IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS)
e-ISSN: 2278-3008, p-ISSN:2319-7676. Volume 10, Issue 4 Ver. II (Jul - Aug. 2015), PP 36-40
www.iosrjournals.org

Residual Effects of Nitrogen Fertilization and Cowpea Residues on Yam (Dioscorea Rotundata Var. Obiouturugo) Production on an Ultisol

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Abstract: *Yam cultivation is generally limited by decreasing soil fertility, occurrence of nutrient imbalances and inappropriate fertilizer practices. A study was carried out at the NRCRI, Umudike in Southeastern Nigeria in 2009 – 2011 to evaluate the residual effect of nitrogen fertilization and cowpea residue on yam (Dioscorea rotundata var. Obiouturugo) production on an ultisol.* ***.*** *Eight treatments, namely: poultry dropping (PD) + 15.5 t ha^{-1} cowpea residue„ brewers' spent grain (BS) + 13.7 t ha^{-1} cowpea residue, sawdust (SD) + 13.9 t ha^{-1} cowpea residue, cow dung (CD) + 19.8 t ha^{-1} cowpea residue , pig dung (PG) + 13.7 t ha^{-1} cowpea residue, combination of all the organic sources (CB) + 18.2 t ha^{-1} cowpea residue, urea (UR) + 14.7 t ha^{-1} cowpea residue and a control (CT) + 11.9 t ha-^{1} cowpea residue, were used. Treatments were applied at recommended rate of 120kg N ha-^{1}in April 2009 and 2010 respectively, one week after planting of maize, with cowpea residue incorporated into the soil in 2010 and 2011 respectively. Significant differences (P< 0.05) in yam production were observed among the different treatments. Nitrogen fertilization and cowpea residue gave higher ware yam yield than the control. The SD plus 13.9 t ha^{-1} cowpea residues treatment significantly gave higher yield (10.53 t ha-^{1}) than the other treatments. The results of this study clearly indicate the importance of nitrogen fertilization and its residual effect on yam production on an ultisol and therefore recommended.*

Keywords: *Nitrogen fertilization, Cowpea residues and yam.*

I. Introduction

Poor soil fertility has been identified as a major constraint to sustainable yam production in Southeastern Nigeria (Chukwu, 2007). Thus, sustaining soil fertility has become a major issue for Nigeria to maintain her global leadership in yam production and to produce enough yams to feed her citizens and support agro industries.Nitrogen deficiency is one of the major limiting factors for yam production in the tropics.Hence, nitrogen fertilizer application is an essential input for yam production in these areas.

Southeastern Nigerian soils like most other tropical soils are usually described as having low nitrogen level (Babalola, 2000). This deficiency in nitrogen could be supplemented with organic and inorganic nitrogen fertilizer sources. Nigerian soil resources and indeed the soil resources of the Southeastern Nigerian have high potential for enhancing agricultural productivity if well managed.Cowpea is a grain legume grown mainly in the savannah regions of the tropics and subtropics in Africa, Asia and South America (Yusuf, et al. 2006). The cultivation of cowpea legume crop offers a potential for meeting the soil fertility requirements at minimal cost to the farmer (Giller, 2001). Legume has been reported to fix up to 100kg of N per year and to improve poor soils (Wilson and Okigbo, 1982). Legumes symbiotically fix part of the soil organic – N in vegetative residues for use of the subsequent crop in addition to many other positive effects on the soil (Bala et al., 2003; Eaglesha, 2005). The residues of some leguminous crops like cowpea improved soil chemical properties by facilitating the utilization of soil P by crops in the low P soils of Northern Guinea Savannah of Nigeria (Emechebe, 1986; Nottidge et al., 2006).Vigorous cowpea varieties compete well against weeds and act as physical barrier between rainfall and the soil surface.

Whether cowpea grown for grain can contribute significant N is poorly understood. It becomes an economic necessity that the excellent N_2 – fixing potential of cowpea will be exploited for the most efficient use of available fertilizer N. Immobilization results in plant usable forms of N in the soil becoming available for subsequent crop growth. This N is used by microorganisms in the decomposition process of corn stalk and sawdust. Once the corn stalk and sawdust decays, immobilization stops and mineralization starts. Immobilization can result in a reduction of inorganic form of N, including nitrate. However, this reduction in nitrate is generally temporary (Hansen et al., 2001; Bakht et al., 2009). Residual effects of N fertilization and compost application can maintain crop yield level for several years after manure or compost application ceases, since only a fraction of the nitrogen and other nutrients in the manure or compost becomes plant available in the first year after application (Eghball, et al.,2002: Ginting,et al.,2003).

Therefore, this study is to evaluate the residual effect of nitrogen fertilization and cowpea residue on ware yam production on an ultisol in Southeastern Nigeria.

II. Materials And Methods

The research was carried out at National Root Crops Research Institute Umudike (NRCRI) research farm (5' 25 N and 7' 35 E) in the rainforest ecological zone of Southeastern Nigeria, the area is 122m above the sea level (NRCRI, 2007). The climate is the humid tropical region with lowland rainforest vegetation. The soil of the study area is classified as ultisol or ferralitic soils (FAO and USDA, 1975) and as summarized by Opara – Nadi, (2000). The experimental site has a number of soil related constraints to agricultural productivity such as low inherent fertility and high susceptibility to soil erosion and drought stress (Babalola and Opara –Nadi, 1993; Opara – Nadi, 2000). The experimental design was a randomized complete block with three replications (RCB). Eight treatments, namely: control (CT) without N sources + 11.9 t ha^{-1} cowpea residue, urea (UR) inorganic source + 14.7 t ha^{-1}cowpea residue, poultry dropping (PD) + 15.5 t ha^{-1} cowpea residue, brewers' spent grain (BS) + 13.7 t ha^{-1} cowpea residue , sawdust (SD) + 13.9 t ha^{-1} cowpea residue, cow dung (CD) + 19.8 t ha^{-1} cowpea residue, pig manure (PM) + 13.7 t ha^{-1} cowpea residue and combinations of all the organic sources (CB) + 18.2 t ha^{-1} cowpea residue. Nitrogen sources were applied at the nitrogen recommended rate of maize of 120 kg N ha^{-1} and the N content of the nitrogen sources were determined in May before planting of maize and cowpea rotation cropping in 2009 and 2010 respectively. The residual effects of the nitrogen fertilizers applied and the effects of the cowpea residues that were worked into the same soil were tasted in white ware yam *(Dioscorea rotundata var. Obiouturugo*) production in 2010 and 2011 respectively. The weight of the cowpea residue was taken in the entire plot before allowing for some time for decomposing before the field was prepared for the subsequent cropping. Mounds were made in the entire plot with a spacing of 1m x 1m. The chemical properties of the nitrogen sources used in the study are in Table 1.

Pre-cropping (undisturbed) composite soil samples were taken from 0 – 30 cm depth from representative field locations before slashing of the study site in 2009 and 2010 and from 0 – 30 cm depth (disturbed) composite soil sample after cowpea harvest in 2009 and 2010 for baseline data Table 2 and Table 3. All observations (sampling and analysis) were done according to the Tropical Soil Biology and fertility (TSBF) programme Handbook of methods, as described by Anderson and Ingram (1989). These samples were analyzed and were used to determine pH using soil water ratio electrode method by McClean, (1982), organic carbon by Walkley and Black (1934) wet oxidation method as modified by Juo,(1979),total N by the macro – Kjeldah distillation (Bremner,1965), available P was determine by the Bray – 1 method (Bray and Kutz,1945), exchangeable cations (ca, mg, kand Na) by extracting K and Na with 1N neutral ammonium acetate solution and determined photo metrically using flame photometer (Black,1965), Ca and Mg were also extracted and titrated with EDTA (1965) and exchangeable acidity was determined by titration method (McClean *et al*.,1965). Data collected were subjected to standard statistical analysis of variance (ANOVA). Treatment means were separated using least significance difference (LSD) at 5% level of probability test.

III. Results And Discussion

Some chemical properties of the nitrogen source used in the study

Brewers' spent grain (BSG) showed the highest total N (5.59%) and Mg (0.30 $cmokg^{-1}$) content when compared with other organic N materials used in the study while SD had the lowest N content Table 1. The data indicated that urea (inorganic fertilizer) with N content of (46%) would be a better N source than the organic sources.

Table 1: Some chemical properties of the organic and inorganic source used in the study

Nitrogen Sources	Total N %	Bray -1 P $mgkg^{-1}$)	Ca	Mg Cmokg	K	Na
UR	46	-	-	-	-	-
PD	1.57	1.15	1.20	0.05	0.40	0.31
BS	5.95	1.12	0.90	0.30	0.05	0.28
SD	0.28	0.39	0.70	0.18	0.28	0.08
CD	1.30	0.15	0.48	0.07	0.23	0.78
PG	1.47	1.25	0.52	0.05	0.27	0.19

The mean (undisturbed) soil chemical properties of the 0 – 30 cm depth of the experimental site determined in 2009 and 2010 before planting of maize was shown in Table 2. The study site soil (Umudike Umuahia in Southeastern Nigeria) showed soil pH of 4.2 which is within the class of extremely acidic (pH 4.1 – 4.6). Soils in this class are low in calcium, magnesium and phosphorus which are normally available to plants. The soil and crop management practice of this study area which had relied much on inorganic fertilizer input and other acid – inducing practices suggested that the low pH (high acidity) of the study site can be described as natural rather than induced. According to USDA (1975), in natural ecosystems, the pH is affected strongly by the mineralogy, climate, weathering and management than any other factor.

The mean (disturbed) soil chemical properties of the 0 – 30 cm depth of the experimental site determined in 2009 and 2010 after cowpea harvest was shown in Table 3. Data after cowpea harvest showed that the different nitrogen sources increased the SOC content in the 0 – 30 cm depth when compared with the initial SOC content. The increase in SOC content was 5.8, 9.6, 16.3, 20.2, 11.5, 8.7, and 19.2 percent respectively for UR, CD, PD, SD, BS, PM, and CB nitrogen sources when compared with the initial SOC content. The results of this study are in agreement with the findings of Dunjana *et al.* (2012) who reported that the addition of cattle manure resulted in significant ($p < 0.01$) increases in SOC. On the other hand, Fening *et al.* (2011) reported that after three cropping seasons, SOC levels declined due to cattle manure compost application.

Differences in total nitrogen content in 2009 and 2010 after cowpea harvest among the different nitrogen sources were significant at the 5% level. However, total nitrogen content in comparism with the CT treatment, UR, BS, PD, SD, PM and CB increased by 75.0, 58.3, 41.7, 33.3, 33.3 and 25.0 percent respectively. The lower C: N ratio after cowpea harvest could be attributed to the higher nitrogen released into the soil by cowpea. Results in available P in this study shows that the addition of organic and inorganic nitrogen fertilization resulted in substantial increase in available P above the initial values. The available P values agree with the findings of Fening *et al.* (2011) who reported that after three cropping seasons, cattle manure compost resulted in significant increases in soil available P. Exchangeable Ca content sampled after cowpea harvest ranged between 3.0cmol kg^{-1} in CT and 3.5cmol kg^{-1} in SD, CD and BS treatments, available Mg content for the same depth ranged between 1.9cmol kg^{-1} in CT and 2.5cmol kg^{-1} in PD.

Depth distribution of exchangeable K and Na after cowpea harvest did not vary so much among different nitrogen sources. For example, K content after cowpea harvest ranged between 0.09cmol kg^{-1} and 0.13cmol kg^{-1} in BS. These results show that the depth distribution of exchangeable Ca, Mg, K and Na after cowpea harvest did follow any particular trend. In comparism with the initial content of exchangeable Ca, Mg, K and Na, it can be observed that the addition of organic and inorganic nitrogen fertilization resulted in increase in these cations which shows the short-term effect of this nitrogen fertilization on soil fertility.

This is in agreement with what Philip, (2009) reported, that cowpea roots reach the sub soil and helps in making moisture accessible to the cowpea and future crop and improved soil properties.

Table 2: Mean chemical properties of 0 – 30 cm depths of the experimental site in 2009 and 2010.

Parameter	0 – 30 (cm depth)
pH (1.1H_2O)	4.2
Organic carbon (%)	0.99
Total nitrogen (%)	0.08
C:N ratio	12.4
Available phosphorus (mg kg^{-1})	22.1
Exchangeable cations (cmolkg^{-1})	
Calcium	1.95
Magnesium	1.35
Potassium	0.10
Sodium	0.07
ECEC (cmolkg^{-1})	4.30
Exchangeable acidity (cmolkg^{-1})	0.76
Base saturation (%)	83.0

Table 3: Soil mean chemical properties of 0 – 30 cm depth sampled after cowpea harvest in 2009 and 2010.

Nitrogen Source	pH (1:1H_2O)	Organic C	Total N	C:N	Avail. P	Exchangeable cations Ca	Mg	K	Na
		—— (%) ——			(mg kg^{-1})	(cmol kg^{1})			
Control (CT)	4.5	1.05	0.12	8.8	19.5	3.0	1.9	0.09	0.07
Urea (UR)	4.7	1.10	0.21	5.2	21.3	3.3	2.3	0.12	0.09
Sawdust (SD)	4.9	1.25	0.16	7.8	20.6	3.5	2.1	0.12	0.09
Poultry dropping (PD)	5.1	1.21	0.17	7.1	21.9	3.4	2.5	0.11	0.10
Cow dung (CD)	5.2	1.22	0.16	7.6	25.1	3.5	2.4	0.10	0.11
Brewers' spent grains(BS)	5.5	1.16	0.19	6.1	23.8	3.5	2.3	0.13	0.12
Pig manure (PM)	5.3	1.13	0.16	7.1	22.4	3.4.	2.2	0.12	0.12
Combination (CB)	5.2	1.24	0.15	8.3	21.8	3.3	2.2	0.11	0.11
Mean	5.1	1.19	0.16	7.8	22.1	3.4	2.3	0.11	0.11
LSD (0.05)	0.4	0.11	0.04	1.3	2.1	0.2	0.2	0.01	0.02

The result of the fresh tuber yield was shown in Table 4. Generally, fresh yam tuber yield was significantly affected by residual nitrogen fertilization and cowpea residue when compared with the control. The SD plus 13.9 t ha^{-1} cowpea residues significantly gave higher yield (10.53 t ha-^{1}) than the other treatments except the CB plus 18.2 t ha^{-1}cowpea residues which gave (10.40 t ha-^{1}) when compared with the control that gave the lowest yield (6.43 t ha-^{1}). The order were SD > CB > PM > CD > BS > PD > UR > CT. Differences in SD plus 13.9 t ha^{-1} cowpea residues among the different N treatments were significant at the 5% level. This observation could be attributed to the long term effect of SD treatment to the soil nutrients. The non- significant effect between SD plus 13.9 t ha^{-1} cowpea residue, and CB plus 18.2 t ha^{-1}cowpea residues may be attributed to the fact that CB also contains some quantity of SD. This agrees with the observation made by (Barbara, 2010; Kirsh, 1959) who observed that SD and wood mulch can potentially lower soil fertility in short term but their long-term value in building soil is beyond question. There was no significant difference between the BS, PD treatments. However, tuber yield in comparism with the CT treatment, UR, BS, PD, SD, PM and CB increased by 8.09, 27.10, 27.84, 63.76, 37.95 and 61.74 percent respectively.

Table 4: The mean crop performance as produced by residual effects of nitrogen fertilization and cowpea residue in 2010 and 2011

Treatment	Establishment count (%)	No. of tubers (no)	Fresh tuber yield (t ha^{-1})
Control (CT)	90.00	18444	6.43
Urea (UR)	88.89	20833	6.95
Sawdust (SD)	94.44	24333	10.53
Poultry dropping (PD)	94.44	24556	8.22
Cow dug (CD)	92.22	20667	8.49
Brewers' spent grain (BS)	95.56	20889	8.23
Pig manure (PM)	93.34	19667	8.87
Combination of organic manure (CB)	92.22	22500	10.40
Mean	83.6	21486	8.52
LSD(0.05)	14.2	1507.9	1.1

IV. Conclusion

The results of this study support the following conclusions;

Generally, nitrogen fertilization and cowpea residue significantly enhanced substantial long term benefits in fresh yam tuber yield. For most of the treatments evaluated SD treatment gave the highest fresh tuber yield.The results of this study clearly indicate the importance of nitrogen fertilization and its residual effect on yam production on an ultisol in Southeastern Nigeria.

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