Asian Journal of Advances in Agricultural Research

3(3): 1-8, 2017; Article no.AJAAR.37677
ISSN: 2456-8864

Effect of Poultry Manure and Urea on Soil Chemical Properties, Nodulation and Yield of Groundnut (*Arachish hypogaeac*) in Akanu Ibiam Federal Polytechnic, Unwana Afikpo Ebonyi State

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJAAR/2017/37677
Editor(s):
(1) Villagomez Cortes Jose Alfredo Santiago, Professor, Faculty of Veterinary Medicine and Animal Science, University of Veracruz, Mexico.
Reviewers:
(1) Miguel Aguilar Cortes, Universidad Autonoma Del Estado De Morelos, Mexico.
(2) Taufiq Ahmad, The University of Agriculture, Pakistan.
(3) Abdullah Taufiq, Indonesian Legumes and Tuber Crop Research Institute, Indonesia.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/22036

Original Research Article

Received 24th October 2017
Accepted 17th November 2017
Published 24th November 2017

ABSTRACT

A Green House study was carried out at the Teaching and Research Farm, Department of Horticulture and Landscape Technology to investigate the influence of the integrated application of poultry manure and urea on soil nutrient properties, nodulation, growth and yield of groundnut (*Arachis hypogeae*) in AkanuIbiam 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 $tons^{-1}$) 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 poultry manure 2 tons ha^{-1} and urea 1 $tonha^{-1}$. 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

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manure and its integration with urea had significant improvement on the number of pods compared with alone application of urea. The maximum improvement on the number of leaves and pod was obtained when poultry manure was applied at 2 tons ha^{-1} integrated with urea at 1 ton ha^{-1}. It was also observed that the number of nodules increased with poultry manure application but decreased with application of urea. Integration of urea with poultry manure is therefore recommended to improve soil fertility and grain yield of groundnut. 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.

Keywords: Poultry manure; urea; nodulation; groundnut.

1. 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. The seeds contain sufficient amount of protein (19%), carbohydrate (63%), fat (6.5%) and essential amino acid (Lineman [1]; Brough and Azam [2]). It is cultivated at altitude ranging from 0-150 m and is generally intercropped with cereals, cassava, yam and cow pea. It fixes atmospheric nitrogen, and hence improves the soil nitrogen that plays its role as a restorative crop (Mukurumbia, [3]). In Nigeria, it is cultivated in the northern regions, characterized by yellow ferratitic soil (Duchaufor, [4]). Since the nitrogen requirement for the other crop (intercropped) is met through nitrogen fixation, therefore the interest has been developed in cultivation of groundnut for its tremendous potentials both as food and in soil fertility maintenance (Somasegaran et al. [5]).

Crop production in Nigeria is hindered by several factors such as low soil fertility as well as restricted access to mineral fertilizer (Nyanabgara and Nyaguambo [6]). In Nigeria, farmers are always faced with the problem of soil fertility decline which has been considered the most important biophysical constraints to crop yield and productivity (Odendo and Okwosa [7]).

Developing soil fertility management options for increasing productivity of stable food crops is a challenge in most part of Nigeria, where soils are constrained by the major mineral element such as potassium, nitrogen and phosphorus deficiencies [8]. Nitrogen, Phosphorus and potassium are among the limiting nutrients for legumes production (Christianson and Viek [9]). Adequate supply of nitrogen is beneficial for carbohydrates and protein metabolism, promoting cell division and cell enlargement (Shehu et al. [10]).

Poultry manure promotes transformation and mineralization of less labile inorganic and organic phosphorus into labile phosphorus in the rhizosphere, which results in higher root phosphorus concentration and higher total phosphorus uptake by plants (Waldrip et al. [11]). Therefore, poultry manure could be a valuable fertilizer and could serve as a suitable alternative to chemical fertilizer in Nigeria (Eneje and Azu, [12]).

Apart from the addition of both mineral and organic nitrogen fertilizers, there is another viable and ecologically friendly strategy for improving nitrogen content of soils. This process which is called biological nitrogen fixation is specifically reserved for leguminous crops (Brady and Weil [13]). A relatively small amount of nitrate or ammonia is produced by lightening, some are produced industrially by the Haber-Bosch process, but the major conversion of Nitrogen (N_2) to ammonia and hence protein is achieved by microorganisms that inhibit the root nodules of legumes in the process of nitrogen fixation (Sorensen and Sesitch, [14]). The process of biological nitrogen fixation in legume nodules is an important soil fertility improvement strategy especially nitrogen economy in many tropical ecosystem (Frankow-Lindberg.and Dahlin, [15]). Walleyn et al. [16] stated that most of the nitrogen eventually returns to the soil when vegetation of legume dies and decomposes and this can be made use of by the upcoming crop.

Even though several literatures have stated that leguminous crops can derive their maximum nitrogen requirement from biological nitrogen fixation and therefore require no external nitrogen fertilizer application, there is still need to 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 (*ArachisHypogea*) in Unwana, South Eastern Nigeria.

2. MATERIALS AND METHODS

The study was carried out at Horticultural Farm of AkanuIbiam 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 et al. [17]). The climatic condition and vegetation types are generally humid tropical rain forest with mean annual rainfall of about 3,500 mm and mean daily temperature of 21°C to 32°C [18].

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

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 to give time for the decomposition of the poultry manure and later thinned down to two seeding per bucket after germination. Adequate watering and weeding were observed throughout the growing period.

2.1 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 [19]; Osodeke, [20]). 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 [21]. The pH was determined in soil to water and soil to $CaCl_2$ at a ratio 1:2 soil water and soil $CaCl_2$ respectively using glass electrode P^H meter [22]. Organic carbon was determined by the wet oxidation method according to Pansu and Gautheyrous [23] and converted to organic matter by multiplying by 1.792. Available P was determined using the Bray II method of Bray and Kurtz [24] as described by [22]. The total nitrogen determination was done by the macro Kjeidahl digestion method [25]. Exchangeable acidity was determined by the nikel extraction procedure as described by Kamprath [26]. Exchangeable basic cations (K^+, Ca^{2+}, Mg^{2+}, Na^+) were determined by the ammonium acetate method (Carter and Gregoich, [27]). 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 [22]. The base saturation was obtained mathematically with

$$\text{BS (\%)} = \frac{\text{total ctions}}{\text{ECEC}} \quad X \quad \frac{100}{1}$$

2.2 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.

3. RESULTS AND DISCUSSION

The physical and chemical properties of the soil used for the study is presented in Table 1. 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 clay loam. These findings are in agreement with the result of Azu et al. [28], who reported a clay – loam soil in Ebonyi State. Soil pH values both in H_2O and $CaCl_2$, showed that the soil was acidic, which suggest the need for liming in order to improve the soil productivity. Several other researchers (Onwuka et al. [29]; Eneje and Azu, [12]) have also reported acidity in most soils of South – Eastern Nigeria. Both organic carbon and organic matter moderately low (1.90 and 3.29% respectively). The total nitrogen was low (0.25%) and phosphorus was found at low concentration (5.62 mg/kg) indicating high fixation and hence low phosphorus availability. The value of phosphorus was lower than the critical value of 15 $mgkg^{-1}$ suggested by Osodeke and Ubah [30]. Calcium was relatively high (3.18 $cmo1kg^{-1}$). The total exchangeable acidity (TEA) was high (4.01 $cmo1.kg^{-1}$) indicating the influence of aluminum and iron oxides (Azu et al.

[28]). The effective cation exchange capacity (ECEC) was moderate (8.27 cmo1/kg) and base saturation (BS) was also relatively moderate (51.51%).

Most studies conducted across South Eastern Nigeria showed that most soils are acidic, low in soil organic carbon, available N, P, K, Na and some micronutrients (Azu et al. [28]; Eneje and Azu [12]). These nutrient deficiencies can affect not only plants but also soil microbes including rhizobia populations (Brady and Weil [13]) and their activities such as N_2 fixation (Osodeke, [20]).

Table 1. Physical and chemical properties of the soil used for the experiment

Properties	values
Sand %	40.13
Silt %	21.56
Clay %	38.31
Texture	clay-loam
pH (H_20)	4.27
pH ($CaCl_2$)	3.78
Organic carbon %	1.90
Organic matter %	3.29
Total Nitrogen %	0.25
Available Phosphorus (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

Table 2. Results of analyzed poultry manure used for the experiment

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

3.1 Effect of Poultry Manure and Urea on Soil Chemical Properties

Result of the effect of poultry manure and urea on soil fertility is shown in Table 3. The application of poultry manure as lone treatments generally increased soil pH both in water and in salt. There were consistent decline in soil pH with increasing 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. 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. [28]). The interaction between the poultry manure and urea showed significant ($P<0.05$) improvement in the soil acidity ([31]; Azu et al. [28]; FAO, [32]) 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^{-1} poultry manure and 1t ha^{-1} urea.

With the exception of ECEC, the lone application of poultry manure was significant ($P<0.05$) in improvement the soil nutrient indices, but the lone application of urea was only significant in influencing the pH, N and the exchangeable bases. However, the interaction between the two treatments was highly significant ($P<0.05$) in influencing the pH, total nitrogen, exchangeable bases and exchangeable acidity.

3.2 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 Fig. 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 increased was proportional to the rate of amendment. These finding are similar to those reported by [33] 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 poultry manure at 2t ha^{-1}. This observation can be attributed to the fact that poultry manure in addition to nitrogen and other elements contains large amount of organic phosphates which mineralized and enrich the soil with the availability of phosphorus which increased nodulation of legumes (Osodeke, [20]; Amba et al. [34]; Thedchanamoorthy and Gurung, [35]; Lomoro, [36]; [37]). Therefore the nodules produced by the plant that had 2 t ha^{-1} poultry manure were significantly higher than the other treatments. Result also showed that the number of nodules was only higher (110.00) in plant that had 1 t ha^{-1} urea compare to control (84.67) and subsequently, the number of nodules decreased with increased rate of urea application (54.50). 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 growth without compromising the process of nodulation (Anteneh, [38]; Amba et al. [34]). Therefore increased application of poultry manure led to corresponding increase in the number of nodules, while urea application rate was inversely proportional to the number of nodules.

3.3 Effect of Poultry Manure and Urea on Number of Leaves

The application of poultry manure and urea both alone and combined treatments had significant (P<0.05) effect on the number of leaves.

Table 3. Effect of poultry manure and urea on soil chemical properties

PM+UR	pH		Aval. P	Org. C	Total N	Exc. bases	Exc. acidity	ECEC	BS
(t/ha)	H_2O	$CaCl_2$	(mg/kg)	(%)	(%)	(Cmol/kg)	(Cmol/kg)	(Cmol/kg)	%
0 + 0	4.13	3.85	4.68	0.89	0.19	4.17	2.97	7.14	58.40
0 + 1	4.00	3.6	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	5.10	1.99	0.39	**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**
L SD(0.05)U	0.126	0.0055	0.192	0.127	0.019	0.0022	NS	NS	NS
LSD(0.05)PM	0.121	0.0203	0.192	0.127	0.019	0.0030	0.00014	NS	2.114
F.LSD(UXPM)	0.237	0.334	0.371	0.260	0.038	0.0065	0.0177	0.135	3.008

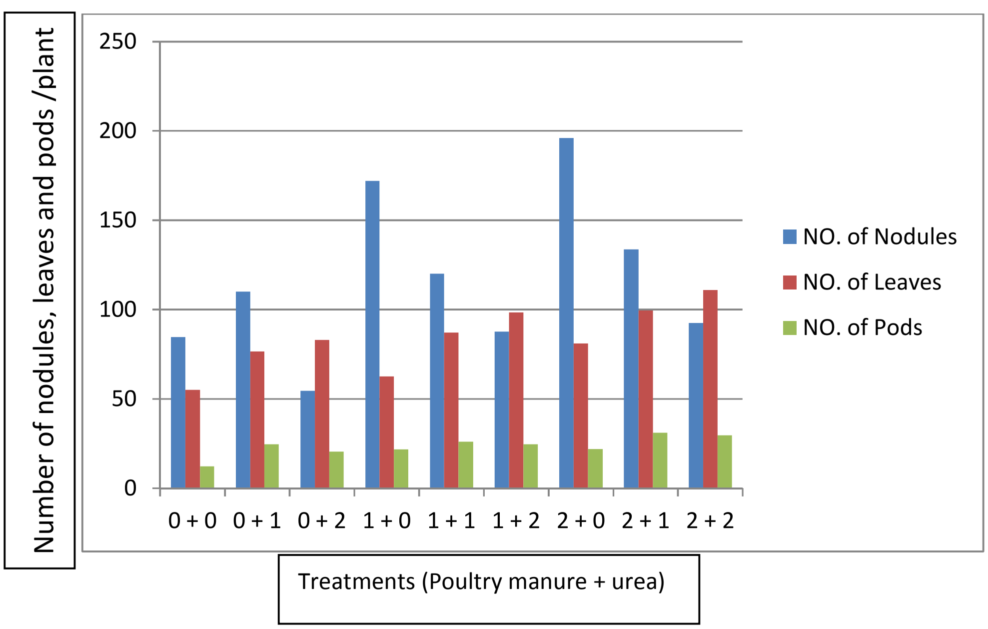

Fig. 1. Number of nodules, growth and yield components of groundnut as affected by the addition of poultry manure and urea

Generally, these treatments increased the number of leaves compare to the control. The application of urea produced maximum number of leaves compare to lone application of poultry manure. 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, [39]). Nitrogen has been known to improve the vegetative growth of plants, therefore, the quicker its release the more the leave growth (Brady and Weil, [13]). It was also observed that the interaction between the two fertilizers had better improvement on the number of leaves compared to the single application. This report is in accord with the report of [37]. The highest number of leaves (110.00) was obtained in the plant that had 2 t ha^{-1} poultry manure and 2 t ha^{-1} urea while the least value (55.00) was obtained in the plant that had only 1t ha^{-1} 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. [28]).

3.4 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. Fig. 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 number of pods compared to either application of both materials as lone treatments [37]. 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, [13]). Consequently, the pot that had 2t ha^{-1} poultry manure and 1t/ha urea had the highest number of pods. Gunri and Nath, [39] have also reported greater yield pods of groundnut when poultry manure was applied at different rates with a recommended dose of mineral nitrogen fertilizer. Similarly, Lomoro, [36] reported significant effect of poultry manure combined with mineral fertilizer on the number and weight of groundnut pods. Previous works on organic and inorganic fertilization 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 ([40]; Ogundare et al. [41]; Rezig et al. [42].

4. CONCLUSION

In general, organic and inorganic fertilizer applications are relevant to boost the fertility status of soils and effectiveness of *Brady rhizobium* for nodulation and yield of groundnut in degraded sandy-loam soils of southeastern Nigeria. 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. Heavy mineral nitrogen application for groundnut production could be harmful, rather the addition of poultry manure 2 tons ha^{-1} with urea at 1 ton ha^{-1} 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.

5. RECOMMENDATION

Based on the findings of this study, the following recommendations are made

i. Urea should be integrated with poultry manure for soil fertility improvement in groundnut production.
ii. Heavy mineral nitrogen fertilization in groundnut production should be discouraged
iii. Application of 2 $tonsha^{-1}$ poultry manure and 1 $tonha^{-1}$ urea should be encouraged to enhance soil fertility and nodulation of groundnut.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://prh.sdiarticle3.com/review-history/22036