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Research Report **Open Access**

Effect of Integrated Use of Soil Conditioner with Fertilizers on Growth, Chlorophyll Content and Yield of Groundnut (*Arachis hypogea* L.)

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Abstract A field experiment was conducted to investigate the interaction effect of soil conditioner with organic and inorganic fertilizers on groundnut (*Arachis hypogaea* L.) production at the experimental farm of Plant Science and Biotechnology Department, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria. Treatments include: T_0 (no soil amendment), T_1 (100% inorganic NPK fertilizer), T_2 (100% organic NPK fertilizer), T_3 (100% organic soil conditioner), T_4 (50% inorganic NPK + 50% organic soil conditioner) and T_5 (50% organic NPK + 50% organic soil conditioner). T_1-T_5 did not affect stem girth, leaf area and root length. T_1 and T_2 significantly increased ($p < 0.05$) stem length, number of leaves and branches. T_4 and T_5 had the best growth, which differed significantly from T_0-T_3. Root number and nodules increased significantly in amended soils. T_1 and T_2 increased relative growth rate and root/shoot ratio non-significantly, but T_4 and T_5 increased them significantly. Leaf total chlorophyll and root mass was not affected by T_1-T_5, while leaf mass significantly increased. Stem mass and total biomass increased significantly under T_1 and T_2, while T_4 and T_5 further increased them remarkably above T_0-T_3. T_1 and T_2 significantly improved pods/plant, pod yield, number of seeds/plant and seed yield, while T_4 and T_5 further enhanced yield. T_1-T_5 significantly increased 100-seed mass while shelling percentage increase was significant only in T_4 and T_5. Growth and yield generally increased in T_3 but non-significant level. Sole application of soil conditioner, organic or inorganic fertilizers though increased yield, none could provide soil conditions and nutrients for groundnut production, while combination of soil conditioner with organic or inorganic fertilizer can greatly increase yield of groundnut for sustainable production.
Keywords Soil amendment; Fertilizers; Soil conditioner; *Arachis hypogaea*; Growth

1 Introduction

Groundnut (*Arachis hypogaea* L.) is the 13th most important food crop of the world, the world's 4th most important source of edible oil and 3rd most important source of vegetable protein (FAO, 2004). Its seeds contain high quality edible oil (50%), easily digestible protein (25%) and carbohydrate (20%). It has a total production of 36.1 million metric tons worldwide at an average productivity of 1.4 metric tons/ha. Globally, 50% of groundnut produced is used for oil extraction, 37% for confectionery use and 12% for seed purpose. Its haulms (vegetative plant part) also provide excellent hay for feeding livestock (FAO, 2004). It is grown in an area of about 26 million hectares in more than 100 countries around the world under different agro-climatic conditions, and Nigeria is one of the major producing countries. Unfortunately, its area and production have reduced greatly, fluctuating between 6.0~8.5 m ha and 6.0~9.5 million tonnes respectively, largely caused by loss of soil fertility (FAO, 2004).

Farmers have long recognized the need to enhance soil fertility through the use of fertilizers. High cost, scarcity and late distribution of inorganic fertilizer coupled with the need for organically produced foods has directed the attention of farmers towards organic sources (Gudugi, 2013). It is therefore necessary to source for available, cheap and environmental friendly materials that can be used solely or integrated for crop production. Organic manures may increase soil fertility and bring about improved crop production potential. This is possibly by changes in soils physical and chemical properties, including nutrient bioavailability, soil structure, moisture retention, cation exchange capacity, soil pH, microbial community and activity, bulk density and aeration

(Lobo et al., 2012). In addition, organic fertilizers generally have greater residual effect on subsequent crops than inorganic nutrient sources due to slow release of their nutrients over time (Omotayo and Chukwuka, 2009; Ogunwale et al., 2002a). Organic fertilization is also important for providing plant with their nutritional requirements without having an undesirable impact on the environment. Addition of organic fertilizers increases plant growth characteristics in plants (Ogunwale et al., 2002b; Suge et al., 2011). It has been shown that increase in tomato yield produced by organic-mineral compounds was greater than those produced by mineral fertilizer applied at the same rate (Solaimam and Rabbani, 2006; Tonfack et al., 2009).

The term soil amendments include the use of fertilizers and soil conditioners in enhancing nutrient and properties of soils, for improved crop production (Lobo et al., 2012). Thus, improvement of soil properties by using soil conditioners is also important for sustainable productivity in agriculture (BCMAFF, 2004). Materials which supply certain essential nutrients to plants for improved productivity are considered to be fertilizers, while those that make the soil more suitable for growth of plants are considered to be soil conditioners (Ezzat et al., 2011). They argued that organic materials that have a carbon/nitrogen ratio greater than 30% should be considered as soil conditioners. In their research, they reported positive influence of a soil conditioner (hydrogel) on growth, yield, quality, nutrient uptake and storability of potato (*Solanum tuberosum*). According to them, fertilizer and soil conditioners must be spread evenly over the soil, and it is effective when incorporated into the crop root zone. Mohammed et al. (2009) observed that soil conditioners had beneficial effect on organic manures or bio-fertilizers by increasing the productivity of sandy soils. They reported an increase in bio-available micronutrients (i.e. Fe, Mn, Zn and Cu) and soil cation exchange capacity, thereby enhancing the release of nutrients to plants.

The use of soil conditioners in improving crop productivity is largely not being practiced and unpopular among farmers in Sub-Saharan Africa, despite the growing knowledge on its use in many parts of the world. Soil conditioners, whether natural (organic) or synthetic, can improve the soil structure through stabilizing the aggregates (Tsado et al., 2011). They can also have a positive effect on soil moisture retention, infiltration and workability. Water absorbent soil conditioners such as hydrogels have shown their efficiency on water use and nutrients uptake by crops in media for plant growth (Ezzat et al., 2007; Tsado et al., 2011). Scientists are therefore faced with the challenge to provide recommendations on the use and effectiveness of new and non-traditional products, since many of such products have not been scientifically evaluated. Studies considering the interaction effect of soil conditioner with organic and inorganic fertilizers in an attempt to increasing the production of important crop like groundnut are largely unavailable in scientific literatures. Considering the above facts therefore, this research aimed at comparatively assessing the influence of sole applications of organic and inorganic fertilizers and soil conditioners on growth and yield of *Arachis hypogaea*, as well as to study the interaction between the soil conditioner and the fertilizers on the performance of the plant. This was carried out in the field so that best advice could be given to groundnut farmers on the best approach to increasing its productivity. The research is aimed at improving groundnut production through the integrated use of soil conditioners with organic and inorganic fertilizers.

2 Materials and Method

2.1 Plant materials

Seeds of Arachis hypogaea were obtained from the Input Supply Unit of Ondo State Agricultural Development Programme (ADP) Office, at Akure.

2.2 Fertilizers and soil conditioner

Liquid organic NPK fertilizer (Ag-zyme), inorganic NPK fertilizer (Sidalco) and organic soil conditioner (Ag-zyme), were obtained from the Input Supply Unit of Ondo State Agricultural Development Programme (ADP) office, at Akure. The solutions were prepared following the manufacturers' instructions, by dissolving 500, 60 and 250 mL of organic fertilizer, inorganic fertilizer and soil conditioner respectively in

50 litres of water.

2.3 Experimental set up

The study was conducted at the experimental farm of Plant Science and Biotechnology Department, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria (7°37’N latitude, 5°44’E Longitude and 100 m above the mean sea level). The field was tilled manually, and seedlings were raised following recommended agronomic practices. Plants were grown in rows, spaced at 45 cm with inter-row spacing of 45 cm. Soil amendment treatments commenced at twenty days after seedling emergence, which include: T_0 (no soil amendment), T_1 (100% inorganic NPK fertilizer), T_2 (100% organic NPK fertilizer), T_3 (100% organic soil conditioner), T_4 (50% inorganic NPK + 50% organic soil conditioner) and T_5 (50% organic NPK + 50% organic soil conditioner). The experiment was arranged in a randomized complete block design (RCBD) with 5 replications per treatment. Treatments were applied in liquid form and irrigations were done at the root zone with 250 mL of the water. Each plant received 250 mL of the solution once/week till the end of the experiment (12 weeks after treatment initiation). The experiment was carried out from January-April 2014, thus the plants received some inputs from natural rainfall besides those provided by the treatments. Growth and yield parameters were as measured at the end of the experiment.

2.4 Growth determination

Shoot length was measured with a steel meter rule from soil level to terminal bud. Leaf area was measured with leaf area meter (LI-COR 300 model) while stem girth was measured using digital vernier caliper (model 0~200 mm). The leaves and primary branches on individual plants were counted manually. At maturity, soil was soaked with water and plants were carefully uprooted to prevent root damage. Samples were washed to measure root length, and count roots and root nodules.

2.5 Total chlorophyll content determination

Leaf total chlorophyll was extracted with 80% acetone following the method of Arnon (1945) and calculated with the formula: $(20.2 \times D_{645} + 8.02 \times D_{663}) \times (50/1000) \times (100/5) \times ½$, where D = absorbance.

2.6 Determination of biomass accumulation

At harvest, plants were separated into leaves, stems and roots. Fresh and dry mass of plant parts were weighed and total biomass was determined. Root/shoot ratio was calculated with the formula: (root mass/shoot mass) while the relative growth rate (RGR) was calculated with: [ln mass2-ln mass1]/ time (days), where mass1 was the biomass at the initiation of treatments, mass2 was the biomass at the end of the experiment, while time was the number of days the treatments lasted.

2.7 Yield measurement

Fresh pods were harvested and counted, sun-dried and weighed at harvest. Number of seeds/plant were counted, seed yield and 100 seed mass were recorded.

2.8 Soil analysis

Soil samples were taken from the experimental farm, shade-dried, passed through a 2-mm sieve, and analyzed for the physico-chemical parameters. Particle distribution of the soil was obtained using the rapid method, while 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 and magnesium were obtained by atomic absorption spectrophotometry. Organic carbon was determined by the wet oxidation method while cation exchange capacity (CEC) was by ammonium distillation method particle distribution using the rapid method 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 and magnesium were obtained by atomic absorption spectrophotometry. Organic carbon was determined by the wet oxidation method while cation exchange capacity (CEC) was by ammonium distillation method, following the standard method of the Association of Official Analytical Chemists

(AOAC, 1985) at the Central Laboratory of National Institute for Oil Palm Research (NIFOR), Nigeria.

2.9 Statistical analysis

Data were subjected to single factor ANOVA and means were separated with Tukey Honest Significant Difference (HSD) test using SPSS version 17.0 software (SPSS Inc., Chicago, IL, USA) at 95% level of significance.

3 Results

The soil had 5.60 pH, 6.19% clay, 4.29% silt, 89.7% sand, 2.89% C, 0.14% N, 9.02 mg/100 g P, 6.24 mg/100g Ca, 1.84 mg/100 g Mg, 0.34 mg/100 g Na, 0.23 mg/100 K, 0.20 mg/100 g H and 8.86 mg/100g CEC. No significant differences ($P > 0.05$) between soil amendment treatments and control were found on stem girth, leaf area and root length (Table 1). Plants subjected to soil amendments had higher values for other growth parameters than in control. Stem length, number of leaves and number of branches in plants amended with soil conditioner (T_3) were higher than in control (T_0), but at a non-significant level ($P > 0.05$). Plants under T_1 and T_2 did not differ ($P > 0.05$) from each other, but had significantly higher values for stem length, number of leaves and number of branches than the control. Both organic and inorganic fertilizers in combination with soil conditioner showed the highest growth (Table 1). T_4 and T_5 did not differ ($P > 0.05$) from each other, but were significantly ($P < 0.05$) higher than in other soil amendment treatments. Root number and root nodules differed significantly ($P < 0.05$) from control in plants grown in amended soils (Table 1). Sole application of inorganic and organic fertilizers increased the relative growth rate and root/shoot ratio of Arachis hypogaea over the control but at a non-significant ($P > 0.05$) level (Figure 1). Inorganic and organic fertilizers in combination with soil conditioner however increased both parameters significantly ($P < 0.05$) above those planted in soils that were not amended (T_0).

Table 1 Growth parameters of *Arachis hypogaea* grown in soil amended with organic and inorganic NPK fertilizers, and organic soil conditioner

Growth parameters	Treatment					
	T_0	T_1	T_2	T_3	T_4	T_5
Stem length (cm)	14.40^c	22.50^b	20.40^b	17.80^{bc}	28.90^a	26.40^a
Number of leaves/plant	94.20^c	128.20^b	122.40^b	100.40^c	148.80^a	143.60^a
Number of branches	7.80^c	13.20^b	11.60^b	8.80^{bc}	16.80^a	17.20^a
Leaf area (cm^2)	6.41^a	6.94^a	6.65^a	6.17^a	6.32^a	6.47^a
Stem girth (cm)	1.41^{ab}	1.51^a	1.53^a	1.52^a	1.53^a	1.48^a
Root length (cm)	52.30^a	53.40^a	51.40^a	47.30^a	54.80^a	52.00^a
Root number	17.20^b	26.20^a	28.80^a	22.60^a	27.60^a	28.80^a
Number of root nodules	92.10^b	110.31^a	124.10^a	103^a	123.23^a	128.71^a

Notes: Each value is a mean of 5 replicates. For each parameter, means with the same letter(s) in superscript on the same row are not significantly different at $P > 0.05$ (Tukey HSD test). T_0 = no soil amendment, T_1 = 100% inorganic NPK fertilizer, T_2 = 100% organic NPK fertilizer, T_3 = 100% organic soil conditioner, T_4 = 50% inorganic NPK + 50% organic soil conditioner, T_5 = 50% organic NPK + 50% organic soil conditioner

Leaf total chlorophyll was not affected by soil amendments (Figure 2). Leaf, stem and root mass were greater under amended soils than in control, and the highest values were obtained at inorganic + soil conditioner (T_4) and organic + soil conditioner (T_5) (Table 2). Among the dry matter variables, only root mass did not show a significant ($P > 0.05$) increase between the soil amendment treatments and control. Leaf mass was significantly higher ($P < 0.05$) in T_1, T_2, T_4 and T_5 but did not differ significantly ($P > 0.05$) in T_3, compared to the control. However, stem mass and total biomass in T_1 and T_2 were significantly higher ($P < 0.05$) while T_3 was not significantly different ($P > 0.05$) in comparison to the control. Addition of soil conditioner to inorganic fertilizer (T_4) and organic fertilizer (T_5) further produced values of stem mass and total biomass that were considerably higher than in other soil amendment treatments (Table 2).

Table 2 Dry mass of plant parts and total biomass of *Arachis hypogaea* grown in soil amended with organic and inorganic NPK fertilizers, and organic soil conditioner

Dry mass parameter	Treatment					
	T_0	T_1	T_2	T_3	T_4	T_5
leaf mass (g)	5.82[b]	8.83[a]	8.44[a]	6.26[ab]	9.89[a]	10.12[a]
Stem mass (g)	9.12[c]	13.54	15.31[b]	10.76[bc]	21.89[a]	23.94[a]
Root mass (g)	1.36[ab]	2.34[a]	2.99[a]	2.55[a]	2.33[a]	2.21[a]
Total biomass (g)	16.74[c]	26.37[b]	24.75[b]	17.70[c]	34.76[a]	37.09[a]

Notes: Each value is a mean of 5 replicates. For each parameter, means with the same letter(s) in superscript on the same row are not significantly different at $P > 0.05$ (Tukey HSD test). T_0 = no soil amendment, T_1 = 100% inorganic NPK fertilizer, T_2 = 100% organic NPK fertilizer, T_3 = 100% organic soil conditioner, T_4 = 50% inorganic NPK + 50% organic soil conditioner, T_5 = 50% organic NPK + 50% organic soil conditioner

Table 3 Yield parameters of *Arachis hypogaea* grown in soil amended with organic and inorganic NPK fertilizers, and organic soil conditioner

Yield parameters	Treatment					
	T_0	T_1	T_2	T_3	T_4	T_5
Number of pods/plant	9.27[c]	15.00[b]	16.00[b]	11.00[bc]	23.40[a]	24.20[a]
Pod yield/plant (g)	14.45[c]	27.02[b]	25.42[b]	15.76[c]	38.02[a]	40.08[a]
Number of seeds/plant	22.14[c]	32.45[b]	34.93[b]	25.69[c]	40.86[a]	41.37[a]
Seed yield/plant (g)	6.68[c]	9.86[ab]	10.31[ab]	6.89[c]	12.19[a]	12.27[a]
100-seed mass (g)	30.80[b]	36.00[a]	35.18[a]	33.98[a]	36.40[a]	37.95[a]
Shelling percentage	53.73[b]	63.48[ab]	59.52[ab]	56.40[b]	68.47[a]	69.38[a]

Notes: Each value is a mean of 5 replicates. For each parameter, means with the same letter(s) in superscript on the same row are not significantly different at $P > 0.05$ (Tukey HSD test). T_0 = no soil amendment, T_1 = 100% inorganic NPK fertilizer, T_2 = 100% organic NPK fertilizer, T_3 = 100% organic soil conditioner, T_4 = 50% inorganic NPK + 50% organic soil conditioner, T_5 = 50% organic NPK + 50% organic soil conditioner

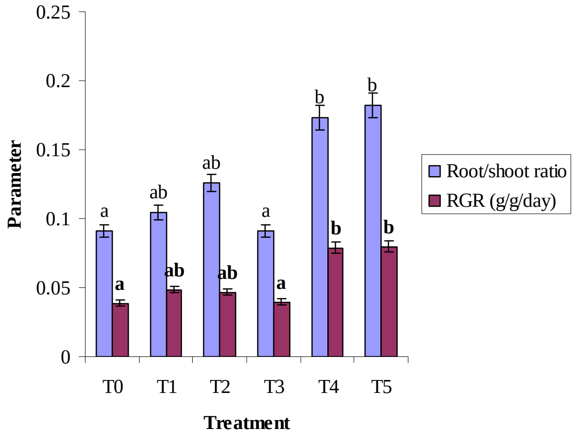

Figure 1 Relative growth rate (RGR) and root/shoot ratio of *Arachis hypogaea* grown in soil amended with organic and inorganic NPK fertilizers, and organic soil conditioner

Notes: T_0 = no soil amendment, T_1 = 100% inorganic NPK fertilizer, T_2 = 100% organic NPK fertilizer, T_3 = 100% organic soil conditioner, T_4 = 50% inorganic NPK + 50% organic soil conditioner, T_5 = 50% organic NPK + 50% organic soil conditioner

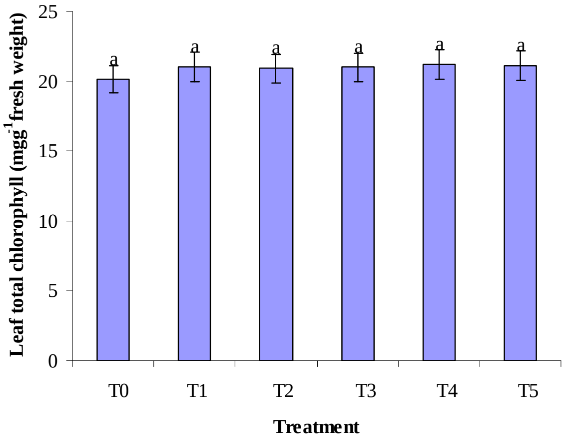

Figure 2 Leaf total chlorophyll of Arachis hypogaea grown in soil amended with organic and inorganic NPK fertilizers, and organic soil conditioner

Notes: T_0 = no soil amendment, T_1 = 100% inorganic NPK fertilizer, T_2 = 100% organic NPK fertilizer, T_3 = 100% organic soil conditioner, T_4 = 50% inorganic NPK + 50% organic soil conditioner, T_5 = 50% organic NPK + 50% organic soil conditioner

Soil amendment solely with inorganic fertilizer (T_1) and organic fertilizers (T_2) significantly ($P < 0.05$) improved yield of Arachis hypogaea over the control considering number of pods/plant, pod yield, number of seeds/plant and seed yield (Table 3). Yield under only soil conditioner (T_3) was higher though, it did not differ ($P > 0.05$) from those grown in soil irrigated with ordinary water (T_0). Addition of soil conditioner to inorganic fertilizer (T_4) and organic fertilizer (T_5) further enhanced yield, which differed significantly ($P < 0.05$) from those amended solely with inorganic (T_1) and organic (T_2) fertilizers. For example, T_1 and T_2 increased number of seeds/plant by 46.57 and 57.77% respectively over the control, but it increased to 84.55 and 86.86% in T_4 and T_5 respectively. Likewise, seed yield/plant increased in T_1 and T_2 by 47.60% and 54.34% respectively, however increased to 82.49 and 83.68% at T_4 and T_5 respectively. The use of soil conditioner alone only increased number of seeds and seed yield by 16.03% and 13.14% respectively, with values that did not differ significantly ($P > 0.05$) from control treatment. The values of 100-seed mass were significantly ($P < 0.05$) higher in plants subjected to soil amendments than did those irrigated with ordinary water. No differences ($P > 0.05$) were however found among the various soil amendments. Shelling percentage increased under soil amendment treatments over the control but one-way ANOVA revealed that only T_4 and T_5 differed significantly ($P < 0.05$) when compared to the control (Table 3).

4 Discussion

Growth and yield improvement in plants grown in soil amended with organic and inorganic fertilizers might be due to nutrient availability, particularly nitrogen, phosphorus and potassium ions according to Maman and Mason (2013) who stated that addition of organic and inorganic fertilizers into soil improves crop yield by making more nutrient available to plants. Suge et al. (2011) showed that organic and inorganic fertilizers improved the vigorous vegetative growth, which in turn led to increased total yields as well as improved fruit quality of eggplant (*Solanum melongena*). Likewise, Maman and Mason (2013) reported improved growth and yield in millet under organic and inorganic fertilizers. Organic inputs also increased growth and yield of carrot (Mehedi et al., 2012). Increase in growth and yield under inorganic fertilizer in this study conforms to earlier research of Makinde et al. (2011). They reported that NPK fertilizer increased the number of nodes, branches, stem girth, plant height, stem girth, number of leaves and leaf area in *Corchorus olitorus*. Similarly, NPK fertilizer produced better growth and yield in *Dioscorea rotundata* (Law-Ogbomo and Remison, 2007), maize (Law-Ogbomo and Law-Ogbomo, 2009) and eggplant, *Solanum melongena* (Nafiu et al., 2011).

Leaf total chlorophyll was not negatively affected probably due to adequate nutrient supply to the plant by the fertilizers. The slight increase in leaf total chlorophyll might be as a result of additional supply of nutrients like magnesium and iron, which are important in chlorophyll formation. The improved biomass was due to enhanced vegetative growth as influenced by fertilizers. Leaf is the site of photosynthetic activities, therefore increases in number brought about increase in leaf surface area available for photosynthesis. The increase in photosynthetic activities resulted in the high biomass observed in the plant. Increased root/shoot ratio is an indication that soil amendments improved root production.

Plants grown in amended soils had better yield in *A. hypogaea*, in agreement with Mutengi et al. (2011) results. They observed increase in yield of maize of 4.8 t/ha and 4.2 t/ha from the sole application of calliadra (green manure). Lekasi et al. (2008) stated that the use of manure can improve crop yield considerably. Gudugi (2013) reported that organic fertilizer at 20 t/ha had higher fruit weight than control in *Abelmuschus esculentus*. Adediran and Banjoko (2003) also observed that inorganic fertilizers increased maize yield. Allam et al. (2009) stated that the proper use of fertilizer can markedly increase the yield and improve the quality of rice.

Soil conditioners, whether natural (organic) or synthetic, can improve the soil structure through stabilizing the aggregates, and can also have a positive effect on moisture retention, fertility, infiltration and workability of soil (Ben-Hur and Keren, 2006; Lobo et al., 2012). Soil conditioners, hydrogel and bovine manure, resulted in higher concentrations of N, P and K uptake by green pepper (*Capsicum annuum*), which was attributed to the increased water use efficiency when soil conditioners were applied. The soil conditioner used solely produced better growth and yield of *A. hypogaea* than the control. When used solely, the inorganic fertilizer had better yield than the organic, but the reverse was the case when used in addition to soil conditioner. Organic inputs do no only provide nutrients but also add to the most important constituent of the soil humus, which provides excellent substrate for plant growth. This could be attributed to the fact that the nutrients in the organic fertilizer were released gradually through the process of mineralization (Smith et al., 1993; Mehedi et al., 2012), maintaining optimal soil levels over prolonged periods of time. Some of the organic substances released during the mineralization may act as chelates that help in the absorption of essential ions and other micro-nutrients (Lobo et al., 2012). Soil conditioners in combination with fertilizers were exceptionally productive probably due to additive effect of fertilizers in *Zea mays* (Tsado et al., 2011). As a result of an improved soil conditions, the roots grew better, more nodules were produced for increased microbial activities, which resulted in improved vegetative growth. Organic materials could have formed complex (or chelate), preventing the precipitation of phosphate, reduced the P-sorption capacity of the soil, enhanced P availability, improved P-recovery or resulted in better utilization by plants (Lobo et al., 2012). Organic materials add carbon into the soil, provides substrate for microbial growth, and subsequent microbial activity. The turnover resulting from the decomposition of organic materials improves C and N mineralization rates, and enzyme activities, which affect nutrient cycling and availability to the plants (Smith et al., 1993).

The most favorable treatment combination of soil conditioner and fertilizers may be due to increased uptake of N and P which resulted in increased number of leaves and branches as well as biomass. Addition of soil conditioner in soil was reported to improve soil physical and chemical properties, which encouraged better root development, increased nutrient uptake and water holding capacity, leading to higher fruit yield and better fruit quality (Tsado et al., 2011; Lobo et al., 2012). Many studies have demonstrated that use of organics could enhance efficiency of chemical fertilizer (Dudal et al., 1995; Suge et al., 2011; Tsado et al., 2011; Lobo et al., 2012). Also, Vanlauwe et al. (2002) reported that combination of organic and inorganic nutrient sources result into synergy and improved conservation and synchronization of nutrient release and crop demand, leading to increased fertilizer efficiency and higher yields. The higher yield from soil conditioner in addition to fertilizers than sole applications is an indication that integrated use of soil conditioner and fertilizers is advantageous over the use or inorganic or inorganic fertilizers alone. Integration of organic input with inorganic and organic fertilizers could therefore be considered as a better option in increasing fertilizer use efficiency and provision of a more balanced supply of nutrients.

5 Conclusion

The study shows that inorganic fertilizer, organic fertilizer and soil conditioner have roles to play in soil fertility management but none can solely supply all the nutrients and soil conditions for groundnut growth and high productivity. Combination of soil conditioner with inorganic and organic fertilizers further improved growth and greatly increased yield in this study. This was due to adequate supply of essential nutrients as nutrient supplying capacity of the soil increased by favorable effect of the organic conditioner on soil physical and biological properties. Therefore, application of soil conditioner in combination with organic and inorganic fertilizers can be used as nutrient sources to meet the soil conditions and nutrient requirements for sustainable groundnut production.

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