FUDMA Journal of Agriculture and Agricultural Technology
ISSN: 2504-9496
Vol. 10 No. 4, December 2024: Pp.21-28

https://doi.org/10.33003/jaat.2024.1004.03.372

THE IMPACT OF ARBUSCULAR MYCORRHIZAS FUNGI (AMF), IDOLE-3-ACETIC (IAA), AND NPK ON SOIL CHEMICAL PROPERTIES AND GROWTH OF CASSAVA IN OKITIPUPA, SOUTHWEST, NIGERIA

[*1]Olojugba Michael Rotimi and [2]Kolawole Oluwaseun

[1&2] Department of Crop, Soil and Pest Management, Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria.

Corresponding Author: mr.olojugba@oaustech.edu.ng or michaelolojugba@gmail.com

ABSTRACT

Conventional agricultural practices mainly rely on agronomic measures and chemical inputs to improve nutrient use efficiency (NUE) which could lead to soil degradation and loss of biodiversity, with detrimental consequences for soil health and ecosystem functioning. This study aims to evaluate the impact of Indole-3-Acetic Acid (IAA), Arbuscular Mycorrhizal Fungi (AMF) as inoculants in combination with NPK doses on soil chemical properties and cassava yield in Okitipua between April to August 2014, Southwest Nigeria. There were five treatments namely, Arbuscular mycorrhizal Fungi, idole-3-acetic (1g), NPK 15:15:15 fertilizer (300kg/ha), Abuscular mycorrhizal Fungi + NPK. 15:15:15 fertilizer and control, the experimental design was Randomized Complete Block Design (RCBD). The results were subjected to statistical analysis using SPSS. AMF showed low impact on the soil from the experimental site. It has showed effect on few soil parameters (Soil pH, TOC, Na^+, Mg^{2+} and base saturation). The addition of NPK to the soil showed positive impact in some soil parameters such as TOC, Na^+, K^+, Ca^{2+}, Mg^{2+} and base saturation. The combination of NPK and AMF (NPK+AMF) has shown more impact in most soil parameters such as TOC, Na, Na^+, Ca^{2+}, Mg^{2+}, base saturation and Mn. NPK, AMF, and the combination of NPK, NPK + AMF have shown impact in the growth of cassava by increasing the height of the cassava plant. NPK, IAA, and NPK+AMF have shown impact in the leaves by the increase in the number of leaves. Only NPK, NPK + AMF had shown impact on the stem of the cassava by increasing the number of stems in all weeks after planting (WAP). The stem diameter shows significant increase from week 1 to week 6 with the help of the applications of NPK and NPK+AMF. This research gives information on the use and benefits of AMF, AMF + NPK in a appropriate proportion to grow cassava in Okitipupa and its environs. If properly managed, it is a promising step to reduce the total dependence on the mineral fertilizers for the growth of cassava in the study area.

Keywords: Arbuscular Mycorrhizal Fungi, Indole-3-acetic, NPK, Soil, Cassava

INTRODUCTION

Manihot species, the cassava plant, also called manioc or yucca, is a crop culture of great importance in Africa, Asia and South America. It is cultivated for its edible tuber roots and leaves, mainly in tropical regions, where it is the third calory source, after rice and corn. It is particularly resistant to drought and adapted to poor fertility soil, making it an excellent choice for marginal farmers that use *M. species* as subsistence agriculture. Moreover, it bears high yield harvests, and the development and application of optimal farming practices promises to increase the worldwide importance of *M. species* cultures and *M. esculenta* derived products (Wasnaire, 2022).

Arbuscular mycorrhizal fungi are soil micro-organism that are known to establish an association with the roots of more than 80% of land plants, including numerous important crop species including *M. esculenta*. This association has been extensively studied and demonstrated to promote plant nutrition and growth, as the fungal symbiont provides its host plant with water and mineral nutrients such as nitrogen, phosphate, potassium. In exchange, the plants transfer a significant part of its photosynthetically reduced carbon to the symbiont under the form of sugars. In addition, this association has been shown to enhance tolerance against biotic and abiotic stresses (Wasnaire, 2022).

M. species culture, however, is constantly threatened by viral diseases, such as the cassava mosaic disease, caused by viruses from the Begomovirus genus, which includes the African Cassava Mosaic Virus. The cassava mosaic disease induces a stunted growth and highly reduces the development of tuber roots in infected plants, which lead to highly reduced yields and huge economic losses (Wasnaire, 2022).

Soil is the most diverse and complex habitat that consists of millions of fungi, billions of bacteria and other macro-organisms (Bardgett and Van Der Putten, 2014). Microorganisms present in soil play important roles in nutrient cycling and shielding plants from harmful effects of abiotic and biotic stresses (Ahmad *et al.*, 2012; Hashem, *et al.*, 2017). Intensive agriculture practices lead to an increase in crop production but in the same time, they posed detrimental effects on the biological and physical properties of soils (Kumar, *et al.*, 2013).

The soil microbiome, including bacteria, archaea, fungi, viruses, and other microbial eukaryotes, has crucial roles in the biogeochemical cycling of nitrogen (N), the maintenance of soil fertility, and the plant nitrogen use efficiency (NUE) in agro-ecosystems (Fierer, 2017). Recent advances in omics-based technologies (e.g., metagenomics, meta-transcriptomics, and metaproteomics) have expanded our understanding of the soil microbiome and their controls on specific N-cycling

processes (Fierer, 2017; Thompson *et al.*, 2017; Trivedi *et al.*, 2017). The crop NUE in modern agro-ecosystems is notoriously low, as more than 50% of N fertilizer applied is lost to the environment through ammonia volatilization, nitrate leaching, and emissions of nitrous oxide (N_2O), the third most important greenhouse gas (Hu *et al.*, 2015; Coskun *et al.*, 2017).

Conventional agricultural practices mainly rely on agronomic measures and chemical inputs to improve NUE, which could lead to soil degradation and loss of biodiversity, with detrimental consequences for soil health and ecosystem functioning (Hu *et al.*, 2018). For example, long-term use of synthetic fertilizers, herbicides, and pesticides can negatively influence bacteria and fungi that create organic matter essential to plants. Propelled by re-generative agriculture, there are growing interests focused on the manipulation of the soil microbiome to reduce soil erosion, to enhance plant growth and disease resistance in agro- ecosystems, and to promote the remediation of heavy metal- contaminated soils (Fierer, 2017; Trivedi *et al.*, 2017). Plants have developed intimate relationships with their interacting soil microbiomes and the environment (termed as the 'phytobiome' reported by Leach *et al.*, 2017). Some plant and crop roots (e.g. *Fallopia spp.* and *Brachiaria humidicola*) can exudates organic compounds to inhibit the ammonia monooxygenase (enzyme capable of oxidizing NH_3 to NH_2OH) and hydroxylamine oxidoreductase (enzyme capable of oxidizing NH_2OH to NO_2) of ammonia oxidizers (Subbaraoa *et al.*, 2009) or to inhibit the metabolic activity of denitrifiers (Bardon *et al.*, 2014). The objectives of this study are to evaluate AMF, IAA and AMF + NPK on the growth parameters and some soil chemical properties in Okitipupa, southwest Nigeria.

MATERIALS AND METHODS

Site selection and description

This experiment was conducted at the research farm, Department of Crop, soil and pest Management, Olusegun Agagu University of Science and Technology, Okitipupa, Ondo State, which lies between latitude 6º 27' and 12.89" N, and longitude 4º 46' and 22.04" E. The soil was gently sloppy and coarse in texture. The soil used was typically sandy soil. The site was free from shaded trees and has been subjected to cultivation of arable crops like maize and vegetables.

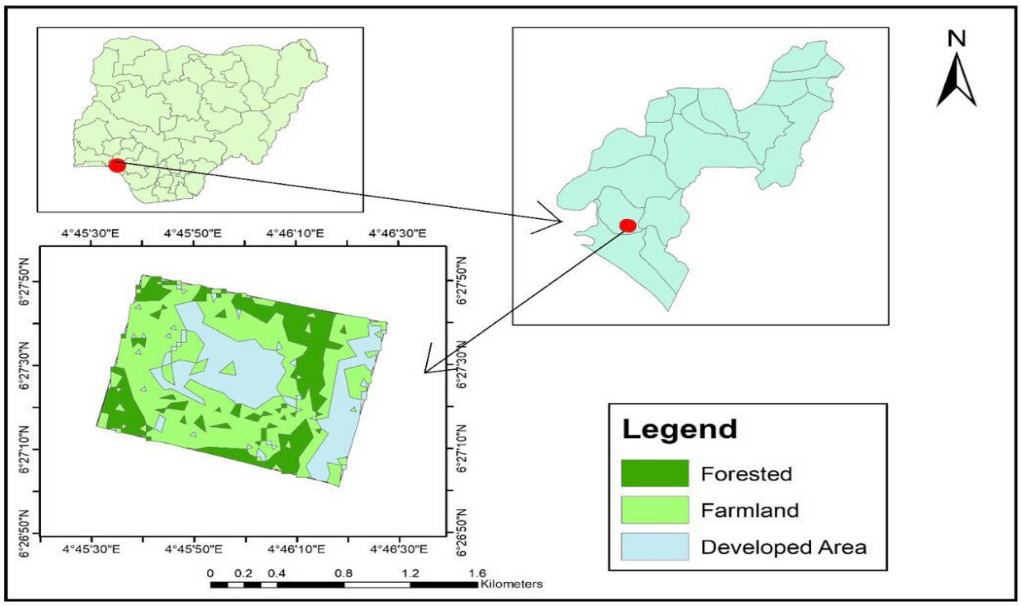

Figure 1. Map of the study area

Land preparation

The land was cleared; all roots, stumps and debris were removed. Ridges were made of 80cm×1m apart. The popular varieties of cassava TMS 419 was planted with the stem cutting of 25cm length with a spacing of 1m×1m in slanting position of angle 45º.

Procedure for isolation of Mycorrhizal from plant roots

- Root collection -Carefully uproot the plant roots and gently wash the roots with sterile rooter to remove any soil or debris

- Surface sterilization -Dip the roots in a disinfectant solution e.g. 70% ethanol or 1% sodium hypochlorate for about 1-2 minutes to eliminate any contaminant.
- Rinsing and crossing -Rinse the roots with sterile water, then carefully extract hyphae or spores from the root sections using sterile forceps
- Place the isolated on a growth medium suitable for fungi e.g. modified melin -Ntritrans medium (MMN)
- Incubate under suitable condition e.g. 25-27°c with appropriate light and dark cycles, maintain high level of sterility throughout the process to avoid contamination

Observation/Subculture

- Observation was carried out at the end of incubation over a period of about 3-7days.
- Subculture was carried out to obtain a pure culture.

Identifications Mycorrhizal

- Identifications were carried out with reference to illustrating general imperfect fungi by Barrel et al 2006.
- Name of Mycorrhizal: *Rhizophagous irregularis*

Experimental design

The total area of the experimental plot is 134.2m. The experiment was laid out as a randomized complete block design (RCBD) with five treatments and three replicates. A 1m×80cm plot was demarcated on the Teaching and Research Farm of Olusegun Agagu University of Science and Technology Okitipupa, Ondo State, Nigeria.

The treatments were: Control (no treatment), AMF, AMF+NPK, IAA and NPK

The treatments were allocated to the plots in each block at random, AMF was inoculated on the plot allocated three days after planting, NPK was applied in a ring form one Month after planting while IAA was sprayed one month after planting, all these treatments were done on the plot allocated.

Treatment application

There were five treatments namely Arbuscular mycorrhizal Fungi, idole-3-acetic (1g), NPK 15:15:15 fertilizer (300kg/ha), Abuscular mycorrhizal Fungi + NPK 15:15:15 fertilizer and control. Bottle cover was used to apply the NPK fertilizers while beer cup was used to apply Arbuscular Mycorrhizal Fungi and idole-3-acetic acid was sprayed to the leaves with the use of perforated bottle.

Agronomic data collection

Collection of data commended four weeks after planting and was done at two weeks interval till tussling stage. 10 representative plants were selected from each treatment, and these constituted the middle plant on each row than made the central column. The growth parameters taken were plant height in cm (a measuring ruler was placed by each plant to take its height from the soil level to the apex of the terminal leaf) and diameter in cm, a Vanier caliper was used to measure the stem girth (10cm above ground).

Soil Sample Collection and Analysis

Soil samples were previously taken randomly and analyzed to know the nutrient status of the area using soil auger to the depth of 0-20cm. At planting, five soil samples in each plot were taken. Samples from each plot were bulked and composite were collected and taken to the laboratory for analysis.

Soil particle size analysis

The particle size is one of the most stable soil properties, consequently its analyses is used as a basis of soil textural classification. Soil particle size analyses to determine the sand, silt, and clay content of each soil sample obtained from the different soil depths across the different management practices of cultivated land, regenerated land and forest land was carried out using the hydrometer method described by [Bouycous, 1951].

A 30-g (oven-dry weight basis) of ≥ 2 mm sieved soil sample was weighed into a 250 ml beaker and 100ml of Calgon solution added to it, after which the mixture was transferred to a dispersing cup and stirred for about 3 minutes with the help of a mechanical stirrer and subsequently transferred to a sedimentation cylinder which was filled to the mark with distilled water while the hydrometer is in the suspension.

A plunger was then inserted which was moved up and down in a vertical rectilinear manner to mix the contents thoroughly, the stirring was completed with three slow smooth strokes, and the time of stirring completion recorded. The hydrometer was lowered carefully into the suspension and readings taken after 40 seconds (R40secs) and the temperature of the suspension recorded with a thermometer. The suspension was remixed using the plunger and the 40 seconds reading recorded until a reliable and constant reading was obtained. Two (2) hours after the final remixing of the suspension, another hydrometer and temperature reading were obtained (R2hrs). The percentage fractions of the suspension were calculated as follows:

% (Silt + Clay) = × 100
Eqn (1)

% Clay = × 100
Eqn (2)

% Silt = % (Silt + Clay) - % Clay
Eqn (3)

% Sand = 100 – [% (Silt + Clay)]
Eqn (4)

Soil textural classes was determined by using textural triangle

Soil chemical properties determination

The soil pH was determined by a pH meter in 1:2.5 soil: water (w/v) suspension (Anderson and Ingram, 1993). Total Organic Carbon (TOC) was determined using the Colorimetric method (Schulte and Hoskins, 2009). The Kjeldahl method was used to determine total Nitrogen (Sáez-Plaza *et al*., 2013). Available phosphorus (Av. P) content in the soil was analyzed following the Bray-1 acid method (Sahrawat *et al*., 1997). Potassium content was determined using a flame photometer (Rhoades, 1983). Effective Cation exchange capacity (ECEC) was estimated by summation of total exchangeable bases and exchangeable acidity (Al + H) determined by 1 M KCl extract

and titrated with dilute sodium hydroxide solution (Anderson and Ingram, 1993).

Data Analysis

The data collected were subjected to analysis of variance (ANOVA) and the means were compared using Duncan multiple range test (DMRT) at 5% significance level. SPSS (version statistical package for soil sciences).

RESULTS AND DISCUSSION

Results

Pre-planting Physio - Chemical Properties of Soil of the Experimental Site.

Table 1 shows the pre-planting physio-chemical properties of soil of the experimental site. The pH (H_2O) showed that the soil was slightly acidic pH = 5.9, the organic carbon was 1.47%, while the total nitrogen was 0.13%, the soil sand and clay contents were 47.69% and 29.46% respectively. While the silt content was 22.93%. The effective cation exchange capacity was 11.90cmol/kg of soil. Also, phosphorous, calcium, magnesium, potassium, sodium, exchange acidity and base saturation were 7.76 mg/kg, 2.80 cmol/kg, 2.94cmo1/kg, 1.55cmol/kg of soil, 0.48cmo1/kg of soil, 1.78cmo1/kg of soil and 52% respectively.

Table 1: Pre-planting Physio - Chemical Properties of Soil of the Experimental Site

Parameters	Control
Sand (%)	47.69±0.37
Clay (%)	29.46±0.37
Silt (%)	22.93±0.14
pH	5.9±0.20
Total N (%)	0.13±0.01
TOM (%)	2.52±0.11
TOC (%)	1.46±0.07
Total P (mg/kg)	7.76±0.13
Na^+(cmol/kg)	0.48±0.02
K^+ (cmol/kg)	1.55±0.29
Ca^{2+}(cmol/kg)	2.80±0.10
Mg^{2+}(cmol/kg)	2.94±0.05
Ex. Acidity(cmol/kg)	1.78±0.01
CEC (cmol/kg)	11.90±0.30
Base Saturation (%)	52.00±1.00

Proximate analysis of AMF host plant (Panicum maximum)

Mycorrhizal of the host plant (Panicum maximum) was 145 cfu/g and percentage colonization of the host root was 35%. It had the pH 0f 5.5, total nitrogen of 0.15%, total organic carbon of 1.71%, total phosphorous of 8.71mg/kg, CEC of 9.81 cmol/kg of soil, Exchange acidity of 1.54 cmol/kg of soil while the base saturation stood at 84.27%.

Table 2: physical and chemical composition of AMF host plant (*panicum maximum).*

Parameters	AMF
pH	5.50±0.30^b
Total N(%)	0.15±0.01
TOM (%)	2.87±0.02
TOC (%)	1.71±0.63
Total P (mg/kg)	8.71±0.77
Na^+(cmol/kg)	0.55±0.04
K^+ (cmol/kg)	1.67±0.02
Ca^{2+}(cmol/kg)	2.95±0.06
Mg^{2+}(cmol/kg)	3.18±0.01
Ex.Acidity(cmol/kg)	1.54±0.03
CEC(cmol/kg)	9.81±0.09
Base Saturation (%)	84.27±0.32

Effect of AMF, IAA, NPK, and NPK+AMF on soil physiochemical properties of the experimental site.

Table 3 shows the effect of AMF, IAA, NPK, and NPK+AMF on soil physiochemical of the experimental site.

The sand and clay contents were 47.69% and 29.46% respectively. While the silt content was 22.93% and showed no significant difference among the treatments. The soil pH values ranged from 4.8 to 5.8 with the highest value recorded from AMF plot while the lowest values were recorded from NPK plot. pH in the AMF plot was significantly higher than other amended plots while plots amended with IAA, AMF+NPK and NPK showed no significance statistically. Total N had significantly highest value in the plot amended with AMF + NPK (0.25 %) while the lowest value of 0.13 % was recorded in the control plot. However, there were no significant differences among the plots amended with IAA, AMF + NPK and NPK. The total organic carbon showed significant differences higher value of 2.05 % than other plots while the lowest value was recorded in the control plot, however, all amended plots had significant higher values over the control plot. The available phosphorous recorded higher value of 9.80 mg/kg in the plot amended with AMF + NPK and significantly different from the control plot, the least value was recorded from the control plot while AMF and IAA plots were not statistically different. The AMF plot had 8.75 mg/kg while the IAA plot had 7.98 mg/kg. Cation Exchange Capacity (CEC), plot amended with AMF + NPK recorded the highest value of 10.69 cmol/kg , IAA plot had 10.63 cmol/kg, NPK plot had 10.45 cmol/kg, AMF plot had 9.81 cmol/kg while the control plot had the lowest value of 7.0 cmol/kg, however there was no significant differences among the amended plot but they showed higher significant values over the control plot. Exchange soil acidity was low significantly in the plot amended with AMF (1.54 cmol/kg) while there was no significant difference among the control, IAA, AMF + NPK and NPK plots. The base saturation was low in the control plot (52 %) and higher in the amended plots with values ranged from 82.58 % to 84.80 %.

Table 3: Effect of AMF, IAA, NPK, and NPK+AMF on soil physiochemical properties and heavy metals

Parameters	Control	AMF	IAA	NPK + AMF	NPK
Sand (%)	47.69±0.37^{a}	47.68±0.50^{a}	47.69±0.10^{a}	47.70±0.20a	47.56±0.21^{a}
Clay (%)	29.46±0.37^{a}	29.47±0.32^{a}	28.77±0.43^{a}	29.47±0.20^{a}	29.78±0.15^{a}
Silt (%)	22.93±0.14^{a}	23.00±0.26^{a}	22.09±0.36^{ca}	22.88±0.30^{a}	22.79±0.15^{a}
pH	5.0±0.20^{b}	5.8±0.30^{a}	4.8±0.95^{c}	4.9±0.04^{c}	4.5±0.03^{c}
Total N (%)	0.13±0.01 ^{c}	0.15±0.01 ^{b}	0.17±0.01 ^{a}	0.25±0.01 ^{a}	0.20±0.10^{a}
TOM (%)	2.80±0.11 ^{c}	2.87±0.02^{a}	3.16±0.04^{b}	3.55±0.10^{c}	3.23±0.02^{b}
TOC (%)	1.46±0.07^{d}	1.71±0.63^{ab}	1.83±0.04^{a}	2.05±0.04^{a}	1.86±0.01^{a}
Total P (mg/kg)	5.76±0.13^{c}	8.71±0.77^{a}	7.98±0.00^{ab}	9.80±3.87^{a}	9.31±0.02^{a}
Na^{+}(cmol/kg)	0.48±0.02 ^{a}	0.55±0.04^{ab}	0.56±0.01^{ab}	0.60±0.01^{b}	0.62±0.10^{b}
K^{+} (cmol/kg)	1.55±0.29 ^{a}	1.67±0.02^{ab}	1.53±0.03^{a}	1.58±0.00^{a}	1.83±0.15^{b}
Ca^{2+}(cmol/kg)	2.80±0.10 ^{a}	2.95±0.06^{ab}	3.23±0.15^{bc}	3.50±0.40^{c}	3.31±0.03^{bc}
Mg^{2+}(cmol/kg)	2.94±0.05^{a}	3.18±0.01^{b}	3.50±0.10^{d}	3.13±0.02^{b}	3.33±0.11^{c}
Ex Acidity(cmol/kg)	1.78±0.01^{a}	1.54±0.03^{b}	1.83±0.05^{a}	1.78±0.01^{a}	1.76±0.10^{a}
CEC (cmol/kg)	07.90±0.30^{c}	9.81±0.09^{a}	10.63±0.23^{b}	10.69±0.09^{b}	10.45±0.01^{b}
Base Saturation (%)	52.00±1.00^{b}	84.27±0.32^{a}	82.58±0.29^{a}	83.13±0.05^{a}	84.80±0.26^{a}

*Mean with same superscript along the rows are not significantly different at p>0.05

Effect of AMF, IAA, NPK, and NPK+AMF on the growth of cassava

Table 4 shows the analysis of the effect of AMF, IAA, NPK, and NPK+AMF on the growth parameters of cassava.

Plant height recorded at WAP5 showed that the control plot had the least value of 93.46 cm while the polt amended with NPK recorded the highest value of height of 165.20 cm, NPK + AMF plot recorded 165.06 cm, AMF recorded 120.26 cm and IAA plot recorded 109.06 cm, all amended

Plots were significantly higher than the control plot. But there was no significant difference between the NPK and NPK + AMF treated plots. At WAP 6, The values of height ranged from 102.23 cm (control plot) to the highest, 192.26 cm from NPK + AMF plot. All treated plots showed significant difference over the control plot. At WAP 7 and WAP 8, similar trends were observed in relation to WAP 6, the highest value of 193.73 cm was recorded at the plot treated with NPK + AMF while the least value of 112.80 cm was recorded at the control plot (WAP 7), Also the highest value of. 2014.06 cm was recorded at the plot treated with NPK + AMF while the control plot recorded the lowest value of 129.20 cm (WAP 8). At WAP 9 and WAP 10, the least values of 137.00 cm and 161.26 cm were recorded at the control plots of WAP 9 and WAP 10 respectively. While the highest values of 248.53 cm and 258.86 cm were recorded in NPK + AMF for WAP 9 an WAP 10 respectively. All treated plots had significant higher values than the control, and NPK + AMF plot had significant higher values than all other treated plots.

On the number of leaves, the control plots recoded significantly low values across the weeks after planting while the plots treated with NPK + AMF recorded higher values in all the weeks under consideration. At WAP 5, control plot had 63.00 while the NPK = AMF recorded 126.00. At WAP 9 and 10, the least count was found on control plot with 110.00 while NPK + AMF plot had significant higher value over others plot, at WAP 10, the control plot had 129.00 while the plot with NPK + AMF had 174.00. On the number of stems, the values ranged from 5.00 to 10.00 in the control plot and the IAA and NPK plots respectively. All treated plots showed over the significant difference over the control but no significant difference among the treated plots.

On stem diameter, Control plot recorded the least across all the weeks under examination. At WAP 5, control had value of 3.06 cm while NPK plot recorded higher value of 6.95 cm and significantly higher than the control plot. At WAP 9 and 10, control had 7.69 cm and 9.66 and WAP 9 and 10 respectively. Also, the highest values of 11.15 and 12.02 cm were recorded from NPK plots at WAP 9 and 10 respectively.

Parameters (cm)	Treatment	WAP5	WAP6	WAP7	WAP8	WAP9	WAP10
Plant Height (cm)	Control	93.46±8.89^{d}	102.23±9.08^{e}	112.80±9.85^{d}	129.20±8.90^{e}	137.00±9.46^{d}	161.26±7.61^{e}
	NPK	165.20±19.0^{a}	176.93±15.5^{b}	191.33±15.7^{a}	205.06±15.8^{b}	227.33±13.8^{b}	251.73±12.7^{b}
	NPK+AMF	165.06±18.9^{a}	192.26±16.7^{a}	193.73±27.4^{a}	214.06±32.5^{a}	248.53±55.0^{a}	258.86±34.8^{a}
	AMF	120.26±8.24^{b}	132.00±5.04^{c}	142.26±5.62^{b}	164.46±2.32^{c}	179.86±3.58^{c}	198.86±5.25^{c}
	IAA	109.06±4.50^{c}	120.76±7.56^{d}	134.00±8.71^{c}	152.26±8.27^{d}	144.33±11.3^{a}	185.33±10.3^{d}
No of Leaves	Control	63.00±9.70^{c}	72.00±10.05^{c}	95.00±11.9^{c}	107.00±12.6^{e}	110.00±6.72^{e}	129.00±3.13^{d}
	NPK	128.00±19.4^{a}	136.60±18.5^{a}	142.00±17.4^{a}	150.00±18.6^{b}	159.00±25.2^{b}	166.00±22.5^{b}
	NPK+AMF	126.00±17.0^{a}	126.00±16.3^{ab}	142.00±12.7^{a}	158.00±9.65^{a}	165.00±14.9^{a}	174.00±13.6^{a}
	AMF	87.00±5.26^{b}	94.00±4.32^{b}	103.00±7.60^{b}	119.00±9.64^{d}	130.00±8.35^{d}	136.00±3.35^{c}
	IAA	95.00±27.5^{ab}	105.00±30.9^{ab}	118.00±29.5^{b}	131.00±26.4^{c}	144.00±37.8^{c}	155.00±41.8^{b}
No of Stems	Control	5.00±2.16^{c}	7.00±0.69^{ab}	9.00±0.69^{d}	9.20±0.69^{ab}	9.20±0.69^{b}	9.20±0.69^{a}
	NPK	10.00±1.27^{a}	11.00±1.73^{a}	11.00±1.73^{a}	11.20±1.73^{a}	10.20±1.73^{a}	9.86±2.08^{a}
	NPK+AMF	8.00±1.00^{b}	8.00±1.00^{ab}	8.00±1.00^{c}	8.33±1.00^{c}	8.73±0.75^{b}	8.73±0.75^{a}
	AMF	8.00±0.57^{b}	9.00±1.00^{b}	9.00±1.00^{ab}	9.40±1.00^{ab}	8.20±1.05^{b}	9.06±0.57^{a}
	IAA	10.00±1.31^{a}	10.33±0.92^{a}	10.00±0.92^{b}	10.33±0.92^{b}	10.33±0.92^{a}	10.33±0.92^{a}
Stem Diameter (cm)	Control	3.06±0.54^{c}	4.92±0.45^{d}	5.48±0.15^{c}	6.60±0.12^{c}	7.69±0.16^{c}	9.66±0.27^{d}
	NPK	6.95±0.78^{a}	7.06±1.18^{a}	8.22±0.16^{a}	9.29±0.25^{a}	11.15±0.69^{a}	12.01±0.37^{a}
	NPK+AMF	6.10±0.92^{a}	6.66±0.76^{b}	7.83±0.99^{a}	8.86±0.88^{a}	10.41±1.17^{a}	11.92±1.29^{b}
	AMF	5.46±0.40^{b}	5.32±0.63^{c}	6.42±0.64^{b}	7.46±0.65^{b}	8.54±0.72^{b}	9.54±0.62^{c}
	IAA	5.23±0.31^{b}	5.22±0.35^{c}	6.07±0.44^{b}	7.56±0.92^{b}	8.38±0.67^{b}	9.50±1.35^{c}

Table 4: Effect of Control, AMF, NPK + AMF, IAA and NPK on the Growth Parameters of Cassava

***Mean with same superscript along the columns are not significantly different at p>0.05**

DISCUSSION

The texture of the area was sandy clay loam. This may be attributed to the lithology of the parent material (Smyth and Montgomery 1962; Olojugba, 2010). The distribution of sand content agrees with the earlier observation of Smyth and Montgomery (1962). They maintained that more sand contents at the topsoil may be due to the high rate of weathering and low soil organic matter.

The low values of clay content may also be because of lithology of the parent materials as well as clay illuviation. Nitrogen, phosphorous, potassium, calcium, magnesium and sodium were low in the study area. This may be due to the over cropping, leaching of soluble cations, soil erosion and lack of proper land management practices in the area. The acidic nature of the soil may be due to the leaching of soluble cations observed in the area as well as the distribution of exchangeable acidity.

On the evaluation of the effect of AMF on soil physical and chemical properties which has shown low impact on the soil from the experimental site. It has shown effect on few soil

parameters (sand, TOM, Na^+, Mg^{2+} and base saturation). Despite its ability to improve characteristics of soil and consequently encourage plant development in normal, as well as in stressful circumstances (Alqarawi *et al.,* 2014a; Alqarawi *et al.,* 2014b) and help improve water stress tolerance by physiological alteration of the above ground organs and tissues (Bárzana *et al.,* 2012).

The inoculation of NPK in the soil has shown impact in some soil parameters such as sand, TOM, Na^+, K^+, Ca^{2+}, Mg^{2+} and base saturation. Out of the three most essential nutrients of NPK (FAO, 2020), potassium (K) was only shown to have impact in the soil from experimental site.

The combination of NPK and AMF (NPK+AMF) has shown more impact in most soil parameters such as sand, silt, TOM, Na, Na^+, Ca^{2+}, Mg^{2+}, base saturation and Mn. This agrees to the study by Bárzana *et al.* (2012), which revealed that Mycorrhizal fungi inoculation increased the available soil N and P concentration when it was combined with 50% NPK dose. And suggest that the inoculation of fields with AM Fungi can reduce the chemical fertilizer application by half while improving soil chemistry (Bárzana *et al.,* 2012).

NPK, AMF, and the combination of NPK and AMF have shown impact in the growth of cassava by increasing the height of the cassava plant. NPK, IAA, and NPK+AMF have shown impact in the leaves by the increase in the number of leaves. Only NPK has shown impact in the stem of the cassava by increasing the number of stems in week 2, 3 and 4. The stem diameter shows significant increase from week 1 to week 6 with the help of the applications of NPK and NPK+AMF. The proper balance and availability of NPK nutrients are crucial for optimizing plant growth, increasing yields and improving crop quality (FAO, 2020). NPK fertilizer is the combination of three macronutrients required by plants, namely nitrogen (N), phosphorus (P) and potassium (K). It is used as a fertilizer in agriculture industry to make plants healthy from nutritional point of view and meet the demand of healthy crops. Nitrogen is crucial for leafy growth, phosphorus for root development and flowering, and potassium for overall plant health and disease resistance (FAO, 2020).

It is generally accepted that AM Fungi can affect plant growth by promoting nutrient uptake especially phosphorus (P), protecting plants against abiotic stress, such as drought, salinity and heavy metals (Zhang *et al.,* 2020; Ren *et al.,* 2019). In this study, AMF has only shown the increase in plant height and reduce the presence of some heavy metals. The combination of NPK+AMF has really shown impact in both the soil chemical properties and the growth of the cassava, which agree to the study by Bárzana *et al.* (2012), the performance of indigenous AMF inoculants in combination with different doses of NPK fertilization led to significant changes in the plant growth parameters. And revealed that mycorrhizal fungi inoculation increased the available soil N and P concentrations when it was combined with a 50% NPK doses.

CONCLUSION AND RECOMMENDATION

Conclusion

This study has clearly shown that the application of NPK, IAA, AMF and NPK+AMF have impact in the soil chemical properties and growth of cassava in Okitipupa, Southwest Nigeria. But the combine inoculation of both AMF+NPK has shown more impact in both soil chemical properties and growth of cassava within the period of six weeks after treatment in Okitipupa, Southwest Nigria.

This study therefore calls for the awareness of farmers in Okitipupa the effect of NPK+AMF as fertilizer on cassava plant.

Recommendations

Based on the findings of this study, the following recommendations are made for the use of AMF, IAA, NPK and NPK+AMF to enhance soil physiochemical properties and growth of cassava.

For the best results, it is recommended to use NPK, IAA, and AMF+NPK. These treatments/fertilizers have been shown to significantly improve the soil parameters compared to the control and the use of AMF, NPK and NPK+AMF for the growth of cassava compared to the control, in Okitipupa, Southwest Nigeria.

Early application is essential in the planting cycle to ensure the plants benefits from improved growth conditions throughout their developments.

Consider inoculating AMF in combination with NPK in other to enhance changes in the plant growth parameters.

REFERENCES

Ahmad, P., Kumar A., Ashraf, M., and Akram, N. A. (2012). Salt-induced Changes in Photosynthetic Activity and Oxidative Defense System of Three Cultivars of Mustard (Brassica juncea L.). *African Joutnal of Biotechnology , 11* (11), 2694-2703.

Alqarawi, A. A., Abd-Allah, E. F., and Hashem, A. (2014a). Alleviation of salt induced adverse impact via mycorrhizal fungi in Ephedra aphylla Forssk. *Journal of Plant Interaction , 9* (1), 802–810.

Alqarawi, A. A., Hashem, A., Abd_Allah, E. F., Alshahrani, T. S., and Huqail, A. A. (2014b). Effect of salinity on moisture content, pigment system, and lipid composition in Ephedra alata Decne. *Acta Biol. Hung , 65* (1), 61–71.

Anderson, J.M., Ingram, J.S.I., 1993. Tropical Soil Biology and Fertility. A HandBook of Methods. C.A.B. International, Wallingtonford, Oxon, UK, p. 33..

Bardgett, R. D. and Van Der Putten, W. H. (2014). Belowground biodiversity and ecosystem functioning. *Nature , 515*, 505-511.

Bardon, C., Florence, P., Floriant, B., Feth el Zahar, H., Gilles, C., Guillaume, M., Thomas, P., Sara, P., Noelline, T., and Franck, P. (2014). Evidence for Biological Denitrification Inhibition (BDI) by Plant Secondary Metabolites. *New Phytology , 204*, 620–630.

Bárzana, G., Aroca, R., Paz, J. A., Chaumont, F., Martinez-Ballesta, M. C., and Carvajal, M. (2012).

Arbuscular mycorrhizal symbiosis increases relative apoplastic water flow in roots of the host plant under both well-watered and drought stress conditions. *Ann. Bot. , 109*, 1009–1017.

Bouycous GN. A recaliberation of hydrometer method for making mechanical analysis of soil. Agronomy journal. 1951; 43:434-438.

Coskun, D., Dev, T. B., Weiming, S., and Herbert, J. K. (2017). Nitrogen Transformations in Modern Agriculture and the Role of Biological Nitrification Inhibition. *Natural Plants , 3*, 17074.

FAO (2020). Fertilizer Development in support to the comprehensive Africa Agriculture Development Programme (CAADP), 23rd regional conference for Africa. Johannesburg, South Africa. 1 & 5 March, 2004, http://www.fao.org/docrep/meeting/008/J1662c.htm :septemter 15, 2007

Fierer, N. (2017). Embracing the unknown: disentangling the complexities of the soil microbiome. *Natural Review of Microbiology , 15*, 579–590.

Hashem, A., Abd_Allah, E. F., Alqarawi, A. A., Radhakrishnan, R., and Kumar, A. (2017). Plant Defense Approach of Bacillus subtilis (Bera 71) Against Macrophomina phaseolina (tassi) Goid in Mung Bean. *Journal of Plant Interaction , 12* (1), 390-401.

Hu, H., Deli, C., and Ji-Zheng, H. (2015). Microbial Regulation of Terrestrial Nitrous Oxide Formation: understanding the biological pathways for prediction of emission rates. *FEMS Microbiological Review , 39*, 729–749.

Hu, Hang-Wei and He Ji-Zheng. (2018). Manipulating the Soil Microbiome for Improved Nitrogen management. *Microbiology Australia March* .

Kumar, A., Gupta, A., Azooz, M. M., Sharma, S., Ahmad, P., and Dames, J. (2013). *Genetic Approaches to Improve Salinity Tolerance in Plants.* (P. In Ahmad, M. M. Azooz, & M. N. Prasad, Eds.) New York.

Kumar, N.V., Rajam, S. and Rani, M. E. (2017). Plant Growth Promotion Efficacy of Indole Acetic Acid (IAA) Produced by a Mangrove Associated Fungi-Trichoderma viride VKF3. *International Journal of Current Microbiology and Applied Sciences , 6* (11), 2692-2701.

Leach, J. E., Triplett, L. R., Argueso, C. T., and Trivedi, P. (2017). Communication in the Phytobiome. *Cell , 169*, 587–596.

Olojugba, M. R (2010) characterization, classification and fertility evaluation of the forest soil of basement complex in the southwestern Nigeria. Evidence from forestry plantations of the Federal University of Technology, Akure, Nigeria. *International Journal of Agriculture and Food Science*: 1, 208-222

Ren, A. T., Zhu, Y., Chen, Y. L., Ren, H. X., Li, J. Y., and Abbott, L. K. . (2019). Arbuscular mycorrhizal fungus alters root-sourced signal (abscisic acid) for better drought acclimation in Zea mays L. seedlings. *Environmental Experiment for Botany , 167*, 103824.

Rhoades, J.D., 1983. Cation exchange capacity. Methods of soil analysis: Part 2 chemical and microbiological properties. 9, pp. 149–157.

Sáez-Plaza, P., Navas, M.J., Wybraniec, S., Michałowski, T., Asuero, A.G., 2013. An overview of the kjeldahl method of nitrogen determination. Part II. Sample preparation, working scale, instrumental finish, and quality control. Crit. Rev. Anal.Chem. 43 (4), 224–272.

Sahrawat, K.L., Jones, M.P., Diatta, S., 1997. Extractable phosphorus and rice yield in an ultisol of the humid forest zone in West Africa. Commun. Soil Sci. Plant Analysis 28 (9–10), 711–716.

Schulte, E.E., Hoskins, B., 2009. Recommended soil organic matter tests. Recommended soil testing. Proc. Northeastern United States 63–74.

Smyth, T.J. and R.J. Montgomery (1962). Soils and land use in central western Nigeria Government west Niger. Press, Ibadan, Nigeria. 265pp

Subbaraoa, G. V., Nakaharaa, M., Hurtadob, P., Onoc, H., Moretab, E., Salcedob, A. F., Yoshihashia, A. T., Ishikawaa, T., Ishitanib, M., Ohnishi-Kameyamac, M., Yoshidac, M., Rondon, M., Raob, I. M., Lascanob, C. E., Berryf, W. L., and Itoa, O. (2015). Evidence for Biological Nitrification Inhibition in Brachiaria Pastures. *Proc.National Academic of Science , 106*, 17302–17307.

Thompson, L. R., Sanders, J. G., McDonald, D., Amir, A., Ladau, J., Locey, K. J., Prill, R. J., Tripathi, A., Gibbons, S. M., Ackermann, G., Navas-Molina, J. A., Janssen, S., Kopylova, E., Vázquez-Baeza, Y., González, A., Morton T., and Song, S. (2017). Earth Microbiome Project Consortium. *A communal catalogue reveals Earth's multiscale microbial* .

Trivedi, P., Peer, M. S., Matthew, D. W., and Brajesh, K. S. (2017). Tiny Microbes, Big Yields: enhancing food crop production with biological solutions. *Microbiological Biotechnology , 10*, 999–1003.

Wasnaire, J. (2022). *Mycorrhizal association dynamics between Rhizophagus irregularis and Manihot esculenta in a context of African Cassava Mosaic Virus infection.* Université catholique de Louvain, Faculté des sciences. Digital access to libraries.

Zhang, X. Y., Zhang, H. J., Zhang, Y. X., Liu, Y. Q., Zhang, H. Q., and Tang, M. (2020). Arbuscular mycorrhizal fungi alter carbohydrate distribution and amino acid accumulation in Medicago truncatula under lead