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Influence of Nitrogen Fertilizer Application on Organic Carbon Content of Underutilized Vegetable Grown Soils In Southwestern Nigeria

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Abstract

The study examined the effect of fertilizer microdosing on organic carbon content of three underutilized vegetables grown soils of southwestern Nigeria in 2016. The study was a 2 x 2 x 5 arranged in a split-split plot design and replicated four times. The main plot was the two locations. The sub plot was two times of nitrogen application and the sub-sub plot was nitrogen application at 0, 20, 40 and 60 kg N ha^{-1} plus 5 ton ha^{-1} of organic fertilizer (OF) (3.5%), and 80 kg N ha^{-1} without OF. *Solanum macrocarpon, Telfairia occidentalis and Amaranthus viridis* were used. Soil organic carbon was determined prior and after the experiment. The average native soil organic carbon were 25.3 gkg^{-1} and 8.5 gkg^{-1} for Ilesa and Ogbomoso, respectively. Application of nitrogen increased SOC in Ogbomoso compared with the control for all the vegetables while a reduction in SOC was obtained at 80 kg ha^{-1}in Ilesa for *S. macrocarpon.* The study concluded that addition of N reduced organic carbon decomposition in the derived savanna and application of 20 kg N ha^{-1} plus 5 ton ha^{-1} of organic fertilizer was optimal for sustaining soil organic carbon for vegetable production in southwestern Nigeria.

Keywords: Soil organic carbon, agroecological zones, time of fertilizer application

Introduction, scope and main objectives

Soils of sub-Saharan Africa (SSA) are highly weathered and predominated by low activity clays such as kaolinites. Soil organic matter acts as a store house for plant nutrient and helps to sustain soil physical properties under intensive cultivation (Idowu and et al., 2014). There is a wild gap between the actual and obtainable crop yields in both SSA and Nigeria in particular, which has been associated with the prevailing poverty level amongst the small-holder farmers. The average fertilizer use in SSA estimated at 10 kg ha^{-1} is the lowest in the world. Inorganic fertilizers are too expensive for the resource-poor farmers. However, fertilizer microdosing is a technology that has been examined for maize production in East Africa and recommended for reducting fertilizer investment. The technology has not been tested on vegetables and on response of soil organic carbon with N addition. Information on effect of N addition on soil organic carbon has been inconsistent, while some authors reported that N addition suppressed soil respiration and enhanced soil organic carbon, others observed the opposite. The main objective of this study was

to examine the influence of nitrogen fertilizer rate on soil organic carbon with a view to establish the optimal nitrogen fertilizer application for vegetable production in rainforest and derived savanna agroecological zones of southwestern Nigeria.

Methodology

Description of the study area

The study was carried out in two locations: Ilesha which lies within Latitude 7^{o} 38' 36" N and Longitude 4^{o} 45' 40" E in Osun State and Ogbomosho which lies within Latitude 8^{o} 6' 35" N and Longitude 4^{o} 18' 41" E Oyo State. The locations represented the rainforest and derived savanna agroecological zones, respectively. Bulk Soil sample was collected at 0-15 cm depth before planting.

Experimental design

The study was a 2 x 2 x 5 arranged in a split- split plot design and replicated four times. The main plot was the two locations: Ilesa in Osun State and Ogbomoso in Oyo State representing rain forest and derived savanna, respectively. The sub plot was two times of nitrogen application, at planting and 14 days after planting, and the sub-sub plot was five rates of nitrogen application consisting of 0, 20, 40 and 60 kg N ha with basal application of 5 ton ha of organic fertilizer (OF) (3.5%), and 80 kg N ha without basal OF. *Solanum macrocarpon, Telfairia occidentalis and Amaranthus viridis* were the testing vegetables.

Planting method

The planting method employed for *A. viridis and S. macrocarpon* was by drilling, and each plot was divided into six rows with spacing of 0.5 m in-between the rows. Four (4) spoonful seed and eight (8) spoons of dry fine sand were added together in a dry deep plastic container and mixed thoroughly. The mixture was evenly spread per row on each plot. *Telfairia occidentalis* was planted at spacing of 0.75 m × 0.50 m per stand making a crop density of 25 stands per plot.

Data collection

Vegetables were harvested at five weeks after planting and thereafter harvested every two week for two times. Soil samples were collected for determination of soil organic carbon after the third week of harvesting the vegetables. Soil organic carbon was determined using the potassium dichromate method of Walkley-Black (1934) described by Sparks (1996).

Data analysis

Data were subjected to analysis of variance. Means were separated using Duncan's multiple Range test at 5% level of probability using SAS software

Results

The results showed that agroecology had a significant influence on native soil organic carbon (SOC) content (Table 1). The native soil organic carbon was 25.3 g kg $^{-1}$ and 8.5 g kg $^{-1}$ for Ilesa and Ogbomoso, respectively. Soil organic carbon content was decreased after crop harvest in Ilesa while an increase in he values were obtained in Ogbomoso, compared with the control. Time of N addition had no effect on SOC in the two locations. Addition of N increased SOC with or without basal organic fertilizer application compared with the control. The average mean for SOC range from 16.2 g kg^{-1} to 20. 2 g kg^{-1} for Ilesa and 6.9 g kg $^{-1}$ to 8.5 g kg^{-1} for Ogbomoso. The vegetable yield in Ogbomoso was higher than in Ilesa (the results are not shown).

Table 1: Effect of Nitrogen Fertilizer Application on Average Soil Organic carbon

	Solanum macrocarpon		*Telfairia occidentalis*		*Amaranthus viridis*	
	Ogbomoso	**Ilesa**	**Ogbomoso**	**Ilesa**	**Ogbomoso**	**Ilesa**
	<----------gkg^{-1}---------->					
Native SOC	6.0	26.4	7.0	15.9	8.1	20.0
Nitrogen kg ha^{-1}						
0	4.1	26.6	6.2	17.2	4.0	14.1
20	6.4	23.8	6.4	15.3	6.2	15.6
40	7.9	28.2	6.8	16.8	5.9	19.4
60	7.3	16.6	8.4	15.9	8.0	21.4
80	9.1	16.6	14.6	16.1	9.1	15.3
Mean	6.9	20.2	8.5	16.2	6.7	17.1

Discussion

Agroecology had a prominent effect on native soil organic carbon and the response of organic carbon to N addition (Table 1). Soil organic matter consists of an accumulation of undecomposed or partly decomposed roots, stems, and leaves of higher plants, and residues of worms, arthropods, bacteria, algae, and fungi. The dead remain of these materials added to the soil are converted into dark coloured complexes known as humus. According to Aduayi (1985), it is conventional to aim at soil organic matter of between 15 to 50 g kg^{-1} to maintain soil fertility. Native soil organic carbon was 25.3 and 8.5 in Ilesa and Ogbomoso, respectively, within the medium fertility class (Sobulo and Adepetu, 1987). Higher soil organic carbon in the rainforest could be due to higher amount of rainfall in the agroecology. Rainforest zone contains more moisture which supports thick vegetation (Adepetu, 2014). After crop harvest, soil organic carbon increased in the derived savanna with a decline under rainforest with exception of *Telfairia occidentalis*. These results can be explained by the report of Tonitto et al. (2013) that although studies have identified the importance of N additions in suppressing soil respiration and enhancing soil organic carbon, early experimental works have shown that litter quality strongly affected rates of litter mass loss, with decomposition varying inversely with litter lignin:N ratios. It was also reported that liter quality in terms of lignin, hemi-cellulose, and cellulose composition is a defining characteristic of the response of litter decomposition to N. Our study confirmed higher rate of organic carbon decomposition in the rainforet., due to higher microbial activities. In order to encourage application of inorganic fertilizer by farmers, fertilizer microdosing technology should be promoted.

Conclusions

The study concluded that application of 20 kg N ha^{-1} plus 5 ton ha^{-1} of organic fertilizer is optimal for sustaining soil organic carbon for vegetable production in rain forest and derived savanna of southwestern Nigeria. Promotion of production of good quality organic fertilizers from abundant organic materials in the region is essential.

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