

Original Research Article

EFFECT OF POULTRY MANURE AND UREA ON SOIL CHEMICAL PROPERTIES, NODULATION AND YIELD OF GROUNDNUT (*Arachis hypogaea*) IN AKANU IBIAM FEDERAL POLYTECHNIC, UNWANA AFIKPO EBONYI STATE

ABSTRACT

A Green House study was carried out at the Teaching and Research Farm, Department of Horticulture and Landscape Technology to investigation the influence of the integrated application of poultry manure and urea on soil nutrient properties, nodulation, growth and yield of groundnut (*Arachis hypogaea*) in Akanu Ibiam Federal Polytechnic, Unwana Southeastern Nigeria. The experiment was laid out into Complete Randomized Design with different levels of poultry manure (0, 1 and 2 tons ha⁻¹) and urea (0, 1 and 2 tons ha⁻¹) replicated three times. Results showed that poultry manure applied alone or combined with urea significantly ($P < 0.05$) improved almost all the soil nutrient properties. Relative to control, best improvements on soil fertility indices such as soil pH, available phosphorus, total nitrogen, organic carbon, Total Exchangeable Acidity (TEB) and Effective Cation Exchange Capacity (ECEC) were obtained in the pot treated with 2 tons ha⁻¹ poultry manure and 1 ton ha⁻¹ urea. Similarly, poultry manure integrated with urea significantly ($P < 0.05$) improved number of leaves and number of pods. Application of urea without poultry manure increased number of leaves better than the lone application of poultry manure, while poultry manure and its integration with urea had significant higher improvement on the number of pods compared with lone application of urea. The highest improvement on the number of leaves and pod was obtained when 2 tons ha⁻¹ poultry manure was integrated with 1 ton ha⁻¹ urea. It was also observed that the number of nodules increased with poultry manure application while inverse relationship existed between the number of nodules and urea application. The highest number of nodules and hence nodulation occurred when 2 tons ha⁻¹ poultry manure was applied, while the least was noted when 2 tons ha⁻¹ urea was added. Integration of urea with poultry manure is therefore recommended to improve soil fertility conditions and grain yield of groundnut. Also, large amount of urea should not be used in groundnut production; rather poultry manure should be incorporated to enhance nodulation and nitrogen availability in soils of Unwana Southeastern Nigeria.

Key words: Poultry manure, urea, nodulation and groundnut.

INTRODUCTION

Groundnut is an edible legume which serves as one of the main sources of income for small holders and commercial farmers. It is mainly grown for its edible seed, and is widely grown in tropics and subtropical regions as grain legume. Because of its high oil content, it has also been classified as oil crop. The seeds contain sufficient quantities of protein (19%), carbohydrate (63%), fat (6.5%) and essential amino acid such as lysine, cysteine and methionine (Lineman 1988; Brough and Azam Ali, 1992). It is cultivated in altitude ranging from 0-1550m and is generally intercropped with cereals, cassava, yam and cow pea. By fixing atmospheric nitrogen, groundnut improves the soil supply of nitrogen that is of benefit to other crops (Mukurumbia 1985). In Nigeria, the cultivation of groundnut is done majorly in the northern regions, characterized by yellow ferratitic soil, with low fertility due to sandy structure (Duchaufor, 1976). Since the nitrogen requirement is met through nitrogen fixation, interest has been developed in cultivation of groundnut for its tremendous potentials both as food and in soil fertility maintenance (Somasegaran *et al*, 1992).

43 Crop production in Nigeria is hindered by several factors such as low soil fertility as well as restricted access to
44 mineral fertilizer (Nyanabgara and Nyaguambo, 2010). In Nigeria, farmers are always faced with the problem of soil
45 fertility decline which has been considered the most important biophysical constraints to crop yield and productivity
46 (Odendo *et al.*, 2004).

47 Developing soil fertility management options for increasing productivity of staple food crops is a challenge in most
48 part of Nigeria, where soils are constrained by the major mineral element such as potassium, nitrogen and
49 phosphorus deficiencies (Jemo *et al.*, 2010). Nitrogen, Phosphorus and potassium are among the limiting nutrients
50 for legumes production (Christianson and Viek, 1991). Adequate supply of nitrogen is beneficial for carbohydrates
51 and protein metabolism, promoting cell division and cell enlargement (Shehu *et al.*, 2010).

52 In order to ensure sustained crop production in the inherently low fertility status of tropical soils, several nutrient
53 and fertility management options have been developed by many researchers and these include the addition of
54 organic and inorganic fertilizers, conservational tillage, mulching and crop rotation (Brady and Weil 2008).
55 Integration of inorganic manures such as urea and poultry manure into the farming system can be a cheaper
56 alternative to alleviating low soil fertility and erosion problems (Odendo *et al.*, 2004).

57 Poultry manure is a nutrient source of crop production (Soremi *et al.*, 2017) and its addition to the soil has been
58 shown to increase soil nutrient indices. Similarly, incorporation of poultry manure into soil promotes transformation
59 and mineralization of less labile inorganic and organic phosphorus into labile phosphorus in the rhizosphere, which
60 results in higher root phosphorus concentration and higher total phosphorus uptake by plants (Waldrup *et al.*, 2011).
61 Therefore, poultry manure could be a valuable fertilizer and could serve as a suitable alternative to chemical
62 fertilizer in Nigeria.

63 Apart from the addition of both mineral and organic nitrogen fertilizers, there is another viable and ecologically
64 friendly strategy for improving nitrogen content of soils. This process which is called biological nitrogen fixation is
65 specifically reserved for leguminous crops (Brady and Weil 2008). A relatively small amount of nitrate or ammonia
66 is produced by lightening, some are produced industrially by the Haber-Bosch process, but the major conversion of
67 Nitrogen (N_2) to ammonia and hence protein is achieved by microorganisms that inhabit the root nodules of legumes
68 in the process of nitrogen fixation (Sorensen and Sesitch, 2007). The process of biological nitrogen fixation in
69 legume nodules is an important soil fertility improvement strategy especially nitrogen economy in many tropical
70 ecosystem (Frankow-Lindberg and Dahlin, 2013). Legumes offer the potential of fixing nitrogen to the soil through
71 biological fixation process which provides a more sustainable nutrient recycling that can enhance crop yields and
72 improve soil fertility, with the ability to fix nitrogen (Amba *et al.*, 2013). Almost all the fixed nitrogen goes directly
73 into the plant, however, Walley *et al.*, (1996), stated that most of the nitrogen eventually returns to the soil when
74 vegetation of legume dies and decomposes and this can be made use of by non-leguminous crops

75 Even though several literatures have stated that leguminous crops can derive their maximum nitrogen requirement
76 from biological nitrogen fixation and therefore require no external nitrogen fertilizer application, there is still need to
77 practically investigate the effect of different fertilizer sources on nodulation of groundnut. This study was therefore

designed to evaluate the effect of poultry manure and urea on soil chemical properties, nodulation and yield of groundnut (*Arachis Hypogaea*) in Unwana, south eastern Nigeria.

MATERIALS AND METHODS

The study was carried out at Horticultural Farm of Akanu Ibiam Federal Polytechnic Unwana. Unwana is located within the South Eastern ecological zone of Nigeria and lies at latitude 5° 48N and longitude 7° 55E (Njoku and Okpara, 2006). The climatic condition and vegetation types are generally humid tropical rain forest with mean annual rainfall of about 3,500mm and mean daily temperature of 21°C to 32 °C (Odurukwe et al., 1995).

POT EXPERIENCE

Soils sample which was collected from 0 – 20cm depth, was air dried, sieved through 2mm sieve after which 5kg of sub-samples were weighed into 10 litre capacity buckets perforated at the bottom.

Appropriate weights of poultry manure and urea were added to each pot. The experiment was laid out into Complete Randomized Design with different levels of poultry manure (0,1 and 2 tons ha⁻¹) and urea (0, 1 and 2 tons ha⁻¹) replicated three times. Four groundnut seeds were sown in each pot after one month of treatment application and later thinned down to two seeding per bucket after germination. Adequate watering was observed throughout the growing period.

DATA COLLECTION

At full bloom (50 days after planting) number of nodules per plant was determined from one plant in each pot. The seedlings was carefully uprooted and washed, all the soil particles was removed and then the nodules were counted (Faizah, 1980; Osodeke, 2002). At full maturity, the other plant in each pot was uprooted and both the number of leaves and pods were obtained by counting.

Post-harvest soils samples were collected from each pot and analyzed for routine chemical properties according to standard laboratory procedures. Particle size distribution was determined using the Bouyocous hydrometer method as describe by Benton (2001). The pH was determined in soil to water and soil to CaCl₂ at a ratio 1:2 soil water and soil CaCl₂ respectively using glass electrode P^H meter (Udo *et al*; 2009).Organic carbon was determined by the wet oxidation method according to Pansu and Gautheyrous (2006) and converted to organic matter by multiplying by 1.792. Available P was determined using the Bray II method of Bray and Kurtz (1945) as described by Udo *et al*; (2009). The total nitrogen determination was done by the macro Kjeidahl digestion method (Simmone *et al.*, 1994). Exchangeable acidity was determined by the nikel extraction procedure as described by Kamprath (1967). Exchangeable basic cations (K⁺, Ca²⁺, Mg²⁺, Na⁺) were determined by the ammonium acetate method (Carter and Gregoich, 2008). Ca and Mg in the extract were determined using the atomic absorption spectrophotometer, while K and Na were determined using the flame photometer. Effective cation exchange capacity (ECEC) was obtained by summation of all the exchangeable cations and exchangeable acidity as described by Udo, *et al*; (2009). The base saturation was obtained mathematically with $BS (\%) = \frac{\text{Total cation}}{\text{Total cation} + \text{ECEC}} \times 100$

STATISTICAL ANALYSES

Data from yield parameters, number of nodulation and soil chemical properties were subjected to analysis of variance (ANOVA) and the means separated using FLSD 0.005.

RESULT AND DISCUSSION

Table 1. Physical and Chemical Properties of the Soil used for the Study

Properties	values
Sand %	40.13
Silt %	21.56
Clay %	38.31
Texture	clayey-loam
PH (H_2^0)	4.27
PH (cac _{l2})	3.78
Organic carbon %	1.90
Organic matter %	3.29
Total Nitrogen %	0.25
Available Phosphonis (mg/kg)	5.62
Ca (cmol/kg)	3.18
K (cmol/kg)	0.06
Mg (cmol /kg)	1.00
Na (cmol/kg)	0.02
TEA (cmol/kg)	4.10
ECEC (cmol/kg)	8.27
B.S %	51.51

The physical and chemical properties of the soil used for the study is presented in Table 1 above. The result showed that the sand, silt, and clay percentages were 40.13, 21.56 and 38.31% respectively. The textural class of the soil was a clayey – loam. This finding is in agreement with the result of Azu *et al* (2017), who reported a clayed – loam soil

in some soils of Ebonyi State. Soil P^H values both in H_2O and $CaCl_2$, showed that the soil was acidity, which suggest the need for liming in order to improve the soil productivity. Several other researchers (Onwuka et al 2007; Eneje and Azu 2009) have also reported acidity in most soils of South – Eastern Nigeria. Both organic carbon and organic matter were moderately low (1.90 and 3.29%) respectively. The total nitrogen was also low (0.25%). The available phosphorus was also low (5.62mg/kg) indicating high fixation and hence low phosphorus availability. The value of phosphorus was lower than the critical value of 15mg/kg suggested by Osodeke and Ubah (2005), for tropical crops. Calcium was relatively high (3.18cmol/kg). The Total Exchangeable Acidity (TEA) was high (4.01cmol/kg) indicating the influence of aluminum and iron oxides in this soil as noted by Azu *et al*; (2017). The Effective Cation Exchange Capacity (ECEC) was moderate (8.27cmol/kg) and Base Saturation (BS) was also relatively moderate (51.51%). Most studies conducted across Southeastern Nigeria showed that most soils are acidic, low in soil organic carbon (SOC), available N, and available P, K and S contents and some micronutrients (Azu *et al.*, 2017; Eneje and Azu 2009). These nutrient deficiencies can affect not only plants but also soil microbes including rhizobia populations (Brady and Weil, 2008) and its activities such as N_2 fixation (Osodeke. 2002).

Table 2: Characteristics of the Poultry manure used for the Study

Properties	Values
pH (H_2O)	8.22
pH ($CaCl_2$)	8.02
Av.P (PPM)	0.95
Nitrogen (%)	1.88
Calcium (%)	5.70
Magnesium (%)	1.90
Potassium (%)	0.51
Sodium (%)	0.069
Organic carbon (%)	4.07

Mean Effect of Poultry Manure and Urea on Soil Chemical Properties

Result of the effect of poultry manure and urea on soil fertility properties is shown in Table 3. Relative to control, the application of poultry manure as lone treatments generally resulted in increase on soil P^H both in water and in salt. The observed increase was proportional to the rate of amendment. There were consistent decline in soil pH with increasing addition of urea as lone treatment. This observation may be attributed to the fact that poultry manure being an organic material contains large amount of basic cations which factored in the reduction of soil acidity.

Table 3. Mean effect of Poultry manure and urea on soil chemical properties

PM+UR (t/ha)	pH		Aval. P (mg/kg)	Org. C (%)	Total N (%)	Exc. Bases (Cmol/kg)	Exc. Acidity (Cmol/kg)	ECEC (Cmol/kg)	BS (%)
	H ₂ O	CaCl ₂							
0 + 0	4.13	3.85	4.68	0.89	0.19	4.17	2.97	7.14	58.40
0 + 1	4.00	3.69	4.99	0.76	0.23	5.00	3.23	8.23	60.75
0 + 2	3.79	3.44	5.55	0.90	0.29	4.94	3.60	8.54	57.85
1 + 0	5.40	4.71	5.63	2.60	0.21	6.63	2.21	8.84	75.00
1 + 1	5.64	5.08	6.02	2.60	0.28	8.92	2.33	11.25	79.29
1 + 2	4.32	4.24	5.10	1.99	0.39	8.71	2.42	11.13	78.26
2 + 0	6.07	5.65	7.15	3.02	0.34	9.76	1.00	10.76	90.71
2 + 1	6.08	5.76	7.39	2.93	0.42	10.81	1.09	11.90	90.84
2 + 2	5.59	5.09	6.48	2.77	0.44	9.54	1.11	10.65	89.58
Mean	5.06	4.59	5.89	2.05	0.31	7.61	2.22	9.83	75.63
SD(0.05)U.	0.126	0.0055	0.192	0.127	0.019	0.0022	NS	NS	NS
SD(0.05)PM	0.121	0.0203	0.192	0.127	0.019	0.0030	0.00014	NS	2.114
LSD (U XPM)	0.237	0.334	0.371	0.260	0.038	0.0065	0.0177	0.135	3.008

This attribute of poultry manure can be harnessed and used as lime in reducing soil acidic. (Onwunka et al 2007). On the other hand, urea, being a mineral fertilizer with no organic component may have been responsible for increased acidity as observed. This report is consistent with the results of other researcher (Azu *et al.*, 2017). The interaction between the poultry manure and urea showed high significant ($P<0.05$) in improving the soil acidity in consonant with the reports of other researchers (Adediran *et al.*, 1999; Azu *et al.*, 2017., FAO, 1976) who reported better performance in soil acidity when organic and inorganic fertilizers are combined. The pH values ranged from 6.08 to 3.79 and the highest value was obtained at the treatment combination of 2t/ha poultry manure and 1t/ha urea. With the exception of ECEC, the lone application of poultry manure was significant ($P<0.05$) in improving the soil nutrient indices, but the lone application of urea was only significant in influencing the P^H , N and the Exchangeable bases. However, the interaction between the two materials was highly significant ($P<0.05$) in influencing the pH total nitrogen, exchangeable bases and exchangeable acidity. The mean table showed that relative to control, the treatments especially their interaction showed greater improvement on soil chemical properties. Other researchers

(Eneje and Azu, 2009; Soremi *et al.*, 2017; Adekiya and Agbede, 2016) have reported improvement on soil chemical properties when poultry manure was used as fertilizer.

Mean Effect of Poultry Manure and Urea on Number of Nodules

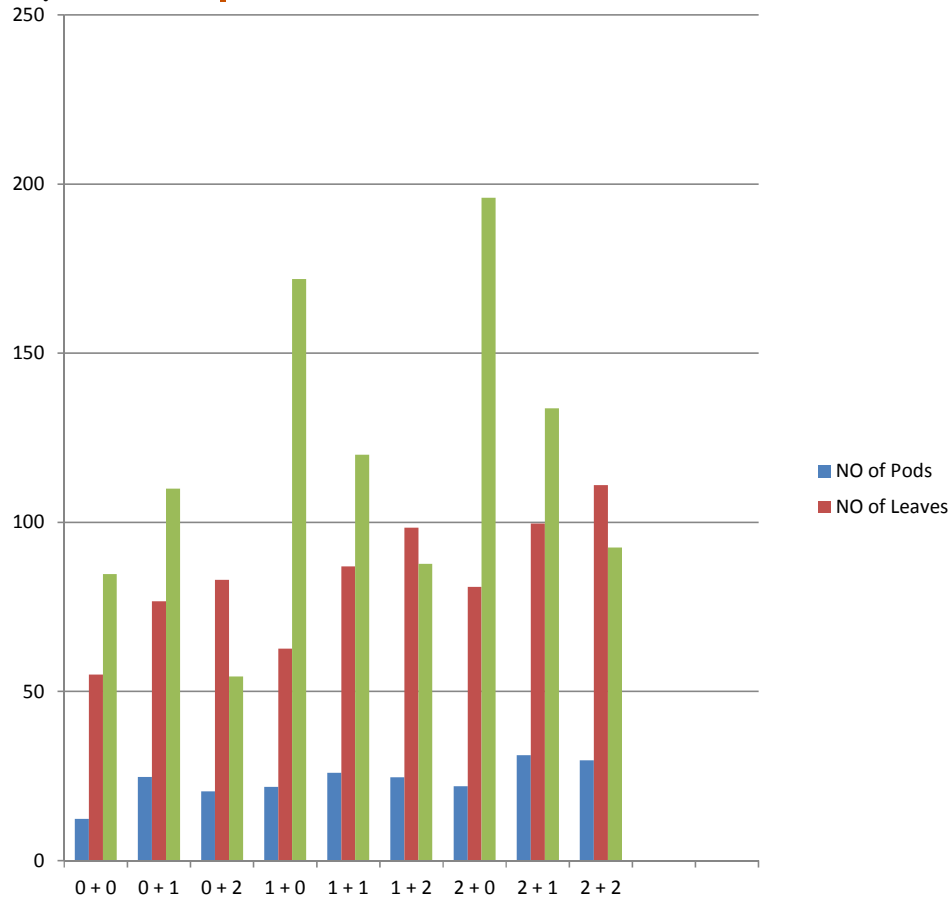
With the exception of urea as lone treatments, the number of nodules was observed to significantly ($P < 0.05$) differ among the various treatments and their combinations. As shown in figure 1, the addition of poultry manure as lone treatment had significant ($P < 0.05$) increasing effect on the number of nodules relative to control and the increase was proportional to the rate of amendment. This finding is similar to those reported by Panda *et al.*, (2012) who found that poultry manure boosts the effectiveness of *Rhizobium* in cowpea. Consequently, the highest number of nodules (196) was obtained in the pot that had 2t/ha poultry manure. This observation can be attributed to the fact that poultry manure in addition to nitrogen and other elements contains large amount of organic phosphorus which when mineralized enrich the soil with the available forms of phosphorus which factors efficiently in nodulation of legumes as noted by other researchers (Osodeke, 2002; Amba *et al.*, 2013; Thedchanamoorthy and Gurung, 1999; Lomoro, 2008; Naveenkurma *et al.*, 2015). Therefore the nodules produced by the pot that had 2t/ha poultry manure was significantly higher than the other treatment levels considered in this study. Result also showed that the number of nodules was only higher (110.00) in pot that had 1t/ha urea relative to control (84.67) and subsequently, the number of nodules decreased with increased rate of urea application as lone treatments and the least amount of nodules (54.50) was recorded in pot that had 2t/ha urea. Nodulation in legumes has been known to require initial nitrogen to boost the process, after which continuous addition of mineral nitrogen may adversely affect the nitrogen fixing organisms. High amount of nitrogen application have been reported to reduce the rate of nodulation, but little quantity have been reported to enhance early vegetative crop growth without compromising the process of nodulation (Anteneh, 2015, Amba *et al.*, 2013). Therefore increased application of poultry manure led to corresponding increase on the number of nodules, while urea application rate was inversely proportional to the number of nodules.

Mean Effect of Poultry Manure And Urea Number of Leaves.

As shown in figure 1 below, the application of poultry manure and urea both as single and combined treatments had significant ($P < 0.05$) effect on the number of leaves. Generally, these treatments increased the number of leaves relative to the control experiment and the observed increases were directed proportional to the rate of treatment application. Compared to the lone application of poultry manure, the single application of urea gave higher number of leaves. This observation may be due to the quick release of nitrogen by urea in relation to poultry manure which takes longer time to release its nutrient content (Gunri and Nath, 2012). Nitrogen has been known to improve the vegetative growth of plants, therefore, the quicker its release the more the leave growth (Brady and Weil, 2008). It was also observed that the interaction between the two fertilizer materials had better improvement on the number of leaves compared to the single application of either of the materials. This report is in accord with the report of Naveenkurma *et al.*, (2015). The highest number of leaves (110.00) was obtained in the pot that had 2t/ha poultry manure and 2t/ha urea while the least value (55.00) was obtained in the pot that had only 1t/ha urea. The most impressive report on the number of leaves observed in experimental pots that had different combinations of poultry

manure and urea agreed with the recent emphasis of supplementation of mineral fertilizers with organic manures for better crop performances and sustainable soil fertility maintenance (Adediran *et al.*, 1999; Azu *et al.*, 2017).

Figure 1. Number of Nodules, growth and yield components of Groundnut as affected by the addition of Poultry manure and Urea.



Mean Effect of Poultry Manure and Urea on Number of Pod

Number of pods showed significant ($P < 0.05$) response to the application of poultry manure and urea both as single or combined treatments. Figure 1 showed that the number of pods ranges from 31 to 12. It was observed that the interaction between the two amendments consistently gave higher values of the number of pods compared to either

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application of both materials as lone treatments. It was also observed that the increase in the number of leaves did not necessarily have a corresponded increase in the number of pods. Naveenkurma *et al.*, (2015), also made similar observation. This observation can be explained on the fact that, while nitrogen may be responsible for the leave growth, other nutrient element especially phosphorus which is in abundance in the poultry manure might have factored more in the seed formation (Brady and Weil, 2008). Consequently, the pot that had 2t/ha poultry manure and 1t/ha urea had the highest number of pods. Gunri and Nath (2012) have also reported greater yield of pods of groundnut when poultry manure was applied at different rates with a recommended dose of mineral nitrogen fertilizer. Similarly, Lomoro, (2008) reported significant positive effect of poultry manure combined with mineral fertilizer on the number and weight of groundnut pods. . Previous works on organic and inorganic fertilization effect on the soil have found to buildup of essential plant nutrients (i.e., N, P, K, S, Ca, Mg, Zn, Fe, Mn, and B) in the soil (Dotaniya *et al.* 2016; Ogundare *et al.*, 2012 Rezig *et al.* 2012). This may have led to the substantial increase on the number and weight of groundnut pods observed in this study.

CONCLUSION

In general, organic and inorganic fertilizer applications are relevant to boost the fertility status of soils and effectiveness of *Bradyrhizobium* for nodulation and yield of groundnut in the degraded sandy-loam soils of southeastern Nigeria. While the combined application of poultry manure and urea is needed to increase the productivity of groundnut in the soils of southeastern Nigeria, increased application of urea may be detrimental to the process of nodulation, which may affect nitrogen economy especially residual nitrogen reserves for subsequent crop. In view of this, heavy mineral nitrogen application for groundnut production should be discouraged, rather the addition of 2 tons ha⁻¹ poultry manure with 1ton ha⁻¹ of urea as booster dose should be emphasized in order to not only boost soil fertility and productivity, but also to enhance nodulation processes in groundnut for long lasting fertility effect in terms of nitrogen.

REFERENCES

- Adeiran, J. A., Akande, M. O., Taswo, L. B., and Sobulo, R. A. (1999). Comparative effectiveness of organic based fertilizer with mineral fertilizers on crop yield. In: Management of the soil resources for sustainable agricultural production in the 21st century, proceedings of the 25th conference of the soil science society of Nigeria (SSSN), Benin City. Pp 91-93.
- Adekiya, A.O. and Agbede, T.M. (2016). Effect of methods and time of poultry manure application on soil and leaf nutrient concentration, growth and fruit yield of tomatoes (*Lycopersicon esculentum*). Journal of Saudi Society of Agricultural Science 9(1):45-52
- Amba, A.A., Agbo, E.B. and Garba, A. (2013), Effect of nitrogen and phosphorus fertilizers on nodulation of some selected legumes in Bauchi, Northern Guinea Savannah of Nigeria, International Journal of Biosciences, 3(10):1-7.
- Anteneh Argaw (2017), Organic and inorganic fertilizer application enhances the effect of *Bradyrhizobium* on nodulation and yield of peanut (*Arachis hypogea* L.) in nutrient depleted and sandy soils of Ethiopia. International Journal of Recycling Organic Waste in Agriculture, 6(3):219-231.
- Azu, Donatus E.O., Osodeke, V.E. and Nwanja, O.U. (2017). Effect of algae on phosphorus sorption characteristics of an ultisol of Southeastern Nigeria. Direct Research Journal of Agriculture and Food Science, vol 5(2):88-95.

291 Benton, Jones J.(2001). Laboratory Guide for Conducting Soil Test and Plant Analysis. CRC Press Boca Raton
 292 Washington D.C.

293 Brady N.C and Weil, R.R. (2008). The Nature and properties of soils (12th edn). Prentice Hall Inc. New Jersey.

294 Bray, R.H and Kurtz L.T. (1945). Determination of total organic and available forms of phosphorus in soils. Soil sci.
 295 59:39-45.

296 Brough, S.H. and Azam-Ali, S.N. (1992). The effect of soil moisture on the proximate composition of Bambara
 297 (*Vigna subterranean(L)verdc*) J. Sci. Food Agric., 60:197-203.

298 Carter, M. R. and Greforich, E. G. (2008). Soil Smapling and Methods of Analysis 2nd (ed). *Can. Soc. Soil Sci.*
 299 1224p.

300 Chriatanson, C.B and Vlek, P.L.G(1991). Alleviating soil fertility constraints to food production in west Africa:
 301 Efficiency of N fertilizer applied to food crops. In Mokwunye. U.(Ed), Alleviating soil fertility constraints
 302 to increase crop production in west Africa. Kluwer Academic publishers, Dordrecht, Netherlands, pp. 45-
 303 59.

304 Dotaniya, M.L., Datta, S.C., Biswas, D.R., Dotaniya, C.K., Meena, B.L., Rajendiran, S., Regar, K.L. and Lata, M.
 305 (2016) Use of sugarcane industrial by-products for improving sugarcane productivity and soil health. Int J
 306 Recycl Org Waste Agric 5:185–194

307 Duchaufour, P. (1976). Allas Ecologiqu dos sold du Monde, Paris, pp. 178

308 Eneje, R. C. and Azu E. O. (2009). Algae compost effect on soil nutrient status and aggregate stability. Journal of
 309 Soil Society of Nigeria, 19(2):88-95.

310 Faizah, A.W.(1980). Symbiosis rhizobium leguminensis competitivities. Introduction den le sol de sunches de R.
 311 Melilotic. These Doctarat. Clande-Benard. University Lyon France.

312 FAO (1976) organic materials as fertilizers, soil bulletins, 27 Rome.

313 Frankow-Lindberg, B.E.and Dahlin, A.S. (2013). N₂ fixation, N transfer, and yield in grassland communities
 314 including a deep-rooted legume or non-legume species. *Plant and Soil*, 370, 567–581.

315 Gunri, S.K. Nath, R.(2012). Effect of organic manures, biofertilizers and biopesticides on productivity of summer
 316 groundnut (*Arachis hypogaeae* L.) in red and laterite zone of west Bengal. Indian Council of Agricultural
 317 Research .<http://www.icar.org.in/> .

318 Jemo, M.C., Nolte, C., Tchienkoua, M.I and Abaidoo, R.C. (2010). Biological nitrogen fixation potential by
 319 soyabeans in two low-p soils of southern Cameroon. Nutr. Cycl. Agroecocyst, 88:49-58.

320 Kamprath, E. J. (1967). Soil acidity and response to liming tech: Bull No.4, Int. soil testing series, N. C. State
 321 University.

322 Linnemann, A.R.(1988). Cultivation of Bambara groundnut in Northern Nigeria. Trop. Crops, Comm., 15:1-14.

323 Lomoro, P.M.A.(2008). The response of groundnut (*Arachis hypogaea*) to phosphorus and organic fertilizer under
 324 irrigation. A Thesis submitted to the University of Khartoum in partial fulfilment of the requirement for the
 325 Degree of Master of Science(Agric), 74 pages.

326 Mukurumbira, L.M. (1985). Effects of the rate of fertilizer nitrogen and previous grain legume crop on maize yields.
327 Zimbabwe Agric. J., 83:177-180.

328 Naveenkumar, B.T., Malligawad, L.H., Halikatti, S.I., Hiremath, S.M., Srineevasa, M.N. and Bidari, B.I.(2015).
329 Effect of different ratios and levels of nitrogen and phosphorus fertilizers, and top dressing of nitrogen
330 fertilizers on growth and yield of groundnut. *Karnataka J. Agric. Sci.*, 28(1):8-10.

331 Njoku, J.C., Okpara, D.A. and Asiegbo, J.A. (2006). Growth and yield response of sweet potato to inorganic
332 nitrogen and potassium in a tropical ultisol. *Nig. Agric. J.* 32:30-41.

333 Nyamangara, J. And Nyagumbo, I.(2010). Interactive effects of selected nutrient resources and tied-ridging on plan
334 growth performance in a semi-arid smallholder farming environment in central Zimbabwe. *Nutr. Cycl.*
335 *Agroecosyst*, 88: 103-109.

336 Odendo, M., and Okwosa E. (2004). Potential for adoption of legume green manure on smallholder farms in
337 western Kenya. In: Bation A. (Ed) *Managing nutrient cycles to sustain fertility in sub-saharan Africa*
338 Science Publishers, Nairobi, Kenya, pp. 557-570.

339 Odurukwe, S. O., Aruebunwa, F. A., Iloka, A. W., Udeabor, A. and Ibedu, M. A. (1995). Physical environment of
340 southeast Nigeria. In: *Indigenous fallow and multipurpose tree and shrub species in the farming system,*
341 *southeastern zone of Nigeria. A report of diagnostic survey, NRCRI, Umudike Pubs.*

342

343 Ogundare, K., Agele, S. and Aiyelari, P. (2012) Organic amendment of an ultisol: effects on soil properties, growth,
344 and yield of maize in Southern Guinea savanna zone of Nigeria. *J Recycl Org Waste Agric* 1:11

345 Onwuka, M.I., Osodeke, V.E. and Okolo, N.A.(2007). Amelioration of soil acidity using cocoa husk ash for maize
346 production in Umudike area of southeastern Nigeria. *Tropical and Subtropical Agroecosystem* 7:41-45.
347

348 Osodeke, V.E.(2002). Estimation of nitrogen fixing capacity of soybean (*Glycin max*) in soils of the forest zone of
349 southeastern Nigeria. *J. Appl. Chem Res.* Vol 8.pp 28 – 34.

350 Panda, P.K.; Nandi, A., Swain, P.K., Patnaik, S.K. and Patnaik, M. (2012) Soil amendment on growth, nodulation,
351 yield, soil health, and economics of Cowpea. *Int J Veg Sci* 18:284–297

352 Pansu, M and Gautheyrou, J. (2006). *Handbook of Soil Analysis: Mineralogical Organic and Inorganic Methods.*
353 Springer, p995.

354 Rezig, A.M.R., Elhadi, E.A. and Mubarak, A.R. (2012) Effect of incorporation of some wastes on a wheat–guar
355 rotation system on soil physical and chemical properties. *J Recycl Org Waste Agric* 1:1

356 Shehu, H.E, Kwari, J.D and Sandable, M.K. (2010). Effect of N.P.K by sesame (*Sesamum indicum*). *Int. J. Bool.*
357 12:845-850.

358 Simmone, E. N., Jones, J. B., Mills, A. H., Smittle, A. A. and Hussey, C. G. (1994). Comparison of analytical
359 methods for nitrogen analysis in plant tissues. *Common Soil Science*, 24:1609-1616
360

361 Somasagaran, P., Abaidao, R.C and Kumaga, F. (1992). Host-bradyrhizobium relationship and nitrogen fixation in
362 bambara groundnut (*Vocandziea subterranean* L.). *Trop. Agric.*, 67:137-142.

363 Soremi, A.O., Adetunji, M.T., Adeyuyigbe, C.O., Bodunde, J.G. and Azeez, J.O.(2017). Effect of poultry manure on
364 some soil chemical properties and nutrient bioavailability to soybean.Journal of Agriculture and Ecology
365 Research International, 11(3):1 – 10.

366 Sorensen, J., and A. Sessitisch. (2007). Plant –associated bacteria-Lifestyle and molecular interations.

367 Thedchanamoorthy, K. and Gurung, I (1999).Scope of enhancing nodulation of groundnut through soil amendments
368 by crop residue of wide C:N ratio. AGRIEAST 1(1):56-58.

369 Udo, E.J., Ibia, T.O. ogunwale, J.A., Ano,A.O and Esu, I.E (2009). Manuel of Soil, Plant and Water Analysis. Sibon
370 Books Ltd, Lagos, Nigeria.

371 Waldrip, H., He, and Z. and Erich, S. (2011). Effect of poultry manure amendment on phosphorus uptake by
372 ryegrass, soil phosphorus fractions and phosphatise acidity. Boil. Fertile. Soils. 47:407-418.

373 Walley, F.L., Tomm, G.O; Matus, A.; Slinkard, A.E., and Van Kessel, C. (1996). Allocation and cycling of nitrogen
374 in an alfalfa-bromegrass sward. Agronomy Journal, 88, 834–843.

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376
377
378
379
380
381
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