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Full Length Research Paper

The effects of NPK and farm yard manure on the growth and development of the African yam bean (*Sphenostylis stenocarpa* Hochst ex. a rich)

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A study on the growth and developmental responses of the African yam bean (*Sphenostylis stenocarpa*) to river sand amended with NPK and Farm yard manure was carried out. Treatment of soil with 25, 50 and 100% farm yard manure (FYM) significantly ($P < 0.01$) retarded the growth and development of the crop while 12.5% significantly enhanced growth. Major mineral elements supplied as NPK, NK, NP, and PK produced significant ($P < 0.01$) stem height value of 10.4 ± 1.74 cm in NPK treatment as against 1.9 ± 0.80 cm of 100% river sand and 9.5 ± 1.49 cm of top soil at 10 weeks after planting (WAP). The crop performed best in 12.5% FYM treated river sand. Ten weeks after sowing, the stem height, number of leaves and leaf area of *S. stenocarpa* were 10.9 ± 1.74 cm, 10.7 ± 1.50 and 17.2 ± 2.40 cm^2, respectively. The corresponding values for 100% river sand (control) treatment were 2.1 ± 0.22 cm, 3.7 ± 0.15 and 4.3 ± 0.05 cm^2, respectively. Farm yard manure contributed to a rise in soil pH with 10.39 before the experiment and 9.4 after, when compared to 100% river sand value of pH 6.18 before and 6.22 after the experiment.

Key word: Manure, chemical elements, top-soil, *Sphenostylis stenocarpa*, growth.

INTRODUCTION

The African yam bean (*S. stenocarpa*) is a proteinous plant of promise. Its current status as a minor crop suggests that this potential is largely under-exploited. Hence, research efforts are required to improve its agronomic characteristics and promote its cultivation as a major crop (Klu et. al, 2000).

To use land continuously for crop cultivation, incorporating organic and inorganic fertilizers to soil would provide multiple benefits for improving the chemical and physical status of the soil which results in improved crop yield (Basso and Ritchie, 2005). Organic fertilizers include farm yard manure (FYM), slurry, worm castings, urine, peat, green manure, compost, dried blood, bone meal, fish meal and feather meal (Haynes and Naidu, 1998). Inorganic fertilizers include sodium nitrate, rock phosphate, limestone, ammonium nitrate, potassium nitrate, NPK fertilizers, muriate of potash (MOP), and supper phosphates (Taylor, 1997).

Both organic and inorganic fertilizers are sources of mineral elements, which plants require for effective growth and development. Essential mineral elements are required in optimum amounts and are classified as micro and macro. Micro elements are needed in extremely small amounts e.g. boron, chlorine, copper, iron, manga-

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Abbreviations: NPK, Nitrogen, phosphorus and potassium-containing fertilizer ; **FYM,** farm yard manure; **NK,** nitrogen and potassium combination; **NP,** nitrogen and phosphorus combination; **PK,** phosphorus and potassium combination; **WAP,** weeks after planting; **MOP,** muriate of potash.

nese, molybdenum and zinc. Macro elements are required in relatively large amounts and they include carbon, hydrogen, oxygen, potassium, calcium, magnesium, nitrogen, phosphorus and sulphur.

Nitrogen, phosphorus and potassium have great effects in plant growth and development. Their deficiencies or excesses result in marked effects on the growth and yield of crops. Nitrogen is a chlorophyll component and it promotes vegetative growth and green colouration of foliage (Jones, 1983). Phosphorus plays a major role in photosynthesis, respiration, energy storage, cell division and maturation. Potassium is important in plant metabolism, protein synthesis and chlorophyll development (Remison, 2005). Urea and muriate of potash are fertilizers that supply nitrogen and potassium, respectively (Jones, 1983) while crystallizer supper is a phosphorus fertilizer.

Effects of addition of organic and inorganic fertilizers

Inorganic fertilizers generally maintain and improve crop yield but long term use results in an increase in water stable aggregation, increased infiltration capacity, decrease in bulk density and increase in soil aggregation (Haynes and Naidu, 1998). Hemingway (1962) also reported algal bloom cases of over application in water logged periods.

Organic manures result in increased organic content leading to increased water holding capacity, increased water stable aggregation and decreased bulk density. Large application resulting to problems such as an accumulation of K^+, Na^+ and NH_4^+ in the soil and production of water repellant substances by decomposer fungi have been reported (Bwenya and Terokun, 2001).

Mineral nutrition and soil pH

Variation of soil pH does not directly influence plant growth and the very marked differences between the natural vegetations of acid and alkaline soils seem to arise from mineral nutrition disturbances or from nutritional effects of soil micro flora. Generally, medium and slightly acidic soil conditions (pH 5.5 – 6.5) have iron, manga-nese, boron, copper and zinc while the slightly acidic and basic soils (pH 6.5 – 7.5) have nitrogen, phosphorus, potassium and calcium (Hewitt, 1952).

The African yam bean grows wild throughout much of tropical Africa and it is common in Central and West African countries especially in Southern Nigeria (Umechuruba and Nwachukwu, 1994). Both its seeds and tubers are edible (Potter, 1992). The objective of this study is to investigate the growth and developmental responses of *S. stenocarpa* to NPK and farm yard manure with a view to obtaining conditions for optimal growth and yield of the crop.

MATERIALS AND METHODS

The study area was in the Ugbowo campus of the University of Benin, Benin City, Edo State, Nigeria which lies within the rainforest ecological zone of Midwestern Nigeria with an annual rainfall of 1825 mm.

The experiment was a completely randomized design of eleven treatments with ninety-nine (99) nursery bags arranged 30 cm x 60 cm in three replicates with sample size of nine. Seeds of *S. stenocarpa* were purchased from a local market in the east of Nigeria. Farm yard manure was obtained dried from a cattle abattoir at Benin Technical College road, Uselu, Benin City, Nigeria. Inorganic fertilizers were provided by the Nigerian Institute for Oil Palm Research (NIFOR) near Benin City. Soil of known weight was treated with 50, 25 and 12.5% (w/w) dried and crushed farm yard manure before placing in polythene bags (35 x 25 cm).

The viable seeds, determined by floatation method (Lotti, 1959) were sown in the evening (Klu et. al, 2000) in soils supplemented with various levels of farm yard manure and major mineral fertilizers at the rate of 550 kg per hectares. Three (3) seeds were sown per bag at a depth of 3 cm (Okeleye et. al, 1999). Hundred percent (100%) river sand and 100% top soil without mineral element supplementations served as controls. Regular watering was carried out.

Shoot emergence was closely followed for their first 10 days. The height of the plant was taken as length of the meristematic tip of the plant. Numbers of leaves were determined by counting only trifoliate leaves. Leaf area was determined by tracing method using graph sheets as described by Remison (2005). Analysis of Variance (ANOVA) was then carried out as described by Sokal and Rohlf (1973). Determination of nitrogen, phosphorus and organic carbon in soil and farm yard manure were done using the micro Kjedahl method. Potassium, calcium and magnesium were determined using the atomic absorption spectrophotometer (SOLAR 969 UNICAM SERIES).

RESULTS

Nine days after sowing, it was observed that shoot emergence was slower with increase in levels of farm yard manure. It took 5 days for shoot to emerge in the control treatment (100% river sand) and 9 days in 100% farm yard manure. Ten (10) weeks after sowing, the mean stem height of *S. stenocarpa* in 12.5% FYM treatment (10.9 ± 1.74 cm) was significantly greater ($P < 0.01$) than those of plants sown in soil treated with 50 % FYM (0.0 ± 0.00 cm) and 25 % FYM (0.0 ± 0.00 cm) compared to control plants (2.1 ± 0.22 cm, Table 1).

Similarly, the mean stem height of *S. stenocarpa* in NPK treated soils (10.4 ± 1.73 cm) was significantly greater ($P < 0.01$) than those sown in soils treated with NK (8.0 ± 0.89 cm), NP (5.5 ± 1.04 cm) and PK (8.7 ± 1.82 cm) when compared with 100% top soil and 100% river sand, control plants 9.5 ± 1.49 and 1.9 ± 0.80 cm, respectively (Table 2).

On the whole, the mean stem height of the 12.5% FYM treated crops was significantly greater than all other treated plants after 10 weeks.

The number of leaves of *S. stenocarpa* in 12.5% FYM treated soil 10 weeks after sowing (10.7 ± 1.50) was

Table 1. Effect of farm yard manure on stem height (cm) of *Sphenostylis stenocarpa*.

Treatment	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks
100% FYM	0.3 ± 0.12	2.2 ± 0.48	2.3 ± 0.49	0.3 ± 0.22	0.0 ± 0.00
50% FYM	0.7 ± 0.19	2.8 ± 0.40	2.1 ± 0.40	0.6 ± 0.34	0.0 ± 0.00
25% FYM	1.4 ± 0.19	5.1 ± 0.39	3.9 ± 0.40	3.6 ± 0.74	1.9 ±0.97
12.5% FYM	2.3 ± 0.17	5.1 ± 0.30	5.4 ± 0.30	7.4 ± 1.26	10.9 ±1.74
100% River sand	1.8 ± 0.20	2.3 ± 0.31	3.1 ± 0.29	3.1 ±0.29	2.1 ± 0.22
Level of significance	***	***	***	***	***

Values are expressed in mean ± standard error of mean.
*** = P < 0.01 (Very highly significant).

Table 2. Effect of addition of NPK on stem height (cm) of *Sphenostylis stenocarpa*.

Treatment	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks
NK	2.8 ± 0.14	5.0 ± 0.24	5.6 ± 0.92	6.2 ± 0.42	8.0 ± 0.89
NP	2.0 ± 0.3	3.8 ± 0.50	4.4 ± 0.60	5.8 ± 0.81	5.5 ± 1.04
PK	2.2 ± 0.41	3.8 ± 0.21	5.7 ± 0.56	5.8 ± 0.90	8.7 ± 1.82
NPK	2.2 ± 0.24	5.5 ± 0.43	7.2 ± 0.56	9.4 ± 1.82	10.4 ±1.74
100% River sand	1.9 ± 0.25	3.7 ± 0.51	3.3 ± 0.55	2.5 ±0.62	1.9 ± 0.80
100% Top soil only	3.2 ± 0.17	6.6 ± 0.32	7.4 ± 0.17	7.5 ± 1.20	9.5 ± 1.49
Level of significance	NS	***	***	***	***

Values are expressed in mean ± standard error of mean.
*** = P < 0.01 (Very highly significant). NS = Not significant.

significantly greater than those of plants sown in soil treated with 50 % FYM (0.0 ± 0.00 cm) and 25 % FYM (0.0 ± 0.00 cm) compared to control plants (3.7 ± 0.15 cm, Table 3).

Also, the number of leaves of *S. stenocarpa* in NPK treted soils (12.8 ± 2.29 cm) was significantly greater (P < 0.01) compared with plants grown in soil treated with NK (5.1 ± 1.34 cm), NP (3.0 ± 1.14 cm), PK (5.9 ± 1.82 cm) and 100% top soil control (10.7 ± 1.48 cm, Table 4).

Generally, the number of leaves of the NPK treated plants was significantly greater than all other treated plants at 10 weeks. 10 (Ten) weeks after sowing, the mean leaf area of *S. stenocarpa* in 12.5% FYM treated soil (17.2 ± 2.40 cm^2) was significantly greater (P < 0.01) than those plants sown in soils treated 50% FYM (0.0 ± 0.00 cm^2) and 25% FYM (5.1 ± 2.58 cm^2) compared to control plants (4.3 ± 0.50 cm^2, Table 5).

Ten weeks after sowing, the mean leaf area of *S. stenocarpa* in 100% top soil (24.3 ± 3.49 cm^2) was significantly greater than those plants sown in soils treated with NPK (24.1 ± 2.94 cm^2) and NK (20.0 ± 3.03 cm^2), NP (20.2 ± 2.60 cm^2) and PK (21.4 ± 1.36 cm^2, Table 6). Generally, the mean leaf area of *S. stenocarpa* was significantly greater in 100 % topsoil (control plants) than all other treated plants, 10 weeks after sowing.

Chemical composition of soil and farm yard manure

Analysis for pH, N, P, K, Ca, Mg, organic carbon in soil and farm yard manure are as shown in Table 7. pH values for 100% FYM, 12.5% FYM, 100% top soil and 100% river sand were 10.39, 9.23, 8.13 and 6.18 in that order and 9.65, 8.31, 7.11 and 6.22 after the experiment. Values of nitrogen were 2.37% N in 100% FYM, 2.24% N in 12.5% FYM and 0.16 N in 100% river sand (control). Values of magnesium were 1037.8 ppm in 100% FYM, 767.0 ppm in 12.5% FYM and 685.4 ppm in 100% top soil.

DISCUSSION

The effect of farm yard manure on shoot emergence of *S. stenocarpa* was observed to be inhibitory with increase in levels of manure. This can be attributed to shortage of oxygen necessary for germination with increase in levels of farm yard manure (Remison, 2005). There was premature death, and retarded growth and development of *S. stenocarpa* in 100% FYM (pH 10.39), and 25% FYM (pH 9.50) compared to plants in 100% river sand control (pH 6.20). This suggests that alkalinity resulted in stresses

Table 3. Effect of farm yard manure on number of leaves of *Sphenostylis stenocarpa*

Treatment	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks
100% FYM	0.4 ± 0.18	1.6 ± 0.44	1.9 ± 0.46	0.3 ± 0.22	0.0 ± 0.00
50% FYM	1.5 ± 0.31	2.8 ± 0.66	1.1 ± 0.39	0.6 ± 0.33	0.0 ± 0.00
25% FYM	2.1 ± 0.42	3.7 ± 0.60	5.9 ± 1.06	3.1 ± 0.63	1.0 ± 0.70
12.5% FYM	2.5 ± 0.17	5.7 ± 0.17	8.8 ± 0.64	9.1 ± 1.54	10.7 ± 1.50
100% River sand	2.0 ± 0.30	2.4 ± 0.50	4.4 ± 0.43	4.1 ± 0.28	3.7 ± 0.15
Level of significance	***	***	***	***	***

Values are expressed in mean ± standard error of mean.
*** = P < 0.01 (Very highly significant).

Table 4. Effect of addition of NPK on number of leaves of *Sphenostylis stenocarpa.*

Treatment	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks
NK	4.5 ± 0.43	8.2 ± 0.56	12.5 ± 0.90	10.4 ± 2.00	5.1 ± 1.34
NP	2.0 ± 0.23	4.0 ± 0.50	6.6 ± 0.87	5.5 ± 1.40	3.0 ± 1.14
PK	2.7	-	-	3 ± 1.30	5.9 ± 1.82
NPK	3.7 ± 0.49	7.8 ± 0.70	13.1 ± 0.89	6.5 ± 0.62	12.8 ± 2.29
100% River sand	2.1 ± 0.70	3.3 ± 0.73	5.0 ± 0.71	2.7 ± 0.49	1.6 ± 0.65
100% Top soil only	3.3 ± 0.18	6.7 ± 0.32	10.7 ± 0.99	10.6 ± 1.31	10.7 ± 1.48
Level of significance	***	***	***	***	***

Values are expressed in mean ± standard error of mean.
*** = P < 0.01 (Very highly significant).

Table 5. Effect of farm yard manure on number of leaf area (cm^2) of *Sphenostylis stenocarpa.*

Treatment	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks
100% FYM	0.0 ± 0.00	13.0 ± 2.61	17.1 ± 2.25	4.4 ± 2.90	0.0 ± 0.00
50% FYM	14.7 ± 2.23	15.3 ± 0.78	19.5 ± 2.18	7.3 ± 3.70	0.0 ± 0.00
25% FYM	14.6 ± 3.11	20.1 ± 1.89	21.9 ± 1.15	20.5 ± 3.94	5.1 ± 2.58
12.5% FYM	18.1 ± 1.51	17.7 ± 1.28	23.3 ± 1.79	23.0 ± 3.03	17.2 ± 2.40
100% River sand	16.9 ± 1.50	17.1 ± 1.30	19.0 ± 1.00	19.8 ± 1.11	4.3 ± 0.50
Level of significance	***	***	***	***	***

Values are expressed in mean ± standard error of mean.
*** = P < 0.01 (Very highly significant).

Table 6. Effect of addition of NPK on leaf area (cm^2) of *Sphenostylis stenocarpa.*

Treatment	2 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks
NK	22.3 ± 2.24	18.1 ± 0.71	18.6 ± 0.70	26.5 ± 1.70	20.0 ± 3.03
NP	19.1 ± 1.36	19.6 ± 1.50	24.4 ± 1.09	23.3 ± 1.58	20.2 ± 2.60
PK	23.7 ± 2.15	20.5 ± 0.69	23.5 ± 1.23	24.6 ± 3.70	21.4 ± 1.36
NPK	22.1 ± 0.93	19.8 ± 0.77	26.5 ± 1.11	26.2 ± 1.14	24.1 ± 0.94
100% River sand	21.1 ± 2.12	19.1 ± 2.68	25.6 ± 4.00	24.0 ± 3.48	6.2 ± 3.16
100% Top soil only	22.0 ± 1.38	19.0 ± 1.05	30.6 ± 0.99	27.5 ± 1.81	24.3 ± 3.49
Level of significance	NS	NS	NS	NS	***

Values are expressed in mean ± standard error of mean.
*** = P < 0.01 (Very highly significant). NS = Not significant.

Table 7. Chemical composition of soil and farm yard manure at the end of the experiment.

Sample	N (% ppm)	P (% ppm)	K (% ppm)	Ca (% ppm)	Mg (% ppm)	Organic C (% ppm)	pH before exp.	pH after exp.
100% FYM	2.37	398.2	2838.0	3489.4	1037.8	16.30	10.39	9.65
12.5% FYM	2.24	154.5	558.4	575.6	767.0	15.40	9.23	8.31
100% Top soil only	0.27	77.6	263.3	637.8	685.4	1.08	8.13	7.11
100% River sand	0.16	32.3	190.3	NA	NA	1.08	6.18	6.22
NK	0.03	45.8	177.2	NA	NA	0.24	6.18	6.22
NP	0.01	45.6	170.6	NA	NA	0.06	6.18	6.22
PK	0.05	66.8	182.3	NA	NA	0.36	6.18	6.22
NPK	0.11	45.3	167.1	NA	NA	0.78	6.18	6.22

NA = Not analyzed.

that did not favour the crop growth and development. This is in line with suggestions by Etherington (1975) that most plants show physiological optima between pH 5 and 7. Above and below this range, many plants show nutritional problems e.g. phosphorus deficiency due to formation of insoluble phosphates. Anetor and Akinrinde (2006) had reported that phosphorus deficiency in soil is an important growth limiting factor and that organic fertilizer sustained soybean growth at a favourable pH. But 12.5% FYM treated river sand at pH of 8.31 resulted in the availability of mineral elements essential for growth and development of *S. stenocarpa* compared with other treatments and controls. This conforms to the report (Ehigiator, 1988) that addition of poultry manure significantly improved plant yield, fruit number and fruit yield of *Solanum melongena*. Similarly, the report of Ende and Talor (1996) shows that sheep manure exerted pronounced influence on seedling growth and leaf nutrient composition of peach seedlings. Chemical analysis of 12.5% FYM treated river sand and 100% FYM show that nitrogen increased with increase in farm yard manure with values of 2.24% N in 12.5% FYM and 2.35% N in 100% FYM. Magnesium also increased with values of 767.0 ppm in 12.5% FYM and 1037.8 ppm in 100% FYM.

This may be due to increased mobilization of nitrogen and magnesium from the soil by micro-organisms with increase in farm yard manure. Organic carbon content also increased with increase in levels of farm yard manure with values of 1.08% in 100% river sand control, 15.4% in 12.5% FYM and 16.30% in 100% FYM. This is in line with the findings of Bwenya and Terokun (2001) that plant and animal waste improved soil physical and chemical properties to provide conducive maize growing environment with appreciable increases in soil organic carbon.

On the other hand, NPK supply showed greater significant effects on the growth and development of *S. stenocarpa* when compared to plants that were supplied NK, NP, PK and controls. For instance, NPK treatment recorded stem height value of 10.4 ± 1.7 cm at 10 weeks while NK had 8.0 ± 0.89 cm, NP had 5.5 ± 1.04 cm, PK had 8.7 ± 1.82 cm as against 1.9 ± 0.80 cm and 9.5 ± 1.49 cm height values of the control treatments respectively at 10 weeks. An NPK fertilizer is a good way of making judicious and efficient use of applied nutrients (Ayoola and Adeniyan, 2006).

The result of economic and vegetative yield, which showed that 12.5% FYM treated plants were favoured, is further supported by experiments (Ehigiator, 1988) that poultry manure improved fruit yield of *Solanum melongena*. Reports also show that nutrients fertilizers are applied to soil to improve crop yield.

Conclusion

The study suggests that farm yard manure will enhance the growth and development of *S. stenocarpa* at low levels in a slightly basic medium. It also showed that *S. stenocarpa* treated with NPK at pH 6.22 did better than those sown in soils treated with NK, NP or PK at the same pH. In conclusion, 12.5% FYM treated soil at pH of 8.31 sustained the crop best. There is thus need to adopt farm yard manure as an alternative to mineral fertilizers in Nigeria. There is also the need to embrace the use of farm yard manure in Nigeria.

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