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Research Article

Influence of Different Rates of Sewage Sludge on Soil Phyisco Chemical Properties, Growth and Yield of Bambara Groundnut (*Vigna Subterranean*) In an Ultisol, Agbani, Enugu, South Eastern Nigeria

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ABSTRACT

The study was conducted in 2015 planting season at teaching and research farm, Enugu State University of Science and Technology, Enugu State Nigeria; the study investigated the effects of different rates of sewage sludge (0, 2, 4, 6 and 8 t/ha) on soil physicochemical properties, growth and yield of Bambara groundnut (Vigna subterranean) in a degraded Ultisol, Agbani, Enugu, South Eastern Nigeria. The treatments were laid out in randomized complete block design with replications. Physicochemical properties of soil, SOM, N, CEC, and available P) were analyzed using standard analytical laboratory methods. The obtained results from the laboratory revealed that application of sewage sludge altered a positive change on soil physicochemical properties in all amended plots than the control plots. The soils from plots treated with 8t/ha of sewage sludge had the highest pH value of 6.9 while the least was found in soil from untreated plots with pH value of 6.1. The Om value was highest in soils from plots treated with 8t/ha of sewage sludge with 5.18% while the least was found in soil from untreated plots with 0.97%. Total Nitrogen was found highest in the soils from plots treated with 8t/ha of sewage sludge with a value of 2.27% while the least was found in soil from untreated plots with value of 0.12%. The CEC value was found highest in soils from plots treated with 8t/ha of the sewage sludge with a value of 11.68 $Cmol+Kg^{-1}$ while the least was found in soils from untreated plots with value of 2.244$Cmol+Kg^{-1}$. The available phosphorus value was highest in soils from plots treated with 8t/ha of sewage sludge with 25.94 Mg/Kg while the least was found in soils from untreated plots with 15.36 mg/kg. Application of sewage sludge improved the growth characteristics and the yield of Bambara groundnut. The highest plant height at 30, 60 and 90 DAP was found on plots treated with 8/ha of sewage sludge with a value of 11.95(cm), 14.86(cm) and 20.45(cm) while the least plant height at 30, 60 and 90 DAP was found on untreated plots with a value 183.79, 339.79 and 680.04. The highest LAI at 30, 60 and 90 DAP was found on plots treated with 8t/ha of sewage sludge with a value of 2.67, 3 and 5.69 while the least plant height at 30, 60 and 90 DAP was found on untreated plots with a value of 1.03, 1.21 and 4.37. The highest plant yield at 140 DAP was found in plots treated with 8t/ha of sewage sludge with a value of 20.62t/ha. Hence, sewage sludge application on soil has been effective in improving soil physicochemical properties, growth and yield of Bambara groundnut. Thus, 8t/ha of sewage sludge is recommended as it has proven to be more effective in altering a positive change on soil physicochemical properties and fertility conditions.

Keywords: Sewage Sludge; Physicochemical Properties; Growth; Yield; Degraded Ultisol; Vigna subterranean

INTRODUCTION

Sewage sludge is an insoluble residue from municipal waste water treatment either after aerobic or anaerobic digestion processes. It is a rich source of plant nutrient usually rich in organic matter [1]. Sewage sludge is a light solid material of sewage waste containing considerable amounts of N, P, K and organic matter as well as micronutrients needed by the soil for plant growth and this has a potential value as a substitute for commercial mineral fertilizer [2]; sewage sludge has a high organic matter content which constitutes 50% of the solid fraction improving the physical and chemical characteristics of the soil as it has high potential of supplying elements such as Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg) along with other elements to the soil [3]. It also contains, available nutrients (Zinc, Iron, Manganese and Sodium) and humic substances (Boron, Lead, Cadmium, Copper and Barium) [4]. Sewage sludge also reduces the leaching of the basic cations due to the increase in macro

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and micro nutrient status of the soil enabling the release of plant essential nutrients in readily available forms [5]. Sewage sludge improves the soil physicochemical and biological properties for it enhances coagulation of soil particles to ensure productivity due to high content of organic matter improving porosity, bulk density, water movement and nutrient retention, microbial activity and aggregate stability [6,7]. Several research findings have shown the effectiveness of sewage sludge as a fertilizer. Harrison et al, (2003) reported that nitrogen, phosphorus and potassium released from sewage sludge into the soil increase the yield of some crops like maize (Zea mays) [8]. Mahdavi and Jafari, (2010) stated that sewage sludge has been successfully been used as fertilizer in the production of high yields and high quality product in both arid and humid environments. Many studies have shown that sewage sludge enhances stable aggregates, improve soil aeration, and permeability.

Bambara groundnut (Vigna Subterranean) belongs to the family of fabaceae and from the genera vigna. Bambara is a pulse crop of immense potential in enhancing food security especially in drought prime agricultural system (Omoikhoje 2008) [9]. This crop ensures soil improvement because of N-fixation as the nodules association with appropriate rhizobia fixes Nitrogen into the soil. The plant growth is 90-50 days for pod maturity. The crop thrives in a soil pH 6.0-6.5 with temperature range of 19-30°C. The crop does well in a light loam soil and the special feature of the crop is that the fruit being as a fertilizer flower above ground but seeds and pods mature in the ground.

Objective of the study

The objective of the research work is to examine the effects of different rates of sewage sludge (0, 2, 4, 6, 8t/ha) on soil physicochemical properties growth and yield of Bambara groundnut (Vigna Subterranean) in a degraded utilsol, Agbani, Enugu, South-Eastern, Nigeria.

MATERIALS AND METHODS

Experimental site

The research was conducted during 2015 cropping season at the Teaching and Research Farm of the Faculty of Agricultural and Natural Resources Management, Enugu State University of Science and Technology. The farm lies between latitude 6°52'N and longitude 7°15'E of the equator of mean elevation 450m above sea level with estimated annual rainfall of about 1700mm – 2060mm; the rainfall patter is bio-model between March and October while the day season is between November and February. The soil is typical paleustult.

Materials and sources

The sewage sludge was obtained from junior staff quarter University of Nigeria Nsukka, Enugu State. The Bambara groundnut (Vigna subterranean) seed that was used as a test crop for the experiment was obtained from Ogbete main market in Enugu.

Field method design

The site was slashed and cleared of grasses with a cutlass; a total area of land (15m x 15m) = 225m^2 was mapped out for the experiment. The field was further divided into 25 experimental sub-plots measuring 2.25m x 1.8m (4.05m^2), each with 0.5m x 1m alley respectively. Tape, meter-rule and pegs as well as twine were used to ensure accurate measurement was ascertained during the map out, the land was tilled using tillage implement such as spade and hoe to ensure easy infiltration and the seeds was sown manually at the spacing of 75cm x 30cm at the depth of 3cm giving a plant population of 450 stands/225m^2.

Experimental design

The experiment was laid out in a Randomized Completely Block Design (RCB). The treatment was applied basally and work in with a spade prior to planting at the rates of (0, 2, 4, 6 and 8ha^{-1}) with five replication and the treatment used was sewage sludge.

SOIL AND LABORATORY ANALYSIS

Soil analysis

Soil samples were collected from different points in the study site to produce an initial composite sampling. At 140 DAP, soil samples were collected from four different points in each plots (with the aid of an auger), the samples were analyzed in the laboratory for the determination of soil physicochemical properties. The determinants were particle size distribution. Soil pH, SOC, SOM, Total N, Soil Exchangeable Bases and Acidity, CEC, Base Sat and Available Phosphorus (Figure 1).

Laboratory analysis

Total Nitrogen was determined using the method of Macro-Kjeldahl (Bremmer, 1996) [10].

Available phosphorus was determined using Bray II Method as outlined by Olsen, (1982) [11].

Cation exchange capacity was by the method of Anderson and Ingram, (1998a) [12].

Soil organic carbon and matter was determined using the acid dichromate as outlined by Anderson [2].

Agronomic measurement

The data collection were on plant height, number of leaves/plant, leaf area index/plan which were collected on 30, 60 and 90 DAP and yield (t/ha) which was collected at 140 DAP as six plants were selected from each plot to determine the average measurement.

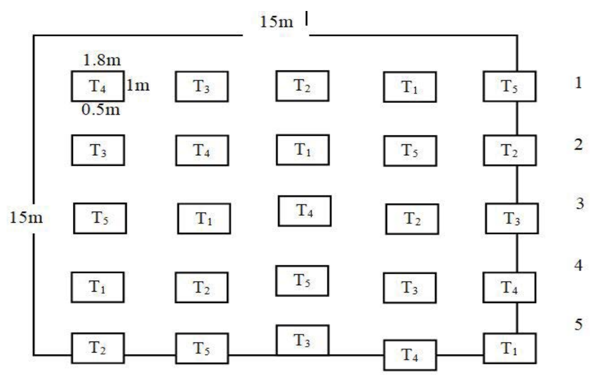

Figure 1: Experimental Field Layout.

KEY

Treatment

T1 – 0 t/ha of sewage sludge (control)

T2 – 2 t/ha of sewage sludge

T3 – 4 t/ha of sewage sludge

T4 – 6 t/ha of sewage sludge

T5 – 8 t/ha of sewage sludge

Plant height was obtained using a meter rule by measuring from the base to the tip of six plants in each plot.

Number of leaves was determined by counting the leaves of identified six plants in each plot.

Leaf area index was calculated mathematically:

LAI = N x L x W/PS

Cultural practices

The field carefully tilled with a spade and hoe after clearing of grasses with a cutlass as stumps were removed with rakes, pre-emergence herbicide was sprayed after collection of samples from the area to avoid contamination of samples and the seed beds were raised to height of 50cm to prevent erosion occurrence during the peak of rainfall leading to the washed out of seedlings. The leaf hoppers and red-head caterpillar was the pests that almost inflicted severe damage to the test crop. Dakash and Mi-force was sprayed at four days interval to control the pest attack. The field was monitored to ensure crop performance was ascertained as the experiment to ensure crop productivity was certain.

Statistical analysis

The data collected from the experiment were analyzed using analysis of variance (ANOVA) for Randomized Completely Block (RCB) design and the detection and separation of treatment means for significant effect was analyzed using Fisher's Least Significant Difference at p = 0.05 as outlined by Obi (2000) (Table 1).

RESULTS AND DISCUSSION

The results in table 2 show that the soil texture class in sandy loam (SL). The percentage clay is 9%, silt 9%, fine sand 46% and coarse sand is 36%. The soil pH before treatment application was 6.0 and general pH interpretation in relative to the level of acidity is according to the rating by USDA-SCS, (1974) show that the soil pH of the study site is slightly acidic. Result of the analysis in Table 2 however show that the organic carbon and matter content of the soil was 0.282% and 4.86% respectively before the treatment application. This is designed as very low. The total Nitrogen was 0.042% before treatment application to the study site. Result shows in Table 1 that soils exchangeable Mg^{2+} of the soil was 1.60 Cmo^{l} + Kg^{1} while the soil CEC was 4.80 Cmo^{l} + Kg^{1} before treatment application to the study site. Analysis indicates that the base saturation of the soil was 59.17% and the available phosphorus content was 16.79$mgkg^{1}$ before application of sewage sludge to the study site (Table 2).

Particle size analysis

After treatment application; results showed in table 3 that the soil texture classes was sandy loam (SL) in all experimental plots but differences in particle size distribution was observed. The plots tread with 4 t/ha of sewage sludge showed a particle size distribution as follows: 11% clay, 10% silt, 40% fine sand and 39% coarse sand. The plots treated with 4 t/ha of sewage sludge showed a particle size distribution as follows: 12% clay, 11% silt, 37% fine sand and 40% coarse sand. The plots treated with 8 t/ha of sewage sludge showed the following particle size distribution: 12% clay, 11% silt, 38% fine sand and 39% coarse sand. The untreated plots remained unchanged in particle size distribution. This slight influence on sand fraction with respect to sewage sludge application could be attributed to the continuous supply of Ca^{2+} and organic matter from sewage sludge to the oil which enhances flocculation of particles and also improves soil aeration and aggregate with effect to microbial activity mixing the soil. According to Ubuoh *et al* (2012) sewage sludge improves particle size (pore space) thereby reducing compaction which resists infiltration and root growth [13]. This consisted with the finding of Snyman *et al.* (2003) that sewage sludge application enhances coagulation of soil particles due to high content of organic matter in relation to microbial activity improving soil efficiency for good productivity [6] (Table 3).

Table 1: Analysis of Variance (ANOVA).

Source of variation	Degree of freedom (general)	Degree of freedom (specific)
Block	(r – 1)	5 – 1 = 4
Treatment	(t – 1)	5 – 1 = 4
Error	(r – 1) (t – 1)	(5 – 1) (5 – 1) = 4 x 4 = 16
Total	(rt – 1)	5 x 5 – 1 = 24

Table 2: Physicochemical Properties of the Soil before Application of Sewage Sludge.

Soil Parameters	Units	Values
Soil texture class	SL	Sandy loam
Clay	%	9
Silt	%	9
Fine sand	%	46
Coarse sand	%	36
pH	H_2o	6
pH	KCI	5
Organic matter	Cmol + Kg-l	0.486
Organic carbon	Cmol + Kg-l	0.282
Nitrogen	%	0.042
Na+	Cmol + Kg-1	0.09
K+	Cmol + Kg-1	0.15
Ca2+	Cmol + Kg-1	1
Mg2+	Cmol + Kg-1	1.6
CEC	Cmol + Kg-1	4.8
Base Saturation	%	59.17
Al3+	Cmol + Kg-1	-
H+	Cmol + Kg-1	1.6
Available Phosphorus	Mgkg-1	6.79

Soil pH

After treatment application; results showed in Table 3 that soil pH increased differently depending on the rate of treatment application. The untreated plots had a slight increase in pH value to 6.1, the plots treated with 2 t/ha sewage sludge had a pH decrease to 5.9 and the plots treated with 6 t/ha of sewage sludge had a pH rise to 6.3 while the plots treated with 6 t/ha of sewage sludge had a pH rise to 6.7. The plots treated with 8 t/ha of sewage sludge had pH rise to 6.9. The respective increase in pH of the study site may be attributed to the high content of lime in sewage sludge neutralizing soil acidity caused by H^{+}. According to Angin *et al.*, (2012) sewage sludge due to its high lime content of soil at all application rates thereby increasing soil pH as at all application is neutralize [14]. This decrease in pH of plots treated with 2 t/ha of sewage sludge may be because of organic acids produced during sewage sludge decomposition which must have accumulation

Table 3: Physicochemical properties of the soil after application of sewage sludge.

Sample	Text	Particle size				pH value		OM%		N	CEC					Base Sat.	Average p
Description	Class	%								Cmol + Kg^{-1}							
Levels of sewage sludge		Clay	Silt	Fine sand	Coarse sand	H_2O	KCL	OC	OM	%	Na^+	K^+	Ca^{2+}	Mg^2	Cmol + Kg^{-1}	%	Mg...
0 t/ha	SL	9	9	46	36	6.1	4.8	0.56	0.97	0.12	0.12	0.28	0.78	0.46	2.44	67.21	15.3
2 t/ha	SL	11	10	40	39	5.9	4.8	1.54	2.65	1.02	0.16	1.04	1.84	1.86	5.91	82.89	18
4 t/ha	SL	12	10	38	40	6.3	5.2	2.06	3.55	1.63	0.19	1.67	2.55	2.3	7.72	86.91	20.2
6 t/ha	SL	12	11	37	40	6.7	5.4	2.43	4.19	2.06	0.21	2.18	3.2	2.83	9.63	87.44	23
8 t/ha	SL	12	11	38	39	6.9	5.2	3.01	5.18	2.27	0.24	2.73	3.85	3.26	11.68	86.25	25.9
$F\text{-}LSD_{.05}$																	

thereby decreasing pH value of the experimental plots. According to Angin *et al.,* (2012) sewage sludge application has a significant effect on soil pH at some rate of application which may be due to accumulation of organic acids generated during the process of organic matter decomposition in sewage sludge [14]. This however shows that the significant treatment effect may be because sewage sludge has acid neutralizing potential as it contains lime. The pH of soils treated with 8 t/ha of sewage sludge significantly increased because with increasing sewage sludge rate, more lime is added to the soil for surface amelioration of oil acidity. Also, the rise of PH of untreated soils may be attributed to the presence of microbial activity enhancing amelioration sub-surface acid through their castings which subsequently mix soils increasing pH [14].

Soil organic carbon and organic matter

After treatment application to the experimental plots they were increased in organic carbon and matter content of the soil. Results in Table 3 showed that the organic carbon and matter content of soil were highly influenced by sewage sludge 8 t/ha with an increment from 0.282% and 0.486% respectively to 3.01% and 5.18% which is seen as the highest increase. The plots treated with 6 t/ha of sewage sludge increased the organic carbon and matter content to 2.43% and 4.19% respectively. The plots treated with 4 t/ha of sewage sludge increased the organic carbon and matter content to 2.06% and 3.55% respectively while the plots treated with 2 t/ha of sewage sludge increased the organic carbon and matter content to 1.54% and 2.65% whereas the untreated plots had a slight increase of organic carbon and matter content to 0.56% and 0.97% respectively. The result indicates that sewage sludge application significantly influenced the amount of organic carbon and matter content in the soil and that sewage sludge has fertility potentials. This general increase in both organic carbon and organic matter content may be because of accumulation organic substances and decomposition of material with the effect of microbial activity releasing organic matter to the soil. This consisted with the finding of Ubuoh *et al.* (2012) that sewage sludge application increases the organic matter content of the soil thereby enhancing soil structures, nutrient and water retention with the effect of microbial activity [13]. According to Angin *et al.,* (2012) sewage sludge application to soils tends to improve soil tilt with increase in organic matter thus soil water relationship is enabled as there will be more available water for plant use [14].

Total nitrogen

After treatment application to the experimental plots, results showed in Table 3 that the total N was highly affected in all amended plots. The soil application of sewage sludge 8 t/ha has high significant effect on Total Nitrogen by increasing the total N from 0.042% to 2.27%. The plots treated with 6 t/ha of sewage sludge showed significant increment of total Nitrogen to 2.06% while the plots treated with 4 t/ha of sewage sludge showed an increment of Total Nitrogen to 1.63%. The plots treated with 2 t/ha of sewage sludge was also positive as it increases Total Nitrogen to 1.02% whereas the untreated plots has a slight increase in Total Nitrogen to 0.12%. This result indicates that sewage sludge is a good source of nitrogen in the soil and this shows that with increasing rates of sewage sludge application soil nitrogen tends to increase. This consisted with the report of O'Connor *et al* (2004) that sewage sludge contains higher amount of nitrogen in sewage sludge application rates [2].

Potassium

After treatment application to the experimental plots, results of the analysis as shown in Table 3 showed that exchangeable K^+ of the soil was highly influenced by sewage sludge 8 t/ha^{-1} with an increment from 0.15Cmol + Kg^{-1} to 2.73mol + Kg^{-1}. The plots treated with 6 t/ha of sewage sludge show a significant effect on the K^+ content by increasing the K^+ content to 2.18 Cmol + Kg^{-1}. The plots treated with 4 t/ha of sewage sludge showed a significant increment of K^+ content to 1.67Cmol + Kg^{-1} while the plots treated with 2 t/ha of sewage sludge as well showed a significant increment of K^+ content to 1.04Cmol + Kg^{-1} whereas the untreated plots had a slight increase of K^+ content to 0.28 Cmol + Kb^{-1}. This result indicates the sewage sludge improves the K^+ content of the soil. According to Suss *et al* (2004) sewage sludge has the ability of recycling possible valuable component like soil exchangeable K+ and other plants nutrients to the soil [4].

Calcium

After treatment application to the experimental plots, results of the analysis as shown in Table 3 above however showed that the soil exchangeable Ca^{2+} was highly affected by sewage sludge 8 t/ha^{-1} with an increment from 1.00Cmol + kg^{-1}. The plots treated with 6 t/ha of sewage sludge showed a significant increment of Ca^{2+} to 3.20 cmol + $kg^{-1.}$ The plots treated with 4 t/ha of sewage sludge showed an increment of Ca^{2+} to 1.84cmol + kg-^{1} whereas the untreated plots had a slight decrease of Ca^{2+} content from 1.00cmol + kg^{1} showing that the test crop used some of the Ca^{2+} content for root production, stem strength and for firm anchorage to the soil. Highest amount of Ca^{2+} was seen in plots treated with

8 t/ha of sewage sludge. This has proven that sewage sludge is a good source of soil exchangeable Ca^{2+} in the soil and according to Cogger *et al* (2004) sewage sludge contains secondary elements like Ca^{2+} and Mg^{2+} that soil requires for flocculation of soil particles and plant growth as well [3].

Magnesium

After treatment application to the experimental plots, results of this soil analysis as shown in Table 3 showed that soil exchangeable Mg^{2+} was positively influenced by sewage sludge 8 t/ha^{-1} with an increment from 1.60 to 3.26 Cmol + Kg^{1}. The plots treated with 6 t/ha of sewage sludge showed a significant increase of Mg^{2+} to 2.83 Cmol + Kg^{1}. The plots treated with 4 t/ha of sewage sludge showed a significant increment to 2.30 Cmol+Kg^{1} whereas the plots treated with 2 t/ha of sewage sludge showed an increment of Mg^{2+} to 1.86Cmol + Kg^{1} while the untreated plots showed a decrease of Mg^{2+} from 1.60Cmol + kg^{1} to 0.46 Cmol + Kg^{1} showing that the test crop requires soil exchangeable Mg^{2+} for green coloration of leaves, root growth and nutrient absorption. This result indicates that sewage sludge application on soil is also a good source of exchangeable Mg^{2+} in the soil and according to Cogger *et al*, (2004) sewage sludge has high potential of supplying elements like K^{+}, Ca^{2+} and Mg^{2+} as well as organic matter to the soil [3]. Highest amount of soil exchangeable Mg^{2+} content was seen in plots treated with 8 t/ha of sewage sludge showing that with increasing rates of application soluble cations increases. According to Angin *et al.* (2012) sewage sludge contains considerable amount of nutrients for the soil thereby increasing K^{+}, Ca^{2+} and Mg^{2+} which are considered as limiting factors of agricultural productivity [14].

Cation Exchange Capacity (CEC)

After treatment application to the experimental plots, results of the analysis showed that 8 t/ha of sewage sludge application had the best significant influence on the soil cation exchange capacity by increasing the CEC value from 4.80Cmol+Kg^{1} to 11.68 Cmol+Kg^{1}. The plots treated with 6 t/ha of sewage sludge showed a significant increment of CEC value to 9.83 Cmol + Kg^{1}. The plots treated with 4 t/ha of sewage sludge on the other hand also significantly increased the CEC values of soil to 7.72$Cmo^{l+}Kg^{1}$ to 2.44 $Cmo^{l+}Kg^{1}$. The higher amount of CEC value in treated plots was as a result of increase in soluble cations with relative to sewage sludge application to the amended plots. Highest amount of CEC value was observed in plots treated with 8 t/ha of sewage sludge application because increase in soluble cations tends to increase absorption surface and binding capacity of cations with respect to macro and micro nutrients. According to Angin *et al.* (2012) sewage sludge has high binding capacity for cations and with increasing rates of application soluble cations like K^{+}, Ca^{2+} and Mg^{2+} increases leading to increase in agricultural productivity [14].

Base Saturation

After treatment application to the experimental plots, results of the analysis showed in Table 3 below that 6 t/ha of sewage sludge had the best significant influence on the base saturation of the soil by increasing the base saturation from 59.17% to 87.44%. The plots treated with 4 t/ha of sewage sludge shows a significant increase of base saturation to 86.9 of 1% while the plots treated with 8 t/ha sewage sludge also significantly increased the base saturation of the soil to 86.25% whereas the plots treated with 2 t/ha of sewage sludge increased the base saturation of the soil significantly to 86.25% whereas plots treated with 2 t/ha of sewage sludge had least increment of base saturation to 82.89%. The base saturation in untreated plots changed as it increased to 67.21%. the higher percent base saturation in treated soils was a result of increased release of Na^{+}, K^{+}, Ca^{2+} and Mg^{2+} by decomposing the organic matter through microbial activity as lime in sewage sludge reduces acidity. Higher percent base saturation in the treated soils relative to untreated soils implied which is a productivity indicator for soil fertility.

Available Phosphorus

After treatment application to the experimental plots, results of the experiment as shown in Table 3 indicates that soil application of sewage sludge 8 t/ha^{-1} had high significant effect on the available soil P. by increasing the available P from 16.79$mgkg^{1}$ to 25.94$mgkg^{-1}$. This may be because of the content of lime in sewage sludge which decreases the solubility of Al^{3+} and Mn2 thus increasing the availability of P. "According to Ngwu, (2006) lime application to soils aid availability of P to plants" [15]. The plots treated with 6 t/ha of sewage sludge showed a significant effect on the availability of soil P. by increasing the available P to 23.02$mgkg^{1}$. The plots treated with 4 t/ha of sewage sludge showed a significant increment of soil available P. content to 20.27$mgKg^{1}$. The plots treated with 2 t/ha sewage sludge as well showed a significant increment of available P [7]. content to 18.01 $mgkg^{1}$ whereas the untreated plots had a slight decrement to 15.36$mgkg^{1}$ showing that the test crop made use of available P. required for its productivity. This increase in soil available P. may be attributed to the high potential of sewage sludge supplying elements like Phosphorus and the effect of lime on solubility of soil minerals to releases nutrients [3] (Table 4).

Result of the study showed that the treatment application has a significant effect on plant height of Bambara groundnut. At 30 DAP; the highest plant height was found in plots treated with 8t/ha of sewage sludge which had 11.95cm and 10.50cm respectively. The plots treated with 2t/ha of sewage sludge had a plant height of 9.88cm whereas the untreated plots had a plant height of 9.26cm. At 60 DAP; the highest plant height was found in plots treated with 8t/ha of sewage sludge which has 14.37cm. this was followed by plots treated with 6t/ha of sewage sludge which has a plant height of 13.71cm, then the plots treated with 4t/ha of sewage sludge gave a plant height of 13.33cm whereas the plots treated with 2t/ha of sewage sludge has a plant height of 11.71cm and finally the untreated plots gave 11.30cm. At 90DAP; the highest plant height was found in plots treated with 8t/ha of sewage which has 20.45 cm. This was followed by the plots treated with 6tha and 4t/ha of sewage sludge which has a plant height of 18.52 cm and 18.35 cm respectively, then the plot treated with 2t/ha of sewage sludge had a plant height of 17.50 cm while the untreated plots has 15.34cm. However there were significant different (p=0.05) found

Table 4: Effect of Different Rates of Sewage sludge application on Plate height (cm) at 30, 60 and 90 DAP.

Treatment Levels of sewage sludge	30 DAP	60 DAP	90 DAP
Sewage sludge 0t/ha-1	9.26	11.3	15.34
Sewage sludge 2t/ha-1	9.88	11.71	17.5
Sewage sludge 4t/ha-1	10.5	13.33	18.35
Sewage sludge 6t/ha-1	10.95	13.71	18.52
Sewage sludge 8t/ha-1	11.95	14.37	20.45
$F\text{-}SLD_{(0.05)}$	0.77	1.55	0.04

between the treatment means at 30, 60 and 90DAP. This may because treatment application has a significant effect as Calcium contact of the soil thereby improving soil flocculation of clay and according to Meredith (1965) crops response to Calcium fertilizer is expected when exchangeable Ca^{2+} is less than 0.2- 0.8cmol+kg^{-1} [16]. Also, it may be because treatment application had a significant effect of Ph value of the soil due to its high lime content reducing the solubility of A1 and Mb (as well as putting a desirable pH range thereby increasing availability forms for usage and according to Ngwu, (2006) lime application to soils decrease toxicity of A1, Mn Fe and increases flocculation of soils particles improving soil structure and aeration/infiltration [15]. Thus, the increase in plants height with respect to sewage sludge application consisted with the findings of Onweremadu et al. (2007) that an increase in plant height performance from different amended plots was due to considerable amount of N. P. and K found in sewage sludge which was supplied to the soil [17] (Table 5).

Table 5: Effect of different rates of sewages sludge application on numbers of leaves (cm) at 30, 60 and 90DAP.

Treatment Levels of sewage sludge	30 DAP	60 DAP	90 DAP
Sewage sludge 0t/ha-1	183.97	339.79	680.04
Sewage sludge 2t/ha-1	209.43	440.43	774.58
Sewage sludge 4t/ha-1	222.16	454.96	758.6
Sewage sludge 6t/ha-1	240.3	488.75	803.94
Sewage sludge 8t/ha-1	276.6	520.98	874.78
$F\text{-}SLD_{(0.05)}$	14.34	110.53	515.79

Results on showed that eh treatment application has a significant effect on the number treated with 8t/ha of sewage sludge which has 276.6. This was followed by the plots treated with 6t/ha of sewage sludge which has 240.30 while the plots treated with 4t/h of sewage sludge gave a number of leaves of 22.16. The plots treated with 2t/ha of sewage sludge has 209.43 whereas the untreated plots gave a number of leaves of 183.97. At 60 DAP; the highest number of leaves was found in plots treated with 8t/has of sewage sludge which has 520.98. This was followed by the plots treated with 6t/ha of sewage sludge which gave a number of leaves 488.75 while the plots treated with 4t/ha of sewage/sludge gave a number of leaves 454.96. The plots treated with 2t/ha of sewage sludge has 440.43 whereas the untreated 8t/ha of sewage sludge which has 874.78. This was followed by the plots treated with 6t/ha of sewage sludge which has 803.94 while the plots treated with 2t/ha of sewage sludge gave a number of leaves of 774.58. The plots treated with 4t/has of sewage sludge had 758.6 whereas the untreated plots has 680.04. this increase in number of leaves maybe as a result on increment in total Nitrogen as well as organic matter and soil exchangeable mg^{2+} which is needed to enhance greenish colouration of leaves and production of leaves. According to Mbagwu et al. (2001) sewage sludge supplies considerable amount of primary and secondary elements as well as organic matter which enhances leaf production due to significant soil exchangeable mg^{2+} in soil properties [18] (Table 6).

Result shown in indicated that the treatment application has a significant effect on leaf area index. At 30 DAP, the plots treated with 8t/ha of sewage sludge gave the highest LAI of 2.57. This was followed by the plots treated with 6h/ha of sewage sludge which has LAI of 1.82, the plots treated with 4t/ha of sewage sludge has 1.43 as LAI and finally the untreated plots had 1.03. At 60 DAP, the highest was found in plots treated 8t/ha sewage sludge which has 3.00 this was followed by plots treated with 6t/ha of sewages sludge which has 2.37 then the plots treated with 4t/ha of sewages sludge had a LAI of 2.25 whereas the plots treated with 2t/ha of sewages sludge had 1.46 and finally, the untreated plots had a LAI of 2.25 whereas the plots treated with 2t/ha of sewages sludge has 1.46 and finally, the untreated plots had a LAI of 1.21. At 90 DAP, the highest LAI was found in plots treated with 8t/ha of sewages sludge which has 5.69, this was followed by the plots treated with 6t/ha of sewages sludge which had 5.33, then the plots treated with 2t/ha of sewages sludge gave a LAI of 5.15 while the plots treated with 4t/ha of sewages sludge has a LAI of 4.61 whereas the untreated plots had 4.37 as a LAI. However, the reason for the significances maybe attributed to the increment on soil exchangeable Mg^{2+} and organic matter which was as a result of increase in treatment application supplying much and the primary and secondary elements to the soil that improves production of leaves and more greenish appearance on the leaves. According to Mbagwu et al. (2001) sewages sludge supplies considerable amount of primary and secondary elements as well as organic matter which enhances leaf production due to significant (soil exchangeable mg^{2+} In soil properties [19-28] (Table 7).

Table 6: Effect of different Rates of sewages sludge Application on Leaf Area index (cm) at 30, 60, and 90 DAP.

Treatment Levels of sewage sludge	30 DAP	60 DAP	90 DAP
Sewage sludge 0t/ha-1	1.03	21.21	4.37
Sewage sludge 2t/ha-1	1.43	1.46	5.15
Sewage sludge 4t/ha-1	1.49	2.25	4.61
Sewage sludge 6t/ha-1	1.82	2.37	5.33
Sewage sludge 8t/ha-1	2.25	3	5.69
$F\text{-}SLD_{(0.05)}$	0.03	0.02	0.04

Table 7: Effect of different rates of sewage sludge application on yield (t/ha) bambara groundnut.

Treatment	Mean yield 140 DAP
Sewage sludge 0t/ha-1	20.62
Sewage sludge 2t/ha-1	25.6
Sewage sludge 4t/ha-1	29.69
Sewage sludge 6t/ha-1	33.51
Sewage sludge 8t/ha-1	44.09
$F\text{-}SLD_{(0.05)}$	7.21

The result of the effect of different rates of treatment application on yield of Bambara groundnut is shown in table 7 above. These results showed that the plots treated with 8t/ha of sewage sludge had the highest yield of 44t/ha. This was followed by plots treated with 6t/ha of sewage sludge which gave a yield of 33.5lt/ha, the plot treated with 4t/ha of sewage sludge fowled with a yield of 29.69t/ha while the plots treated with2t/ha of sewage sludge gave a yield of 25.60t/ha whereas the untreated plots has yield of 20.62t/ha which is seen as the lowest. However. Significant treatment differences were found between treatment means. Results indicated that the yield of all amended plots were higher than the untreated plots when compared. This may be due to loss of nutrient without replenishing or leaching of basic cations in the untreated plots but for the treated plots, it could be a result of increment in soil exchangeable caption. Organic matter as well as N.P and available nutrients. According to Cogger et al. (2004) sewage sludge has high potential of supplying element like N, P, K, Ca, Mg and available nutrient which is essential for crop growth and production of yield [12]. Sewage sludge also reduces the leaching of basic cations due to increase in macro and micro nutrients status of soil enabling the release of plant essential nutrients in readily available forms [5]. Generally, the plots treated with 2 t/ha of sewage sludge improve yield by 4.98 t/ha when compared with the untreated plots, the plots with 4 t/ha of sewage sludge improve its yield by 4.09 t/ha when compared with plots treated with 6 t/ha of sewage sludge. This significant effect could be attributed to the ability of sewage sludge supplying Ca^{2+} which enhances flocculation of soil particles thereby creating an enabling soil physical condition for better plant uptake, proper infiltration and aerations, water retention through increase in pore size distribution and permeability. Also, the lime content in sewage sludge reduces solubility of Al and Mn thereby allowing a desirable pH range for nutrient uptake by plants possibly with increased in availability of P and fertility condition of soil for greater yield [28-33].

CONCLUSION

From the results of the experiment also, it showed that sewage sludge improved the entire productive/fertility indicators of the soil such as SOC, SOM, CEC, PH, BASE SAT. As a result, the result of the experiment showed that sewage sludge application on soil had a significant increase in growth characteristics and yield of Bambara groundnut (Vigna subterranean) in the study area.

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