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Soil Chemical Properties and Interactive Effect of Livestock Manure and Variety on Growth, Yield, Seed Nutritional and Proximate Compositions of Groundnut (*Arachis hypogaea* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Unavailability and escalating cost of fertilizer coupled with the need to safeguard the environment has called for the use of local nutrient resources for soil fertility management. A pot experiment was carried out to investigate the effect of manure from different livestock dungs on soil chemical properties as well as the interaction effect of variety and manures on growth, yield, as well as seed nutritional and proximate composition of tah-erect and tah-creeping varieties of groundnut (*Arachis hypogaea* L.). Plants were grown in soil amended with poultry dung (PD), cow dung (CD) and goat dung (GD) while the treatment with no dung (ND) served as the control. The experiment was laid out in complete randomized design with 5 single plant replicates per treatment. Results showed that livestock manure generally enhanced the nutrient content of the soil compared to the control. Soil amended with PD contained the highest N, P. K, Ca, Mg and Na followed by CD, and then GD. Organic content was highest under CD followed by GD and least in PD. Heavy metals including Fe, Mn, Cu and Zn were higher under CD than in GD and PD. There was a significant difference ($p<0.05$) in number of leaves, number of branches, shoot length and stem girth among the treatments in both varieties, where PD followed by CD displayed superiority over GD, which was however better than the control. PD led to the highest number of seeds, seed fresh and dry weights

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in both varieties as compared to CD and GD, which were better than the ND where the least values were recorded. Seed N, P, K, Mg and Ca were increased in both varieties by livestock manure applications. Except the carbohydrate content that was unaffected, proximate parameters including protein, fat, crude fibre, percentage ash and moisture content in the seeds of the two varieties were higher in plants grown in manure-treated soil than in the control. Livestock manure enhanced availability of nutrients in soil for increased vegetative growth and seed yield, as well as seed nutritional and proximate values in the two varieties of *Arachis hypogaea*.

Keywords: Manure; soil; groundnut; growth; yield; seed nutrient content.

1. INTRODUCTION

The peanut or groundnut (*Arachis hypogaea*) belongs to the family Fabaceae. After China and India, Nigeria and the United States of America are the third largest producer of groundnut in the world [1]. Peanuts can be eaten raw, used in recipes, made into oils, textile materials, and peanut butter, as well as many other uses. In general, peanut products are considered safe for human use. It is rich in essential nutrients and in a 100 g serving, it provides 570 calories and are an excellent source (defined as more than 20% of the Daily Value, DV) of several B vitamins, vitamin E, several dietary minerals, such as manganese (95% DV), magnesium (52% DV) and phosphorus (48% DV), and dietary fiber. They also contain about 25% protein per 100 g serving, a higher proportion than in many tree nuts [1].

According to Eswaran et al. [2], three quarters of farm land in Africa is severely degraded leading to loss of soil health and soil quality. The per capita arable land is limited due to high population growth rate, and the traditional use of fallow is not a viable method to increase soil nutrient levels. The level of inorganic fertilizer use is very low due to cost, availability, lack of credit and low grain prices resulting from limited market options. Besides, the use of inorganic fertilizers has been discovered to increase soil acidity and soil degradation [3].

The use of organic matter in farming in recent years is gaining impetus due to realization of inherent advantages it confers in sustaining crop production and also maintaining dynamic soil nutrient status and safe environment [4-5]. Organic manure have a profound effect on improving soil physical, chemical and biological properties hence enhancing productivity of field crops.

Organic manure helps to improve the physical condition of the soil and provides the required plant nutrients. It enhances cation exchange capacity and acts as a buffering agent against undesirable soil pH fluctuations [6-7]. Its application has been found to have higher comparative economic advantage over the use of inorganic fertilizer. A previous study showed that application of broiler liter at the rate of 15 t/ha, N at 40 kg/ha, P at 30 kg/ha and K at 30 kg/ha gave higher growth and fruit yield than in control [8]. When sufficient quantity of manure was applied on a continuous basis, it permitted stable intensified crop production. Organic manures help in improving soil structure and soil aeration, and therefore improve the activities of soil organisms [9]. The loss of organic matter in soil which consequently results in its acidity, nutrient imbalance and low crop yields can be restored by using off-farm organic wastes [10].

Interestingly, livestock production including poultry, cattle and goat is rapidly increasing due to increasing demand for eggs, milk, meat and other animal products in West Africa particularly in Nigeria. Unfortunately, large quantity of livestock dung generated are usually being disposed to the environment rather than recycling it for crop production. In view of the above, there is therefore the need to use local organic nutrient resources for soil fertility management and to optimize crop yield to meet the food needs of the growing population. This study aimed at investigating the potential of manures from poultry, cattle and goat dungs to improve growth, yield and seed nutritional and proximate composition of tah erect and creeping varieties of groundnut, which are widely cultivated in South Western Nigeria. Groundnut (*Arachis hypogaea* L.) is an annual plant belonging to the Fabaceae family. Tah erect variety has semi-erect growth habit and is suitable for all growing seasons while Tah creeping has stretching growth habit an.d longer maturity period than tah erect. They are improved varieties with long stalks and are high yielding, early maturing, readily available and commonly grown by local farmers in South-Western Nigeria where the experiment was conducted.

2. MATERIALS AND METHODS

2.1 Experimental Location

The study was conducted at the screen house of Plant Science and Biotechnology Department, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria (7°37 ^{1}N latitude, 5°44 ^{1}E Longitude and 100 m above the mean sea level).

2.2 Planting Materials

Matured seeds of groundnut (*A. hypogaea* L.) were obtained from the National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, Nigeria.

2.3 Experimental Set Up

Top soil was collected from the University experimental farm, air-dried and sieved through to remove stones. It was a loamy soil with physic-chemical properties earlier described by Kekere and Omoniyi [11]. The soil was a loamy soil as described The livestock dungs of poultry (PD), cow (CD) and goat (GD) were collected from the Agricultural Development Programme project site at Akure in Ondo State, Nigeria in February 2015, which were air-dried and allowed to cure for 1 month before application to the soil. The cured dungs were later pounded in a mortar with pestle to increase their surface area for easy application and mineralization. The treatments were incorporated by manually mixing the dungs with the soil. Three viable seeds each of the two varieties of *A. hypogaea*, tah erect (V1) and tah creeping (V2) were sown in perforated polythene bags (30 cm diameter and 33 cm depth) filled with 20 kg of the soil-manure mixture. Each of the animal dungs was applied to the potted soils at the rate of 5 t/ha of the organic manure, which amounted to the rate of 50 g organic manure per pot, similar to method that has being used before [12,13]. Planting of seeds was carried out 24 hours after incorporation of the treatments. Three weeks after planting, seedlings were thinned to one per pot. It was a 2 x 4 factorial experiment with 2 varieties of *Arachis hypogaea*, tah erect (V1) and tah creeping (V2) as the experimental crops with 4 treatment levels; organic manure from dungs of poultry (PD), cow (CD) and goat (GD) were used for the investigation of interaction effects, and those grown in soil without manure served as the control. The combined treatments were V1ND, V1PD, V1CD, V1GD, V2ND, V2PD, V2CD and V2GD. All treatments were replicated five times and laid in a completely randomized design. Growth parameters including shoot length, number of leaves, number of branches and stem girth were measured. The experiment ended in June 2015 (12 weeks after planting) by harvesting the pods with the seeds collected and counted. Their fresh weight was determined after which they were oven-dried at 80℃ for dry weight measurement.

2.4 Seed Analysis

Dried seeds of the two varieties of *Arachis hypogaea* were milled for chemical analyses. Total N was determined by micro–Kjeldahl method [14]. For P, K, Ca and Mg, samples (0.5 g) were ashed, dissolved in 10% HCl and diluted to 50 ml. P was determined using Vanado molybdate colourimetry. Ca and Mg were determined by EDTA titration, while Na and K was by flame photometry. Seeds were also assayed for proximate compositions: crude protein, fat and carbohydrate, crude fiber, total ash and moisture contents following the method of AOAC [15].

2.5 Soil Analysis

Soil samples were collected from the pots after the termination of the experiment for the analysis of chemical properties. The soil samples were air-dried, passed through a 2-mm sieve, and analyzed for the chemical properties. Soil pH was measured in 1:1 soil: water suspension. Nitrogen was determined by the modified Kjeldahl method while phosphorus was assayed by Bray's P1 solution and read on a spectrophotomer. Cations were extracted with 1.0 M ammonium acetate solution at pH 7.0; sodium and potassium contents in the extract were determined by flame photometry while calcium, magnesium, copper, Iron, zinc and manganese were obtained by atomic absorption spectrophotometry. Organic carbon was determined by the wet oxidation method.

2.6 Statistical Analysis

The data obtained were subjected to one-way analysis of variance (ANOVA) and means were separated with Duncan's multiple range tests at 5% level of probability using SPSS 21.0.

3. RESULTS

Analysis of soil at the end of the experiment showed that there was generally an improvement in the nutrient content of the soil amended with livestock manure as compared to the control (Table 1). The manure increased soil pH

significantly over the control. Soil amended with PD contained the highest N, P. K, Ca, Mg and Na, followed by CD, while GD was the least. The organic content was however highest in soil supplemented with CD followed by GD and least in PD. Soil amended with cow dung had higher concentrations of heavy metals including Fe, Mn, Cu and Zn than in those treated with goat dung and poultry dung. The results revealed that there was a significant difference in shoot length, stem girth, number of leaves and branches among the treatments in both varieties (Table 2). Poultry dung followed by cow dung showed superiority over goat dung and control in all the growth parameters, which follow a similar trend. For example, Tah-erect variety grown in soil amended with PD and CD had the highest values of 185.53 and 165.32 number of leaves respectively, which were better than the GD (163.10) but lowest at ND (158.81). Similarly, Tah-creeping had 178.75 and 169.31 leaves at PD and CD respectively, while a lower value of 166.77 leaves was obtained at GD but the least number of leaves of 153.94 was recorded at ND (control). In the case of yield, plants grown in manure-amended soil had better yield than the control (Table 3). Soil treated with poultry dung gave the best yield in both varieties. In tah-erect variety, highest number of seeds, seed fresh weight and dry weight of 51.24, 37.82 and 37.50 respectively were obtained under PD while lower values of 48.21, 35.16 and 31.41 were obtained under cow dung, which were however higher than 26.15, 35.14 and 25.16 in goat dung-treated plants. Meanwhile, plants without amendment with livestock dungs had the least values of 26.71, 26.40 and 20.90 for number of seeds, seed fresh weight and seed dry weight respectively. Similar trend was recorded in tah-creeping variety with the highest number of seeds, seed fresh weight and dry weight of 46.12, 40.20 and 31.61 respectively under PD while lower values of 42.23, 37.56 and 28.58 were recorded at cow dung, which were however higher than 40.15, 32.14 and 25.33 in goat dung-treated plants, but plants without amendment with livestock dungs had the least values of 34.16, 28.58 and 22.08 respectively. The livestock manures significantly enhanced seed nutritional content (Table 4) and proximate composition (Table 5) parameters. Seed N, P, K, Mg and Ca were increased in both varieties of *Arachis hypogaea* grown in soil amended with manures. Although, the seed carbohydrate content was not affected in plants grown in soil amended with livestock manures in comparison with the control, protein, fat, crude fibre and percentage ash content in the seeds were higher in plants grown in manure-treated soils relative to the control.

4. DISCUSSION

Soil amended with animal manure had higher nutrient content than the control. It has earlier been reported that poultry manure (PM), pig manure (PM), cattle manure (CM) and goat manure (GM) were composed of macro-nutrients [16-18]. The increase in soil pH due to the application of animal manure as observed in this experiment confirmed the earlier findings that the contents of base elements (K, Ca and Mg) in animal dung will serve to reduce soil acidity [18]. The highest value for the percentage carbon in soil amended with cow dung confirms the result of Odedina et al. [18] that the cattle manure had the highest values in soil C and organic matter compared to poultry, goat and pig manures. The soil amended with poultry dung having the highest nutrient content in this study agrees with the previous research in which poultry manure had the highest values in % Na, K, Ca, Mg and N compared to goat and pig manures [18]. The presence of higher heavy metals in soil treated with animal manure corroborates the findings of Moyin-Jesu [16-17] that Fe and Cu concentrations were present in poultry manure. Application of animal manure enhanced vegetative growth in the two varieties of *Arachis hypogaea*. Growth increase under the application of animal manure has also been reported on Amaranthus [6]. Plants grown in soil amended with animal manures had higher number of leaves and branches than in the control while those treated with poultry manure gave the best response. Likewise, highest number of leaves and branches per plant and fruit yield in tomato were recorded in plots treated with poultry manure [7]. The increase in number of branches observed in this study concurs with the earlier report made by Dantata et al. [19]. Also, poultry manure recorded the highest values in the height and plantable stake in *Manihot esculenta* than in plants grown with pig, cattle and goat manures similar to what was obtained in this study. Also, poultry manure gave the highest biomass production and yield, and was superior to other treatments including NPK fertilizer in cassava, which was attributable to release of nutrients such as N, P, K, Zn, Fe, Ca and Mg contained in the organic manures and taken up by the plant [18]. Soil amendment with livestock dungs improved seed yield in the two varieties of groundnut studied.

Table 1. Chemical properties of soil amended with different livestock manures after harvesting two varieties of *Arachis hypogaea*

Treatment	pH H2O	pH KCl	OC	Total N	P	Ca	Mg	K	Na	Fe	Mn	Cu	Zn
				g/kg			cmol/kg				mg/kg		
V1ND	5.00^{b}	5.56^{b}	7.90^{c}	1.08^{a}	7.29^{b}	2.26^{a}	0.36^{ab}	0.29^{ab}	0.31^{ab}	93.30^{ab}	68.50^{b}	1.03^{a}	1.11^{ab}
V1CD	6.65^{a}	5.40^{a}	18.24^{a}	1.81^{a}	11.25^{ab}	2.61^{a}	0.60^{a}	0.53^{ab}	0.61^{a}	121.25^{a}	68.80^{b}	1.41^{ab}	1.61^{a}
V1GD	6.60^{a}	5.50^{a}	14.24^{ab}	1.61^{ab}	9.63^{ab}	2.35^{a}	0.40^{a}	0.40^{ab}	0.69^{a}	112.35^{a}	78.25^{b}	1.49^{ab}	1.40^{a}
V1PD	6.60^{a}	5.85^{a}	10.20^{bc}	2.11^{a}	13.73^{a}	2.78^{a}	0.65^{a}	0.88^{a}	0.63^{a}	101.00^{a}	68.85^{b}	1.17^{ab}	1.26^{a}
V2ND	5.75^{b}	5.02^{b}	7.40^{c}	1.03^{a}	6.26^{b}	2.27^{a}	0.38^{ab}	0.23^{ab}	0.43^{ab}	93.60^{ab}	64.55^{b}	1.05^{ab}	1.14^{ab}
V2CD	6.75^{a}	5.50^{a}	18.57^{a}	1.74^{ab}	10.76^{ab}	2.58^{a}	0.62^{a}	0.48^{ab}	0.31^{ab}	123.15^{a}	89.25^{a}	1.28^{ab}	1.54^{a}
V2GD	6.70^{a}	5.70^{a}	13.82^{ab}	1.27^{ab}	9.31^{ab}	2.37^{a}	0.43^{ab}	0.44^{ab}	0.79^{ab}	117.92^{a}	83.95^{a}	1.11^{ab}	1.32^{a}
V2PD	6.75^{a}	5.65^{a}	10.49^{ab}	2.12^{a}	13.36^{a}	2.80^{a}	0.66^{a}	0.98^{a}	0.66^{a}	98.10^{ab}	71.10^{a}	1.08^{a}	1.19^{ab}

Values are mean ± S.E of 5 replicates. Values with the same letter in each column are not significantly different at p < 0.05 (Duncan Multiple Range test). V1= tah erect, V2= tah creeping, ND= no dung, PD = poultry dung, CD = cow dung, GD = goat dung

Likewise, tomato fruit yield increased when treated with livestock dungs [19]. Similar results of increased growth and yield have been reported in tomato [7,9,19,20]. The growth and yield increase in this study can be attributed to the fact that nutrients contained in the livestock manures were available for crop uptake after their mineralization and released to the soil. This shows that poultry manure was readily available and in the best form for easy absorption by the plant roots, hence there was a boost in the morphological growth of the plant leading to increased yield [9]. The obtained results corroborated the finding of [21] in okra production in which they reported that organic manure, especially poultry manure could increase length of crops when compared with other sources of manure. Furthermore, it has been reported that higher yield response of crops due to organic manure application could be attributed to improved physical and biological properties of the soil resulting in better supply of nutrients to the plants [9,10]. The improvement in the seed nutritional values of *Arachis hypogaea* by the livestock manures corroborates the findings that manures from duck, poultry, turkey, cattle, swine and goats increased significantly soil and crop macronutrient content and yield of crops such as coffee, amaranthus, okra, pepper, sorghum and maize [22-30]. Increase in seed nutritional composition in plants treated with animal manures is in line with the report that significant differences were observed in tuber Na, K, Ca, Mg, P, N, Zn and Fe of *Manihot esculenta* [18]. Increase in the moisture content of the seed in soil treated with different animal manure may also be due to their conditioning effect and increases it ability to take up water which after transpiration, some portion are retain in the seeds.

Table 2. Interaction effects of variety and livestock manure on the growth parameters of groundnut (*Arachis hypogaea*)

	Shoot length (cm)	Stem girth (cm)	Number of leaves	Number of branches
V1ND	16.42^{ab}	3.12^{a}	158.81^{b}	12.61^{ab}
V1PD	21.83^{a}	4.11^{a}	185.53^{a}	13.33^{a}
V1CD	19.41^{a}	3.72^{a}	165.32^{ab}	13.91^{a}
V1GD	17.84^{a}	4.63^{a}	163.10^{ab}	14.27^{a}
V2ND	15.91^{ab}	3.01^{ab}	153.94^{b}	12.68^{ab}
V2PD	21.13^{a}	3.98^{a}	178.75^{a}	15.17^{a}
V2CD	18.86^{a}	3.91^{a}	169.31^{a}	14.87^{a}
V2GD	16.80^{a}	3.302^{a}	166.34^{ab}	13.89^{a}

Values are mean ± S.E of 5 replicates. Values with the same letter in each column are not significantly different at p < 0.05 (Duncan Multiple Range test). V1= tah erect, V2= tah creeping, ND= no dung, PD = poultry dung, CD = cow dung, GD = goat dung

Table 3. Interaction effects of variety and organic manure on the yield parameters of *Arachis hypogaea*

Treatment	Number of seeds/ plant	Seed fresh weight/ plant (g)	Seed dry weight/plant (g)
V1ND	26.71^{b}	26.40^{b}	20.90^{b}
V1CD	48.21^{a}	35.15^{a}	25.41^{b}
V1GD	26.15^{b}	25.14^{b}	20.16^{b}
V1PD	51.24^{a}	37.82^{a}	29.50^{a}
V2ND	34.16^{b}	28.58^{b}	22.08^{b}
V2CD	42.23^{a}	37.56^{a}	28.58^{ab}
V2GD	40.15^{a}	32.14^{a}	25.33^{b}
V2PD	46.12^{a}	40.20^{a}	31.61^{a}

Values are mean ± S.E of 3 replicates. Values with the same letter in each column are not significantly different at p < 0.05 (Duncan Multiple Range test). V1= tah erect, V2= tah creeping, ND= no dung, PD = poultry dung, CD = cow dung, GD = goat dung

Table 4. Interaction effects of variety and livestock manure on the nutritional composition of *Arachis hypogaea*

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
V1ND	3.36^{d}	0.23^{c}	1.48^{b}	1.91^{b}	0.73^{b}
V1CD	4.39^{b}	0.40^{b}	2.19^{a}	2.42^{a}	1.64^{a}
V1GD	4.16^{c}	0.39^{b}	2.15^{a}	2.23^{a}	1.56^{a}
V1PD	4.54^{b}	0.75a	2.11^{a}	2.82^{a}	1.95^{d}
V2ND	3.85^{d}	0.13^{c}	1.62^{b}	1.32^{b}	0.79^{b}
V2CD	4.37^{b}	0.52^{b}	2.15^{a}	2.37^{a}	1.66^{a}
V2GD	4.26^{b}	0.44^{b}	2.10^{a}	2.31^{a}	1.55^{a}
V2PD	5.18^{a}	0.78^{a}	2.39^{a}	2.84^{a}	1.87^{a}

Values are mean ± S.E of 3 replicates. Values with the same letter in each column are not significantly different at p < 0.05 (Duncan Multiple Range test). V1= tah erect, V2= tah creeping, ND= no dung, PD = poultry dung, CD = cow dung, GD = goat dung

Table 5. Interaction effects of variety and livestock manure on the seed proximate composition (%) of *Arachis hypogaea*

Treatment	Ash (%)	Fat (%)	Crude protein (%)	Carbohydrate (%)	Moisture (%)	Crude fibre (%)
V1ND	3.22^{a}	35.55^{b}	26.75^{b}	7.51^{a}	4.28^{b}	4.49^{ab}
V1CD	3.31^{a}	43.82^{a}	35.13^{a}	6.62^{a}	6.44^{a}	5.40^{a}
V1GD	3.43^{a}	42.19^{a}	33.54^{a}	8.84^{a}	6.44^{a}	5.46^{a}
V1PD	3.62^{a}	45.68^{a}	33.35^{a}	7.30^{a}	7.29^{a}	5.83^{a}
V2ND	2.31^{ab}	37.19^{b}	25.05^{b}	8.48^{a}	4.02^{b}	4.46^{ab}
V2CD	3.33^{a}	43.78^{a}	35.73^{a}	7.65^{a}	6.30^{a}	5.28^{a}
V2GD	3.39^{a}	42.75^{a}	33.55^{a}	8.49^{a}	6.35^{a}	5.53^{a}
V2PD	3.44^{a}	45.10^{a}	30.73^{a}	7.55^{a}	7.22^{a}	6.03^{a}

Values are mean ± S.E of 3 replicates. Values with the same letter in each column are not significantly different at p < 0.05 (Duncan Multiple Range test). V1= tah erect, V2= tah creeping, ND= no dung, PD = poultry dung, CD = cow dung, GD = goat dung

5. CONCLUSION

Application of livestock manure increased total fruit yields as well as improving fruit quality in the two varieties of groundnut. The cow and poultry dungs were the superior source of manure to obtaining good yield in groundnut. However, soil amendment with 100% poultry dung produced the best response, it is therefore considered as the best for improving the productivity of *Arachis hypogaea* among the various animal dungs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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