# INFLUENCE OF ORGANIC WASTES AND UREA ON SOIL PROPERTIES, NODULATION, GROWTH AND YIELD OF COWPEA (*Vigna unguiculata*) IN IMO STATE, NIGERIA.

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**Abstract**
An experiment was carried out at the Teaching and Research Farm of Federal University of Technology Owerri to evaluate the effect of organic and inorganic manure application on soil properties, growth performances and nodulation of cowpea (*vigna unguiculata*). The treatments consisted of 1.3t $ha^{-1}$ poultry manure (PM), 1.3t $ha^{-1}$ pig slurry (PS), 1.3 t $ha^{-1}$ of urea, combination of the three treatments (PM, PS and Urea) and control which did not receive any treatment. The treatments were arranged in a randomized complete block design (RCBD) with three replications. Soil samples were collected and analyzed using standard methods; and data collected were subjected to analysis of variance. Results obtained revealed that plots treated with the mixture of poultry manure, pig slurry and urea fertilizer (PM + PS + Urea) significantly (P=0.5%) improved soil properties such as soil pH (5.77), soil organic matter (7.79 g $kg^{-1}$) and other soil properties like total porosity (50.2), moisture content (160.3) and exchangeable bases (1.95) when compared to singly applied treatment and the control plots. The same rate also recorded the highest plant height (60.2 cm), leaf area 42.3 $cm^2$, number of leaves (90) and number of nodulation (8.33) 10 weeks after planting. From the results obtained, admixture of the treatments studied proved soil properties, growth and number of nodulation of cowpea and is therefore recommended for cowpea production in the studied area.

**Keywords: Cowpea, soil amendment, soil fertility, nodulation, perfomance**

## Introduction

In the semi arid tropics including parts of Asia and Africa, cowpea (*Vigna unguiculata* (L) walp) has been known as one of the most important food and forage legumes (Singh, 2005; Timko *et al.*, 2007). It is largely grown in the west and central Africa countries. Its value lies with its high protein content well as its ability to tolerate draught and to fix atmospheric nitrogen if allowed to grow on a poor soil (Akinyele *et al*., 1986).. It is mainly used for human consumption, livestock feed and soil cover as green manure (Abd El-Mageed *et al*., 2001). Cowpeas are not only versatile and delicious, but also important for human health, offering a number of health benefits, such as their ability to improve digestion, aid sleep disorders, manage diabetes, protect the heart, detoxify the body, promote healthy skin, aid in weight loss, and strengthen circulation. Its grain provides a cheap and nutritious food for relatively poor urban communities (Aliyu, 2011), the grain contains about 25% protein and 64% carbohydrate. Cowpea is a genuine African crop for hay and forage production. (Chinma *et al*., 2008).

Many legumes of which cowpea belong to contain symbiotic bacteria called rhizobia within nodules of their root systems. Nodulations in cowpea is generally reduced in acid-aluminum-rich soils where even tolerant strains fail to infect root hairs (Applebaum, 1990). Biological nitrogen fixation is the process used by microorganisms living in the soil to fix nitrogen in leguminous plants. These bacteria have special ability of fixing nitrogen from the atmosphere, molecular nitrogen ($N_2$) into ammonia ($NH_3$). This then means that the root nodules are sources of nitrogen for legumes, making them relatively rich in plant proteins.

Cowpea is a valuable component of farming systems in many areas because of its ability to restore soil fertility for succeeding cereal crops grown in rotation with it (Carsky et al., 2002, Tarawali, et al., 2002; Sanginga et al., 2003). The use of organic manure is containing relatively low concentration of nutrients and handling them is labour intensive, there has been largely increase in their use over. In Nigeria, 80% of the cowpea production is mainly from the savanna zone of the country (FAO, 1999). A wide range of seed yields have been recorded for cowpeas but they are generally low. Among the factors responsible for the low yields are low soil fertility, as most tropical soils are deficient in essential nutrients particularly nitrogen and phosphorus (Jones and Wild 1975). Currently, attention has diverted towards the use of organic manure because of the rising cost of inorganic fertilizers joined with their inability to give the soil the desired health (Oyedeji et al., 2014). Meanwhile, the use of inorganic fertilizer in limited by cost and scarcity while the use of organic manure is limited by the large quantities needed to meet crop nutritional needs due to its low nutrient content. This study therefore was carried out to investigate the use of organic manure as an alternative to inorganic fertilizer for cowpea production.

## Materials and Methods

### The study area

The experiment was conducted at Teaching and Research Farm in the School of Agriculture and Agricultural Technology, Federal University of Technology Owerri, Imo State, Nigeria. The area lies between latitude $5^{o}17^{1}$N and $5^{0}38^{1}$N and longitude $7^{0}$ $11^{1}$E and $7^{0}45^{1}$E in a tropical rainforest zone of Southeastern Nigeria. The area has an annual rainfall of about 2500mm and mean annual temperature ranges from $27^{0}$C - $29^{0}$C with average relive humidity of 79%. The area is dominated by ultisols derived from coastal plain sands and characterized by low cation exchange capacity, low organic matter content, low pH and are also highly leached (Onweremadu *et al.,* 2011, Onwudike *et al.,* 2017). Rainforest is the dorminant vegetation of the area characterized by multiple plant species.

### Land preparation and experimental design

A three year fallow was manually cleared and mapped out into five experimental plots each measuring 3 x 3m with inter plot distance of 1 m. Composite soil samples were randomly collected from the experimental area at the depth of 0 – 15 cm for pre-planting soil analysis. The plots were manually tilled with hoe into bed form. A randomized complete block design was used with five treatments that are replicated three times given a total of fifteen experimental plots. The treatments consisted of 1.3t $ha^{-1}$poultry manure (T1), 1.3 t $ha^{-1}$ pig slurry (T2), 1.3 t $ha^{-1}$ urea (T3), combination of the T1+ T2 +T3 (T4) and control which did not receive any treatment (T5).

The treatments were applied on the plots and then worked into the soil with hand hoe. Cowpea seeds were planted three per hole at a spacing of 50 cm x 50 cm and thinned down to one seed per stand one week after planting.

### Measurement of growth parameters

Two weeks after planting, four plants were tagged on each plot for data collection on weekly bases. Number of leaves on tagged plants, plant height and leaf area were measured. Leaf area was calculated using the method of Nwafor *et al*., (2010) while number of leaves was counted and plant height was measured using a metre rule. Nodulations counts of cowpea were also carried out by counting the number of nodules on the plant.

### Laboratory analysis

Soil samples were collected from each experimental plots at the maturity of the plants and are analyzed as follows. Particle size distribution analysis was determined by hydrometer method according to the procedure described by Gee and Or (2002). Soil pH in soil water ratio 1:2.5 was measured by according to Hendershot et al., (1993). Total Nitrogen was determined according to Bremmer and Yeomans (1988). Available phosphorus was extracted using I N Bray II solution method (Olsen and Sommers, 1982). Organic carbon was determined by Olsen and Sommer, (1982). Exchangeable bases were extracted according to the procedure of Thomas (1982) method. Exchangeable acidity was by Mclean, (1982) method. Effective cation exchange capacity (ECEC) was calculated as the sum total of exchangeable bases (TEB) and exchangeable acidity (EA). Base Saturation was calculated by dividing TEB with ECEC and multiplied by 100.

Data analysis was done using analyses of variance (ANOVA) and simple correlation analysis

## Results and Discussion

### Properties of Soil before the study and nutrient composition of the manure

Physico-chemical properties of soil prior to cropping are shown in Table 1. Results showed that the soil of the study location are low in nutrient content with low moisture (160.3), strongly acidic (4.5), low organic matter content (3.18), low effective cation exchange capacity (0.33) and base saturation (45.45).

The chemical properties of manures used in the study are shown in Table 2. Poultry manure (0.43) had higher nitrogen than pig slurry (0.33) while pig slurry (1.61) had higher organic matter content and available phosphorous (0.68) than poultry manure. These results revealed that as these organic materials contain different concentrations of plant nutrients their influence on the growth of plant would also vary.

**Table 1: Physico-Chemical Properties of Soil before the Study**

| Soil property | Unit | values |
|---|---|---|
| Silt | $gkg^{-1}$ | 8.4 |
| Clay | $gkg^{-1}$ | 76.4 |
| TC | | Sand |
| BD | $gcm$-$^{3}$ | 1.32 |
| TP | % | 50.2 |
| MC | $gkg^{-1}$ | 160.3 |
| pH ($H_2O$) | | 4.5 |
| pH(KCl) | | 4.11 |
| OC | $gkg^{-1}$ | 3.18 |
| TN | $gkg^{-1}$ | 0.12 |
| Av.P | $Mgkg^{-1}$ | 119.9 |
| Ca | Cmolk $g^{-1}$ | 0.08 |
| Mg | Cmolk $g^{-1}$ | 0.01 |
| K | Cmolk $g^{-1}$ | 0.01 |
| Na | Cmolk $g^{-1}$ | 0.05 |
| TEA | Cmol $kg^{-1}$ | 0.08 |
| ECEC | Cmolk $g^{-1}$ | 0.33 |
| BS | % | 45.45 |

TC= textural class, BD= bulk density, TP= total porosity, MC= moisture content, OC= organic carbon, TN= total nitrogen, Av.P= Available Phosphorus, TEA= total exchangeable acidity, ECEC= effective cation exchange capacity, BS= base saturation.

**Table 2: Nutrient Composition of Manures Used in the Study**

| Nutrient (%) | Poultry Manure | Pig Slurry |
|---|---|---|
| OC | 1.16 | 1.61 |
| TN | 0.43 | 0.33 |
| P | 0.2 | 0.68 |
| Ca | 0.85 | 0.92 |
| Mg | 0.69 | 0.52 |
| K | 0.73 | 1.08 |
| C/N | 3.22 | 3.33 |

OC=organic carbon, TN= total nitrogen, C/N= carbon-nitrogen ratio

**Effect of treatments on soil physical properties**

Table 3 showed the results of the effect of treatments (on soil physical properties. The particle sizes of the soils were marginally improved with application of the amendment although; they did not change the textural class of the soil. This report was in agreement with Troech and Thompson (1993) who stated that good soil management practices may slightly raise the clay fraction of the soil and improve soil productivity but cannot change the textural class. According to Onwudike et al., (2015), textural class of the soil is a function of weathering in association with parent materials influenced by climate over time. It was revealed that soil bulk density was significantly ($p<0.05$) reduced with application of treatment combinations when compared to the control plot or single application of the fertilizers. Application of organic manure significantly ($p<0.05$) improvement soil BD, TP and moisture content when compared with the plots amended with inorganic fertilizer or the control plots.

**Table 3: Effect of treatments on soil physical properties**

| Treatment | Sand $gkg^{-1}$ | Silt $gkg^{-1}$ | Clay $gkg^{-1}$ | TC | BD $gcm^{-3}$ | TP % | MC $gkg^{-1}$ |
|---|---|---|---|---|---|---|---|
| Poultry manure (PM) | 902.3 | 45.1 | 52.7 | Sand | 1.07 | 59.75 | 190.40 |
| Pig slurry (PS) | 895.3 | 48.9 | 55.8 | Sand | 1.13 | 57.48 | 199.27 |
| Urea fertilizer (U) | 923.9 | 53.3 | 9.4 | Sand | 1.12 | 57.61 | 196.06 |
| PM + PS + U | 925.3 | 59.1 | 15.6 | Sand | 1.10 | 58.49 | 186.87 |
| Control | 914.2 | 61.2 | 24.6 | Sand | 1.99 | 24.6 | 157.37 |
| **$LSD_{(0.05)}$** | **NS** | **NS** | **NS** | | **0.11** | **4.17** | **7.10** |

NS = not significant, TC= textural class, BD= bulk density, TP= total porosity, MC= moisture content

**Effect of treatments on soil chemical properties**

Results on the effect of treatments on soil chemical properties are presented in Table 4. Results showed that application of the fertilizers significantly (P=0.05) increased soil chemical properties such as soil pH, soil organic matter, available phosphorus and exchangeable bases. The highest pH (5.77) was recorded from plots with mixture (PM+PS+U) of the treatments, PM recorded pH value of 5.49 while the lowest pH (5.33) was observed from the urea fertilizer. The highest soil organic carbon (7.79) was recorded from plots amended with the admixture of the three fertilizers; this was followed by plots treated with poultry manure (PM) while the least was the plots treated with pig slurry (PS). The same trend was observed in soil available phosphorus where plots treated with mixture of the fertilizers recorded the highest value of 35.51$mgkg^{-1}$ while the least was from plots treated with urea.

Plots treated with combination of three recorded highest TEB (1.95$molkg^{-1}$), while the least was recorded with plot treated with urea fertilizer. Furthermore, combination of treatments recorded the higher value of ECEC (2.94 cmol/kg) while the lowest value was recorded from plots treated with urea fertilizer.

**Table 4: Effect of treatments on soil chemical properties**

| Treatment | pH ($H_2O$) | **pH (KCl)** | **OC g/kg** | **TN g/kg** | **AP Mg/kg** | **Ca** | **Mg** | **K** | **Na Cmol/kg** | **TEB** | **TEA** | **ECEC** | **BS %** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Poultry manure (PM) | 5.42 | 4.94 | 3.46 | 0.17 | 28.80 | 0.51 | 0.59 | 0.12 | 0.03 | 1.25 | 1.12 | 2.36 | 52.73 |
| Pig slurry (PS) | 5.40 | 4.55 | 2.72 | 0.13 | 25.44 | 0.56 | 0.59 | 0.41 | 0.02 | 1.57 | 1.15 | 2.72 | 57.63 |
| Urea fertilizer (U) | 5.33 | 4.14 | 3.33 | 0.14 | 20.39 | 0.51 | 0.44 | 0.22 | 0.02 | 1.19 | 1.15 | 2.34 | 50.60 |
| PM + PS + U | 5.77 | 4.59 | 7.79 | 0.22 | 35.51 | 0.80 | 0.62 | 0.51 | 0.02 | 1.95 | 0.99 | 2.94 | 66.23 |
| Control | 4.97 | 4.11 | 3.26 | 0.19 | 19.07 | 0.40 | 0.31 | 0.10 | 0.01 | 0.82 | 1.47 | 2.29 | 35.90 |
| $LSD_{(0.05)}$ | **0.16** | **0.18** | **1.66** | **0.02** | **1.79** | **0.09** | **0.18** | **0.15** | **0.08** | **0.28** | **0.13** | **0.22** | **6.94** |

OC= organic carbon, TN= total nitrogen, TEB= total exchangeable bases, TEA= total exchangeable acidity, ECEC= effective cation exchange capacity, BS= base saturation

**Effect of treatments on growth parameters of cowpea**

Figure 1 showed the results of the effect of animal manure and urea on the number of leaves of cowpea plant. The highest number of leaves was recorded on plots treated with mixture of all the treatments. Amongst the treatments, the distribution was in a decreasing order of control>Urea>PS>PM>PM+PS+U. All growth parameters were affected by manure application and admixture of all treatments recorded the highest values on cowpea height (58cm), leaf area and on leaf number. This increase in the number of leaves could be attributed to high N level and P content of the mixtures as well as the concentration of the elements in the soil. The improvement in crop parameters is associated with increase N, P and K levels in the soil as agreed by Reyhan and Amiraslani (2006). Edu *et al.*, (2015) made similar observation with application of organic and inorganic manure on *Telfera occidentalis* plant.

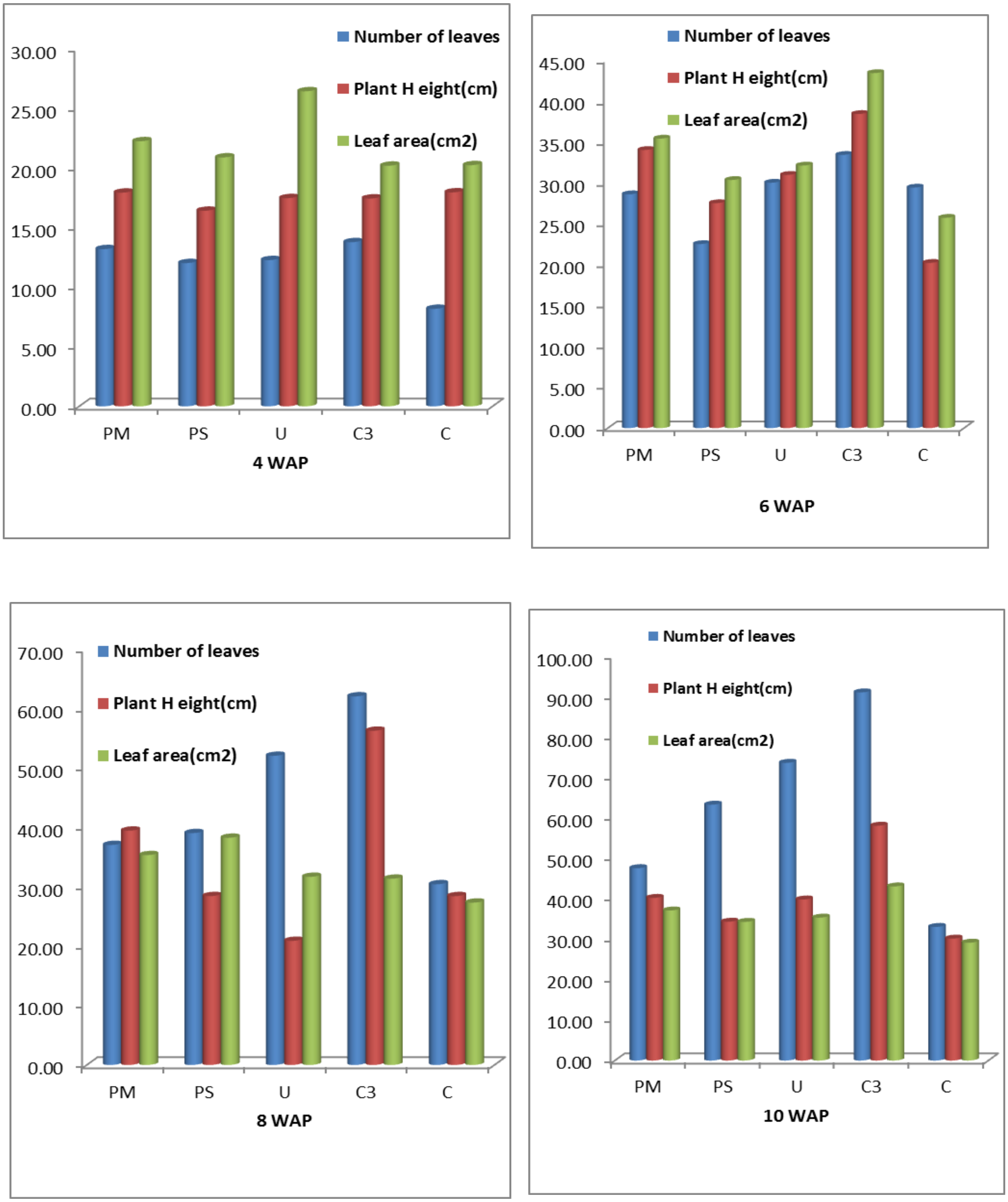


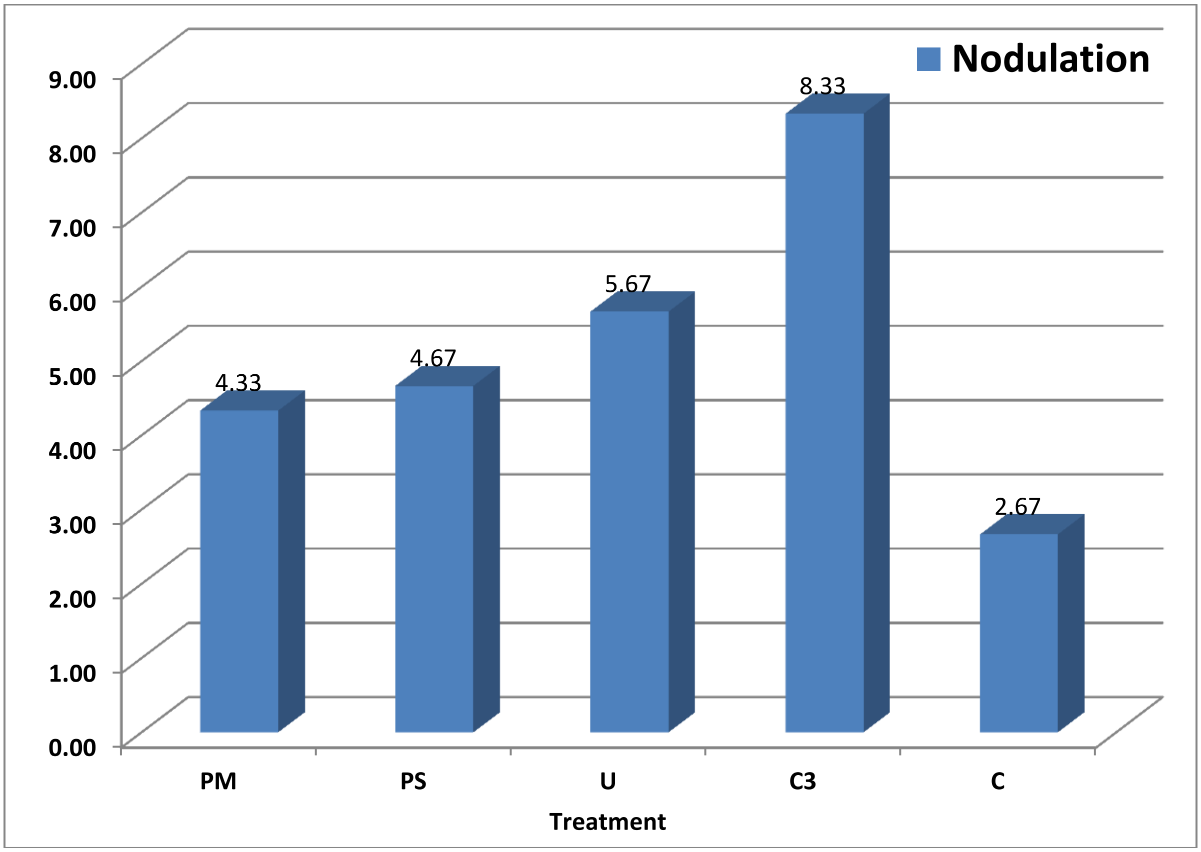

**Figure 1: Effect of Treatments on the Growth Parameters of Crop, PM=Poultry manure, Ps= Pig slurry, U= urea, C3= PM+PS+U and C=control**

**Effect of Treatments on the Nodulation**

Effects of treatments on the number of root nodules of cowpea are shown in Figure 2.

Plots amended with animal manure and urea recorded higher values of root nodules as compared with the control plot. The lowest number of nodules (2.67) per plant was obtained from the untreated (control) plot and this was followed by the plots treated with urea while the highest number of nodules (8.33) was obtained from plots that received a mixture of treatments. The trend of nodulation performance was PM+PS+U> Urea> PS>PM>control.

These findings showed that application of manure enhances symbiosis with nodule bacteria. This is in agreement with findings of Gerald (2004), who observed that addition of organic manure in the soil enhances symbiotic relationship between micro organisms in the soil. Increase in the number of nodulation with manure application could be attributed to improved soil pH, organic matter and exchangeable bases




PM = poultry manure, PS = pig slurry, U = urea, C3 = PM+PS+U, C = Control

**Fig. 2. Effect of Treatments on the Nodulation**

**Relationship between Nodulation and Soil Physicochemical Properties**

Relationships between nodulation and soil properties are presented in Table 5. Results showed that nodulation significantly correlated positively with base saturation (r = 0.797), Ca (r = 0.784), ECEC (r = 0.714) and Mg (r = 0.672). Similarly, there was positive correlation between nodulation count and total exchangeable bases (r = 0.804) and negatively correlated with TEA (r = -0.755).

Increase in soil organic matter that resulted to increased exchangeable bases could be attributed to positive correlation between nodulation and base saturation since organic matter serve as the reservoir for exchangeable bases (Onwudike *et al.*, 2016). It can be inferred that the negative correlation between nodulation and total exchangeable acidity results to increased concentration of $H^+$ and $Al^{+3}$ ions on the soil exchange complex which causes reduction of nodulation number as a result of poor microbial population within the rhizosphere of cowpea plants.

**Table 5: Relationship between Nodulation and Soil Physicochemical Properties**

| Soil Property | Nodulation | Significant Level |
|---|---|---|
| Av.P | 0.036327 | Not significant |
| BD | 0.385841 | Not significant |
| BS | 0.797214 | ** |
| Ca | 0.78364 | ** |
| ECEC | 0.713745 | ** |
| MC | 0.402888 | Not significant |
| Mg | 0.672317 | * |
| OC | 0.119017 | Not significant |
| TEA | -0.75523 | ** |
| TEB | 0.804322 | ** |
| Clay | -0.30836 | Not significant |
| TN | -0.0809 | Not significant |
| pH($H_2O$) | 0.489251 | Not significant |

*and ** = significant at 0.05 and 0.01 probability levels respectively

**Conclusion and Recommendation**

The study investigated the effect of application of selected animal manure (poultry manure and pig slurry) and urea on the growth and nodulation of cowpea plant in acidic soils. The result obtained from the study showed that admixture of poultry manure, pig slurry and urea fertilizer significantly improved soil properties (soil pH, organic matter and exchangeable bases) when compared to other treatments applied singly. Plant height, leaf area and number of leaves nodulation count of cowpea were highest in plots treated with admixture of the three treatments. Application of admixture (poultry manure, pig slurry and urea) proved best over other nutrients applied singly and is recommended for good cowpea nodulation.

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