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DYNAMICS OF ORGANIC CARBON AND PHOSPHORUS ON A SOYBEAN FIELD AMENDED WITH BIOFERTILIZERS, ORGANIC AND INORGANIC FERTILIZERS

M. O. Adigun[1]*, O. A. Babalola[2], I. O. Abiola[3], O.O Afolabi[1] and N. E. Etukudoh[4]

[1*]*Department of Biological Sciences, Crawford University, Faith City, Igbesa, Ogun State,*
[2]*Department of Soil Science and Land Management, Federal University of Agriculture, Abeokuta, Nigeria*
[3]*Crop Production Technology Department, Federal College of Forestry, Jericho, Ibadan, Nigeria*
[4]*Department of Soil Science, Rivers State University of Science and Technology, Port Harcourt,*
Email: micadigun@crawforduniversity.edu.ng

ABSTRACT

This study was carried out to examine the dynamics of organic carbon and phosphorus of the soil shown to soybean. The experiment was conducted at the Federal University of Agriculture, Abeokuta, Nigeria. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three treatments to study the effect of poultry manure at 0, 5, 10 tons/ha, phosphorus source chemical fertilizer (SSP, mycorrhizal) and *Bradyrhizobium* on the growth and yield of soybean (*Glycine max)*. Treatment was replicated three times. Observations was taken at 4th, 6th, 8th, 10th, 12th and 14th week after planting (WAP) on the Agronomic data of soybean plant. Also the chemical properties of the soil were taken before and at harvesting. Significant difference between the treatments in some growth and yield parameters of soybean were obtained. The result shows that there were different responses of the crop as a result of various treatments. Crops inoculated with treatment performed better in plant height, leaf area, stem girth for growth parameters and in soil minerals (Organic C and available P), while significant difference were observed in yield component such as the weight of 100 seed/hectare. The study concludes that soybean growth and soil obtained minerals was enhanced by the interactive effect of treatments which include the poultry manure, *Bradyrhizobium* and the phosphorus source (SSP, Mycorrhizal). That is, 5 tons/ha of poultry manure with Mycorrhizal produced the highest yield of soybean within the week interval.

Keywords: Soybean, Mycorrhizal, *Bradyrhizobium*, Single super phosphate, Poultry manure.

INTRODUCTION

Soil fertility issues have recently become of mounting interest of tropical Africa. This is due largely to growing need to achieve food security for a rapidly expanding population which has led to intensive exploitation of crop/land resources. Part of the challenges to improve crop production in Nigeria is the maintenance of soil fertility and productivity (Adigun *et al.*, 2013). In the past, cultural methods such as shifting cultivation, practice of crop rotation by peasant farmers were basically the methods of conserving their soil which also helps to sustain and improve the soil fertility and productivity. The use of fertile soil with high organic matter enhances the soil activities and therefore improves the productivity. Soil organic matter is decomposed by soil organisms for the benefit of the ecosystem and this plays a substantial role in providing ecosystem services for plant growth through improvement of soil quality (Cooke, 1982).

Soil quality explains how effectively the soil should accept, hold and release nutrients and other chemical constituents for crop growth, to promote and sustain root growth, maintain suitable soil biotic habitat and resist degradation. Most soil in Nigeria is dominated by low activity clay minerals (LAC) that are strongly weathered with low nutrient status. One way of solving this problem is the use of organic nutrient resources and inorganic fertilizers (Adigun and Babalola, 2016). However, many studies have shown that continuous use of inorganic fertilizers may lead to soil chemical degradation (Agboola, 1980), which may be detrimental to the ecosystem and the purchasing cost is high etc. however, many studies (Debele, 1999; Agboola and Akinnifesi, 1991) have indicated that the key to soil fertility in Nigeria is the improvement of organic matter. The agricultural practices capable of sustaining crop production, renewing the soil organic matter and soil nutrients at low cost are imperative and organic farming is reinforced in Nigeria by high cost and unavailability of inorganic fertilizers, thereby hindering its uses and rendering Nigeria agricultural system unsustainable. The application of organic amendments to soil improves soil organic matter content in low fertility soils which is an environment favorable waste to management strategy (Kumar and Goh, 2000).

Micro-organism is greater in population density and diversity, also responsible for conditioning of litters present in the soil and aiding in the decomposition of organic matter. The result is the release of plant nutrients to the soil for plant uptake. The activities carried out by these micro- organisms' helps in enhancing soil porosity, organic matter decomposition, soil moisture, available of nutrients in soil such as phosphorus, potassium and other elements (Clapperton *et al.*, 2002). Activities such as intensive cultivation, fertilizer application, mechanized land clearing, indiscriminate use of agro chemicals affects their population and species diversity, therefore care must be taken in order not to lose a multiple amount of them from soil. Organic fertilizers such as poultry manure have been applied to promote soil productivity. However, there is a usually positive correlation between the number of micro organisms and organic matter content or litter of plant residues in the soil (Adejuyigbe, 1994).

MATERIALS AND METHODS

Experimental Site

The field experiment was carried out on one of experimental fields behind the Federal University of Agriculture, Abeokuta, of (latitude 7^0.13N and longitude 3^0.28E) south west Nigeria between August and September 2011.

Experimental Design

Experiment was setup using four treatment arranged in Randomized complete block design with three replicates.

Soil was amended with the following treatments.

A. Phosphorus source (Mycorrhizal and Single super phosphate)
B. Poultry manure (0, 5 and 10 tons/ha)
C. *Bradyrhizobium.*
D. Control

PLANTING AND TREATMENT APPLICATION

Total experiment plot was 36 units (25 m by 25 m) in the whole study area with a land area of 625 m^2 with alley which was cleared manually and divided into individual plots of 3 m by 3 m using pegs, Soybean was planted using 5 cm by 75 cm spacing with a plant population/ha = 266,000. Seeds were planted in rows using drilling method, thinning was not necessary. 5 mls of Arabic gum with 2.5 grams of *Bradyrhizobium* for 500 grams of soybean was prepared for seed inoculation while soil inoculation was done for Mycorrhizal fungi.

Table 1: A Tabular Illustration on the Application of Treatment on Individual Plot Size is Stated Below:

Myc 0pm	Myc 10pm	Myc 5pm	Brad/Ssp 0pm	Ssp 0pm	Brad/Myc 5pm
Brad/Ssp 10pm	Ssp 5pm	Brad/Myc 5pm	Ssp 10 pm	Brad/Myc 0 pm	Brad/Myc 10 pm
Myc 10pm	Myc 0pm	Brad/Ssp 0pm	Myc 5pm	Brad/Ssp 5pm	Brad/Ssp 10 pm
Ssp 5pm	Ssp 0pm	Brad/Myc 0pm	Ssp 10 pm	Brad/Myc 10 pm	Brad/Myc 10 pm
Myc 5pm	Myc 10pm	Brad/Ssp 10pm	Ssp 10 pm	Brad/Ssp 5pm	Myc 0pm
Brad/Ssp 0kg/ton	Ssp 5kg/ton	Brad/Myc 5kg/ton	Ssp 0kg/ton	Brad/Myc 0kg/ton	Brad/Myc 10kg/ton

SAMPLING COLLECTION

Soil sample was collected from each plot in the field using a soil auger in moist and air dried form. This was sieved with 2 mm sieve for laboratory analysis and the sample was taken twice, 4th and 8th week after planting.

AGRONOMIC DATA

Observations were taken on the plant height, stem girth and leaf area of the soybean plant on weekly basis, from 4th week after planting till maturity. Yield parameters such as Weight of 100 seeds (TSW) and Seed weight (ton/ha) were also taken into consideration.

Chemical Analysis

Soil samples collected were analyzed for organic carbon, cation exchangeable capacity, organic matter, total nitrogen, exchangeable bases, available phosphorus and pH.

Statistical Analysis

Data collected was analyzed using analysis of variance (ANOVA) where significant means was separated using least significant difference (LSD).

RESULTS AND DISCUSSION

Pre Planting Physico-Chemical Properties of the Soil.

Table 2 shows the result of the physico-chemical properties of the soil before planting. The soil was sandy soil with pH at 8.7%, organic carbon 0.6%, total nitrogen 1.4% and silt 4.6%.

Table 2: Pre – Planting Physico-Chemical Properties Of The Soil

PROPERTIES	VALUES
%Sand	91
%Silt	4.6
%Clay	4.4
Soil texture class	Loamy-Sandy
pH (soil water)	8.7
%Organic carbon	0.6
%Nitrogen	1.4
%Organic matter	1.0
K (cmol/kg)	0.18
Na (cmol/kg)	0.21
Ca (cmol/kg)	0.64
Mg (cmol/kg)	0.58
Exchangeable acidity (cmol/kg)	1.31
Cation Exchange Capacity (cmol/kg)	2.92
Available P (mg/kg)	17.73

The Influence of Treatments on plant Height

As regards to plant height, table 3 indicates that there was significant variations from 4, 8, 10, 12 and 14 WAP, SSP has the lowest at 4, 10, 12, 14 and *Bradyrhizobium* inoculation at 8WAP and Mycorrhizal with the highest value and the control (without *Bradyrhizobium*) at 8, 10, 12 and Mycorrhiza at 14 WAP also has the maximum height and *Bradyrhizobium* with the lowest. At 10 and 12 WAP, SSP and *Bradyrhizobium* inoculation are significantly different compared to other treatment. This signifies the effect of organic and inorganic amendment on plant height while the inorganic soil treatment produces the highest at various week intervals except SSP.

The Influence of Treatment Interaction on Plant Height

As regards to treatment interaction on plant height, table 3 shows that there was a significant variation all through with Myc and 10 tons poultry manure producing the highest plant height from 4-14 WAP, SSP with 5 tons of poultry manure having the lowest value at 4WAP, SSP with 10 tons of poultry manure also with the lowest at 8 and 10 WAP and Brad/Myc and 10tons of poultry manure at 12 and

14 WAP. This signifies the effect of interaction of organic and bio fertilizer amendment on plant height in soil treatment which produces the highest value at various week intervals.

Table 3: The Main Effect of Poultry Manure, P Source and *Bradyrhizobium* on Plant Height (Cm) from (4 – 14WAP)

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Poultry manure Source						
0(tons)	12.22 a	21.55 a	29.58 a	35.20a	42.78a	47.99a
5(tons)	12.39 a	22.12a	30.54a	36.22 a	42.89a	46.34ab
10(tons)	12.94a	21.29a	29.24a	34.15a	40.85a	44.13b
P value	0.18	0.37	0.39	0.19	0.34	0.04
P source						
Mycorrhiza	13.23 a	22.09 a	30.69a	36.32a	43.56 a	48.11a
SSP	11.80b	21.21 a	28.89 b	34.07 b	40.79b	44.19b
P value	0.00	0.10	0.02	0.01	0.03	0.00
***Bradyrhizobium* Source**						
No *Bradyrhizobium*	12.28 a	22.24 a	31.03 a	36.42 a	44.99 a	47.00 a
Bradyrhizobium	12.75 a	21.06 b	28.5 b	33.97 b	36.35 b	45.30 a
P value	0.20	0.02	0.00	0.01	0.00	0.18

Table 3: The Interactive Effect of Poultry Manure, P Source and *Bradyrhizobium* on Plant Height (Cm) from (4-14 WAP).

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Brad/Myc/10pm	12.27ab	19.27c	25.84ef	30.39a	35.59a	41.73cd
Brad/SSP/10PM	13.39a	22.65abc	31.97abc	36.98abc	38.58cd	44.49bc
Myc/10pm	13.75a	24.31a	34.76a	40.93a	52.15a	53.25a
SSP/10PM	12.27ab	18.92c	24.40f	28.29c	37.06d	37.05d
Brad/Myc/5PM	13.45a	21.90bcd	30.81bcd	37.83abc	38.47cd	45.71bc
Brad/SSP/5PM	12.92ab	21.76bcd	28.65cde	34.11abc	45.70b	46.95bc
Myc/5PM	13.19a	22.85ab	32.18abc	36.57b	47.05ab	48.67ab
SSP/5PM	9.99c	21.62bdc	30.52bcd	36.25bc	40.34cd	44.03bc
Brad/Myc	13.02ab	20.02de	27.38def	32.18de	38.77cd	45.65bc
Brad/SSP	11.45bc	20.41dce	26.61ef	32.30de	39.00cd	47.29bc
Myc	13.69a	23.99ab	33.16ab	39.90ab	49.32ab	53.67a
SSP	10.71c	21.76bcd	31.18abc	36.47bc	44.05bc	45.49bc
P value	0.001	0.009	0.003	0.001	0.001	0.001

The Influence of Treatment on stem Girth

As regards to table 4, the stem girth were not significantly different from each other ($p<0.5$) in 4, 6, 8, 10 and 14 WAP. However, at 12 WAP, 0 tons/ha of poultry manure alone produced more stem girth than 10 tons/ha of poultry manure treatment but was comparable to other treatments.

Table 4: The Main Effect of Poultry Manure, P Source and *Bradyrhizobium* on Stem Girth (Cm) from 4 – 14 WAP.

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Poultry manure Source						
0(tons)	0.10 ^{a}	0.15 ^{a}	0.21^{a}	0.28^{a}	0.37^{a}	0.46^{a}
5(tons)	0.10 ^{a}	0.27 ^{a}	0.23^{a}	0.27^{a}	0.36^{ab}	0.44^{a}
10(tons)	0.10 ^{a}	0.74 ^{a}	0.22^{a}	0.27^{a}	0.34^{ab}	0.45^{a}
P value	0.16^{a}	0.18 ^{a}	0.20^{a}	0.51^{a}	0.10^{a}	0.10^{a}
P source						
Mycorrhiza	0.10 ^{a}	0.37^{a}	0.22^{a}	0.27^{a}	0.36^{a}	0.46^{a}
SSP	0.10 ^{a}	0.40^{a}	0.22^{a}	0.28^{a}	0.35^{a}	0.44^{a}
P value	0.16^{a}	0.90^{a}	0.20^{a}	0.77^{a}	0.85^{a}	0.10^{a}
***Bradyrhizobium* Source**						
No *Bradyrhizobium*	0.10 ^{a}	0.38^{a}	0.22^{a}	0.28^{a}	0.35^{a}	0.46^{a}
Bradyrhizobium	0.10 ^{a}	0.40^{a}	0.21^{a}	0.27^{a}	0.36^{a}	0.44^{a}
P value	0.16	0.94	0.10	0.38	0.25	0.10

The Influence of Treatment Interaction on Stem Girth

Table 5 result shown below indicates that at 4, 6 and 8 WAP, all values of stem girth are significant with no difference but there was variation in stem girth at 6WAP where treatment interaction at SSP and Brad/Myc with 10tons/ha of poultry manure produced the highest stem girth. But from 10 – 14 WAP, there was significant difference all through with variation in stem girth value which signifies the effect of organic and bio-fertilizer amendment on stem girth.

Table 5: The Interactive Effect of Poultry Manure, P Source and *Bradyrhizobium* on Stem Girth (Cm) from (4 – 14 WAP).

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Brad/Myc/10PM	0.1^{a}	1.30^{a}	0.21^{a}	0.27^{ab}	0.35^{ab}	0.42^{cd}
Brad/SSP/10PM	0.1^{a}	0.15^{a}	0.01^{a}	0.28^{ab}	0.33^{ab}	0.45^{bcd}
Myc/10PM	0.1^{a}	0.17^{a}	0.23^{a}	0.27^{b}	0.35^{ab}	0.51^{ab}
SSP/10PM	0.1^{a}	1.34^{a}	0.22^{a}	0.28^{ab}	0.32^{b}	0.42^{cd}
Brad/Myc/5PM	0.1^{a}	0.14^{a}	0.22^{a}	0.28^{ab}	0.35^{b}	0.48^{abc}
Brad/SSP/5PM	0.1^{a}	0.49^{a}	0.23^{a}	0.28^{ab}	0.35^{a}	0.41^{d}
Myc/5PM	0.1^{a}	0.28^{a}	0.23^{a}	0.27^{a}	0.35^{a}	0.40^{d}
SSP/5PM	0.1^{a}	0.16^{a}	0.23^{a}	0.28^{ab}	0.36^{ab}	0.49^{ab}
Brad/Myc	0.1^{a}	0.17^{a}	0.21^{a}	0.27^{ab}	0.36^{ab}	0.45^{bcd}
Brad/SSP	0.1^{a}	0.14^{a}	0.21^{a}	0.26^{a}	0.40^{a}	0.46^{bcd}
Myc	0.1^{a}	0.15^{a}	0.23^{a}	0.31^{a}	0.37^{a}	0.53^{a}
SSP	0.1^{a}	0.15^{a}	0.21^{a}	0.27^{a}	0.33^{a}	0.41^{cd}
P value	**0.001**	**0.55**	**0.95**	**0.067**	**0.044**	**0.001**

The Effect of Treatments on Leaf Area from 4 – 14 wap.

The leaf area of a plant is directly related to its photosynthetic capacity. The higher the leaf area, the higher the rate of photosynthesis. Table 6 shows that leaf area in the 4 and 12 WAP was not significantly different from one another but it was observed that 10 tons/ha of poultry manure fertilizer recorded the lowest value at 6 and 8 WAP. By the 10^{th} week, *Bradyrhizobium* was significantly different from other treatments.

Compared with the 10 tons/ha poultry manure applied soils, there was better occurrence by wider leaf breadth and longer lengths, at 14 WAP, 5 tons/ha of poultry manure had higher leaf area with other treatments with the exception of *Bradyrhizobium* having the lowest. This implies that there was an advantage in using organic fertilizer rather than the inorganic fertilizer with greatest returns in terms of food manufacture in the plants which leads to greater yield though not in all cases.

Table 6: The Main Effect of Poultry Manure, P Source and *Bradyrhizobium* on Leaf Area (Cm^2) from 4 – 14 WAP.

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Poultry manure Source						
0(tons)	5.58 [a]	13.81 [a]	23.69 [ab]	29.78 [ab]	38.32 [a]	41.83 [ab]
5(tons)	5.47 [a]	13.41 [ab]	25.77 [a]	32.64 [a]	36.69 [a]	43.43 [a]
10(tons)	5.59 [a]	12.18 [b]	21.82 [b]	27.07 [b]	35.41 [a]	38.28 [b]
P value	0.97	0.12	0.03	0.00	0.26	0.02
P source						
Mycorrhiza	5.45 [a]	13.34 [a]	25.13 [a]	30.89 [a]	38.05 [a]	41.91 [a]
SSP	5.58 [a]	12.93 [a]	23.39 [b]	28.78 [a]	35.57 [a]	40.45 [a]
P value	0.73	0.55	0.02	0.12	0.09	0.36
***Bradyrhizobium* Source**						
No *Bradyrhizobium*	5.73 [a]	13.65 [a]	25.50 [a]	31.30 [a]	37.65 [a]	41.99 [a]
Bradyrhizobium	5.31 [a]	12.61 [a]	22.02 [a]	28.38 [a]	35.96 [a]	40.36 [a]
P value	0.25	0.13	0.00	0.03	0.24	0.30

Effect of Treatment Interactions on Leaf Area from 4 – 14 WAP

Table 7 shows that the leaf areas from 4 to 14 WAP were all significantly different from each other but it was observed that Myc has the highest area of leaf at 4 and 6 WAP. Also at 8 and 12 WAP, Myc with 10 and 5 tons/ha of poultry manure produced the highest area respectively while treatment interaction was influenced at 12 and 14 WAP where Brad/Myc with 5 tons/ha of poultry manure possess the highest value of leaf area compared to other treatments.

Table 7: The Interactive Effect of Poultry Manure, P Source and Bradyrhizobium on Leaf Area (Cm^2) from 4 – 14 WAP.

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Brad/Myc/10pm	4.10^{d}	9.57^{d}	18.39^{d}	21.48^{d}	28.70^{b}	31.75^{d}
Brad/SSP/10PM	7.31^{ab}	13.45^{abc}	22.66^{abcd}	30.16^{abc}	35.33^{a}	44.85^{ab}
Myc/10pm	6.45^{abc}	15.01^{ab}	28.44^{a}	33.64^{ab}	34.17^{a}	42.04^{abc}
SSP/10PM	4.17^{d}	10.67^{cd}	17.82^{d}	21.48^{d}	36.97^{a}	34.48^{cd}
Brad/Myc/5PM	4.84^{cd}	13.71^{abc}	27.94^{a}	34.86^{a}	39.51^{a}	47.82^{a}
Brad/SSP/5PM	5.73^{bcd}	14.01^{abc}	22.28^{abcd}	30.74^{abc}	39.51^{a}	39.51^{abc}
Myc/5PM	5.49^{bcd}	14.44^{ab}	27.89^{d}	33.66^{ab}	42.00^{a}	42.61^{ab}
SSP/5PM	5.81^{bcd}	11.48^{bcd}	24.95^{abc}	31.32^{abc}	26.89^{b}	43.77^{ab}
Brad/Myc	4.36^{d}	10.84^{cd}	20.67^{bcd}	27.07^{bcd}	37.75^{a}	41.30^{abc}
Brad/SSP	5.50^{bcd}	14.11^{abc}	20.19^{cd}	25.96^{d}	36.10^{a}	36.92^{bc}
Myc	7.50^{a}	16.45^{a}	27.46^{a}	34.63^{a}	40.95^{a}	45.94^{a}
SSP	4.98^{cd}	13.85^{abc}	26.44^{ab}	31.52^{abc}	38.46^{a}	43.15^{ab}
P value	0.001	0.009	0.003	0.001	0.001	0.001

The Influence of Treatments on Yield Parameters

Table 8 shows that the influence of treatment was significantly different in grain yield and in thousand seed weight. However, Mycorrhizal alone produced more grains and also has the highest value in thousand seed weight while SSP alone has the lowest grain yield and 10 tons/ha of poultry manure with the lowest value in thousand seed weight comparable to other treatments.

Table 8: The Main Effect of Poultry Manure, P Source and *Bradyrhizobium* on Yield Parameters.

Treatments	Grain per plot (kg/plot)	Thousand Seed Weight (kg/plot)
Poultry manure Source		
0(tons)	100.1[a]	8.84[a]
5(tons)	103.5[a]	9.04[a]
10(tons)	106.8[a]	8.32[a]
P value	8.20	1.12
P source		
Mycorrhiza	109.8[a]	9.07[a]
SSP	97.1[b]	8.40[a]
P value	5.12	0.89
***Bradyrhizobium* Source**		
$Brad_0$	106.1[a]	8.82[a]
$Brad_1$	100.1[a]	8.66[a]
LSD	6.54	0.92

The Influence of Treatments Interaction on Yield Parameters

From table 9 below, the yield of soybean was influenced by the treatment interaction of Myc/10pm produced the highest grain yield per plot and at a thousand seed weight while the lowest value of grain yield was observed with SSP and treatment interaction of Brad/Myc/10pm in the thousand seed weight, which implies that interaction between organic and bio-fertilizer soil amendment produces the maximum yield of soybean.

Table 9: The Influence of Treatment Interaction on Yield Parameters.

Treatments	Thousand Seed	Grain per plot
Weight (kg/plot)	(kg/ha)	
Myc/10pm	90.97^{a}	106.3^{a}
Brad/Myc	85.93^{a}	89.733^{cde}
Brad/Myc/5pm	84.83^{ab}	93.567^{c}
Myc/5pm	83.5^{abc}	102.167^{ab}
Brad/SSP/10pm	81.37^{a}	91^{cde}
SSP	80.6^{abc}	82.6^{e}
SSP/5pm	78.57^{abc}	84.367^{de}
Myc	78.43^{abc}	104.767^{a}
Brad/SSp/5pm	76.23^{a}	92.5^{cd}
Brad/SSP	73.1^{abc}	83.633^{a}
SSP/10pm	64.57^{a}	90.5^{cde}
Brad/Myc/10pm	63.5^{c}	94.8^{bc}

Influence of Biofertilizer, Inorganic and Organic Soil Amendment on Soil Organic Carbon, Organic Matter and Available p.

As observed in Table 10, the effect of treatments in soil organic carbon, organic matter were not significantly different at 4 and 8 WAP but the control was significantly different from others in organic matter at 8 WAP while available phosphorus was not significantly different in any of these treatment. This signifies that the effect of treatment on soil does not really cause much change in soil organic carbon and available phosphorus.

Table 10: The Main Effect of Bio-Fertilizer, Inorganic and Organic Soil Amendment of Soil Organic Carbon, Organic Matter and Available Phosphorus at 4 and 8 WAP.

Treatments	%Organic Carbon		%Organic Matter		Available P(mg/kg)	
	4WAP	8WAP	4WAP	8WAP	4WAP	8WAP
Poultry manure Source						
0(tons)	1.52 [a]	1.50 [a]	2.63 [a]	2.59[a]	30.10[a]	42.96[a]
5(tons)	1.29[a]	1.21[a]	2.23[a]	2.10[a]	20.34[a]	30.33[a]
10(tons)	1.44[a]	1.49[a]	2.50[a]	2.58[a]	27.79[a]	42.22[a]
P value	0.27	0.36	0.28	0.36	0.02	0.01
P source						
Mycorrhiza	1.38[a]	1.33[a]	2.38[a]	2.30[a]	26.54[a]	37.72[a]
SSP	1.46[a]	1.47[a]	2.52[a]	2.54[a]	25.64[a]	39.28[a]
P value	0.51	0.48	0.50	0.46	0.78	0.71
***Bradyrhizobium* Source**						
No *Bradyrhizobium*	1.39[a]	1.21[a]	2.39[a]	2.08[b]	24.9[a]	41.6[a]
Bradyrhizobium	1.45[a]	1.60 [a]	2.51[a]	2.76[a]	27.20[a]	35.32[a]
P value	0.60	0.03	0.59	0.03	0.49	0.12

The effect of Treatments Interaction on Soil Organic Carbon, Organic Matter and Available p.

Table 11 shows the interactive effect of the treatments in the soil indicating no significant difference in soil organic carbon, organic matter in each plot at 4 WAP but significantly different in available phosphorus with SSP/10pm producing the higher organic carbon and organic matter and Myc/10pm in available phosphorus.

Organic carbon was significantly different at 8 WAP with Myc/10pm having the highest value at 8WAP and the lowest with treatment application of Brad/Myc/5pm while soil with Brad/SSP/10pm producing the highest phosphorus compared to treatment with Myc/5pm with the lowest value where there was significant difference in the available phosphorus at 8 WAP.

Table 11: The Interactive Effect of Bio-Fertilizers, Inorganic and Organic Amendment on Soil Organic Carbon, Organic Matter and Availability Phosphorus at 4 and 8 WAP.

Treatments	%Organic Carbon		%Organic Matter		Available P(mg/kg)	
	4WAP	8WAP	4WAP	8WAP	4WAP	8WAP
Myc/0pm	1.64[a]	1.52[a]	19.77[b]	2.61[abc]	30.72[ab]	40.34[abcd]
Myc/5pm	1.47[a]	1.63[ab]	37.45[a]	2.81[ab]	19.77[b]	24.60[d]
Myc/10pm	1.20[a]	2.20[a]	25.85[ab]	3.80[a]	37.45[a]	52.61[a]
SSP/0pm	1.44[a]	1.36[abcd]	20.59[ab]	2.35[abcd]	25.85[a]	35.81[abcd]
SSP/5pm	1.23[a]	1.51[abc]	28.83[ab]	2.61[abc]	20.59[ab]	25.81[d]
SSP/10pm	1.73[a]	1.37[abcd]	31.2[ab]	2.38[abcd]	28.83[ab]	32.73[bcd]
Brad/Myc/0pm	1.60[a]	1.27[bcd]	21.64[ab]	2.19[bcd]	31.2[ab]	45.67[abc]
Brad/Myc/5pm	1.08[a]	0.62[d]	18.45[b]	1.07[d]	21.64[ab]	32.49[bcd]
Brad/Myc/10pm	1.29[a]	0.78[cd]	32.62[ab]	1.34[cd]	18.45[b]	30.61[cd]
Brad/SSP/0p	1.42[a]	1.86[ab]	19.55[b]	3.22[ab]	32.62[ab]	50.03[ab]
Brad/SSP/5pm	1.38[a]	1.10[cd]	26.43[ab]	1.90[bcd]	19.55[b]	38.42[abcd]
Brad/SSP/10pm	1.56[a]	1.61[abc]	0.20[a]	2.79[abc]	26.43[ab]	52.92[a]
P value	0.61	0.01	0.62	0.01	0.20	0.07

DISCUSSION

The ability of organic manure in enhancing the release of available P from SSP has been related to increase in microbial activities and the acidic soil conditions created by the decay of the organic manure (Chen *et al.*, 2006; Kim *et al.*, 1997; Rashid *et al.*, 2004). Different organic materials will create different soil environmental conditions (Bangar *et al.*, 1985; Nair and Ngouajio 2012) and hence leading to differences in the release of available P from SSP in soil amendments. Such situations might be the reasons behind the significant performance of the PM in enhancing higher release of available P in the amendments because PM has been found to produce higher microbial biomass and hence acidic conditions in soil amendments (Lin *et al.*, 2010; Adigun and Babalola, 2016). Organic fertilizer should be generally considered for incorporation into the soil before planting as a result of their tendency to improve the soil nutrient element and activities of soil. Thereafter, inorganic fertilizer can then be applied when the plant has been established for effective nutrient supply for plant growth.

RECOMMENDATION

Since organic amendments take a while to release its constituent nutrient elements for plant growth and inorganic fertilizers releases its nutrient element immediately after application therefore, both organic and inorganic amendments should be recommended to soil for optimum productivity.

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