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Research Article
Tillage Methods and Poultry Manure Application Effects on the Growth and Yield of Groundnut (*Arachis hypogaea* L.) in Calabar, Nigeria

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Abstract

Background and Objective: Developing suitable tillage practices and sustainable soil fertility options are important components of any soil management programme aimed at the enhancement of the production and productivity of food crops which is a challenge in Nigeria and most countries of Sub Saharan Africa. A field study was therefore; conducted to investigate the effects of traditional tillage methods and poultry manure application on the growth and yield of groundnut (*Arachis hypogaea* L.) in Calabar. **Materials and Methods:** A factorial experiment was conducted at the University of Calabar, Teaching and Research Farm during the 2013 and 2014 cropping seasons. Three tillage methods (ridge, flat tilled and flat untilled) and four rates of poultry manure consisting of (0, 5, 10, 15 t ha^{-1}) were used in the study. The treatment combinations were laid out in a randomized complete block design with three replications. **Results:** Flat tilled soil was comparatively better compared to the other tillage methods with respect to plant height, number of branches, number of leaves, leaf area, leaf area index, days to 50% flowering, length of pod, number of pods, number of seeds per pod, pod and seed yield in tonnes per hectare. Poultry manure at the rate of 15 t ha^{-1} produced superior plant height, number of branches, number of leaves, leaf area index, days to 50% flowering, 100-seed weight, length of pod, number of pods and number of seeds per pod. **Conclusion:** Flat tilled soil amended with PM at 15 t ha^{-1} recorded the best growth and yield of groundnut.

Key words: Tillage methods, poultry manure, groundnut, growth and yield, sustainable soil fertility

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is the third most important leguminous crop due to its high nutritive seed value. It is rich in protein and edible fats in addition to other vital nutrients such as calcium, potassium, phosphorus, magnesium and vitamin E[1].

Manure improves soil tilth, soil humus content, biological activities and physical structure[2], thereby increasing fertility and enhancing plant growth. Growing concerns about high cost and harmful effects of chemical fertilizers on the soil and environment makes organic manure a better and safer alternative[3]. Therefore, Umoetok *et al*.[4] reported that poultry manure (PM) is environmentally friendly, easy to handle with little or no health hazards compared to inorganic fertilizer.

Poultry manure is an important nutrient source for crop production[5-7]. It is a rich but cheap source of most organic nutrients has a low C:N ratio, increases soil organic carbon, total nitrogen, available P, soil porosity as well as enhances soil microbial activities[3,6,8-9]. Nitrogen and phosphorous are among the limiting nutrients for cereal and food legume production[10] but for maximum economic value of plant nutrients derivable from PM application, it should meet crops nutrient requirements[11]. Unlike mineral fertilizer, it adds organic matter to soil which improves soil structure, soil retention and uptake of plant nutrient, aeration, soil moisture holding capacity and water infiltration[6,12]. Application of PM decreases adsorption capacity but increases the solubility of P[13]. Manures not only provide adequate P to growing plants but also increase the soil solution P and available[14] P. Phosphorous is associated with increased root density and proliferation which aid in extensive exploration of the root zone and the supply of nutrients and water to the growing plant, resulting in increased growth and yield[15]. Also, Waldrip *et al*.[16] reported that incorporation of PM into the soil promoted the transformation and mineralization of less labile inorganic and organic phosphorous into labile-phosphorous in the rhizosphere, which resulted in higher root phosphorous concentration and uptake by plants. Adequate supply of nitrogen is beneficial for carbohydrate and protein metabolism, promoting cell division and enlargement[17]. It is also associated with high photosynthetic activities, vigorous growth and dark green pigmentation[18]. Kidinda *et al*.[19] reported that 7 t ha^{-1} of PM which was the highest rate of application resulted in a better yield increase in maize. Uko *et al*.[20] reported that 10 t ha^{-1} PM significantly increased plant height, number of leaves, leaf area, fresh and dry weights of waterleaf (*Talinum fructicosum*). Uwah *et al*.[21] reported that the number of corms and cormels of cocoyam did not differ significantly with PM rates of 10 and 15 t ha^{-1} in 2006 but number of corms and cormels peaked at 15 t ha^{-1} PM in 2007. Ajari *et al*.[22] reported that PM could increase plant height and number of branches of okra plant. Application of 12 t ha^{-1} PM increased seed weight, number of pods per plant, 1000-grain weight, pod yield as well as grain yield in bambara groundnut[23]. Ibrahim *et al*.[3] reported that application of 3 t ha^{-1} PM resulted in significant increase in vegetative characters such as plant height, canopy, number of branches and reduction in days to 50% flowering in groundnut. Mukhtar *et al*.[18] also found that application of 2 t ha^{-1} PM produced the highest number of pods, pod weight, pod yield, haulm yield as well as pod yield. However, an application of 20 t ha^{-1} manure has been recommended by Akanza and Yao-Kouame[24].

Tillage practices are critical components of soil management systems[25], crucial for crop establishment, growth and ultimately yield[26]. Tillage creates an ideal seeding condition for plant emergence, development and unimpeded root growth[27]. It may also influence soil physical, chemical and biological characteristics, which in turn may alter plant growth and yield but changes in soil properties differ among management practices[28]. According to Srivastava *et al*.[29], the objectives of tillage include the development of a desirable soil structure or suitable tilth for seed bed. Lal[30] and Greenland[31] stated that appropriate tillage practices avoid the degradation of soil but maintain crop yields as well as ecosystem stability. Similarly, Ojeniyi and Adekayode[32] observed that manual heaping and ridging which are components of the traditional tillage methods maintained higher values for soil organic carbon, P, K, Ca, Mg and higher cowpea and maize yield compared to conventional tillage. These alternatives to mechanical tillage methods can lead to substantial savings in labour costs, while ensuring sustainable soil use and maintenance. Tillage systems are site specific and depend on crop, soil type and the climate[33]. Rao[34] found conventional tillage superior to no tillage, reduced tillage or mulching with a number of crops-sun hemp (*Crotalaria juncea*), barley (*Hordeum vulgare*), mustard (*Brassica juncea*) and chickpea (*Cicer arietinum*) grown in the dry season. However, Rodiguez and Lal[35] found no positive significant effect of conventional tillage practices on soil properties that can support adequate soil fauna and flora. Memon *et al*.[36] reported that the degree of soil compaction, soil bulk density and soil moisture condition are important factors that influence seedling emergence and crop yield. However, a slight compaction is needed to gain good contact between seed and soil particles, which can be achieved by well-planned tillage practices which provide optimum environment necessary for seed germination and effective plant growth [37]. Vogel *et al.*[38] reported that yield of maize was greater with ridging plots, thereby increasing the economic yield of the crop. According to Musambasi *et al.*[39], maize planted on ridges attained the highest grain yield (519 kg ha^{-1}). Several authors[37,39] emphasize the link between crop residue management and tillage and recognized them as the two practices with major impact on soil conservation especially in the semi-arid zones. Peeyush *et al.*[40] reported that though the greatest maize yield of 1865 kg ha^{-1} was achieved with conventional tillage, it was not significantly higher than that obtained with minimum tillage (1837 kg ha^{-1}). Maurya and Lal[41] stated that no-tillage practices compared to ploughed soil at short term reduced soil compaction and bulk density. It is therefore essential to choose a tillage practice that sustains the soil physical properties for successful growth of agricultural crops[42]. Due to the compelling need to find a suitable but cheap and adoptable tillage and soil fertility management option for sustainable production, this study was undertaken to examine the effects of the traditional tillage methods and poultry manure on the growth and yield of groundnut in Calabar.

MATERIALS AND METHODS

Description of the study area: The study was carried out from June-September in 2013 and 2014 cropping seasons at the Faculty of Agriculture Teaching and Research Farm, University of Calabar. Calabar which is located between latitudes 4.5- 5.2° N and latitudes 5.0 and 8.6° E, has total annual rainfall which varies from 3000-3500 mm. The annual temperature in the area ranged from 21-29°C while annual relative humidity was 70-85%. The soil was sandy loam, strongly acidic in reaction with low nutrient reserve[20] and classified as an Akpan-Idiok *et al.*[43].

Experimental design and treatments: The experimental design used was a 4×3 factorial experiment laid out in a randomized complete block design (RCBD) with three replications. The experiment consisted of a factorial combination with four levels of poultry manure (PM) (0, 5, 10 and 15 t ha^{-1}) and three tillage methods (TM) (ridge, flat tilled, flat untilled). The size of the experimental area measured 13 ×43 m giving 559 m^2 area.

Agronomic practices: Two groundnut seeds per stand were sown at a spacing of 30×20 cm and later thinned to one seedling per stand two weeks after germination, giving a plant population of 166,666 plant stands per hectare. Poultry manure treatments were applied to the plots two weeks before planting. The plots were kept weed-free throughout the period of the experiment.

Physical and chemical properties of soil at the experimental site: Before ploughing, random soil samples were collected from 0-15 cm depth of the soil in the experimental area by the use of soil Auger and mixed together before obtaining a composite soil sample. The soil sample were thoroughly mixed, air-dried and sieved through a 2 mm sieve and taken for physico-chemical analysis in the laboratory using methods outlined by IITA[44].

Poultry manure analysis: The poultry manure used for the experiment was collected from the poultry section of the Teaching and Commercial Farms, University of Calabar. The manure was shade dried, crushed and analyzed for its nutrient contents.

Data collection on growth and yield parameters: Data were collected from the four middle rows of groundnut stands from each plot. The agronomic variables measured were plant height, leaf area index, which was done by measuring the length and maximum breath of randomly chosen functional leaves and multiplying with a factor of 0.821 divided by the plant spacing[45], these data were taken at two weekly intervals. Data were also taken on days to 50% flowering, length of pods (cm), number of pods per plant, number of seeds per pod, threshing (%), 100-seed weight, pod yield and seed yield (t ha^{-1}).

Data analysis: The data collected was subjected to a two-way analysis of variance (ANOVA) for a 4×3 factorial in randomized complete block design (RCBD) and significant treatment means were compared using the Fisher's Least Significant Difference (FLSD) performed at 5% significance level[46] using Microsoft excel.

RESULTS

As Table 1 showed that the soil texture at the experimental site was loamy sand. The pH was low (4.60 and 4.70) and exchange acidity was high (3.04 and 3.20) for 2013 and 2014, respectively. Coupled with low nitrogen (0.08 and 0.09 %), organic carbon (1.35 and 1.37%) and exchangeable bases including, potassium (0.09 and 0.11 Cmol kg^{-1}), calcium (1.30 and 1.25 Cmol kg^{-1}) and magnesium (0.20 and

Table 1: Physico-chemical analysis of soil at experimental site as well as poultry manure (PM) used in the study in 2013 and 2014

	2013		2014	
Soil and PM property	Soil	PM	Soil	PM
pH (H_2O)	4.60	6.20	4.70	6.50
Organic carbon	1.35 (%)	37.65 (%)	1.37 (%)	38.65 (%)
Total N	0.08 (%)	3.15 (%)	0.09 (%)	3.25 (%)
Available P	53.50 (mg kg^{-1})	2.22 (%)	53.50 (mg kg^{-1})	2.18 (%)
Exchangeable K	0.09 (cmol kg^{-1})	3.30 (%)	0.11 (cmol kg^{-1})	4.05 (%)
Exchangeable Ca	1.30 (cmol kg^{-1})	9.96 (%)	1.25 (cmol kg^{-1})	8.93 (%)
Exchangeable Mg	0.20 (cmol kg^{-1})	3.68 (%)	0.22 (cmol kg^{-1})	3.55 (%)
Exchangeable Na	0.018 (cmol kg^{-1})	1.34 (%)	0.016 (cmol kg^{-1})	0.018 (%)
Exchangeable acidity	3.04 (cmol kg^{-1})		3.20 (cmol kg^{-1})	
ECEC	4.71 (cmol kg^{-1})		4.84 (cmol kg^{-1})	
Base saturation (%)	55.00		55.00	
Sand (%)	79.30		77.00	
Silt (%)	7.70		8.00	
Clay (%)	13.00		15.00	
Textural class	Sandy loam		Sandy loam	

Table 2: Effects of tillage methods (TM) and poultry manure (PM) on plant height, leaf area index at 9 weeks after planting (WAP), 50% flowering and pod length of groundnut

	Plant height		Leaf area index		Days to 50% flowering		Length of pods (cm)	
Treatments	2013	2014	2013	2014	2013	2014	2013	2014
Tillage methods (TM)								
Ridges	19.54	24.27	2.97	3.2	26.00	27.13	2.46	2.85
Flat tilled	23.69	29.41	4.16	4.29	26.67	27.65	2.74	5.43
Flat untilled	19.92	20.22	2.95	3.20	25.00	26.00	2.43	2.68
LSD (0.05)	NS	0.060	0.75	0.04	NS	0.25	NS	0.17
Poultry manure (PM) levels (t ha^{-1})								
0	19.22	19.85	2.25	2.41	25.89	26.93	2.39	2.75
5	20.53	21.50	3.30	3.66	27.33	27.82	2.41	2.85
10	22.01	22.35	3.73	3.89	27.11	27.82	2.62	3.10
15	22.43	22.96	4.15	4.29	29.00	28.47	2.75	5.92
LSD (0.05)	1.14	0.080	0.87	0.06	1.360	0.250	0.19	NS
Interactions (TM×PM)								
Ridges×0 t ha^{-1} PM	18.20	17.58	1.90	2.08	26.00	27.13	2.31	2.84
Ridges×5 t ha^{-1} PM	18.20	21.52	2.68	3.53	27.67	28.63	2.43	2.84
Ridges×10 t ha^{-1} PM	20.13	21.28	4.37	2.63	26.00	27.13	2.63	3.00
Ridges×15 t ha^{-1} PM	21.83	21.25	2.95	4.54	27.67	28.63	2.49	2.73
Flat tilled×0 t ha^{-1} PM	22.53	23.11	3.02	3.23	26.67	27.65	2.65	2.84
Flat tilled×5 t ha^{-1} PM	23.20	24.00	4.13	4.16	27.00	27.55	2.54	3.04
Flat tilled×10 t ha^{-1} PM	24.07	24.64	4.42	4.16	26.67	27.65	2.68	3.47
Flat tilled×15 t ha^{-1} PM	24.97	25.33	5.06	4.56	27.00	27.55	3.10	12.38
Flat untilled×0 t ha^{-1} PM	16.93	18.86	1.84	1.92	25.00	26.00	2.23	2.55
Flat untilled×5 t ha^{-1} PM	20.40	18.99	3.10	3.28	27.33	27.29	2.27	2.68
Flat untilled×10 t ha^{-1} PM	20.50	21.14	2.40	4.49	25.00	26.00	2.55	2.84
Flat untilled×15 t ha^{-1} PM	20.50	22.29	4.45	3.13	27.33	27.29	2.65	2.66
LSD (0.05)	NS	0.25	NS	0.17	NS	NS	NS	NS

NS: Not significant

0.22 Cmol kg^{-1}) for 2013 and 2014, respectively. However, available phosphorus was moderate and the soil had medium base saturation.

Effects of tillage methods (TM) on the growth and yield of Bambara groundnut: The data in Table 2 showed that tillage methods did not significantly affect plant height or days to 50% flowering in 2013. From the results, groundnuts planted on flat tilled plot were taller (23.69 cm) but not significantly ($p>0.05$) taller than those on ridged and flat untilled plot with heights of 19.54 and 19.92 cm respectively. However, in 2014, plants sown on flat tilled plots were significantly ($p\leq 0.05$) taller (29.41 cm), when compared to plants grown on ridges and untilled flats, which were 24.27 and 20.22 cm respectively. Also plants on flat tilled plots reached days to 50% flowering later (27.65 days) than plants grown either on ridged (27.13 days) or flat untilled plots (26 days) in 2014. The leaf area index in 2013 and 2014 were significantly higher ($p \leq 0.05$) among plants grown on flat tilled (4.16 and 4.29). Length of pods were not significantly influenced by tillage methods adopted in 2013 but in 2014, groundnut planted on flat tilled plots had pod length of 5.43 cm.

Data inn Table 3 showed that the number of pods in 2013 was statistically at par ($p > 0.05$) among plants sown on flat-tilled (10.96 cm) and ridged plots (10.60 cm) but significantly ($p \leq 0.05$) higher among plants grown on flat untilled plots (6.74 cm). In 2014 however, number of pods was significantly higher ($p \leq 0.05$) in plants on flat-tilled plots (20.39) when compared to ridged plots (11.62) and which in turn produced significantly higher number of pods produced on flat un-tilled plots (7.31). Also in 2013, Pod yield was statistically similar ($p > 0.05$) among flat tilled and ridged plots (2.03 and 1.67 kg ha^{-1}) but significantly higher ($p \leq 0.05$) than pod yield of 1.24 kg ha^{-1} obtained from flat-untilled plots. In 2014 however, flat tilling resulted in significantly higher pod yield of 4.13 kg ha^{-1} ($p \leq 0.05$) than ridged and flat untilled plots (2.20 and 1.45 kg ha^{-1} respectively). Threshing (%) was significantly influenced by tillage in 2014 only. Groundnut sown on ridges had significantly higher threshing (%) (68.04%) compared to the flat-tilled plots (63.90%) which in turn had significantly higher threshing (%) than flat-untilled plots (52.53%), respectively. Table 4 shows that 100-seed weight was not significantly influenced by tillage methods in both years of the study. However, in 2013, 100 seed weights ranged from 31.81, 31.75 and 31.42 g on ridged, flat untilled and flat tilled plots, respectively whereas in 2014, they ranged from 57.51, 33.09 and 32.70 g on flat tilled, flat untilled and ridged plots respectively. Also, seed yield in 2013 was statistically at par ($p > 0.05$) among plants sown on flat-tilled (0.72 t ha^{-1}) and flat–untilled plots (0.71 t ha^{-1}) but significantly ($p \leq 0.05$) higher in plants grown on ridges (0.44 t ha^{-1}). In 2014, seed yield increased significantly ($p \leq 0.05$) in ascending order from flat- tilled (1.35 t ha^{-1}) to ridged (0.75 t ha^{-1}) and flat-untilled plots (0.50 t ha^{-1}).

Effects of poultry manure (PM) on the growth and yield of Bambara groundnut: Data presented in Table 2 showed that in 2013, Bambara groundnut plants fertilized with 15 t ha^{-1} of PM had the tallest plants (22.43 cm) which were not significantly taller than plants fertilized with 10 t ha^{-1} PM (22.01cm). However, both rates of application produced significantly ($p \leq 0.05$) taller plants when compared to those fertilized with 5 t ha^{-1} PM with plant height of 20.53 cm

Table 3: Effects of tillage methods (TM) and poultry manure(PM) on number of pods/plant, number of seeds per pod, pod yield and threshing (%) of groundnut

	Number of pods/plant		Number of seeds/pod		Pod yield (t ha^{-1})		Threshing (%)	
Treatments	2013	2014	2013	2014	2013	2014	2013	2014
Tillage methods (TM)								
Ridges	10.69	11.62	1.85	2.75	1.67	2.20	65.8	68.04
Flat tilled	10.96	20.39	2.15	4.71	2.03	4.13	63.4	63.90
Flat untilled	6.74	7.31	1.75	2.56	1.24	1.45	51.8	52.53
LSD (0.05)	2.96	0.07	0.22	0.04	0.59	0.05	NS	0.450
Poultry manure (PM) levels (t ha^{-1})								
0	8.50	9.27	1.76	2.02	1.17	1.29	55.4	57.81
5	8.91	10.39	1.96	2.85	1.60	2.12	64.4	65.04
10	10.19	10.32	1.92	2.98	1.93	2.30	66.8	67.32
15	10.26	22.43	2.03	5.51	1.90	4.66	54.8	55.79
LSD (0.05)	NS	0.10	NS	0.06	NS	0.06	NS	0.600
Interactions (TM×PM)								
Ridges×0 t ha^{-1} PM	10.90	12.10	1.47	2.14	0.89	1.06	66.8	73.37
Ridges×5 t ha^{-1} PM	9.60	10.88	2.03	2.92	1.98	2.82	69.8	70.24
Ridges×10 t ha^{-1} PM	11.27	11.72	2.07	3.29	2.26	2.91	67.0	67.78
Ridges×15 t ha^{-1} PM	11.00	11.77	1.83	2.66	1.56	2.02	60.1	60.78
Flat tilled×0 t ha^{-1} PM	10.53	10.88	2.37	2.45	1.92	2.04	57.7	58.00
Flat tilled×5 t ha^{-1} PM	10.37	13.06	2.13	2.79	1.91	2.53	63.8	63.99
Flat tilled×10 t ha^{-1} PM	12.10	11.25	1.90	2.84	2.17	2.53	67.1	67.61
Flat tilled×15 t ha^{-1} PM	10.80	46.34	2.30	10.77	2.15	9.41	65.1	65.98
Flat untilled×0 t ha^{-1} PM	4.07	4.83	1.53	1.47	0.67	0.77	41.7	42.06
Flat untilled×5 t ha^{-1} PM	6.77	7.22	1.90	2.86	0.91	1.00	60.1	60.89
Flat untilled×10 t ha^{-1} PM	7.20	7.98	1.80	2.81	1.37	1.47	66.2	66.56
Flat untilled×15 t ha^{-1} PM	8.93	9.19	1.97	3.10	1.99	2.56	39.3	40.60
LSD (0.05)	NS	0.30	NS	0.18	NS	0.18	NS	1.810

NS: Not significant

Table 4: Effects of tillage methods (TM) and poultry manure (PM) on 100 seed weight and seed yield (t ha^{-1})

	100-seed weight (g)		Dry seed yield (t ha^{-1})	
Treatments	2013	2014	2013	2014
Tillage methods (TM)				
Ridges	31.81	32.70	0.44	0.50
Flat tilled	31.42	57.51	0.72	1.35
Flat untilled	31.75	33.09	0.71	0.75
LSD (0.05)	NS	NS	0.20	0.01
Poultry manure (PM) levels (t ha^{-1})				
0	31.52	32.32	0.52	0.58
5	30.94	32.79	0.57	0.62
10	32.04	33.36	0.62	0.66
15	32.12	65.93	0.78	1.61
LSD (0.05)	NS	0.140	NS	0.02
Interactions (TM×PM)				
Ridges×0 t ha^{-1} PM	32.36	32.10	0.23	0.31
Ridges×5 t ha^{-1} PM	31.03	31.97	0.29	0.37
Ridges×10 t ha^{-1} PM	32.73	33.84	0.45	0.49
Ridges×15 t ha^{-1} PM	31.83	32.88	0.77	0.81
Flat tilled×0 t ha^{-1} PM	31.67	32.44	0.77	0.81
Flat tilled×5 t ha^{-1} PM	30.33	33.66	0.71	0.73
Flat tilled×10 t ha^{-1} PM	31.17	32.65	0.72	0.73
Flat tilled×15 t ha^{-1} PM	32.50	131.29	0.70	3.13
Flat untilled×0 t ha^{-1} PM	31.27	32.42	0.56	0.61
Flat untilled×5 t ha^{-1} PM	31.47	32.72	0.71	0.75
Flat untilled×10 t ha^{-1} PM	32.23	33.58	0.70	0.76
Flat untilled×15 t ha^{-1} PM	32.03	33.64	0.87	0.88
LSD (0.05)	NS	NS	NS	0.05

NS: Not significant

Application of 0 t ha^{-1} PM had significantly ($p\leq0.05$) shorter plant (19.22 cm) relative to other rates of application. In 2014, the same trend of response were observed, 15 t ha^{-1} PM did not differ significantly from 10 t ha^{-1} with plant heights 22.96 and 22.35 cm respectively. Both rates of application however, produced significantly ($p\leq0.05$) taller plants when compared to those fertilized with 5 t ha^{-1} PM with plant height of 21.50 cm which in turn differed significantly ($p\leq0.05$) from plants receiving 0 t ha^{-1} PM rates which were averagely 19.85 cm tall. The leaf area index were statistically at par ($p>0.05$) for PM application rates of 15, 10 and 5 t ha^{-1} in 2013 with values of 4.15, 3.73 and 3.30 respectively but these were significantly ($p\leq0.05$) larger than plants treated with 0 t ha^{-1} of PM having a value of 2.25. In 2014, groundnut plants fertilized with 15 t ha^{-1} PM had significantly ($p\leq0.05$) larger leaf area index (4.29) compared to plants that received 10 t ha^{-1} PM (3.89) which in turn had significantly larger leaves (3.66) compared to 0 t ha^{-1} PM with leaf area index of 2.41. The number of days to 50% flowering when 15 t ha^{-1} PM was applied was 29 DAP which was significantly longer when compared to 27.11 and 27.33 DAP for plants fertilized with 10 and 5 t ha^{-1} PM respectively in 2013, though both were statistically at par with respect to 50% flowering. Plants fertilized with 0 t ha^{-1} PM had the least number of days to 50% flowering (25.89 DAP) but not significantly different from those at 5 t ha^{-1} PM application. In 2014, the number of days to 50% flowering was 26.93 DAP which was significantly the least for plants that received zero PM ($p\leq0.05$) when compared to 27.82 DAP each, observed when 5 and 10 t ha^{-1} PM were applied, respectively. A significantly ($p\leq0.05$) longer number of days to 50% flowering was observed when 15 t ha^{-1} PM was applied. Length of pods 2.75 and 2.62 cm obtained with 15 and 10 t ha^{-1} PM application were statistically similar and significantly longer ($p\leq0.05$) than pod length for the 0 and 5 t ha^{-1} PM treated plants (2.39 and 2.41) respectively. In 2014 however, PM had non-significant ($p>0.05$) effects on pod length.

Table 3 shows that the effects of PM on the number of pods per plant, number of seeds per pod, threshing (%)and pod yield (t ha^{-1}) were not significant in 2013. However, in 2014, PM at 15 t ha^{-1} resulted in significantly ($p\leq0.05$) higher number of pods per plant (22.43) and number of seeds per pod (5.51) compared to 5 and 10 t ha^{-1} (2.85 and 2.95) which were statistically but significantly higher ($p\leq0.05$) than the control (2.02). During the same period, pod yield increased significantly ($p\leq0.05$) with each increment in PM rates up to 15 t ha^{-1} (1.29, 2.12, 2.30 and 4.06 for 0, 5, 10 and 15 t ha^{-1} PM, respectively). The threshing (%) at 10 t ha^{-1} PM

(67.32 %) was significantly ($p\leq0.05$) higher than at all other PM rates applied. Data from Table 4 shows that one hundred seed weights were 30.92, 31.52, 32.04 and 32.12 g in plots fertilized with 5, 0, 10 and 15 t ha^{-1} PM respectively, whereas dry seed yield were 0.52, 0.57, 0.62 and 0.78 t ha^{-1} in plots fertilized with 0, 5, 10 and 15 t ha^{-1} PM respectively but these were not significantly influenced ($p>0.05$) by PM in 2013. In 2014 however, PM at 15 t ha^{-1} produced a 100-seed weight of 65.93 g which was significantly higher than that at all other PM application rates. Also the seed yield followed similar trend of increment, PM at 15 t ha^{-1} produced a dry seed yield of 1.61 t ha^{-1} which was significantly ($p\leq0.05$) higher when compared to that obtained for other rates of PM application.

Interaction effects of poultry manure and tillage methods: Data from Table 2 shows that consistently, 15 t ha^{-1} PM rate on flat-tilled plots resulted in tallest plants (25.33 cm) having the highest LAI (4.56) which were significantly higher when compared to all other treatment combinations in 2014 only. Also Table 3 shows that in 2014, interactions of PM at 15 t ha^{-1} x flat-tilled resulted in significantly ($p\leq0.05$) highest number of pods per plant, number of seeds per pod and pod yield compared to other treatment combinations. Plants fertilized with 0 t ha^{-1} PM on ridged plots had a threshing (%) of 73.37% which was significantly higher ($p\leq0.05$) than other treatment combinations followed by 5 t ha^{-1} PM on ridged plots (70.24%), 10 t ha^{-1} PM on ridged plots (67.78 %) and 10 t ha^{-1} PM on flat tilled plot (67.10 % while 15 t ha^{-1} PM on flat untilled plot had significantly the least threshing percentage (40.60%). Table 4 shows that 15 t ha^{-1} PM applied on flat-tilled plots produced significantly ($p\leq0.05$) higher seed yields (3.13 t ha^{-1}) compared to other treatment interactions. Non-significant interactions were observed in 2013 for all the growth and yield parameters considered in this study.

DISCUSSION

The texture of the soil at the study site was loamy sand which is known to be fragile in nature and susceptible to leaching and erosion by surface run-off water. This corroborates the observation of Anikwe[47], who worked on soil with similar textural characteristics. Also, the low exchangeable bases and organic carbon content of the soil coupled with low soil pH typifies the soil of the study site which are indicators of low soil fertility. Soils with these attributes need effective soil management through an adequate tillage method and application of PM capable of supplying appreciable quantities of nutrient elements and organic matter. Tillage had only slight effects on most of the vegetative attributes of groundnut. The most outstanding effects were observed on leaf area index of which the flat tilled soil tended to produce wider leaves that covered wider areas around the plant. The effect of methods of tillage on length of pods, number of pods per plant, number of seeds per pod, pod and seed yield were more profound and the flat tilled soil enhanced these yield and yield attributes more than the ridged and flat untilled soils respectively indicating that some degree of tillage is essential for groundnut, especially for effective peg penetration and pod yield enhancement. Peeyush *et al.*[40] reported that though maize yield was higher with conventional tillage, it was not significantly higher than that obtained with minimum tillage. However, Vogel *et al.*[38] and Musambasi *et al.*[39] obtained greater yield increases when crops were planted on ridges which represent conventional tillage. Ojeniyi and Adekayode[32] also observed that manual heaping and ridging which are components of the traditional tillage methods maintained higher values for soil organic carbon, P, K, Ca, Mg and higher cowpea and maize yield compared to conventional tillage. Flat tilling and ridging make the soil softer and facilitate easy penetration of pegs into the soil as well as allow for better conservation of soil moisture, which ultimately was used more efficiently by the crop for longer periods as compared with no till[47]. This also may be due to the absence of crusting and preservation of the macropore system[48] in the flat-tilled and ridged plots. The increase in plant height, number of leaves and number of branches with increasing rates of PM application could be attributed to increased availability of nitrogen and other nutrients released by PM throughout the experiment. Increasing rates of poultry manure led to significant improvement in leaf area and leaf area index. This in turn allowed for greater light interception which is of great benefit for photosynthesis and the yield of groundnut. Similar observation was made by Dwyer and Stewart[49]. Dauda *et al.*[50] also reported that photosynthetic capacity of crops is a function of leaf area index whereas[51] observed that the number of leaves produced by a plant as well as its leaf area and leaf area index, are directly proportional to the photosynthates produced. Poultry manure contains essential nutrient elements associated with high photosynthetic activities and thus promotes root and vegetative growth[11,22,52-54]. It also improves soil moisture retention, soil structure and aeration in addition to increased availability of nitrogen. Nitrogen is known to enhance physiological activities in crops thereby improving the synthesis of photo-assimilates[55]. Applications of poultry manure increased soil pH[56] thus enhancing the release and availability of plant nutrients to the crops[54].

Poultry manure application also resulted in increase in number of pods per plant and seed yield. Higher number of pods and seed yield as a result of PM application can directly be attributed to the cumulative increase in the plant vegetative growth including increase in the number of leaves, plant height and branches as a result of balanced nutrition supplied to the plants by PM. This could lead to effective photosynthesis and distribution of the carbohydrates that resulted in the higher number of fruits[57]. Higher number of fruits has also been attributed to large plant canopy size and higher number of fruiting branches due to nutrient application which provided more space for flowering and subsequent higher number of fruits[28]. Higher numbers of fruits as a result of nutrient application have been reported in garden eggs[58], chili pepper[28]. Dauda *et al.*[50] also reported that increased fruit set and number of fruits was associated with nitrogen application due to vigorous foliar growth and increased meristematic and physiological activities in the plant resulting in production of more assimilate used in formation of pods. Application of PM might have also resulted in higher microbial activity in the soil and elevated organic matter production resulting in increased availability of nutrients such as N, P and K which enhanced the yield of crop[59,60]. Also at 15 t ha^{-1}, PM was more significant in enhancing the growth and yield attributes of groundnut although application of 12 t ha^{-1} poultry manure was found to increase seed weight, number of pods per plant, 1000 grain weight, pod yield as well as grain yield in bambara groundnut[23]. Ogbonna[55] observed an increase in the fruit yield of eggplant with increased rates of poultry manure up to 15 t ha^{-1} whereas Uko *et al.*[20] had significant increase in growth and yield of waterleaf (*Talinum fructicosum* L.) Juss.) with the application of 10 t ha^{-1} PM. Poultry droppings applied at 15 t ha^{-1} enhanced yield of peanuts especially when planted on flat tilled soil.

This study is advantageous to the extent that the resource poor farmers can sustainably produce groundnut with poultry manure, an environmentally friendly soil nutrient source and without excessive disturbance to the soil especially taking into consideration the fragile nature of the soil and its susceptibility to erosion. The groundnut farmers in this area can avail themselves of the abundant poultry manure as an alternative to the scarce and expensive mineral fertilizer as well as adopt flat tillage option as vital components in sustainable soil management for profitable groundnut production in a low input agriculture. This is also a management strategy for clean disposal of poultry droppings which otherwise constitutes an environmental nuisance. However, the major limitation of the study was drudgery associated with manual land preparation.

CONCLUSION

Flat tilled soil was found to provide a favourable soil environment for groundnut production than ridged and flat untilled soil. Poultry manure application at 15 t ha^{-1} was found to be superior to other levels of application. There was also an evidence of a significant increase in groundnut yield due to the combination of flat tilled and 15 t ha^{-1} of poultry manure.

SIGNIFICANCE STATEMENT

The flat tilled soil as a tillage option coupled with the application of poultry manure is an affordable and adoptable package to the resource poor small holder farmers involved in groundnut production. The farmer can profitably and sustainably produce groundnut without chemical fertilizer and conventional tillage methods which apart from being expensive may harm the environment. Planting on flat tilled soil and the application of 15 t ha^{-1} poultry manure, is therefore recommended for groundnut farmers in the study area.

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