomato crop found that in all experiments the ratio between leaf and stem dry weight was 7:3 and that this ratio did not change with crop development. The highest yield of pod biomass obtained at harvest in the *Tithonia spp* -dominated fallow soil which was due to its high phosphorus content and is in agreement with the observations of ISRAEL (1987) that cowpea has a high phosphorus requirement. The highest number of pods produced was observed in the *Panicum maximum* fallow soil because it had the highest number of root nodules which can fix atmosphere nitrogen and hence contribute significantly, towards the nitrogen nutrition of cowpea. Similar results were obtained by AWONAIKE (1991).

In this study, it was observed that soils from different fallows had significant effects on the leaf number, leaf area, shoot height, pod number, stem dry weight, leaf dry weight, root dry weight and pod dry weight of cowpea. It was interesting to note that *Panicum maximum* fallow soil had the best growth characteristics and highest yield of biomass. There were significant lower values for almost all the growth parameters examined in *Chromolaena odorata* -dominated fallow soil. It is often suggested that, as a short fallow species, *Chromolaena odorata* has serious adverse effects on agricultural productivity and on the weed composition and subsequent food crops (MCFAYDEN and SKARRATT 1996).

In conclusion, we suggest that farmers who are interested in cultivating cowpea, fallow lands dominated by *Chromolaena odorata* should as much as possible be avoided, as cowpea growth is adversely affected on such fallow soil, while fallow lands dominated by *Panicum maximum* is highly recommended for farmers who are interested in vegetative growth as such fallow soils tend to have greater organic matter content, organic carbon content and exchangeable cations, which favour cowpea (*Vigna unguiculata*) seedling growth. Farmers who are interested in yield of pods are recommended to grow their cowpea in Tithonia spp -dominated fallow soil.

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