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The Effects of Different Doses of Inorganic and Organic Fertilizers on the Physiology and Yield of White Yams' (*Dioscorea Rotundata*-Poir) Vine Cuttings under Continuous Cropping System

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Abstract **Original Research Article**

Yam is one of the oldest recorded major food crops that are sources of income, carbohydrates and many synthetic drugs grown by small–scale farmers in Africa. Low yield is caused by nutrients depletion due to desertification, over cultivation, over grazing, excessive use of inorganic fertilizers among others. This work examines the physiological and yield influence of different doses of inorganic fertilizers compared with green manure of *Gliricidia sepium* and Arbuscular mycorrhizal fungus on white yam's vine cuttings on a continuous cropping system. The work was laid out in complete randomized block design (CRBD). Treatments consisted of Arbuscular mycorrhizal fungi (*Glomus mosseae*), *Gliricidia sepium,* Nitrogen-phosphorous and Potassium (NPK) fertilizer, Super Phosphate fertilizer and Urea fertilizer which were either applied singly and or in combinations. Parameters measured were leaf chlorophyll content, relative water content, roots dry weight, shoot dry weight, tubers' diameter and tuber fresh weight. Data obtained were subjected to analysis of variance while means were separated using Duncan multiple range test (DMRT). Results obtained showed that AMF combined with green manure of *Gliricidia sepium* enhanced vine cuttings' leave chlorophyll content, tuber shoot and root weights. There was positive correlation between vine cuttings chlorophyll production and mini-tubers yield in white yam. The use of bio fertilizers in yam production will not only make its cultivation more affordable, but will also increase its yield alleviate hunger and poverty and remove farmers' over dependence on inorganic fertilizers in Nigeria in particular and all over the yam growing regions of the world.

Keywords: Vine cuttings; chlorophyll content; tuber yield; Gliricidia sepium; physiology.

INTRODUCTION

Yam is the common name of plant species in the genus *Dioscorea* which belong to the family Dioscoreaceae that form edible tubers. About 50-60 of the varieties are cultivated for food or pharmaceutical purposes. Yam requires a well distributed rainfall of 1,500 mm per annum and a permeable soil with high fertility. Oyetunji and Osonubi [1]; FAO [2] reported that yams are important in the diet of the people of West Africa as it supplies caloric energy to over 80 % of the populace and that over 36 million metric tons of yams are produced annually in Nigeria. Yams have great potential not only as food; the peel is sometimes used as feed for livestock. Industrially, it is used for the production of alcohol and fuel for energy, manufacture of gums and adhesives etc. Yams are sources of proteins, fats and vitamins [3-7].

Traditionally, food yams are propagated vegetatively by means of tubers of either whole or cut tuber of about 250-800 g [8]. This vegetative method of planting competes with human consumption as farmers need to set aside 30 %, of his produce for planting, thus makings cultivation expensive for large-scale farmers. This high cost of production is attributed to the use of seed yam tubers, which account for about 30 % of the total yield coupled with high cost of labour [9]. The propagation of food yams using yam vine cuttings represents a departure from the conventional method of propagation using tubers. This technology offers a rapid, clean, and cost-effective mass method of multiplying yam. It could effectively address the need for fast and wide distribution of high-quality improved varieties to meet the increasing demand for the crop [10].

Some of the problems militating against yam production in West Africa sub region is the low multiplication ratio of 1: 4 to 1:10 [11], scarcity of 'clean' seed yams, absence of seed yams producing institution in West Africa, high cost of labour, over cultivation leading to depletion of soil nutrients, desertification, erosion among others.

This study aimed at producing seed yams (mini-tubers) using an ecologically friendly approach

MATERIALS AND METHOD

Study Location and Experimental Design

This study was conducted in the Department of Botany, University of Ibadan, South-West Nigeria. The experimental design used for the study was a complete randomized block design with five replicates.

Planting of Vine Cuttings

Healthy vines of *D. rotundata* were excised from the plants, 130-140 Days After Planting (DAP) using a sharp razor blade in the morning between 7.00-9.00 am. From the middle portion of each vine, 20 cm long cutting with three nodes and six leaves were prepared. To promote roots initiation, vines were carefully wounded by scraping to remove the epidermis at the lower end of the nodes and dusted with Indole-3-Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA). Shallow ditches of 2-3 cm depths were dug by hand on the bagged soil. The vines were layered vertically with their leaves upright to trap sunlight in order to produce more assimilates that will be translocated to the rooting zone. After 4 weeks of planting vines were treated with 80 g of leaves of *Gliricidia sepium*, 20 g Arbuscular mycorrhizal fungi (AMF), 200 kg/ha NPK, 300 kg/ha NPK, 400 kg/ha NPK, 600 kg/ha NPK, 30 kg/ha UF, 40 kg/ha UF, 30 kg/ha SPF (Superphosphate fertilizer), 40 kg/ha SPF singly and in combination and the untreated (control).

Chlorophyll Contents Determination

Chlorophyll contents determination was done using pocket chlorophyll meter MO-SPC-SPAD 502 (Konica Minolta, USA) at different weeks after planting.

Determination of Percentage Relative Water Content (R W C)

Fresh leaves collected from each treatment were cut with cork borer in to small discs, which were weighed and recorded as sample's Fresh Weight (W). The samples were then hydrated to full turgidity in distilled water for 4 hours under normal room conditions. These were removed from the water after 4 hours and the adhering moisture was quickly dried off with filter paper and immediately weighed as the Turgid Weight (TW). Samples were then dried in an oven at 80 ^{o}C for 24 hours, cooled in a desiccator and later weighed as the dry weight.

The following formula was used to determine the Relative Water Content (R W C).

$$RWC\ (\%) = \frac{W - DW}{TW - DW}\ X\ 100$$

Where,

W = sample fresh weight;
DW = sample dry weight;
TW = sample turgid weight.

Statistical analysis

Data obtained were statistically analysed using analysis of variance (ANOVA) at $\alpha_{0.05}$, and correlation while different means of treatments were compared using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Table-1 showed the chlorophyll contents of yam vines treated with 20 g of AMF, 80 g of plant manure of *Gliricidia sepium* (GM), different doses of NPK fertilizer (NPK), Superphosphate Fertilizer (SPF) and Urea Fertilizer (UF). Eighty gram of GM and combined treatments of 80 g GM+AMF and 80 g GM+200 kg/haNPK gave the highest amount of chlorophyll content at 10 WAT, 12 WAT, 14 WAT, 16 WAT and 18 WAT. No significant difference existed in the chlorophyll contents between 80 gGM and 200 kg/haNPK1 treated yam vines at 10 WAT. Similarly, there was no significant difference between the chlorophyll contents of plants treated with AMF, 300 kg/haNPK1, 400 kg/haNPK1 600 kg/haNPK1 and 80 gGM+200 kg/haNPK. At 12 WAT, significant difference was observed between AMF and different doses of NPK i.e. 300 kg/haNPK1, 400 kg/haNPK1, 400 kg/haNPK2 and 600 kg/haNPK2. Furthermore, there was no significant difference between the chlorophyll contents of 30 kg/haSPF1 and 30 kg/haUF1 plants.

At 14 WAT, no significant difference exist between the chlorophyll content of 200 kg/haNPK1, 300 kg/haNPK1, 400 kg/haNPK1 and 600 kg/haNPK2 plants. Likewise, the there was no significant difference between the plants treated with 30 kg/haUF1 and 40 kg/haUF1. The chlorophyll contents of plants treated with 80 gGM and 80 gGM+200 kg/haNPK at 16 WAT were not significantly different but were significantly different from 80 g GM+AMF and AMF treated vines. Likewise there was no significant difference between the chlorophyll contents of the different doses of NPK treatments (200 kg/haNPK1, 300 kg/haNPK1, 400 kg/haNPK1 and 600 kg/haNPK2) at 16 WAT.

However, vine cuttings treated with 600 kg/haNPK1 and 400 kg/haNPK2 were different from each other in their chlorophyll contents. The chlorophyll contents of vines treated with 40 kg/haSPF1 and 40 kg/haSPF2 were significantly different. 40 kg/haUF1 and 40 kg/haUF2 were not significantly different. At 18 WAT, 80 g GM+NPK treated vines had the highest amount of chlorophyll production (81.07 µmol/m^2) which was significantly different from those of 80 g GM+AMF, 80 g GM and AMF. Significant difference existed between chlorophyll contents of yam vines treated with 400 kg/haNPK1 and 400 kg/haNPK2. Chlorophyll contents in vines treated with 600 kg/haNPK1 was also different from 600 kg/haNPK2. The untreated (control) vines had the least value through the period of the experiments.

Percentage Relative Water Contents (RWC) of yam vine cuttings treated with AMF and other soil amendments under continuous cropping system

Relative water contents of yam vines treated with *G. mosseae*, 80 g GM, different doses of NPK, superphosphate fertilizer (SPF) and urea fertilizers (UF) were determined and were presented in Table-2. It was observed that at 10 WAT, vine treated with 80 g GM+AMF, 80 g GM and 80 g GM+200 kg/haNPK had significantly higher RWC. This was significantly different from AMF, 200kg/haNPK1, 300 kg/haNPK1, 400 kg/haNPK1 and 600 kg/haNPK1. It was observed that there was significant difference between the water contents of vines treated with 400 kg/haNPK1 and 400 kg/haNPK2. The RWC of yam vines treated with 40 kg/haUF2, 30 kg/haUF1, 30 kg/ha SPF1, 40 kg/haSPF1 and 40 kg/haSPF2 were significantly not different. Combined treatment of 80 g GM+30 kg/haUF was significantly different in their RWC from the untreated (control) vines.

At 12 WAT, values that were not significantly different were observed in yam vines treated with AMF, 200 kg/haNPK1, 300 kg/haNPK1, 400 kg/haNPK1, 400 kg/haNPK2, 600 kg/haNPK1, 600 kg/haNPK2, 80 gGM, 80 gGM+AMF and 80 g GM+200 kg/haNPK at 12 WAT. Percentage RWC of plants treated with 30kg/haSPF1, 40 kg/haSPF1, 40 kg/haUF1, 80 gGM+30 kg/haUF and the untreated plants were not significantly different. At 14 WAT, no significant difference existed between the water contents of yam vines treated with 30 kg/haSPF1, 40 kg/haSPF2, 30 kg/haUF1, 40 kg/haUF1, 40 kg/haUF2 and the untreated (control). The highest percentage water content was observed in vines treated with 80 g GM+AMF (76.2 %). This was significantly higher than the water contents of vines under 80 g GM, AMF, 80 g GM+200 kg/haNPK treatments at 14 WAT. No significant difference between 40 kg/haUF1 and the control. Percentage water contents were higher in vines under the combined treatments of 80 g GM+AMF (80.8 %) at 16 WAT. This value was significantly different from 80 g GM alone and AMF treated yam vines. Significant relationship existed between the percentage water contents of vine treated with 40 kg/haUF2 and 30 kg/haUF1. At 18 WAT, the highest percentage water content was observed in 80 gGM+AMF (86.3 %) while the untreated vines had the least (49.2 %).

Water content of yam vines under 80 gGM+200 kg/haNPK, 80 gGM, AMF, 300 kg/haNPK1, 400 kg/haNPK2, 600 kg/haNPK1 and 600 kg/haNPK2 were not significantly different. Also, there was no significant difference between the percentage water contents of vines treated with 40 kg/haSPF1, 40 kg/haSPF2, 30 kg/haUF1, 40 kg/haUF1 and 40 kg/haUF2 but, were significantly different from the untreated vines. Water content of yam vines under 80 gGM+200 kg/haNPK, 80 gGM, AMF, 300 kg/haNPK1, 400 kg/haNPK2, 600 kg/haNPK1 and 600 kg/haNPK2 were not significantly different. Also, there was no significant difference between the percentage water contents of vines treated with 40 kg/haSPF1, 40 kg/haSPF2, 30 kg/haUF1, 40 kg/haUF1 and 40 kg/haUF2 but, were significantly different from the untreated vines. Water content of yam vines under 80 gGM+200 kg/haNPK, 80 gGM, AMF, 300 kg/haNPK1, 400 kg/haNPK2, 600 kg/haNPK1 and 600 kg/haNPK2 were not significantly different. Also, there was no significant difference between the percentage water contents of vines treated with 40 kg/haSPF1, 40 kg/haSPF2, 30 kg/haUF1, 40 kg/haUF1 and 40 kg/haUF2 but, were significantly different from the untreated vines.

Water content of yam vines under 80 gGM+200 kg/haNPK, 80 gGM, AMF, 300 kg/haNPK1, 400 kg/haNPK2, 600 kg/haNPK1 and 600 kg/haNPK2 were not significantly different. Also, there was no significant difference between the percentage water contents of vines treated with 40 kg/haSPF1, 40 kg/haSPF2, 30 kg/haUF1, 40 kg/haUF1 and 40 kg/haUF2 but, were significantly different from the untreated vines.

Yield responses of yam vine cuttings treated with AMF and other soil amendments under the nutrient-depleted soil

The effect of AMF inoculation, green manure of *G. sepium* and different doses of inorganic fertilizers application on the yield characters of yam vine cuttings under the field conditions was presented in Table 3. It showed that 80 gGM+AMF vines yielded the longest tuber (14.5 cm) which was not significantly different from 80 gGM+30 kg/haUF, 80 gGM+200 kg/haNPK, 80 gGM, AMF, 200 kg/haNPK1, 400 kg/haNPK1, 400 kg/haNPK2, 600 kg/haNPK2 and 40kg/haSPF1. Significant difference was recorded between 40 kg/haSPF1 and 40 kg/haSPF2 in their length of tubers but no significant difference was observed between 40 kg/haSPF2, 30 kg/haUF1, 30 kg/haUF2 and the control. The least tuber length was observed in the vines treated with 40 kg/ha SPF2 and 40 kg, UF1 (6.9 cm). This was not significantly different from 30 kg UF1 and 40 kg UF2 treated yam vines.

Tuber weight was significantly influenced by 80 g GM+AMF, AMF, 400 kg/haNPK2 and 600 kg/haNPK1. These values were significantly di fferent from 200 kg/haNPK1, 300 kg/haNPK1, 600 kg/haNPK2, 80 gGM and 80 gGM+200 kg/haNPK. The least tuber weight was observed in 40 kg/haUF2, but was not different (p≤0.05) from 40 kg/haUF1 and the untreated. Eighty gram GM (80 g GM) significantly increased the tuber diameter (6.97 cm). This value was significantly different from those of 80 g GM+AMF, 80 g GM+200 kg/haNPK and 300 kg/haNPK1. Forty grams per hectare of SPF applied once (40 kg/haSPF1) had the least value for tuber diameter. These were not significantly different from 30 kg/haSPF1.

Table-4 showed the growth characters as affected by AMF, GM and inorganic fertilizers treatments. Yam vines on 80 g GM+AMF treated soil had enhanced shoot weight. This value was not significantly different from those of 80 g GM+200 kg/haNPK and 80 g GM. Vines treated with AMF also had enhanced shoot weights which was significantly different from 80 g GM+30 kg/haSPF, 200 kg/ha NPK1, 300 kg/ NPK1, 400 kg/ha NPK1. Different quantities of NPK fertilizers application did not reflect any significant difference in their shoot weights. Similar observation was made for different doses of SPF and UF treatments as there was no difference in their shoot weights. Yam vines treated with 200 kg/haNPK1 had the highest root weight (3.13) that was significantly higher than all the inorganic fertilizer treatments. The least root weights was observed in the untreated vine (control) which was significantly different from 80 g GM+AMF, 40 kg/haUF1, 40 kg/haUF2, 30 kg/haSPF1, 40 kg/haSPF1, 40 kg/haSPF2, 400 kg/haNPK2 and 600 kg/haNPK1 treated vines.

Pearson correlation coefficient of yam vines treated with AMF under nutrient-depleted soil

Pearson correlation coefficient of yam vine cuttings treated with AMF showing relationship between chlorophyll contents and yield as presented in Table-5 revealed that shoot weights was strongly correlated with root weights, tuber weights, tuber width, RWC and chlorophyll contents.

Table-1: Chlorophyll content (μmol/m^2) of yam vines treated with different doses of inorganic and organic fertilizers under continuous cropping system

Treatment	Weeks After Treatment (WAT)				
	10	12	14	16	18
AMF	47.70^{bc}	59.97^{bcd}	62.83^{cd}	65.27^{bc}	73.87^{bc}
200 kg/ha NPK1	53.37^{b}	55.00^{cde}	60.30^{cde}	64.97^{c}	71.27^{bcd}
300 g/ha NPK1	50.70^{bc}	48.97^{e}	60.10^{de}	63.30^{c}	71.33^{bcd}
400 kg/ha NPK1	47.23^{bc}	50.67^{e}	56.20^{ef}	62.77^{c}	70.33^{cd}
600 kg/ha NPK1	47.47^{bc}	53.87^{de}	59.83^{de}	65.27^{bc}	70.03^{cd}
400 kg/ha NPK2	40.23^{de}	50.00^{e}	60.67^{cde}	66.67^{abc}	62.80^{ef}
600 kg/ha NPK2	45.37^{cd}	52.00^{e}	62.40^{cd}	64.87^{c}	65.80^{de}
30 kg/ha SPF1	22.53^{g}	33.17^{gh}	36.77^{h}	42.57^{fg}	44.43^{hi}
40 kg/ha SPF1	30.20^{f}	30.83^{ghi}	43.00^{g}	46.07^{ef}	50.70^{g}
40 kg/ha (SPF2	20.83^{g}	26.97^{hij}	33.80^{hi}	35.77^{gh}	47.63^{gh}
30 kg/ha UF1	18.80^{g}	24.93^{ij}	27.93^{ij}	31.40^{h}	39.17^{ij}
40 kg/ha UF1	19.93^{g}	21.60^{j}	29.33^{fg}	30.17^{h}	43.37^{hi}
40 kg/ha UF2	17.63^{g}	23.77^{j}	23.43^{j}	28.90^{h}	36.80^{jk}
80 g GM	52.43^{b}	62.03^{b}	66.00^{bc}	72.73^{ab}	77.23^{ab}
80 g GM+200 kg/ha NPK	51.87^{bc}	60.97^{bc}	69.80^{ab}	72.83^{ab}	81.07^{a}
80 g GM+30 kg/ha SPF	31.80^{f}	35.60^{g}	43.67^{g}	50.63^{de}	60.10^{ef}
80 g GM+30 kg/ha UF	36.37^{ef}	41.93^{f}	53.23^{f}	55.20^{d}	57.50^{f}
Control	22.30^{g}	21.63^{j}	28.37^{ij}	30.63^{h}	32.90^{k}
80 g GM + AMF	59.53^{a}	68.70^{a}	71.70^{a}	73.57^{a}	77.30^{ab}

Values are means of five replicates. Means with the same letter in a column are not significantly different (DMRT at p<0.05). 600 kg/haNPK1 = 60 g of NPK fertilizer applied once; 400 kg/haNPK2 = 40 g of NPK fertilizers applied twice in 20 g each; 30 kg/haSPF1 = 3 g of superphosphate fertilizer applied once; 40 kg/haSPF1 = 4 g of superphosphate fertilizer applied once; 40 kg/haSPF2 = 4 g of superphosphate fertilizer applied twice at 2 g each; 30 kg/haUF1 =3 g of Urea fertilizers applied once; 40 kg/haUF1 of Urea fertilizers applied once GM= Green Manure*;* AMF= Arbuscular mycorrhizal fungi.

Table-2: Effects of different doses of inorganic and organic fertilizers under continuous cropping system On the Relative Water Content (RWC) of yam vine cuttings

Treatment	Weeks After Treatment (WAT)				
	10	12	14	16	18
AMF	53.77^{abc}	63.17^{a}	72.37^{abc}	77.10^{ab}	81.60
200 kg/ha NPK1	55.07^{ab}	60.03^{a}	65.03^{cd}	75.00^{ab}	79.50^{b}
300 kg/ha NPK1	53.53^{abc}	65.30^{a}	69.67^{abc}	75.00^{ab}	81.90^{ab}
400 kg/ha NPK1	51.93^{bc}	62.00^{a}	64.93^{cd}	72.67^{b}	79.57^{b}
600 kg/ha NPK1	54.80^{ab}	61.50^{a}	64.10^{cd}	77.03^{ab}	83.73^{ab}
400 kg/ha NPK2	47.27^{c}	63.03^{a}	69.90^{abc}	74.47^{ab}	83.00^{ab}
600 kg/ha NPK2	49.70^{bc}	61.07^{a}	66.60^{bcd}	73.17^{b}	83.63^{ab}
30 kg/ha SPF1	39.00^{d}	41.0^{cd}	50.93^{fg}	50.70^{d}	54.67^{d}
40 kg/ha SPF1	40.23^{d}	43.23^{cd}	43.40^{g}	51.23^{d}	52.43^{de}
40 kg/ha SPF2	39.67^{d}	46.27^{bc}	44.07^{fg}	48.50^{def}	50.47^{de}
30 kg/ha UF1	40.10^{d}	38.27^{d}	47.60^{fg}	50.10^{de}	50.23^{de}
40 kg/ha UF1	34.33^{de}	42.03^{cd}	44.80^{fg}	44.03^{ef}	50.37^{de}
40 kg/ha UF2	38.77^{d}	45.20^{bc}	47.83^{fg}	49.30^{de}	50.97^{de}
80 g GM	60.43^{a}	62.70^{a}	71.40^{abc}	79.07^{ab}	82.90^{ab}
80 g GM+200 kg/ha NPK	60.00^{a}	63.93^{a}	74.13^{ab}	81.00^{a}	83.73^{ab}
80 g GM+30 kg/ha SPF	40.30^{d}	50.77^{b}	58.97^{de}	61.20^{c}	64.53^{c}
80 g GM+30 kg/ha UF	36.30^{de}	41.43^{cd}	52.83^{ef}	57.80^{c}	60.80^{c}
Control	30.20^{e}	40.10^{cd}	43.67^{fg}	42.60^{f}	49.20^{e}
80 gGM+AMF	58.83^{a}	64.50^{a}	76.20^{a}	80.80^{a}	86.27^{a}

Values are means of five replicates. Means with the same letter in a column are not significantly different (DMRT at $p<0.05$).

Table-3: Yield response of yam vine cuttings to different doses of inorganic and organic fertilizers under continuous cropping system

Treatment	Yield parameters		
	Tuber length (cm)	Tuber weight (g)	Tuber diameter (cm)
AMF	12.20^{abc}	115.07^{a}	5.17^{cdef}
200 kg/ha NPK1	12.13^{abc}	99.43^{abcd}	5.90^{abcd}
300 kg/ha NPK1	9.53^{d}	107.53^{ab}	6.07^{abc}
400 kg/ha NPK1	10.57^{cd}	106.83^{ab}	5.33^{bcdef}
600 kg/ha NPK1	14.10^{a}	115.27^{a}	5.30^{bcdefg}
400 kg/ha NPK2	11.00^{c}	115.93^{a}	5.00^{cdefgh}
600 kg/ha NPK2	11.30^{c}	101.37^{b}	5.57^{bcde}
30 kg/ha SPF1	8.93^{e}	60.43^{ef}	3.90^{h}
40 kg/ha SPF1	10.77^{cd}	73.10^{cdef}	4.50^{efgh}
40 kg/ha SPF2	6.87^{f}	60.07^{ef}	4.10^{gh}
30 kg/ha UF1	7.03^{ef}	69.17^{def}	4.63^{efgh}
40 kg/ha UF1	6.87^{f}	52.13^{f}	3.87^{h}
40 kg/ha UF2	7.00^{ef}	47.27^{f}	4.13^{fgh}
80 g GM	13.3^{b}	107.8^{ab}	6.97^{a}
80 gGM+20kg/haNPK	12.87^{abc}	90.30^{abcde}	6.27^{ab}
80 g GM+30kg/ha SPF	9.93^{d}	77.67^{bcdef}	4.73^{defgh}
80 g GM+30kg/ha UF	10.13^{cd}	66.43^{de}	5.20^{bcdef}
80 g GM+AMF	14.47^{a}	115.70^{a}	5.97^{abc}
Control	7.33^{ef}	48.37^{f}	4.17^{fgh}

Values are means of five replicates. Means with the same letter in a column are not significantly different (DMRT at $p<0.05$).

Table-4: Growth assessment of yam vine cuttings treated with different doses of inorganic and organic fertilizers under continuous cropping system

Treatment	Shoot weight (g)	Root weight (g)
AMF	18.10[ab]	2.47[abcd]
200 kg/ha NPK1	13.67[cd]	3.13[a]
300 kg/ha NPK1	12.77[cd]	2.23[bcde]
400 kg/ha NPK1	14.47[bcd]	2.13[cdef]
600 kg/ha NPK1	12.57[cde]	1.93[defg]
400 kg/ha NPK2	11.97[cde]	1.93[defg]
600 kg/ha NPK2	13.53[cd]	2.77[abc]
30 kg/ha SPF1	7.60[g]	1.53[efg]
40 kg/ha SPF1	7.10[g]	1.63[efg]
40 kg/ha SPF2	8.43[efg]	1.63[efg]
30 kg/ha UF1	6.57[g]	1.37[fg]
40 kg/ha UF1	7.00 [g]	1.50[efg]
40 kg/ha UF2	8.20 [fg]	1.53[efg]
80 g GM	18.97[a]	2.63[abcd]
80 gGM+20kg/ha NPK	19.13[a]	2.93[ab]
80 gGM+30kg/ha SPF	16.53[abc]	2.10[def]
80 g GM+30kg/ha UF	12.00[cde]	1.67[efg]
80 g GM+AMF	20.77[a]	2.50[abcd]
Control	6.97[g]	1.17[g]

Values are means of five replicates. Means with the same letter in a column are not significantly different (DMRT at p<0.05).

Table-5: Correlation coefficient between the yield and physiological characters of vine cuttings of yam treated different doses of inorganic and organic fertilizers under continuous cropping system

Parameters	Shoot weight	Root weight	Tuber weight	Tuber Width	Tuber length	RWC
Shoot weight						
Root weight	0.655**					
Tuber weight	0.677**	0.850**				
Tuber width	0.563**	0.870**	0.779**			
Tuber length	0.732**	0.843**	0.748**	0.839**		
RWC	0.629**	0.886**	0.812**	0.840**	0.852**	
CHL	0.698**	0.849**	0.845**	0.826**	0.832**	0.862**

**. Correlation is significant at the 0.01 level (2-tailed).
RWC = Percentage Relative Water Contents; CHL = Chlorophyll contents

Vine cuttings treated with AMF, green manure of *G. sepium*, poultry manure and different regime of inorganic fertilizers applications on the field showed that the combined treatments of 80 g GM+AMF significantly enhanced the production of chlorophyll at weeks 10, 12, 14, 16 and 18 after planting. This is a confirmation of the reports of Poulton *et al*., [12] that AMF can potentially act as photo-stimulators and can alter the gene expression, cellular programing and organ development of the host plants. The 200kg/haNPK1 and 300 kg/haNPK1 both applied once enhanced higher chlorophyll production than their higher doses or when they were applied in split form (600 kg/haNPK2, 400 kg/haNPK2 and 300 kg/haNPK2). This corroborated the findings of Law-Ogbomo and Remison [13], that, growth and yield per plant increased as fertilizer application increased up to 300 kg/ha and that this declined thereafter (e.g., 400 kg / ha). Analysis of variance showed that the effects of treatments were highly significant to yam chlorophyll production.

Similar result was observed for the relative water content, but there was no significant difference between 80gGM, AMF, 200kg/haNPK1, 300kg/haNPK1, 400kg/haNPK1, 600kg/haNPK1 (all applied once), 400 kg/haNPK2 and 600 kg/haNPK2 (applied in split forms) in their RWC. It was obvious that combinations of GM and NPK enhanced both chlorophyll production and the water contents in yam vine cuttings but reverse was the case for the combined treatments of UF+GM and SPF+GM. Combination of GM+AMF, and GM+NPK yielded higher tuber length, weight and width, while 400 kg/haNPK2 treated plants also had the higher tuber weight, but did not translate to higher tuber length or width.

There was a positive relationship between root weights and tuber width (r = 0.870), tuber weight (r = 0.850) and chlorophyll production at 18 WAT (r = 0.849). Tuber weight and chlorophyll were also associated at p <0.01 (r = 0.845). Relative water contents (18 WAT) was strongly and positively correlated with shoot weights, root weights, tuber weights and tuber width at p < 0.01; (r =0.629; 0.886; 0.812; 0.840 and 0.852) respectively. There was a strong relationship between the chlorophyll contents and the yield of yam vine cuttings. All the other treatments except the UF, SPF and the control enhanced the yield performance of yam vines but at varying degrees. The analysis of the growth parameter showed that AMF and GM applied singly and in combinations significantly improved the shoot and root weights in yams [14]. The 200 kg/haNPK1 treated plants had the highest value for root weight in this study. This also confirms the report of Anon [15]; Law-Ogbomo and Remison [13], that, NPK fertilizer application to white yam is necessary for improving crop productivity and that the yield increase in fertilized plots have been attributed, among other factors to longer vines, leafiness and efficient transfer of assimilates to the sink leading to greater total dry weight. There was a strong correlation between shoot, tuber and the root weights of the plants from vine cuttings in yam.

CONCLUSION

The effects of different doses of inorganic fertilizers' applications on the physiology and yield of yam were confirmed in this study. It was evident that 200 kg/ha of NPK (20 g) significantly enhanced chlorophyll, water contents, tuber, shoot and root weights in white yam. Increase in the amount of NPK from 200 kg/ha (20 g) to 300 kg/ha (30 g), 400 kg/ha (40 g) and 600 kg/ha (60 g) did not have appreciable increase in these physiological and yield characters. But the combined treatments of 200 kgNPK with green manure of *G. sepium* enhanced higher value for root, tuber and shoot weights. Physiological and yield responses of white yam to urea fertilizers and superphosphate were very poor. But when combined with AMF there was a little increase in the chlorophyll synthesis, tuber weights and tuber lengths in plants from vine cuttings. This shows that urea and superphosphate fertlizers did not enhance yield in yams.

The effects of organic manure (green manure of *Gliricidia sepium* and poultry manure) cannot be over-emphasized in that it significantly influenced leaf chlorophyll, water contents and yield characters in vine cuttings. The shoot and tuber weights of white yam were also influenced by the application of green manure of *G. sepium*. Combined treatments of green manure with AMF significantly influenced higher values for yam mini-tuber weight [16]. This corroborates the findings of Gutteridge and Shelton [17] that *G.sepium* is rich organic mulch because it improves cropping land, stabilisation of slopping landscapes from erosion and rehabilitation of degraded or saline lands.

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