

IMPACT OF ORGANIC AND INORGANIC AMENDMENTS ON SOIL CHEMICAL PROPERTIES AND SOYBEAN CROP PERFORMANCE IN NSUKKA, SOUTHEASTERN NIGERIA

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Abstract:

Soil amendments influence soil fertility and increase crop yield. A field experiment was conducted at the University of Nigeria Teaching and Research Farm, Nsukka to examine the effects of organic and inorganic amendments on the chemical properties and crop performance of soybean (*Glycine max*). Twelve treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments comprised individual and combined applications of urea (N), single super phosphate (SSP), N₁₅P₁₅K₁₅ (NPK), poultry manure (PM), cattle dung (CD), including a control. Soil samples from each treatment plot were characterized before cropping and after harvest. Results of the effects of amendments on the rhizosphere and growth and yield of soybean showed that there was significant increase in soil chemical properties. The number of trifoliolate functional leaves and grain yield of soybean (5.70 t ha⁻¹) were significantly highest with application of T₉ as compared to other treatments.

Keywords: Organic and Inorganic amendments, soil microorganisms, Microbial biomass, Chemical properties, Crop performance.

Introduction

Soybean (*Glycine max*) is one of the major food crops of the world. It is an annual crop, practically easy to grow, that produces more protein and oil per unit of land than almost any other crop (Akande *et al.*, 2007). It is a versatile food plant that can be used in different forms and is capable of supplying most nutrients. It can be substitute for meat and to some extent for milk and is capable of reducing protein malnutrition. In order to maximize the yield of soybean crop, improved cultural practices such as organic and inorganic fertilizer applications can be used. Application of mineral fertilizers can improve the nutrient balance of soils, which may lead to increases in crop yields. However, its continuous use is harmful both to human health and the environment (Glick, 2003; Aberagi *et al.*, 2024). Nevertheless, the harmful effects of mineral fertilizers could be avoided by using organic fertilizers which is known to play major role in sustaining soil fertility and crop productivity (Soumare *et al.*, 2003; García-Orenes *et al.*, 2016). Organic manures are more preferred and environmentally friendly than chemical fertilizers (Iqbal *et al.*, 2019; Aberagi *et al.*, 2024) to reduce the contamination of soil, water and environmental resources, however farmers are not interested to use organic amendments owing to slow release and producing low yields as compared to chemical fertilizers (Rehman *et al.*, 2017).

The combined use of organic and inorganic fertilizers provides various benefits for enhancing the chemical and physical status of the soil as well as increasing yield of soybean in continuous cropping (Basso and Rictchie, 2005; Aberagi *et al.*, 2024). This integrated fertilizer application is reported to improve and increase soybean growth and yield, and soil fertility (Wijanarko, 2016). The present investigation was conducted with the aim to evaluate

the effect of organic and inorganic farming practices on the chemical properties of the soil as well as on the growth and yield of soybean.

Materials and Methods

The study was carried out in the University of Nigeria (UNN) Teaching and Research Farm at Nsukka in Enugu State in South-eastern Nigeria. The UNN Teaching and Research farm behind the Meteorological Station, is located on latitude 6° 52 'N and longitude 7° 24'E in the derived savannah agroecological zone of Enugu State, South-Eastern Nigeria. This area has an elevation of 477 meters above mean sea level. The location is characterized by two seasons, namely; rainy and dry seasons. The rainy season lasts from April to October with a short break in the month of August (August Break). Average annual rainfall is about 1550 mm and more than 85 % of this rain falls within the rainy season. The average minimum and maximum temperatures are about 22 and 30°C, respectively, while the average relative humidity rarely falls below 60 % (Asadu, 2002). The soils of the area have high percentage of sand and granular structure at the top and the topsoil is characterized by rapid to very rapid permeability (Obi and Asiegbu, 1980).

Treatment Description

The details of the treatments along with their representational symbols are as listed below

- T₁ : Control
- T₂ : 30 kg Nha⁻¹ of urea, which contains 45 % N
- T₃ : 60 kg Pha⁻¹ of single super phosphate (SSP), which contains 18 % P
- T₄ : 200 kg ha⁻¹ of NPK 15:15:15
- T₅ : 10 t ha⁻¹ of Poultry Manure
- T₆ : 15 t ha⁻¹ of Cattle Dung
- T₇ : 15 kg Nha⁻¹ of Urea + 5 t ha⁻¹ of Poultry Manure
- T₈ : 15 kg Nha⁻¹ of Urea + 7.5 t ha⁻¹ of Cattle Dung
- T₉ : 30 kg Pha⁻¹ of single super phosphate + 5 t ha⁻¹ of Poultry Manure
- T₁₀ : 30 kg Pha⁻¹ of single super phosphate + 7.5 t ha⁻¹ of Cattle Dung
- T₁₁ : 100 kg ha⁻¹ of NPK 15:15:15 + 5 t ha⁻¹ of Poultry Manure
- T₁₂ : 100 kg ha⁻¹ of NPK 15:15:15 + 7.5 t ha⁻¹ of Cattle Dung

The above twelve (12) treatments were laid out in a randomized complete block design with 3 replications. Accordingly, the treatments were assigned to 36 plots measuring 2 m x 1 m and spaced 1 m and 1.5 m between plots and between replicate blocks, respectively. Soybean variety TGX 1830-2E was sown three seeds per hole at a spacing of 50 cm x 10 cm as recommended by the International Institute of Tropical Agriculture (IITA). The soybeans seedlings were thinned to two seedlings per hole at the age of 10 days after sowing (DAS). Each plot contains eight rows of four stands each (two plants per stand), resulting in 64 plant stands per plot. The inorganic fertilizers were applied to the experimental plots in ring form at two weeks after sowing (immediately after the first weeding), at different rates.

Soil Data Collection: Composite soil samples were taken from a depth of 0 - 20 cm from the experimental site prior to land preparation. The samples were taken randomly across the field using an auger. The samples were then air-dried under laboratory conditions, thoroughly mixed and passed through a 2 mm mesh sieve and packaged for laboratory analyses. After soybean harvest, three auger soil samples were taken and then composited for each plot. The composite samples were analyzed to assess changes in soil fertility status due to the effect of the application of organic and inorganic fertilizer applications.

Laboratory Analysis: Auger- soils samples were sieved to pass through 2 mm mesh for laboratory analysis. Soil pH was determined in water and 0.1 N KCl at a soil : liquid ratio of 1:2.5 using a glass electrode pH meter (Udo *et al.*, 2009). Soil organic carbon was determined by wet digestion method of Walkley-Black, using acid dichromate solution as outlined in Soil Survey Staff (1999). Total nitrogen was determined by the macro Kjeldahl digestion and distillation method as outlined by Udo *et al.*, (2009). The available phosphorous was extracted by the Bray I method and determined by the molybdenum blue method (Kuo, 1996). Exchangeable Ca^{2+} , Mg^{2+} , K^+ , and Na^+ were leached from the soil sample using NH_4OAc (pH 7.0) buffer. The Na^+ and K^+ were measured with a flame photometer while Ca^{2+} and Mg^{2+} were determined using Atomic Absorption Spectrophotometer as outlined by Udo *et al.*, (2009). The cation exchange capacity was determined by using 1M NH_4OAc at pH 7.0 as outlined by Udo *et al.*, (2009).

Statistical Analysis: The data obtained from the different parameters were analyzed using analysis of variance (ANOVA). The Duncan Multiple Range Test was used to compare the significant means at 5% probability level using SPSS software.

Results and Discussion

Soil physical and chemical properties of the experimental soil before planting: Particle size distribution of the soil before planting had a high content of sand (756 g kg^{-1}) and low amount of silt (124 g kg^{-1}) and clay (120 g kg^{-1}). The textural class of the soil was sandy loam (Table 1). Such soils may lack absorptive capacity for basic plant nutrients and may be susceptible to erosion menace (Abua and Edet, 2007). Soil bulk density was 1.43 g/cm^3 (Table 1). The value is with the normal range for soils that are not degraded through mechanical cultivation and will not impede root penetration, good aeration and water movement for optimum root growth (Esu, 2010).

The pH (distilled water) of the soil was 5.2 (Table 1) and was rated as strongly acid (Landon, 1991; FAO, 2004; Udo *et al.*, 2009). The pH status is common for soils of the tropical southeastern region that are highly weathered and leached of basic cations from the soil solum. This may be due to high rainfall associated with the tropical environment with the predominance of low activity clays and the porous nature of the soil (Obi, 1991). Soil organic matter was 2.82 %, indicating a moderately low concentration (Landon, 1991; FAO, 2004; Udo *et al.*, 2009). Low SOM may be associated to rapid mineralization against humification (Haynes, 2005) or high temperatures that favour mineralization (Ibia, 2001). Total nitrogen (TN) content was 0.22 % and is within the low level (0.1 - 0.2 %) on the FAO (2004) scale. Such values may be attributed to the high C:N ratio (excess carbon), which slows down decomposition of SOM, resulting in the immobilization by microbes (Ayeni and Adeyele 2012; Pei *et al.* 2019). This nitrogen immobilization by microbes creates nitrogen deficiencies in the soil and may cause the appearance of the older leaves of the crop to be light green or pale yellow starting from the tip. The low N content may most likely cause stunted growth of the crop.

The available phosphorus (Av. P) content of the soil was 12.90 mg kg^{-1} . This value is within the moderate level (8 mg kg^{-1} and 20 mg kg^{-1}) required for productive soils on the FAO (2004) scale. Exchangeable calcium content of the soil was $0.93 \text{ cmol kg}^{-1}$, which was within the low range according to FAO (2004) scale. Strongly acid soils are deficient in calcium and are not good enough for most crops (NPFS, 2009).

Table 1: Physical and Chemical properties of the experimental soil before planting

Parameter	Value
Clay (g kg ⁻¹)	120
Silt (g kg ⁻¹)	124
Sand (g kg ⁻¹)	756
Textural class	Sandy loam
BD (Mg/m ³)	1.43
pH (H ₂ O)	5.20
% SOM	2.82
% Total N	0.22
AvP (mg kg ⁻¹)	12.90
Ca ²⁺ (cmol kg ⁻¹)	0.93
Mg ²⁺ (cmol kg ⁻¹)	0.60
K ⁺ (cmol kg ⁻¹)	0.11
Na ⁺ (cmol kg ⁻¹)	0.12
CEC (cmol kg ⁻¹)	4.85

BD = Bulk Density, Av. P = Available phosphorus, SOM = Soil organic matter, CEC = Cation exchange capacity.

Exchangeable magnesium of the soil was 0.60 cmol kg⁻¹ and was also within the very low level (< 0.3) on the FAO (2004) scale. Exchangeable potassium value was 0.11 cmol kg⁻¹ and was within the very low level (< 0.2) on the FAO (2004) scale. This low value may be due to the low exchange capacity and high exchangeable acidity of the soil. Exchangeable sodium content of the soil was 0.12 cmol kg⁻¹ and was within the low level (0.1 - 0.3) on the FAO (2004) scale. Excessive amount of exchangeable sodium reverses the process of aggregation and causes soil deflocculation (Chapman, 1976).

Generally, these low values of exchangeable bases may be as a result of the high sand content in the soil which predisposes the soil to excess leaching due to high rain fall in the study area. According to the report by Adekayode (2010) these low values maybe attributed to intensive land use through cropping and other land use practices. The soil was also characterized by very low CEC of 4.85 cmol kg⁻¹, attributable to leaching of exchangeable bases probably due to factors such as high rainfall, dominance of low activity clay, low clay content (Agbede, 2009) and low organic matter content of the soil (Donahue *et al.*, 1983). This indicates inherent poor fertility status of the soil.

Effects of organic and inorganic amendments on chemical properties of soil after crop harvest: The result of the effects of organic and inorganic amendments on chemical properties of soil after soybean harvest is shown in Table 2. The result showed that the highest pH value of 6.74 (indicating a moderately acid status) was observed in the application of 10 t ha⁻¹ of poultry manure (T₅), followed by (T₁₁), (T₉) and (T₇), while the lowest value (5.31 indicating a strongly acid status) was observed in the control (T₁). It was observed that the application of poultry manure alone or in combination with inorganic fertilizers increased soil pH. This increase in soil pH may be attributed to higher Ca content of the PM. Furthermore, essential plant nutrients added from the decomposition of the organic manure contributed to the rise in pH of the soils. This finding is in agreement with the study of Islam *et al.* (2013) who reported that the application of PM increased the pH of the soil. The highest SOM content and CEC were obtained from 30 kg P ha⁻¹ + 5 t PM ha⁻¹ (T₉), followed by T₁₁ and T₇, with the lowest values obtained from T₁ (Table 3). The highest SOM in T₉ may be attributed to higher carbon content in T₉, SOM content is known to contribute significantly to CEC of tropical soils (Asadu and Akamigbo, 1990; Asadu *et al.*, 1997).

The application of T₉ had the highest significant ($p < 0.05$) effect on SOM and CEC values of 4.49 % and 20.89 cmol kg⁻¹, respectively, which was followed by T₁₁ and T₇. T₁ produced the lowest values of 1.97 % and 19.36 cmol kg⁻¹, respectively. The increase in CEC content with T₉ could be attributed to high availability of OM which provides more nutrients (NPK) compared to the other treatments. The CEC values obtained in the soil in all the plots were high and generally above the initial (pre-planting) concentration of 4.83 cmol kg⁻¹. These values are regarded as suitable for crop production if other factors are favourable (FAO, 2004).

Table 2: Effects of amendments on chemical properties of soil after crop harvest

Treatments	pH H ₂ O	SOM %	TN %	Av.P mg kg ⁻¹	Cacmol kg ⁻¹	Mg	K	Na	CEC
T1	5.31j	1.97k	0.25d	19.95k	0.43f	0.57h	0.11f	0.11cde	9.59f
T2	5.45i	2.76j	0.28c	34.58j	0.47e	0.64de	0.14d	0.12a	17.92d
T3	5.45i	3.90f	0.25d	46.69g	0.51d	0.62fg	0.13e	0.07gh	20.47b
T4	5.49h	3.94e	0.28bc	41.09h	0.41g	0.61g	0.12ef	0.10e	20.82b
T5	6.74a	3.97d	0.29b	55.22e	0.76a	0.64cde	0.15bc	0.12ab	20.09bc
T6	5.86f	3.44i	0.27c	39.46i	0.51d	0.63efg	0.14cd	0.09f	18.38d
T7	6.46d	4.05c	0.29bc	56.30c	0.57b	0.65cd	0.16b	0.10e	20.91b
T8	5.87f	3.52h	0.25d	54.95f	0.52d	0.66c	0.15c	0.11bcd	17.69de
T9	6.54c	4.49a	0.33a	87.63a	0.77a	0.92a	0.18a	0.08g	22.89a
T10	6.22e	3.46i	0.27c	54.96f	0.51d	0.61g	0.12ef	0.07h	16.87e
T11	6.59b	4.45b	0.29bc	73.09b	0.77a	0.86b	0.18a	0.12abc	22.62a
T12	5.83g	3.55g	0.26d	55.84d	0.55c	0.63ef	0.14cd	0.11de	19.51c

T1= Control

T2= N = Urea 30 kg Nha⁻¹

T3= SSP = Single super phosphate 60 kg Pha⁻¹

T4 =NPK 15:15:15 200 kg ha⁻¹

T5= PM = Poultry manure 10 t ha⁻¹

T6= CD = Cow dung 15 t ha⁻¹

T7= N + PM (15 kg Nha⁻¹) + (5 t ha⁻¹)

T8= N + CD (15 kg Nha⁻¹) + (7.5 t ha⁻¹)

T9 = P + PM (30 kg Pha⁻¹) + (5 t ha⁻¹)

T10= P + CD (30 kg Pha⁻¹) + (7.5 t ha⁻¹)

T11= NPK + PM (100 kg ha⁻¹) + (5 t ha⁻¹)

T12= NPK + CD (100 kg ha⁻¹) + (7.5 t ha⁻¹)

Mean with the same letter(s) in the columns are not significantly different (Duncan's New Multiple Range Test, ($p \leq 0.05$))

The soil TN significantly ($p < 0.05$) increased with the use of amendments. The application of the amendments significantly increases the total nitrogen content when compared with the control. The highest value of 0.33 g kg⁻¹ was noted in T₉, while the least value of 0.25 g kg⁻¹ was obtained in T₁. The TN content of the study area was moderate (FAO, 2004), both before and after the experiment. The moderate level of TN observed after harvesting (plant uptake) could be attributed to the ability of the crop to fix atmospheric nitrogen to the soil (Singh *et al.*, 2012; Ciampitti *et al.*, 2021). The range of Av. P content of the soil varies from 19.95 to 87.63 mg kg⁻¹. Highest Av. P content (87.63 mg kg⁻¹) was obtained in T₉ and lowest (19.95 mg kg⁻¹) in T₁. The highest Av. P content in T₉ may be attributed to the synergetic effect of the application of PM (which is rich in essential nutrients such as NPK and OM) and SSP to the plot. Generally, the values of Av. P content obtained after harvest were above the initial status (12.90 mg kg⁻¹) of the soil. Phosphorus is less likely to leach vertically into the ground water but more likely to move from the plot by means of runoff (Elliot *et al.*, 2009; Prasad and Chakraborty, 2019).

The exchangeable bases (Ca, Mg, K and Na) ranged from 0.41 to 0.77 cmol kg⁻¹ for Ca; 0.57 to 0.92 cmol kg⁻¹ for Mg; 0.11 to 0.18 cmol kg⁻¹ for K and 0.07 to 0.12 cmol kg⁻¹ for Na. The exchangeable bases were generally very low (FAO, 2004) in all the plots. These low values of exchangeable bases can be attributed to the high sand content in the soil which makes the soil susceptible to excess leaching of the cations down the profile (Igwe and Udegbunam, 2008), due to high rain fall in the study area. Treatment T₉, T₁₁ and T₅ had the highest effects on calcium level of the soil and were not significantly ($P > 0.05$) different from

each other in their effect but were different from other treatments. The T₁ had the least calcium level.

Effects of organic and inorganic amendments on soybean growth parameters: The effect of organic and inorganic amendments on plant height, number of trifoliolate functional leaves per plant and dry matter are presented in Tables 3, 4 and 5, respectively. Generally, growth parameters were significantly enhanced by the application of the amendments. At 30, 60 and 90 days after sowing (DAS), the application of 15 kg N ha⁻¹ + 5 t PM ha⁻¹(T₇) produced plant with the highest plant height (32.56 cm at 30 DAS, 66.31 cm at 60 and 66.50 cm at 90 DAS and at harvest). It was followed by T₅ (31.70 cm at 30 DAS and 65.32 cm at 60 and 65.41 at 90 DAS and at harvest) (Table 3). Jadhav *et al.* (2013) reported that the application of PM on soybean recorded significantly higher plant height, number of leaves plant⁻¹ and number of branches plant⁻¹. At 30 DAS the lowest plant height of 17.23 cm of soybean plant was observed in T₁ (control) where no amendments were applied. Lowest plant height at 60 and 90 DAS and at harvest (25.97, 26.11 and 26.11 cm) was observed at T₁₀.

Table 3: Effects of organic and inorganic amendments on plant height (cm)

Treatments	30 DAS	60 DAS	90 DAS	At harvest
T1	17.23g	29.94i	30.06j	30.06j
T2	21.18e	33.48h	33.71h	33.71h
T3	21.34e	34.61g	34.90g	34.90g
T4	31.70b	63.18c	63.35c	63.35c
T5	31.70b	65.32b	65.41b	65.41b
T6	18.29f	28.08j	28.23k	28.23k
T7	32.56a	66.31a	66.50a	66.50a
T8	21.35e	35.44f	35.69f	35.68f
T9	22.07d	37.22e	37.40e	37.40e
T10	21.18e	25.97k	26.11l	26.11l
T11	23.84c	54.89d	55.03d	55.03d
T12	18.24f	33.18h	33.39i	33.39i

T1= Control
T2= N = Urea 30 kg Nha⁻¹
T3= SSP = Single super phosphate 60 kg Pha⁻¹
T4 =NPK 15:15:15 200 kg ha⁻¹
T5= PM = Poultry manure 10 t ha⁻¹
T6= CD = Cow dung 15 t ha⁻¹
T7= N + PM (15 kg Nha⁻¹) + (5 t ha⁻¹)
T8= N + CD (15 kg Nha⁻¹) + (7.5 t ha⁻¹)
T9 = P + PM (30 kg Pha⁻¹) + (5 t ha⁻¹)
T10= P + CD (30 kg Pha⁻¹) + (7.5 t ha⁻¹)
T11= NPK + PM (100 kg ha⁻¹) + (5 t ha⁻¹)
T12= NPK + CD (100 kg ha⁻¹) + (7.5 t ha⁻¹)

Mean with the same letter(s) in the columns are not significantly different (Duncan's New Multiple Range Test, (p ≤ 0.05)

The highest number of trifoliolate functional leaves produced by soybean plant was obtained from plot amended with T₉ (Table 4). Control (T₁) had the least number of trifoliolate functional leaves. Generally, the data shows that there was no increase in plant height and the number of trifoliolate functional leaves at 90 DAS and at harvest.

The dry matter of soybean crop was also enhanced at 30, 60 and 90 DAS as well as at harvest. This progressive increase up to harvest may be due to the plant ongoing accumulation of organic material. Among the amendments applied, T₉ recorded significantly highest dry matter production per plant at each stage of observation than the rest of the treatments and it was followed by T₁₁ (Table 5). However, T₁ recorded significantly lowest dry matter production per plant at all stages of observation as compared to other treatments.

Table 4: Effects of organic and inorganic amendments on number of trifoliolate functional leaves per plant

Treatments	30 DAS	60 DAS	90 DAS	At harvest
T1	3.12g	9.37j	17.56k	17.56k
T2	3.12g	9.21k	17.19l	17.19l
T3	4.30e	16.60e	22.48g	22.48g
T4	3.13g	12.65g	21.46h	21.46h
T5	4.75b	17.64b	22.74f	22.74f
T6	3.22f	12.26h	21.31i	21.31i
T7	4.30e	16.22f	28.63e	28.63e
T8	4.43c	18.22a	30.09d	30.09d
T9	4.83a	18.16a	30.54a	30.54a
T10	4.39cd	17.25cd	30.28b	30.28b
T11	4.34de	17.09	30.18c	30.18c
T12	3.23f	10.14i	18.55j	18.55j

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T5= PM = Poultry manure 10 t ha⁻¹
T6= CD = Cow dung 15 t ha⁻¹
T7= N + PM (15 kg Nha⁻¹) + (5 t ha⁻¹)
T8= N + CD (15 kg Nha⁻¹) + (7.5 t ha⁻¹)
T9 = P + PM (30 kg Pha⁻¹) + (5 t ha⁻¹)
T10= P + CD (30 kg Pha⁻¹) + (7.5 t ha⁻¹)
T11= NPK + PM (100 kg ha⁻¹) + (5 t ha⁻¹)
T12= NPK + CD (100 kg ha⁻¹) + (7.5 t ha⁻¹)

Mean with the same letter(s) in the columns are not significantly different (Duncan's New Multiple Range Test, (p ≤ 0.05))

Table 5: Effects of organic and inorganic amendments on dry matter

Treatments	30 DAS	60 DAS	90 DAS	At harvest
T1	2.06j	20.34h	23.10g	23.94f
T2	2.39h	20.87g	23.55g	24.49f
T3	2.98d	24.54d	28.33d	29.87c
T4	2.45g	21.55f	26.43e	27.63d
T5	3.16c	25.51c	31.82bc	32.04b
T6	2.32i	21.46f	25.25f	26.07e
T7	3.26b	26.77b	32.43ab	33.54a
T8	3.25b	26.54b	32.21abc	33.45a
T9	3.34a	27.22a	32.71a	33.76a
T10	2.83e	23.56e	27.65d	28.31d
T11	3.30ab	26.79b	31.59c	32.45b
T12	2.53f	21.54f	26.87e	27.62d

T1= Control
T2= N = Urea 30 kg Nha⁻¹
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T7= N + PM (15 kg Nha⁻¹) + (5 t ha⁻¹)
T8= N + CD (15 kg Nha⁻¹) + (7.5 t ha⁻¹)
T9 = P + PM (30 kg Pha⁻¹) + (5 t ha⁻¹)
T10= P + CD (30 kg Pha⁻¹) + (7.5 t ha⁻¹)
T11= NPK + PM (100 kg ha⁻¹) + (5 t ha⁻¹)
T12= NPK + CD (100 kg ha⁻¹) + (7.5 t ha⁻¹)

Mean with the same letter(s) in the columns are not significantly different (Duncan's New Multiple Range Test, (p ≤ 0.05))

Effects of organic and inorganic amendments on some yield parameters: The effect of organic and inorganic amendments on some yield parameters is presented in Table 6. The seeds yield per plant, 100 seed weight and grain yield (t ha) were influenced significantly by the different treatment combinations. Among the different treatment combinations, T₉ recorded significantly higher seed yield per plant (17.81 g) which was statistically at par with T₁₁ (17.36 g), while T₁ recorded significantly lowest seed yield per plant (5.96 g) at harvest as compared to other treatments under study (Table 8). This could be attributed to the synergistic effects of poultry manure and inorganic fertilizer (phosphate fertilizer) on the

chemical, physical and biological properties of the soil. Similar results were reported by Virkar and Tumbare (2011) and Waghmare *et al.* (2012). Similarly, higher 100 seed weight was also recorded with T₉ (15.02 g).

Maximum grain yield per ton was recorded with T₉ (5.70 t ha⁻¹) which was statistically at par with T₁₁ (5.56 t ha⁻¹). However, T₁ recorded significantly lowest seed yield per plant (5.96 g) and lowest grain yield per ton (1.91 t ha⁻¹) as compared to other treatments under study. Similar results were reported by Bandyopadhy *et al.* (2004), Waghmare *et al.* (2012) and Devi *et al.* (2013).

Table 6: Effects of organic and inorganic amendments on some yield parameters

Treatments	seeds yield plant ⁻¹ (g)	100 seed weight (g)	Grain yield (t ha ⁻¹)
T1	5.96i	10.79e	1.91i
T2	13.32e	10.97e	4.26e
T3	16.74b	13.30bc	5.35b
T4	15.55c	13.85abc	4.97c
T5	13.75e	12.71cd	4.40e
T6	8.48h	10.32e	2.71h
T7	14.68d	13.31bc	4.70d
T8	8.60h	10.61e	2.75h
T9	17.81a	15.02a	5.70a
T10	9.55g	10.56e	3.06g
T11	17.36a	14.41ab	5.56a
T12	10.40f	11.65de	3.32f

T1= Control

T2= N = Urea 30 kg Nha⁻¹

T3= SSP = Single super phosphate 60 kg Pha⁻¹

T4 =NPK 15:15:15 200 kg ha⁻¹

T5= PM = Poultry manure 10 t ha⁻¹

T6= CD = Cow dung 15 t ha⁻¹

T7= N + PM (15 kg Nha⁻¹) + (5 t ha⁻¹)

T8= N + CD (15 kg Nha⁻¹) + (7.5 t ha⁻¹)

T9 = P + PM (30 kg Pha⁻¹) + (5 t ha⁻¹)

T10= P + CD (30 kg Pha⁻¹) + (7.5 t ha⁻¹)

T11= NPK + PM (100 kg ha⁻¹) + (5 t ha⁻¹)

T12= NPK + CD (100 kg ha⁻¹) + (7.5 t ha⁻¹)

Mean with the same letter(s) in the columns are not significantly different (Duncan's New Multiple Range Test, ($p \leq 0.05$))

Conclusion

The study showed that soils in Southeastern Nigeria were found to be low in quality; however combined use of organic and inorganic amendments (poultry manure and phosphate) enhanced the chemical properties of the soil and boost soybean growth and yield compared to sole application of either of them. From the results obtained, it can be inferred that the soil amended with 30 kg P ha⁻¹ + 5 t PM ha⁻¹ (T₉) was more effective in improving chemical properties of soil and soybean performance than sole application of any of the organic or inorganic fertilizers or combined.

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