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Effect of different organic composts and inorganic fertilizer on nodulation, nitrogen fixation and grain yields of soybean (Glycine max L.) under field conditions.

[1]Ogunrewo, O. M.*, [2]Olayinka, A., [3]Taiwo, L. B., [3]Oyedele, O. A.

1Department of Agricultural Sciences, College of Agriculture, Food Science and technology (CAFST), Wesley University, Ondo (WUO), Ondo State, Nigeria.

2Department of Soil Science and Land Resources Management, Obafemi Awolowo University (O.A.U), Ile-Ife, Nigeria.

3Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan, Nigeria.

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Corresponding Author's E-mail Address: bolabusuyi@yahoo.com .+2348068657224

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ABSTRACT

The study assessed the effects of composted corn wastes, poultry droppings and inorganic fertilizer on the number of nodules, nitrogen fixation and grain yields of soybean (Glycine max L.) under field conditions for 2 seasons. The experiments were conducted in the research sub-station of the Institute of Agricultural Research and Training, (IAR&T), Ilora, Oyo State, South Western Nigeria: (Derived Savanna Agro-ecology). Six experimental treatments namely; composted corn wastes boiled with table salt, composted corn wastes boiled with water alone, composted un-boiled corn wastes, composted poultry droppings, NPK 20-10-10 fertilizer and control were applied to a soil with low fertility status. Soybean (Glycine max L.) seeds were planted in a Randomized Complete Block Design (RCBD) and replicated 6 times. The plantings were carried out twice at two consecutive plantings. The number of nodules, amount of nitrogen fixed as well as grain yield were evaluated. The field trial results showed a higher number of nodules, nitrogen fixation and grain yield response when the un-boiled composted corn wastes (F3) and composted poultry droppings only (F4) were applied to the field compared to the other treatments. The number of nodules, nitrogen fixation and yield were significantly higher at the end of the second plantings compared to the first reflecting a residual effect of the composts. The study concluded that the application of composted corn wastes and poultry droppings especially when the seeds were inoculated with Rhizobium and mycorrhiza improved the number of nodules, N_2 fixation and grain yield of soybean (Glycine max L.) even when no boiling treatment was applied to the corn wastes. It is therefore recommended that maize cobs be converted to composts for improved soil productivity.

1.0. Introduction

Low fertility status in tropical soils has become a major concern to soil scientists and other stakeholders handling soils. This has become of paramount importance because of the rapid population increase experienced in the region which has to be fed (Azeez and Adetunji, 2004). This challenge has directly impacted crop productivity and hence the consumption pattern of the people. Sustainable crop production, therefore, require judicious management of all nutrient sources available on the farm or in the society at large (Ogeh, 2010). Intensive and conscientious efforts being made by the farmers from time to time to resuscitate the declining soil fertility include the use of high input agricultural materials such as fertilizers, pesticides and chemicals (Onwuka *et al.,* 2010). This has not given 100% result in Africa because our farmers are mostly smallholders and are often not able to afford the cost of these chemicals (Opara-Nadi *et al.,* 2000; Odedina *et al.,* 2011). An alternative to the use of these chemicals, therefore, becomes imperative. This include the use of materials like corn cobs, sheaths, maize stover, rice bran, poultry manure, cow dung and crop residues among several others (Fagbenro, 2000). These materials are valuable, readily available and potentially rich in soil nutrients and microorganisms. If they are composted and well harnessed, they can be of immense benefit to the soil rather than allowing them to lie around on the farm and in the society where their management can be very challenging (Olayinka, 2001a). These wastes when composted can be used to grow a number of crops such as grains, tubers and legumes of which soybean*(Glycine max L.)* is an important example.

Soybean is *(Glycine max L.)* a legume of the pea family that grows in the tropical, subtropical, and temperate climates. It is excellent in dietary fibre, vitamins, oil and minerals, making it important for daily dietary recommendations (Daramola and Taiwo, 1999). Soybean is an important legume associated with N-fixing in the presence of symbiotic bacteria and this can be used to solve the problem of soil infertility prevalent in many of the tropical soils (Akinola and Ojeniyi, 2011). Nodulation is a complex process by which growths known as nodules are formed on the roots of plants especially legumes. Nodules are spots where symbiotic bacteria carry out the process of nitrogen fixation. (Huvaneswari *et al.,* 1988). Nitrogen fixation is of great importance in soil health because it helps in replenishing N loss from the soil as the atmospheric N are converted into plant usable forms in exchange for fixed C by the nitrogen fixing bacteria. Nodules are highly oxygen sensitive and can be prevented from forming if the N content is too high (Dupont *et al.,* 2012). The amount of N found or fixed in a soil is of utmost importance because N is a major component of important cell constituents such as amino acids, DNA, RNA, ATP, vitamins and hormones (Saad and Lam-Son, 2014). The objective of this research was therefore to assess the effects of composted corn wastes and inorganic fertilizers on number of nodules, nitrogen fixation and ultimately the grain yield in soybean (*Glycine max L.*) under field conditions.

2.0. Materials and Method

2.1. Experimental site

This experiment was carried out at the research outstation of IAR&T Ilora, (Derived Savanna) Oyo State, South West Nigeria; (between latitudes 7°, 46′ and 7° 47′N; and between longitudes 3° 59′ and 3° 60′E; approximately 285 m above mean sea level). The site has been cultivated with tomatoes and vegetables for several years without fertilizer application. The site was sampled with core sampler to test the soil for preliminary nutrient content.

2.2. Compost preparation

Poultry manure which had been left to decompose for four weeks was obtained from the Poultry Farm of the IAR&T, Ibadan. Corn wastes, namely, corn cob and sheath were also obtained from the teaching and research farm. They were both air-dried. The poultry manure was crushed and sieved while the corn wastes were crushed and broken into pieces to allow for more surface area for microbial decomposition and reaction. The poultry manure and corn wastes were composted for about 8 weeks using the Passive Air Composting Technique (PACT) (Taiwo, 2007). The composts produced were thereafter used for the field experiments.

The treatments were as follows:

1. Control (soil only) - (F_0)
2. Soil + 5 t/ha composted corn wastes boiled with water and NaCl salt - (F_1)
3. Soil + 5 t/ha composted corn wastes boiled with water only - (F_2)
4. Soil + 5 t/ha composted un-boiled corn wastes - (F_3)
5. Soil + 5 t/ha composted poultry droppings - (F_4)
6. Soil + 100kg N /ha NPK 20-10-10 fertilizer - (F_5)

2.3. Field Experiment

The experiment was conducted in the 2013 1and 1024 cropping seasons. The land was ploughed and the plots were laid out in a dimension of 2 m X 2 m each with an alley of 0.5 m between each of the plot in a randomized complete block design (RCBD). The composts were applied at the rate of 5 ton /ha into each plot two weeks prior to planting of the soybean *(Glycine max L.)* seeds in order to allow for the composts to equilibrate before cultivation (Soretire and Olayinka, 2013a). The soybean seeds were pre-inoculated with rhizobium and mycorrhiza and thereafter planted by drilling at a spacing of 50 cm x 50 cm. Weeding was carried out manually twice using hoe.

2.4. Sample analysis

At 8 weeks, 18 plants (6 treatments by 3 replicates) were harvested to determine the number of nodules formed by counting. The amount of nitrogen fixed using ureide method was also carried out. The remaining plants were left to grow till maturity after 18 plants were also harvested and observed for grain yields.

2.5. Statistical analysis

Statistical analyses of all data collected were carried out using ANOVA at 0.05 level of significance. Separation of means was done using the Duncan's New Multiple Range Test (DNMRT) with SAS (SAS, 9.1 version 2002-2003).

3.0. Results and Discussion

3.1. Physical and Chemical Properties of the Soils Used for the Experiment

Table 1 shows the physical and chemical properties of the soil used for the experiment, with a textural class of Sandy clay loam; 51% sand, 29% silt and 20% clay respectively. The Bray-1 P, Organic C and Total N were low at 11.23 ppm, 6.1 g / kg and 0.4 g / kg respectively. The soil showed an acidic condition with a pH of 5.7 in distilled water while the C:N ratio was moderate at 15. The exchangeable cations reflected low fertility status with Ca^{2+},

Mg^{2+}, K^+ and Na^+ at 2.80, 2.01, 0.51 and 0.07 cmol / kg, respectively (Table 1).

3.2. Chemical Properties of the Composts Used for the Experiments

The chemical properties of the composts used for the field experiment is presented in Table 2. The pH values of the composted corn wastes boiled with salted water (F_1), with water only (F_2), un-boiled corn wastes (F_3) and poultry droppings (F_4) were 8.1, 7.8, 7.9 and 8.0, respectively. These pH values being slightly alkaline were expected to improve the soil reaction which was already acidic (5.7 in H_2O). The total N contents of the composts were higher than that of the soil with the values for F_1, F_2 and F_3 being 3.2, 3.5 and 2.9 g / kg, respectively, and F_4 having the highest value of 12.6 g / kg. Hence, these composts were expected to enhance the soil N contents and improve the soil properties in the course of the experiment.

The total P contents for F_1, F_2 and F_3 were very high with values of 1.1, 1.0 and 1.6 g / kg, respectively, while that of F_4 (2.4 g / kg) was even higher than those of F_1 and F_2 by about 100%. The C: N ratios of the four composts were moderate and within the range appropriate for proper plant growth as F_1, F_2, F_3 and F_4 had values of 16, 17, 17 and 12 respectively. The higher values of the C: N ratios of F_1, F_2 and F_3 compared to F_4 (poultry droppings compost) might be due to the carbonaceous nature of the corn wastes used in the composts F_1, F_2 and F_3. Total K and Na contents were highest in F_3 (27.6 and 30.8 g / kg, respectively) while Ca and organic C contents were highest in F_4 (135.5 and 152.8 g / kg, respectively). The cations which are generally high in the different composts would make more nutrients available for the plants cropped on the soil (Olayinka *et al.,* 1998).

Table 1: The physical and chemical properties of the soil used for field experiment

Parameters	Values
Particle Size Analysis (g / kg)	
Sand	510
Silt	290
Clay	200
Textural Class	Sandy clay loam
Bray-1 P (mg / kg)	11.23
pH (H_2O) 1:1	5.7
Organic matter (g / kg)	10.5
Organic C (g / kg)	6.1
Total N (g / kg)	0.4
C:N Ratio	15
Exchangeable Cations (Cmol(+) / kg)	
Ca^{2+}	2.80
Mg^{2+}	2.01
K^+	0.51
Na^+	0.07

Table 2: Chemical properties of the organic fertilizers used as soil amendments.

Organic Fertilizers	pH (water)	Organic C	Total N	P	K	Ca	Mg	Na	C:N
		(g / kg)							
F_1	8.1	51.0	3.2	1.1	22.8	46.5	9.1	30.8	16
F_2	7.8	61.0	3.5	1.0	21.4	65.6	1.4	23.5	17
F_3	7.9	50.0	2.9	1.6	27.6	54.4	9.4	24.3	17
F_4	8.0	152.8	12.6	2.4	14.8	135.5	12.3	17.2	12

Where, F1= Composted corn wastes boiled with water and NaCl salt
F2 = Composted corn wastes boiled with water only
F3 = Composted un-boiled corn wastes
F4 = Composted poultry droppings

3.3. Effects of different composts and Inorganic Fertilizer on Number of Nodules of Soybean (Glycine max L.) after planting in the field for two consecutive seasons.

Figure 1 shows the effects of composted corn wastes plus poultry droppings and inorganic fertilizers on nodulation of soybean (*Glycine max L.*) planted on the field after inoculation with both rhizobium and mycorrhiza. The results showed that nodulation in the control at both plantings were significantly lower than those of the other treatments except that of the inorganic fertilizer (F_5) for both rhizobial and mycorrhizal treatments. The treatments were thus significant. This also explains that the use of synthetic fertilizer gave a similar effect as if the soil was left untreated. This shows that inorganic fertilizer may not always be effective in soybean cultivation exercise.

At the end of the first planting, it was observed that nodulations in soybean treated with F_1, F_2, F_3 and F_4 were not significantly ($p<0.05$) different from each other while at the end of the second planting, F_1, F_2 and F_3 were significantly ($p<0.05$) higher than the remaining treatments. The treatment F_4 had become significantly ($p<0.05$) lower and not significantly ($p<0.05$) different from F_5. This trend shows that the corn waste composts had mineralized over time thereby making more nutrients available for the microorganisms to thrive and enhance nodulation at a threshold where optimum number of *rhizobia* can affect nodulation (Daramola and Taiwo, 1997). The higher values after the second plantings reflect the residual effects of the nutrients released by the composts after two plantings.

3.4. Effects of different Composts and Inorganic Fertilizer on Nitrogen Fixation in Soybean (Glycine max L.) After Two Consecutive Plantings in the field.

Figure 2 shows the effects of composted corn wastes, poultry droppings and inorganic fertilizer on the amount of nitrogen fixed by inoculated soybean (*Glycine max L.*) planted for two consecutive seasons in the field. The control was significantly lower than the results of the other treatments. There was no significant difference ($p<0.05$) observed in the Nitrogen fixed by soybean fertilized with the three corn waste composts (F_1, F_2 and F_3) but they were higher than N fixed by soybean treated with poultry manure alone (F_4). This might be as a result of the addition of more nutrients by the corn wastes which made more nutrients available for the microbes fixing the nitrogen to thrive on. Generally, more nitrogen was fixed at the end of the second planting from the compost treated test crop compared to those of the first planting, showing a residual effect of the corn waste treatments. This might be due to more nutrients release through mineralization after a period of time compared to the nitrogen fixed in the inorganic fertilizer (F_5) treated soybean where depletion was observed. The subsequent release would be beneficial to farmers as the nutrients are gradually released compared to the 'rapid and waste' release commonly found in synthetic fertilizer use. This finding is in correlation with the findings of Obatolu (1991) and, Lawal *et al.,* (2011).

It was observed that the trend seen in nitrogen fixation was similar to what was observed in the number of nodules formed above in this experiment. This similarity in trend confirms that the rate of nodulation may be directly proportional to the amount of nitrogen fixed in a legume. This observation is consistent with the findings of many workers (Antunes and Goss, 2005; Havlin *et al.,* 2009; Uzoma *et al.,* 2013).

3.5. Effects of different composts and Inorganic Fertilizer on the Grain Yields (t/ha) of Soybean (Glycine max L.) after Two consecutive Planting Seasons in the Field.

The effects of corn wastes plus poultry droppings composts and inorganic fertilizer on the grain yield of soybean (*Glycine max L.*) treated with R*hizobia* and mycorrhiza planted in the field for two consecutive planting seasons are shown in Table 3. The grain yields obtained in the control were significantly ($p<0.05$) lower than in the other treatments except for inorganic fertilizer (F_5) treated soil. inoculated with *Rhizobium* at the end of the first planting where a slight increase was observed. Some indigenous nutrient present couple with *Rhizobium* may have been responsible for the little increase.

No significant ($p<0.05$) difference was observed in grain yield of soybean treated with salt-boiled corn wastes (F_1) and the water-boiled (F_2) corn waste composts. This similarity in their grain yields might be due to the fact that they were both subjected to boiling treatment unlike F_3 which

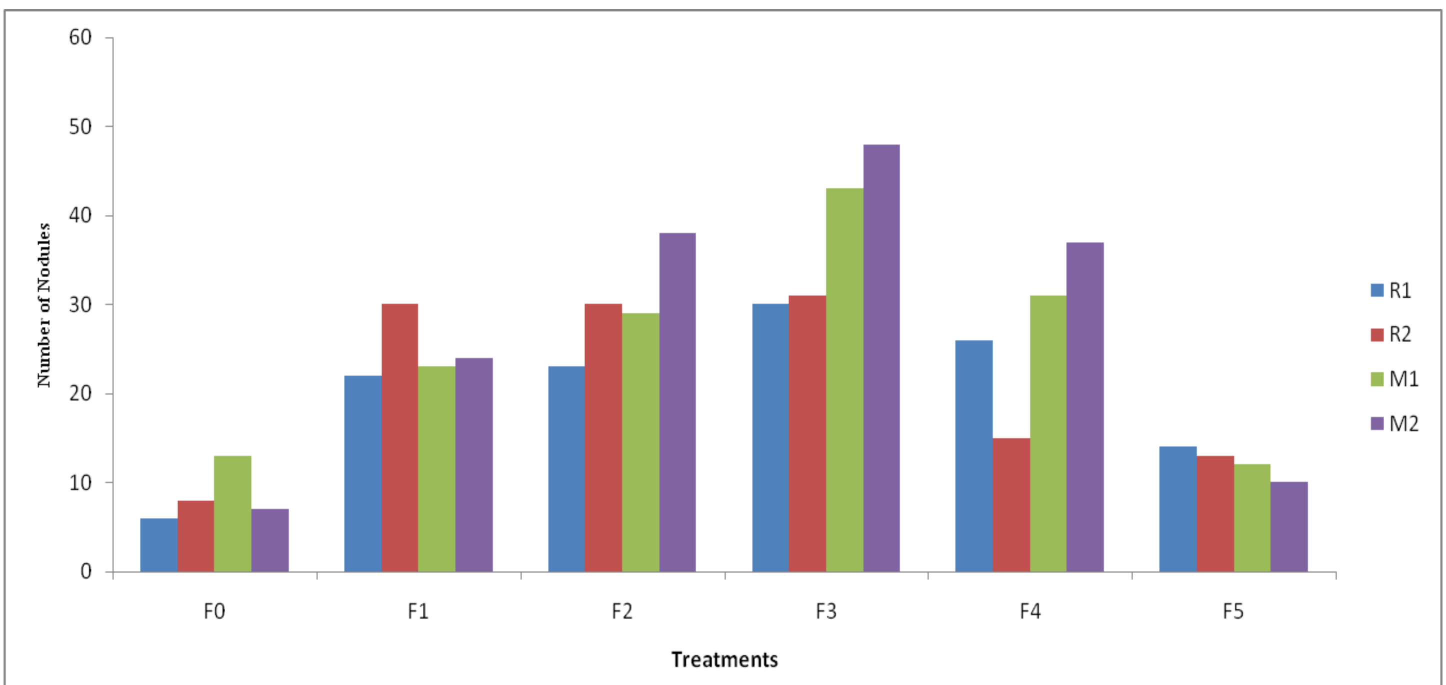

Figure 1: Effects of composted corn wastes, poultry droppings and inorganic fertilizer on the number of nodules of soybean (Glycine max L) at the end of the first and second 8-week plantings in the field.

Where, F0 = Control (soil only)
F1= Soil + 5 t/ha composted corn wastes boiled with water and NaCl salt
F2 = Soil + 5 t/ha composted corn wastes boiled with water only
F3 = Soil + 5 t/ha composted un-boiled corn wastes
F4 = Soil + 5 t/ha poultry droppings composted
F5 = Soil + 0.125 t/ha NPK 20-10-10 fertilizer
R1 = Rhizobium inoculated soil, first planting
R2 = Rhizobium inoculated soil, second planting
M1 = Mycorrhiza inoculated soil, first planting
M2 = Mycorrhiza inoculated soil, first planting

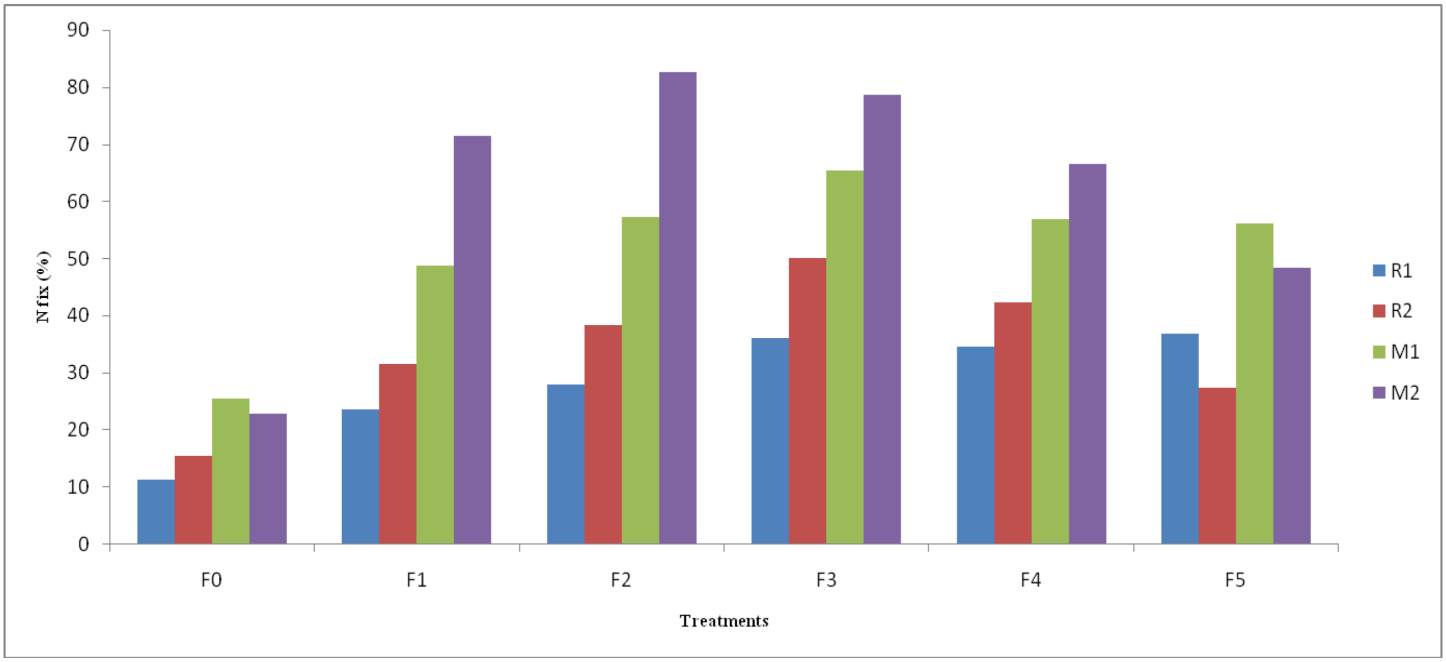

Figure 2: Effects of composted corn wastes, poultry droppings and inorganic fertilizer on nitrogen fixation (%) by soybean (Glycine max L) at the end of the first and second plantings under field conditions.

Where, F0 = Control (soil only)
F1= Soil + 5 t/ha composted corn wastes boiled with water and NaCl salt
F2 = Soil + 5 t/ha composted corn wastes boiled with water only
F3 = Soil + 5 t/ha composted un-boiled corn wastes
F4 = Soil + 5 t/ha poultry droppings composted
F5 = Soil + 0.125 t/ha NPK 20-10-10 fertilizer
R1 = Rhizobium inoculated soil, first planting
R2 = Rhizobium inoculated soil, second planting
M1 = Mycorrhiza inoculated soil, first planting
M2= Mycorrhiza inoculated soil, first planting

Table 3: Effects of different organic composts and inorganic fertilizer on the grain yields (t / ha) of inoculated soybean (Glycine max L.) at the end of first (1) and second (2) plantings in the field.

	Rhizobium		**Mycorrhiza**	
Treatments	1	2	1	2
F_0	1.80d	1.25e	0.89e	1.49d*
F_1	2.87bc	3.05c	2.05cd	3.29bc
F_2	2.87bc	3.15c	2.34bc	3.24c
F_3	4.20a	7.24a	2.55ab	4.64a
F_4	3.45ab	4.07b	2.70a	4.15ab
F_5	2.25cd	2.19d	1.72d	2.92c

*Means followed by same letters within the same column are not significantly different (Duncan's New Multiple Range Test, $p < 0.05$).

Where F0 = Control (soil only)
F1= Soil + 5 t/ha composted corn wastes boiled with water and NaCl salt
F2 = Soil + 5 t/ha composted corn wastes boiled with water only
F3 = Soil + 5 t/ha composted un-boiled corn wastes
F4 = Soil + 5 t/ha poultry droppings composted
F5 = Soil + 0.125 t/ha NPK 20-10-10 fertilizer

was not boiled. The grain yield obtained from F_3 (where 5 ton / ha of un-boiled composted corn wastes) was used and that of the poultry droppings only compost (F_4) at the end of both plantings were significantly ($p<0.05$) higher than the remaining treatments. They were both observed to be significantly ($p<0.05$) higher than F_1 and F_2 for all the plantings. This confirms the release of more nutrients for the soybean plants by these treatments than in the boiled composts where some of the nutrients might have been lost to heating.

The grain yields were observed to be generally higher at the end of the second planting compared with the first, further signifying a subsequent release of nutrients by organic wastes over time due to nutrient mineralization and consistent release for plant use. This is consistent with the findings of several workers where a slow release pattern of nutrient was observed upon amending soil with organic materials (Adediran *et al., (*1999); Amosu and Okogun (2011).

4.0. Conclusion and Recommendation

The corn wastes boiled with salt (F_1) and the one boiled with water only (F_2) generally gave lower values of number of nodules, nitrogen fixed and grain yields compared with the un-boiled corn waste composts (F_3) and the poultry droppings composts (F_4). This study also showed that applying farm wastes in the untreated form (i.e. the forms in which they naturally occur on the farm without any stressful treatment such as heating) once they are composted is of great nutrient value to crop growth and hence yields as observed in the soybean yields in this experiment.

The use of corn and poultry wastes as a means of soil nutrient improvement especially in the composted form without any complex treatment at the rate of 5 tons / ha is therefore recommended for soybean cultivation. These wastes instead of being a source of environmental pollution can be composted and utilized as soil amendment in order to enhance crop productivity. The un-boiled corn wastes will be easier to obtain and the cost of preparing the composts will also be reduced.

The use of biofertilizers as part of agronomic practices in legume production is also hereby recommended. These biofertilizers which include rhizobium and mycorrhiza will aid in increasing the number of nodules formed, the amount of nitrogen fixed and ultimately the grain yield in the soybean (*Glycine max L.*). It is also recommended that inorganic fertilizer be discouraged gradually due to its negative effect on soil properties and crop yield over time.

References

Adewumi, I. (2004). Municipal solid waste management: The need for a paradigm shift. *Ife Environmentalist, NISEM, Ife.* Pp 24.

Akinola, M. O. and Ojeniyi, S. O. (2011). Soil properties and soybean performance as influenced by tillage in Ado-Ekiti, Southwest Nigeria. *Nigerian Journal of Soil Science* 21(1): 10-15.

Amosu, S. A. and Okogun, J. A. Effect of Organo-mineral and Inorganic fertilizers on the nodulation and nitrogen uptake of Soybean and cowpea. *Nigerian Journal of Soil Science* 21(1): 85-90.

Antunes, P. M. and Goss, M. J. (2005). Communication in the tripartite symbiosis formed by Arbuscular mycorrhizal fungi, rhizobia and legume plants: A review. In Zobel, R. W. and Wright, S. F. (eds.). Roots and Soil Management: Interactions between Roots and the Soil. Agronomy monograph Number 48. Pp 272.

Azeez, J. O. and Adetunji, M. T. (2004). Comparative effects of organic and inorganic fertilizers on soil chemical properties: An incubation study. *Proceedings of the 29th Annual Conference of the Soil Science Society of Nigeria. December 6 -10, 2004. University of Agriculture, Abeokuta, Nigeria.* Pp198-200.

Daramola, D. S and Taiwo, L. B. (1997). Effects of inoculums size and phosphorus application on nodulation and N_2 fixation in cowpea (*Vigna unguiculata (L.) walp*) using ^{15}N methodology. *Ife Journal of Agriculture* 19 (1&2): 24-35.

Daramola, D. S. and Taiwo, L. B. (1999). Evaluation of nodulating and N_2 fixing capacity of six soybean (*Glycine max (L)Merill)* cultivars with and without inoculation with cowpea *Bradyrhizobium spp. Ife Journal of Agriculture* 20 (1&2): 1-9.

Dupont, L., Alloing, G., Pierre, O., Msehli, S., Hopkins, J., Hérouart, D. and Frendo. P. (2012).

The Legume Root Nodule: From Symbiotic Nitrogen Fixation to Senescence. Pg137-169.

Fagbenro, J. A. (2000). Analysis and use of organic materials. *Proceedings of the 26th Annual Conference of the Soil Science Society of Nigeria, Ibadan, Oyo State Nigeria.* October 30th to 3rd November, 2000. P 141-154.

Havlin, J. L., Beaton, D. B., Tisdale, S. L. and Nelson, W. L. (2009). Soil fertility and fertilizers- an introduction to nutrient management.7th ed. Pearson Education Inc. Prentice Hall. Pp 515.

Huvaneswari, T.V. , Andrew P.L. and Wolfgang D. B. Efficiency of Nodule Initiation in

Cowpea and Soybean. *Plant Physiol* (68): 1210-1215.

Lawal, L.O., Olaniyan, A. A., Okafor, B. N., Chikaleke, V. A. and Odofin, J.O. (2011). Growth and Yield of Sweet orange (*Citrus sinensis L.*) as influenced by organic- based fertilizer treatment on an Alfisol in Ibadan. *Nigerian Journal of Soil Science* 21 (1): 70-74.

Mba, C. C. (2011). Biofertilizer and Biogas production. *Biogas and Biofertilizer Production and use*. Papers presented at the train the trainers workshop on compost making, Biogas / Biofertilizer production and use organized by the Federal Fertilizer Department (FFD) in collaboration with National Programme for food security, Abuja, Nigeria. Pp 30-37.

Obatolu, C. R. (1991). Growth and nutrient uptake of Coffee (*Coffee spp*) seedlings grown on different organic materials. *Ph.D. Thesis, University of Ibadan.* Pp

Odedina, J. N., Ojeniyi, S. O. and Odedina, S. A. (2011). Comparative effect of animal manures on soil nutrients, nutrient status and performance of cassava. *Nigerian Journal of Soil Science* 21(1): 58-63.

Ogeh, J. S. (2010). The performance of maize in acid infertile soil amended with municipal tree leaf residue and phosphorus. *Nigerian Journal of Soil Science* 20 (2): 76-81.

Olayinka, A., Adetunji, A. and Adebayo, A. (1998). Effect of organic amendments on nodulation and nitrogen fixation by cowpea. *Journal of Plant Nutrition* 21 (11): 2455 -2464.

Olayinka, A. (2001a). Environmentally-friendly way of managing poultry litter. *Proceedings of the Workshop organized by World Poultry Science Association (Nigerian Branch) and Department of Animal Science, O.A.U, Ile-Ife., 2001. Pp. 37-41.*

Onwuka, M. I., Osodeke, V. E. and Ano, A. O. (2010). Assessment of the effects of some liming materials on some soil chemical properties in a degraded Ultisol of Southern Nigeria. *Nigerian Journal of Soil Science* 20 (2): 54 – 62.

Opara-Nadi, O. A., Omenihu, A. A., and Ifemedebe, S. N. (2000). Effects of organic wastes, fertilizers and mulch on productivity of an ultisol. *Proceedings of the 26th Annual Conference of the Soil Science Society of Nigeria, Ibadan, Oyo State Nigeria.* October 30th to 3rd November, 2000. 112-120.

Saad, S and Lam-Son, P. (2014). Nitrogen Fixation in Legume Nodules: Metabolism and

Regulatory Mechanisms. *Int. J. Mol. Sci* (*15):* 19389-19393.

SAS (SAS, 9.1 version 2002-2003).

Senjobi, B. A., Ande, O. T. and Akindolie, M. S. (2012). Performance of *Abelmoschus esculentus L. Moench* as influenced by different organic manure amendments in Yewa enclave of Ogun State, Nigeria. *Environtropica* 8: 60 -72.

Soretire, A. A. and Olayinka, A. (2013a). Response of soybean (*Glycine max L.*) to cow dung and wood ash application in tropical acid soils of south-western Nigeria. *Nigerian Journal of Soil Science* 23 (2): 103-113.

Taiwo, L. B. (2011a). Production and Use of biofertilizers for crop production. *Biogas and Biofertilizer production and use.* Papers presented at the Train the Trainers