Influence of NPK Fertilizer and Cow Dung Manure Application on Soil Chemical Properties, Growth and Yield of Sweet Potato (*Ipomoea batatas*)

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Abstract. In recent time, the production of sweet potato has been on the decrease despite its numerous economic potentials and nutritional values. The decrease in production of the crop has been traced to the decline in nutrient status of the soil in areas of production. High rainfall, crop removal, rapid mineralization of SOM and intensive cultivation of land are major contributing factors to declining nutrient status of soil. The problem of quantitative understanding of cow dung manure on yield of sweet potato still persists. Hence, this study tends to evaluate the application effect of cow dung and fertilizer (NPK 15 -15-15) on performance of sweet potato (*Ipomoea batatas*). The experiment was a randomized complete block design (RCBD) with three replicates. The treatments (5.0 t/ha cow dung, 10t/ha cow dung, 250 kg/ha NPK fertilizer and a control) were applied at three weeks after planting. Data were taken at two week-interval on growth parameters of Vine length, Number of branches, Number of leaves and Leaf Area. Sweet potato plants that received 5t/ha of cow dung manure and 250kg/ha NPK fertilizer produced significantly ($p>0.05$) longer vines, leaves and branches than those that received 10t/ha of cow dung manure and control. The cow dung manure at 5t/ha were in most cases better than 250kg/ha of NPK fertilizer in enhancing tuber yield of sweet potato. Based on result of this study and the fact that tuber yield of sweet potato is a function of its growth attributes, cow dung manure at 5t/ha is recommended for sweet potato production.
Keywords: sweet potato, cow dung, NPK, growth, yield

Introduction

Nigeria is the second largest producer of sweet potato in Africa and third in the world with 2,150,000 MT annually. It is an important food and vegetable crop that is grown throughout the, world especially in the tropics for its edible tubers and leaves. The potentials of organic fertilizer for soil fertility management, the deleterious effect of inorganic fertilizers on soil properties and the scarcity and cost are as well known. But the problem of quantitative understanding of cow dung manure on yield of sweet potato still poses a problem

It is an important food and vegetable crop that is widely distributed throughout the world particularly in the tropics. Sweet potato originated from tropical America and has been cultivated probably From B.C. Today, the crop remains one or the three most important root crops in the world, following the Irish potato *(Solanum tuberosum)* and cassava *(Manihot esculenta).*

The chemical composition of sweet potato tubers vines widely according to the cultivars, climatic conditions, and degree of maturity and duration of storage. Generally, sweet potato shoots and tuberous roots provide energy, protein, vitamins and minerals sufficient for both man and livestock. The major characters affecting the culinary qualities of sweet potato are sweetness, moisture, texture, fibrousness and flavor of tuber affecting the cooking or processing. The use of organic fertilizer sustains cropping system through better nutrients recycling and improvement of soil physical, chemical and biological properties (Abdulraheem, *et. al.*, 2017a).

Sweet potato is a highly adaptable crop. It grows at latitudes ranging from 40^0N to 32ºS, at altitudes ranging from 0 to 300m. Of all the cultivated root and tuber crops; sweet potato is the best at adapting quickly to new condition. Nevertheless, its growth and development can be affected by adverse environmental factors. Despite its adaptability, sweet potato does not survive in low temperature (10°C or less) while growth normally stops at 15°C. The optimum temperature for sweet potato production is 24°C.

One of the major constraints to potato production in southeastern Nigeria is low soil fertility. Hence the use of soil amendments like application of organic and inorganic fertilizers are highly encouraged (Abdulraheem and Charles, 2016). Chemical fertilizers are commonly used to improve soil fertility (FAO, 2000). However, the effect of chemical fertilizer on highly weathered, low organic matter and nutrient poor soil without any compensatory organic input sources has been reported to have limited residual effects (Okigbo, 2000).

In the past decades, intensive use of chemical fertilizers at recommended rate (NPK 15:15:15) was advocated for crop production in the tropics in order to alleviate these nutrient deficiencies (Anonymous, 2000). Presently the use of chemical fertilizers as soil amendment has become cost intensive and has often been linked to negative effects on environment (causing residual effects on the soil). In view of these problems, the use of organic manure, crop rotation, crop residues, legumes and green manure are substitutes for chemical fertilizers (Salau, 2005).

Organic matter modifies soil physical and chemical properties and releases nutrients for a longer period of time. Cow dung abounds in cattle markets as waste product and are useful organic materials that can be utilized to supplement the quantity of mineral fertilizers needed for sweet potato production (Asawalam and Onwuidike, 2011).

Organic farming deviates only a little from the natural environment in supplying nutrient to crop and thereby reducing risk. The advantages of organic farming include increased soil fertility and thus results in higher yields, conservation of the environment also being friendly to soil organisms. Organic fertilizer improves both the physical and chemical soil properties. It also promotes infiltration, protects against erosion and facilitates the spread and penetration of plant roots. The slow release nature of organic fertilizer prevents loss of nutrients through leaching. It also has long term effect or soil fertility (Ojeniyi, 2002).

Abdulraheem *et. al.* (2017b) agreed that instead of allowing pig manure to waste at dump sites, it could be used as substitutes for scarce and expensive chemical fertilizer. It is effective source of nutrients which are available for uptake of okra plant

Therefore to evaluate the effects of cow dung manure at different rate and comparison with NPK chemical fertilizer on the following objectives; to determine the effect of cow dung and NPK fertilizer on soil physical and chemical properties, and to determine the effect of cow dung and NPK fertilizer on the growth and yield of sweet potato.

Methods

The field experiment was carried out during April - July, 2017 planting season at the Teaching and Research site of the College of Education, Lanlate, Oyo State Nigeria. This area is lies between latitude 7^0 30'N and Longitude 3^0 52'E in the tropical rainforest belt f Nigeria. There are two rainy seasons; one from April to July (early season) and the other from mid-August to November (late season). Annual average minimum and maximum temperatures are 24.80^0C and 28.10^0C respectively. The mean relative humidity is about 75%. The soil at the site is classified as an alfisol (Oxic tropuldalf) according to (Adeputu *et. al.*, 1979). There were four treatments replicated three times in a randomized complete block design (RCBD). The treatments consisted of; the control (no manure and no fertilizer), 5 t/ha cow dung, 10 t/ha cow dung and 250kg/ha NPK fertilizer. The experimental site contains 12 plots and each plot contains 6 stands of sweet potato. Prior to planting, soil samples were collected from each plot and bulked for chemical analysis. Sweet potato vines (variety TIS 87/0087) was cut into 20 cm length, and planted at a spacing of 60 cm x 90 cm on flat. Sweet potato vines were planted at an angle of 45^0, after which treatments were applied 3 weeks after planting. Periodically vines of each treatment plots were trained / dragged to their respective plots to avoid nutrient flow between plots. Manual weeding was carried out at 5th and 8th weeks after planting.

The pH was determined in distilled water by with the aid of pH meter. Total N was determined by macrokjeldahl method (Bremner, 1965). Nitrogen content of the digest was thereafter read on Technicon Autoanalyser. Available P was determined using Bray P^{-1} extractant (0.03M NH_4F and 0.025M HCl) and was later read on spectrophotometer after colour development (Murphy and Riley, 1962) Exchangeable bases (Ca, Mg, K and Na) were determined using 1M neutral ammonium acetate (1M NH_4OAc pH 7.0) solution as extractant. Sodium, potassium and calcium in the filtrate were determined by flame photometry while Mg was determined with the aid of atomic absorption spectrophotometer (AAS). Organic carbon (C) and organic matter were determined by wet dichromate procedures of Nelson and Sommers (1982). Texture was determined by hydrometer method.

Data obtained on growth and yield parameters were analysed statistically using ANOVA (Analysis of variance). The treatments means were compared on the statistical package for social sciences (SPSS) using the Duncan multiple range test (DMRT) at 5% level of probability. Data obtained from number of leaves were first transformed using square root transformation method before proceeding with analysis of variance due to large count of leaves.

Results and Discussion

Analytical data of pre-cropping surface soil at the site of experiment are shown in Table 1. The test soil was marginal in organic matter (OM), adequate in Nitrogen, Calcuim, Magnesium and Potassium but inadequate in Phosphorus and slightly acidic (Akinrinde and Obigbesan, 2000). Therefore the soil requires application of fertilizing amendment that will particularly supply P for enhancing crop production.

There is significant differences in soil chemical properties such as soil pH, organic matter, soil Nitrogen, available phosphorus, exchangeable potassium, calcium and magnesium were evident. The application of cow dung manure increased soil pH in water from 5.86 - 6.12 (T_2) and 6.09(T_3) (Table 3). The use of cow dung improved the pH of the soil more than application of NPK fertilizer. Okigbo (2000) reported that application of NPK fertilizer on soil that have experienced leaching can lead to deficiency of some nutrient elements such as Zn and Mg, which may lead to soil acidification.

Table 1: Initial soil analysis of experimental site at Lanlate

Properties	Values
pH (H_2O)	6.50
Organic Matter (g/kg)	28.0
Total nitrogen (N) g/kg	3.20
Available phosphorous (P) (mg/kg)	8.80
Exchangeable calcium (cmol/kg)	7.31
Exchangeable magnesium (Mg) (cmol/kg)	2.50
Exchangeable sodium (Na) (cmol/kg)	1.60
Exchangeable potassium (K) (cmol/kg)	0.30
Sandy (g/kg)	878.0
Silt (g/kg)	54.0
Clay (g/kg)	68.0
Texture	Loamy sand

Table 2: Chemical composition of Cow dung used in the study

Cow dung Composition	Concentration
Nitrogen (%)	1.19
Phosphorus (%)	0.3
Potassium (%)	0.48
Sodium (%)	0.19
Calcium (%)	2.60
Magnesium (%)	0.56

Table 3: Effects of NPK Fertilizer and Cow Dung on Soil Nutrient Contents

Experiment	pH	OM	N	P	K	Ca	Mg
		(%)		(mg/kg)	(cmol/kg)		
Control	5.85	2.91	0.09	9.12	0.21	2.55	2.53
5 t/ha CDM	6.13	6.72	0.24	12.61	0.39	4.40	3.09
10.0 t/ha CDM	6.11	6.48	0.20	12.66	0.33	4.50	3.17
200kg/ha NPK	5.94	4.74	0.23	11.69	0.31	3.27	2.63

Means in the same columns not followed by same letters are significantly different at 5% level of significance by Duncan's Multiple Range Test (DMRT).

Keys: CDM – Cow dung manure, NPK - Nitrogen Phosphorus Potassium (15:15:15)

Table 4: Effects of Cow Dung Manure and NPK Fertilizer on Growth Parameters of Sweet Potato

Treatments	NT	TW(g)	TL(cm)	TG(cm)
Control	2.89[d]	656.89[b]	66.27[a]	23.87[b]
5t/ha (cow dung)	4.67[a]	950.22[a]	69.00[a]	32.82[a]
10t/ha (cow dung)	3.44[c]	805.56[ab]	71.07[a]	33.43[a]
200kg/ha NPK	4.22[b]	843.11[ab]	76.03[a]	33.53[a]
SE±	0.11	75.54	2.88	2.42

Means having the same letter(s) in the same column are not significantly different from each other at 5% level of probability by Duncan Multiple Range Test (DMRT).

NT=Number of Tubers; **TW**=Tuber Weight; **TL**=Tuber Length; **TG**=Tuber Girth.

Table 5: Effects of Cow Dung Manure and NPK Fertilizer on Leaf Area

Treatment	leaf area (cm^2)
Control	389[a]
5t/ha (cow dung)	390[a]
10t/ha (cow dung)	393[a]
250kg/ha NPK	387[a]

Means having the same letter(s) in the same column are not significantly different from each other at 5% level of probability by Duncan Multiple Range Test (DMRT).

Application of 5t/ha and 10t/ha of cow dung significantly increased soil organic matter more than other treatments (Table 3). Increase in organic matter of the soil due to application of cow dung could be attributed to the potential of organic waste to enrich soil organic matter. Benckiser and Simarmata (1994) reported that 5.0t of solid manure contains on the average about 900kg of organic matter. Sommerfeldt and Chung (1985) also reported that application of 10ton/ha cow dung increased soil organic matter by 0.025% per annum. Soil applied with

5t/ha, 10t/ha cow dung manure and NPK fertilizer significantly increase N, P, K, Na, Ca, Mg composition of the soil compared to the control as shown in Table 3.

Sweet potato plants that received 5t/ha of cow dung manure and 250kg/ha NPK fertilizer produced significantly ($p>0.05$) longer vines, leaves and branches than those that received 10t/ha of cow dung manure and control. The cow dung manure at 5t/ha were in most cases better than 250kg/ha of NPK fertilizer in enhancing tuber yield of sweet potato. This could be because of the organic fertilizer improved both physical and chemical properties of the soil, which is in accordance with observation of Adeoye (2008).

The relatively poor performance of cow dung manure at 10t/ha might be as a result of excess nutrients contained in the organic materials which may be assuming toxicity level. This is in accordance with observation of Babalola et al. (2002), Giwa and Ojenyi (2005) who reported that very high manure application would depress growth and yield irrespective of the manure sources. The poor performance of T_4 (250kg/ha NPK fertilizer) might be due to leaching of nutrients beyond the root zone and can also lead to toxicity of plants due to nutrient imbalance, soil acidity.

Result of this investigation showed that the fertility of a degraded soil can be improved by addition of cow dung manure. Cow dung manure proved superior over other rates in the improvement of soil properties such as pH, organic matter, total nitrogen, available phosphorus, exchangeable cations. Application of 5t/ha cow dung and 250 kg/ha NPK fertilizer were not significant statistically in growth of sweet potato but significantly higher to other treatments. Also 5t/ha enhanced yield of sweet potato than other treatments. Since tubers weight is a function of growth parameters, cow dung manure at 5t/ha is therefore recommended for sweet potato production in southwest Nigeria. There is need to investigate this in other agro-ecological zones with other crops.

Conclusions

Sweet potato plants that received 5t/ha of cow dung manure and 250kg/ha NPK fertilizer produced significantly ($p>0.05$) longer vines, leaves and branches than those that received 10t/ha of cow dung manure and control. The cow dung manure at 5t/ha were in most cases better than 250kg/ha of NPK fertilizer in enhancing tuber yield of sweet potato. Based on result of this study and the fact that tuber yield of sweet potato is a function of its growth attributes, cow dung manure at 5t/ha is recommended for sweet potato production.

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