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Review Article

The effects of inorganic fertilizer on soil characteristics and production of Egg Plant (*Solanum melongena* L.) in Warawa area of Kano State

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Abstract

The research was conducted to evaluate the effects of inorganic fertilizer (NPK) on soil characteristics and productivity of *Solanum melongena* in Warawa local government area of Kano State. The research was conducted by analysis of the soil and Ten soil samples from two different sites (farmers and experimental site) were collected by stratified random sampling method and were analyzed for physico-chemical properties (pH, organic matter, total nitrogen, phosphorous, exchangeable bases, exchangeable acid, micronutrients and cation exchange capacity). The findings of the cultivation shows that, at 0/15kg level of inorganic fertilizer, highest number of fruits, diameter of fruit (cm) and weight of fruits observed at farmers' site while at experimental site 0.05kg and 0.10kg had the highest. Therefore farmers of Warawa town should maintain 0.15kg level of inorganic fertilizer in order to counteract the problems associated with the cultivation of pepper in their area.

Keywords: Cultural practices, *Solanum melongena*, cultivation, productivity, Warawa local government

INTRODUCTION

Rapid increase in world population and especially in developing countries brings about increase in food needs and this makes the development of dry season (irrigation) a potentially effective investment to service the basic needs for food and employment in these countries. The development of irrigation in Nigeria was dated by Ibrahim (1991) to the pre-colonial era when traditional means were used to apply water to land for dry season farming in the northern part of the country. According to Aminu (2006), the production of vegetables such as onion, tomato, pepper under irrigation in northern states of Nigeria has been found to be a lucrative economic activity because of the readymade market available in the vicinity of production area and particularly in the southern states of the country where there has always been demand for them.

Eggplant (*Solanum melongena* L.) also known as garden egg, aubergine, brinjal, or Guinea squash, is in the fourth ranked vegetable crops. It is of considerably economic importance in Asia, Africa, and subtropics (India, Central America), but is also grown in some warm temperate regions (Mediterranean area, South of the USA). In 1999, 1.3 million ha were cultivated in the world for a total production of 21.2 million metric tons of which 92.4% of the world production was covered by Asia (F.A.O, 2012).

Although lower than that of tomato, eggplant nutritious value is comparable to other common vegetables. Its fresh weight is composed of 92.7% moisture, 1.4% protein, 1.3% fibre, 0.3% fat, 0.3% minerals, and the remaining 4% consists of various carbohydrates and vitamins (A and C) (Fuchsia, 2006). Eggplant is susceptible to numerous diseases and parasites, particularly bacterial wilt, *Fusarium* and *Verticillium* wilts, nematodes and insects. It exhibits partial resistance to most of these pathogens, but often at insufficient levels. This crop is highly vulnerable to plant parasitic nematodes especially with *Meloidogyne* spp. or root knot nematodes.

Inorganic fertilizers are chemical products of either minerals or synthetic origin that provide nutrients to stimulate plant growth. Unlike the organic, inorganic fertilizers are usually quick releasing formulas making nutrients rapidly available to plants. Introduction of inorganic fertilizer in the early to mid-20th century was responsible for massive increases in what individual farmers could produce. The major problem was the result of too much application. A plant can only utilize so much during its cycle of growth; the leftovers have the tendency to pollute the environment causing problems. When using inorganic fertilizer, nutrients are immediately available to plants and the exact amount of a given element can be measured before feeding plants; however, commercial fertilizer, particularly nitrogen is easily leached out by rain or irrigation. Regardless of using organic, inorganic fertilizer or a combination of the two it is important to follow the manufacturer's guidelines regarding timing of application, placement of the fertilizer to be used.

Inorganic fertilizers are designed to address the tendency of soils nutrient, which is a very common problem in farms. One distinctive advantage of inorganic fertilizer is it contains all the 3 major nutrients, nitrogen, phosphorus and potassium. Additionally, this type of fertilizer can provide plants with immediate nutrients supply when the need arises, unlike organic fertilizer that only have a slow release capacity. Inorganic fertilizers work faster and may be utilized in balance of the farms need. They are also less costly than commercial organic fertilizer as well as may be used in concentrated amounts.

The main disadvantage of inorganic fertilizers is that they have acidic content. Acids that is present in inorganic fertilizers such as hydrochloric acid and sulfuric acid leads to high level of soil acidity that could in turn have a destructive effect on nitrogen fixing bacteria. These microorganisms play a major role in the supply of nitrogen needed by growing plants. Another disadvantage is in over application of the fertilizer, plants only need certain amount of nutrients that can be absorbed. When the fertilizers are used excessively, the rest of the unused or unabsorbed one has the tendency to travel into ground water due to irrigation and rain. The aim of this study is to find out the opinion of farmers as well as the effects of inorganic fertilizer on soil characteristics and production of eggplant (*solanum melongena* L.) in Warawa irrigation area of Kano state.

MATERIALS AND METHODS

Experimental site:

The study was carried out at Warawa village which is located in Warawa Local Government Area of Kano State, with approximate location of latitude 11^{o} 21^{1}N and longitude 8^{o} 09^{1}E. The area lies within the tropical continental climatic environment, with a very long period of dry season that lasts between 6 and 8 months (October to April) and a shorter period of rainy season i.e (May to September) with August at the peak period of the rainy season; the main annual rainfall is less than 1,000mm. Both mean daily and mean annual temperature vary. The days are hot due to the intensive solar radiation while nights are usually colder. The months of November to February are usually cold with temperature of less than 24^{0}C, due to the influence of the harmattan winds which originates from the Sahara desert. While other months are moderately hot with a mean monthly temperature range of 27^{o}C to 30^{o}C.

The area is found within the Sudan savannah region which is characteristically a grassland region with scattered trees, which are mostly water-resistant. The availability of grass makes it suitable for cattle rearing and other animal grazing. Over 90% of the inhabitants of the area are farmers cultivating cereals, legumes and vegetable crops. During the dry season, Kura reservoir water is being used to irrigate about 150 ha of smallholder farmlands. The reservoir has a capacity to store 12.5 million cubic meters of water and has the potential to irrigate 400ha of land. The major crops cultivated in the area during the dry season are: pepper, garden egg, tomato, lettuce, maize, potato and melon.

Soil Sampling

Black *et al.* (1975), Tisdale (1975) and Barrow (1993) stated that the magnitude of variation within the soil determines the intensity with which soil would be sampled to give accurate estimate of some soil characteristics. London (1991) explained that the scale and intensity of survey depends on the variability of the soils and land farms and the proposed land uses. In this regard, for the purpose of this research, the following pattern of soil sampling was adopted.

The two sites of study (farmers and experimental sites) were selected for the study. The soils of the two sites are similar, with similar land forms, geology, land use and vegetation and topography are similar. The main difference is the way each site support the growth and development of vegetable (especially pepper).

Stratified random sampling was used for the purpose of collecting soil samples (Idris, 2010). Ten soil samples were collected from each site which was stratified into ten units base on physiographic and management system, then each unit was randomly sampled. The soil samples were collected using hand shovel from 0 to 15cm. A total of twenty soil samples were collected from both farmers and experimental sites. The soil were dried and crushed with motar and pestle and pass through a 2mm sieve, the samples were analyzed in the laboratory for their physical and chemical properties [pH (H_2O), pH ($Cacl_2$), organic matter (OM), total nitrogen (TN), phosphorus (P), exchangeable bases (Ca, Mg, K, Na), exchangeable acid (H+Al), micronutrients (Cu and Zn) and cation exchange capacity (C.E.C)].

Laboratory Technique

Determination of soil PH

Soil to water ratio (1:2.5) was used to determine the soil PH. 20g of air-dry soil (passed 2mm sieve) to 50ml beaker was weighed and 20ml of distilled water was added. The suspension was vigorously stirred several times during the next 30 minutes with a glass rod. The suspension was then allowed to stand undisturbed for about 30 minutes to allow most of the suspended clay to settle out from the suspension. The electrodes of the pH meter were inserted into the partly settled suspension and the pH value was taken within 30 seconds after immersion.

Determination of Organic Matter

To determine the organic contents of the matter the percentage of organic carbon was determined first and the result multiplied by 1.729. To determine the organic carbon, the following procedure was followed:

1. Representative sample was taken, ground grid, and passed through 0.5mm sieve.
2. One gram of soil was weighed and place in the 250ml flask.
3. Ten mills of 1N $K_2Cr_2O_7$ solution was pipette accurately into each flask and swirl gently to disperse the soil.
4. Twenty mills Conc. H_2S0_4 was added rapidly from a measuring cylinder. Immediately the flask was swirl gently until soil and reagent are mixed, the swirl vigorously for one minute. The flask was rotated again and allowed to stand on a sheet of asbestos for about 30 minutes.
5. One hundred mills of distilled water was added after standing for 30 minutes and allowed cool again. The suspension was filtered because it was cloudy.
6. Five mills of O- phosphoric acid was added to sharpen the colour change at the end point.
7. Three to four drops of incubator were added and filtrated with 0.5N ferrous sulphate solution on a white background. As the point approached the solution took on a greenish cast and then changes to dark green. At this point ferrous sulphate drop was added until the colour changes sharply from blue to red (maroon colour) in reflected light against a white background.
8. The blank determination was made in the same way but without soil to standardize dichromate.
9. The results was calculated using the following formulae:

$$\% \text{ organic C in soil} = (K_2Cr_2O_7 - FeSO_4 \frac{0.003 x 100 x (F)}{\% \text{ of air in dry soil}}$$

Where F = correction factor = 1.33

Meq = normality of solution x ml of solution sed

Or

$$\frac{\text{Organic C}}{\text{Air – dry basis}} = \frac{(\text{Blank titre – actual titre}) \times 0.3xmx(F)}{\% \text{ of air – dry soil}}$$

Where F = correction factor = 1.33

M = concentration of $FeSO_4$

Percentage organic matter (OM) will be calculated thus:

% OM = % OC x 1.729

Determination of Exchangeable Bases

Ammonia saturation method (at pH 7.0) was used to determine the exchangeable bases which include sodium (Na), Potassium (K), Calcium (Ca) and Magnesium (Ma). Ten grams of air dried soil sample was weighed into a plastic bottle, 100ml of 1N ammonium acetate solution was added and the content of plastic bottle was shaken for 30 minutes. The mixture was then allowed to settle. Then the supernantant liquid was correctly decanted, as completely as possible through a funnel ad filter paper into a 250ml volumetric flask. The processes were repeated twice, each time decanting the supernatural liquid into the 280ml flask. Finally the volume of flask was added with ammonium acetate solution.

However, sodium (Na) and potassium (K) were determined using flame photometer choosing appropriate range of standards from which the sample values were extrapolated while calcium (Ca) and magnesium (Mg) on the other hand were determined by EDTA titration.

Calcium and Magnesium

Twenty mills of the exchangeable base extracts was pipette into a clean conical flask. It drops of ammonium chloride, ammonium hydroxide buffer solution (NH_4O_4 – NH_4Cl) was added and then 2 drops of eriochrome black T was also added then the mixture was filtered against 0.01N EDTA solution until the true blue and point was obtained.

Calculations

Me/100g of Ca & Ma = M1 of EDTA used x normality 0.01 of EDTA
100 x Vol. of extracts
ML of EDTA used for titration x et

Determination of Exchangeable Acid in Soil

Five grams of air dried soil was weighed into a 50ml centrifuge tube and add 30ml of INKCL the centrifuge was covered tightly with a rubber stopper and shake for 1 hour on a reciprocating shaker. The content was centrifuged at 2,000rpm for 15 minutes. The decant was carefully clear supernatant into a 100ml volumetric flask. Another 30ml of 1N CL was added to the same soil sample and shake for 30 minutes, step two were repeated and clear supernatant were transferred into the same volumetric flask. Step 3 was repeated for the third time and clear supernatant were decanted into the same volumetric flask. The volume was made up to mark with 1N KCL.

Titration for H and Al

Twenty five (ml) of KCL extract was pipette into a 250ml Erlenmeyer flask 100ml of distilled water was approximately added 5 drops of phenolphthalein indicator was added, and the solutions were titrated with 0.01m NaOH to a permanent pink and point with alternate stirring and standing. A few more drops of indicator was added to bring the solution back to the colourless condition and 10ml of NaF solution were added. While, stirring the solution constantly, the solution was titrated with 0.01 HCl until the colour of the solution disappears because the colours doesn't return within 2 minutes. The milli equivalents of acid used an equal to the amount of exchangeable Al.

The value from the milli equivalent of total acidity was subtracted from the first titration to obtain the milli equivalent of exchangeable H and Al in meq per 100g of soil.

Determination of Total N in Soil

Two grams of soil was weighed into Kjeldahl flask or digestion tube, 20ml of distilled water was added, the flask was swirled for a few minutes and was allowed to stand for 30 minutes. About 3g of catalyst and 20ml of concentrated H_2SO_4 was added. Heat continuously until the water has been removed and fronting has ceased the heat is increased until the digest clears. The mixture was boiled for 5 hours. The heating was regulated during this boiling so that the H_2SO_4 condensed about half way up the neck of the flask or tube the flask is allowed to cool and some distilled water was added slowly with shaking.

Carefully the digest was transferred into another clean flask, all the sand particles were retained in the original digestion flask because sand can cause severe pumping during distilled water for about 4 times and each portion were transformed into the same flask. The mark was made with distilled water.

Ten (ml) of boric acid (H_3BO_3) solution was added into a 500ml Erlenmeyer flask which was then placed under the condenser of the distillation apparatus. The end of the condenser was at about 4cm above the surface of the H_3BO_3 solution 10ml of 40% NaOH was added slowly into 10ml of digest in the flask which has been attached to the distillation apparatus. The temperature was raised until it boils. The condenser kept cool (below 30^oC) by allowing sufficient water to flow through and regulate heat to minimize frothing ad prevent suck back. About 5oml distillate was collected and then stopped distillation.

NH_3 liberated were titrated with standard HCl or H_2SO_4 .Three drops of indicator were added the colour change at the end point from green to pink.

N constant in the soil was

$$\%N = \frac{0.014 \times vd \times N \times 100 \times TV}{\text{Wt of soil} \times AD}$$

Where

VD	=	Volume of digest
N	=	Normality of acid
TV	=	Titre value
AD	=	Liquor or digest

Determination of Available Phosphorus (P)

Bray No 1 method was used to determine available phosphorus (P). To do that, 1g of air dried soil was weighed into a 15ml centrifuge tube, 7ml of the extraction solution were added and shaken for 1 minute o a mechanical shaken and centrifuge the suspension at 2,000 rpm for 15 minutes. The solution was transferred into an acid washed volumetric flask.

The phosphorus content was determined in the extract calorimetrically using ascorbic acid molybdate blue because it is recommended for analysis of P in plant extracts.

Determination of Cu and Zn

Hydrochloric acid extraction method was used, below is the procedure followed:

1. A 5g of 2mm sieved soil was weighed into 100ml plastic bottle
2. Fifty mills of 0.1m HCl was added and shaken for 30 minutes
3. The solution was filtered through No 42 filter paper or centrifuge
4. The Cu and Zn were determined on an atomic absorption spectrophotometer.

Determination of CEC

The C.E.C of the soils was determined by summing the value of exchangeable base and that of acid.

Number, Weight and Diameter of Fruit

The number of fruits on each plant selected was counted and their mean was recorded. The weight of ten (10) randomly selected fruits in a bed was weighed and their mean was recorded. The diameter of the fruit was obtained by rounding the fruits with a thread and later placed on a meter rule to get the exact diameter in centimeter (cm).

Data Analysis

All data recorded were statistically analysed by one way analysis of variance (ANOVA) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Egg plant matures at 12 weeks (3 months) after transplanting when the colour of the fruits turn red/yellow (Komolafe and Joy, 1999). The greatest yield (%) in Warawa area was 40-50 bags/ha which shows a decrease compared to the yield of 5-10 years back (Table 1, Part D).

The highest number of fruits harvested per bed, the greatest diameter of fruit and the greatest weight of fruits per bed observed were in the fertilizer treated plants which differ from the quantity applied by the farmers with an increase in quantity from first application progressively as a result of which sodicity effect occur which lead to low productivity and dryness of the plants after transplanting in the area. This was similarly observed by many workers, Osman and George (1984) reported an increase in study of the effect of mineral nutrition on seed yield and quality of sweet pepper plant. Gill *et al.* (1974) reported a considerable increase in number of fruits per plants as well as seed yield. Waknade and Morey (1982) similarly observed an increase in yield in field grown chilies upon application of phosphate.

Table 1. Physico-chemical parameters of the soil where farmer's and experimental sites

Soil variable	Farmers site		Experimental site		t-test value	Table value
	Mean	St. dev.	Mean	St. dev.		
Sand %	83	1.8	85	3.10	0.432	2.262
Clay %	10	1.30	9.60	4.80	0.410	"
Silt %	6.80	0.98	5.40	1.30	0.610	"
pH (H_2O)	6.30	0.20	6.30	0.20	NS	"
pH ($CaCl_2$)	5.90	0.30	6.30	0.40	4.04	"
OM %	0.90	0.40	0.40	0.20	30.48	"
TN %	0.05	0.01	0.05	0.08	N.S	"
P (ppm)	95.90	14.90	20.10	7.70	0.450	"
Ca (me/100g)	3.30	1.50	1.97	0.50	1.390	"
Mg (me/100g)	0.80	0.20	0.64	0.30	3.478	"
K (me/100g)	0.20	0.12	0.48	0.83	6.81	"
Na (me/100g)	0.20	0.03	0.20	0.01	N.S	"
H+Al (me/100g)	0.80	0.30	0.80	0.20	N.S	"
Cu (ppm)	5.20	1.60	0.50	0.90	41.230	"
Zn (ppm)	0.20	0.50	3.80	0.20	0.40	"
C.E.C	6.80	3.80	4.01	1.50	17.375	"

Table 2. Mean number of fruits, diameter of fruit (cm) and weight of fruits (g) of *Solanum melongena* treated with different level of inorganic fertilizer

Levels of inorganic fertilizer	10 WEEKS AFTER TRANSPLANTING				14 WEEKS AFTER TRANSPLANTING					
	NF		DF		NF		DF		WF	
	Site A	Site B	Site A	Site B	Site A	Site B	Site A	Site B	Site A	Site B
0.00kg/bed	0.50	1.25	2.55	4.50	8.25	8.75	10.00	12.73	41.03	40.80
0.05kg/bed	2.75	3.25	6.10	7.38	12.25	10.75	13.28	15.08	43.73	60.33
0.10kg/bed	3.25	3.50	9.73	9.68	10.00	14.25	13.98	14.30	63.13	62.35
0.15kg/bed	4.25	2.50	8.30	5.85	16.75	11.25	14.65	13.53	60.75	43.78
0.20kg/bed	2.50	2.25	5.85	5.90	9.75	9.50	12.58	10.00	26.08	27.30
LSD 5%	NS	NS	4.33	2.89	4.38	NS	2.21	2.06	3.56	4.05

WAT - weeks after transplanting
NF - Number of fruit
DF - Diameter of fruit
WF - Weight of fruit
SITE A - Farmers site
SITE B - Experimental site
NS - Not significant

CONCLUSION

The results obtained in this study are generally in agreement with the following conclusion:

i. The result of this investigation reveals that farmers' activities positively affect soil properties due to low productivity.

ii. The soil of the study area has good internal drainage with moderate available nutrients, it doesn't encounter permeability and salinity but sodicity problems.

iii. From the result of the study it can be concluded that at the farmers site the best level of inorganic fertilizer that enhanced better growth and yield of eggplant (*Solanum melongena)* was 0.15kg while at experimental site was 0.10kg.

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