THE COMBINE EFFECT OF GRASSCUTTER MANURE AND NPK FERTILIZER ON SOIL PROPERTIES, GROWTH AND YIELD OF CARROT

Abstract

The use of inorganic fertilizer to produce most vegetables in Ghana like carrot is in ascendency in Asante Mampong and its environs and its continuous use has a rippling effect on soil health and productivity and the high cost of these fertilizers is a challenge to most poor resourced farmers in Ghana. Field experiment was conducted in 2010 major raining season at the University of Education Winneba, Faculty of Agriculture Education research field at Mampong in the forest-transitional zone of Ghana on the Bediase series. The objective of the study was to evaluate the effect of grasscutter manure in combination with NPK fertilizer on soil physical and chemical properties, growth and yield of carrot. The treatments were 300kgNPK/ha, combination of half rate NPK fertilizer and different rates of grasscutter manure (GM) thus; (5tGM$_1$/ha+150kgNPK, 7.5tGM$_2$/ha+150kgNPK and 10tGM$_3$/ha+150kgNPK/ha) and control (without amendment), were laid out in a randomized complete block design with 3 replications. Application of grasscutter manure in combination with NPK fertilizer significantly improved the soil's physical conditions particularly, soil bulk density, total porosity, and gravimetric moisture content than the NPK alone and the control. Compared with the control, the treatment combinations significantly increased soil organic carbon, N, organic matter concentrations and exchangeable cations. Plant height, number of leaves, tap root length and root yield of treatment combinations were higher than

NPK and the control. Also the treatment combinations significantly reduced nematode presence and number of roots deformed. For good soil health, grasscutter manure in combination with NPK would be better than either manure or NPK alone.

Key words: Grasscutter manure, bulk density, total porosity, gravimetric moisture, inorganic fertilizer.

1.0 INTRODUCTION

Scarcity, competition and tenure system for land is becoming intense with the continuous rise in human population and thus resulting in the continuous use of land for farming year after year in sub Saharan- Africa particularly Ghana. The traditional shifting cultivation that was hitherto used to ensure that the crops get adequate soil nutrient supply to promote maximum yield is not sustainable. The application of inorganic fertilizer which supplies nutrient in their right quantities at a faster rate becomes the better choice in this regard. Bumb and Baanite [1] reported that failure to replenish poor tropical soil can initiate and perpetuate a downward spiral of soil degradation, and ultimately lead to severe crop losses resulting in poverty, hunger and malnutrition. Continuous inorganic fertilizer application may lead to soil acidity. Chemical fertilizers do not sustain soil fertility for long since they release nutrients at a faster rate. Couple with these factors enumerated, the high cost of inorganic fertilizers has become a major challenge to most poor resourced farmers in Ghana and as such cannot afford which eventually will lead to low production.

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In view of this, adoption of more sustainable strategies for the maintenance of soil fertility under such conditions becomes imperative to sustain crop yield. The use of organic manure can be an alternative nutrient input. Generally, nutrient content of organic manure are relatively lower than the inorganic fertilizers but they have the additional property of improving the physical properties of the soil particularly the water infiltration rate, bulk density, water holding capacity, and aeration. Again, the biological characteristics of soil, such as biomass, biological activity, and biodiversity, can also be improved through the addition of organic manure [2].

Carrot (*Daucus carota*) is one of the major vegetables cultivated in Ghana especially in Mampong and surrounding villages in the Ashanti region. Farmers in this area produce large quantities of carrot to feed both local and distant markets. Most households in Ghana have realized the nutritive importance of carrot in their diet. This has led to an increase in demand for carrot, but yield of carrot per unit area has stagnated due to constraints of production which include low nutrient levels of soil as well as root knot nematode infestation. The constant decline in food production as a result of reduced length of fallow period on land and increase in population with scarce land resources prompt farmers to amend soil with organic and inorganic materials in order to enhance plant growth and increase crop yield [3].

Due to low income levels of most farmers in the Asante Mampong area, the application of adequate or right inorganic fertilizers is not frequent therefore farmers resort to the use of different organic soil amendments in order to increase soil fertility. There are several organic soil amendments which include materials such as chicken manure, cattle manure, cocoa pod husk, compost and solid waste [4, 5]. The other organic manure which has not caught the attention of many farmers and scientists is grasscutter manure. Currently, there are over two thousand farmers officially rearing domesticated grasscutter (*Thryonomys swinderianus*) in most districts in Ghana [6]. This number keeps on increasing daily as grasscutter rearing has been found to reduce the poverty level of most Ghanaians. Disposal of grasscutter faeces and other waste is a bigger challenge to grasscutter farmers and scientists in Ghana and West Africa [6]. Even though this problem of waste disposal continues to persist, there is scarcity of information on the recommended application rates for crop use, especially for vegetable production. Certainly, there is the need to investigate into the rate and time of application of grasscutter manure for carrot production. Atakora *et al*. [7] researched into the use of grasscutter manure in cultivation of carrot and recorded appreciable results which were compared to chicken manure. Different levels of grasscutter manure alone gave higher yield in carrot and improved the physical and chemical attributes of soil [8].

The combined use of grasscutter manure and NPK fertilizer however has not been cited or widely researched into compared to chicken manure in combination with NPK fertilizer.

Several research have shown that combined application of inorganic and organic fertilizers have resulted in significant increases in crop yield and increases in soil nutrients as compared with sole application of inorganic fertilizers [9, 10, 11, 12]. It is also reported that inorganic fertilizer and manure combinations have also been found to be economically efficient [13, 14]. The objective of this study therefore was to investigate the use of grasscutter manure in combination with NPK fertilizer on carrot growth and yield and soil physico-chemical properties. This study will help in exploring other available means of combining grasscutter manure with NPK fertilizer to improve soil fertility and reduce overdependence on only inorganic fertilizer. In this way the full potential of grasscutter manure as soil fertility amendment will be unveiled for full exploration for sustainable crop production in Ghana.

2.0 MATERIALS AND METHODS

2.1 Experimental site and location

The study was carried out within April and July, 2010 in the major raining season at the College of Agriculture Education, University of Education, Winneba, Mampong- Ashanti campus located in the forest-transitional zone of Ghana. The area has bimodal rainfall pattern with the major rainy season occurring from March to July and minor rainy season from September to November. Between the two seasons is a short dry spell in August [15].

The soil at the project site is of the Bediese series of the savannah Ochrosol. The soil is sandy loam, well drained with thin layer of organic matter [16] with characteristic deep yellowish red colour, friable and free from stones. The pH ranges from 6.5-7.0 [16]. It is permeable, and has moderate water holding capacity [17, 18].

2.2 Experimental design and treatments

A Randomised Complete Block Design (RCBD) with five (5) treatments and three (3) replications was used. The five treatments, made up of one NPK fertilizer rate, three combinations and a control (without amendment) were assigned to each block. Each bed measured 2.0m × 1.5m. The treatments were 300kgNPK/ha, combination of half rate NPK fertilizer and different rates of grasscutter manure (GM) thus; (5tGM$_1$/ha+150kgNPK, 7.5tGM$_2$/ha+150kgNPK/ha and 10tGM$_3$/ha+150kgNPK/ha) and control (without amendment)

The grasscutter manure was obtained from the grasscutter farm at the College of Agriculture, University of Education Winneba.

2.3 Carrot cultivation

The land was ploughed and harrowed in mid-April, 2010. The field was later levelled and laid out before manure application at the 3rd week in April in 2010. The manures were applied a week after ploughing and were allowed to decompose for two weeks before bed preparation. Beds measuring 2m x 1.5m were prepared with hoe to a height of 25cm and levelled with rake. Seeds of carrot variety '*new improved kuroda*' were sown by drilling to a depth of about 2cm at 25cm between rows on each bed. The beds were covered with straw to prevent excessive heat and possible falling off of the tiny seeds. The straw was removed after emergence. Emergence was observed six days after sowing.

2.4 Soil and Plant Sampling Analysis

The soil chemical and physical properties were measured based on recommended methods. The pH was carried out using [19] method. Nelson *et al* [20] method was used to measure Organic Carbon and Organic matter. Cation exchange capacity (CEC) was carried out using [21] method. Available P was determined using Bray 1 extraction procedure [22]. Nitrogen was carried out using [23] and K content —was determined by the use of the photometric method 24] and . Potassium was determined using the flame photometer and Ca and Mg by EDTA titration [25].

Bulk density was determined from soil cores collected at 0-15cm depth on the field with core sampler. Samples were weighed and oven dried at a temperature of 105°C for 24 hours. The dry bulk density was determined as follows:

$$\text{Bulk density (g cm}^{-3}\text{)} = \frac{W_1}{V_1}$$

where W_1 is the weight of the undisturbed oven-dried soil sample and V_1 is the volume of the soil which is equal to the volume of the core sampler [24].

Moisture content was determined on gravimetric basis [24].

Total porosity was calculated by the formula; $f = 1 - \rho b/\rho s$ where f is total porosity, ρb is bulk density and ρs is particle density (2.65 g cm-1) [26].

Ten plants per plot were randomly selected from the middle rows and tagged for data collection. Plant heights were taken weekly after thinning with a metre rule, measuring was done from the base of the plant to the apex of the longest leaf. The number of leaves was counted every week. Root length was measured with a 30cm rule at harvest from the crown to the end of the root. Root diameter was measured immediately after harvest with the aid of a veneer calliper. Root yield from the harvestable area of each plot of twenty plants was determined with an electronic balance.

2.5 Data Analysis

The data was analysed using SAS Package, and the means were ~~separated~~ compared using ANOVA.

3.0 RESULTS AND DISCUSSION

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Table 1: Effect of Grasscutter manure and NPK fertilizer on soil physical properties

Treatments	Bulk Density (g/cm^3)	Total Porosity (%)	Gravimetric Moisture Content (%)
300kgNPK/ha	1.4	47.17	10.91
5tGM_1/ha + 150kgNPK/ha	1.35	49.06	10.94
7.5tGM_2/ha + 150kgNPK/ha	1.34	49.54	11.60
10tGM_3/ha + 150kgNPK/ha	1.33	49.59	11.83
Control	1.5	43.43	9.08
LSD ($P < 0.05$)	0.1057	2.574	1.513
CV (%)	4.1	2.9	7.4

***GM: Grasscutter Manure**

3.1 Soil physical properties

The application of $10tGM_3$/ha + 150kgNPK/ha recorded the lowest bulk density and followed by $7.5tGM_2$/ha + 150kgNPK/ha, $5tGM_1$/ha + 150kgNPK/ha and 300kgNPK/ha treatments respectively while the control recorded the highest bulk density (Table 1). At 5% probability level there were significant differences between all the treatment combinations and the control. However there was no significant difference between the sole NPK fertilizer applied (300kgNPK/ha) and the control. The significantly lower bulk density recorded by the combination treatments were as a result of the presence of the grasscutter manure in those treatments which by the activities of the soil fauna involved in its decomposition helped reduced its bulk density. This is consistent with the earlier studies by [27] who observed in 2004, 2005 and 2006 seasons that poultry manure improved the soil's soil physical properties significantly by reducing the soil bulk density. They further noted that yearly application of poultry manure had cumulative positive effects on soil physical properties. The results is in conformity to [8] that when grasscutter manure was added to the soil as an amendment, it significantly reduced the soil's bulk density.

For the influence of treatments on total porosity, it was observed that, there was significant (P =0 .05) difference between the treatment combinations and the 300kgNPK/ha. The treatment combinations relatively recorded higher total porosity values than the 300kgNPK/ha (Table 1). It has earlier been reported that grasscutter manure significantly increased total porosity [8]. Also, the use of organic plus inorganic fertilizers has been found to improve soil physical conditions as asserted by [28]. The increases observed in the total porosity of the combined treatments again could also be as a result of the decreased bulk densities that were recorded by those treatments as suggested by [29] that, the application of manure as a soil amendment decreases bulk density and increases total porosity since bulk density is inversely proportional to total porosity. This suggests that the addition of grasscutter manure to soils can ~~has~~ have cumulative positive effect on porosity.

From Table 1, the influence of the treatments on the gravimetric moisture content followed a similar pattern as it did in the total soil porosity, where 300kgNPK/ha and all combination treatments were significantly difeferent from the control ~~but not from each other~~. The $5tGM_1$/ha + 150kgNPK/ha recorded the highest gravimetric moisture content followed by $10tGM_3$/ha + 150kgNPK/ha, $7.5tGM_2$/ha + 150kgNPK/ha and 300kgNPK/ha treatments respectively with the control recording the lowest gravimetric moisture content.

The improvement in soil moisture content observed could be attributed to increase in organic matter content as a result of the grasscutter manure application. This observation is in line with the work of [7] who found that the application of a combination of poultry manure and NPK to soil increased soil organic matter which led and increase in the soil moisture content. Ewulo *et al*. [30] also reported that, poultry manure additions up to fifty tons per hectare improved soil physical properties by increasing soil moisture content.

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Table 2: Effects of amendments on nutrient levels and chemical characteristics of soil

Treatments	pH H_2O 1:1	Org C %	Total N %	Org M %	Ca me/ 100g	Mg me/ 100g	K me/ 100g	Na me/ 100g	ECEC me/ 100g	Aval P (ppm)	
300kgNPK/ha	**5.9**	**1.76**	**0.15**	**3.04**	**3.20**	**1.33**	**0.54**	**0.11**	**5.82**	**75.21**	[illegible]
$5tGM_1$/ha+ 150kg NPK/ha	**6.0**	**1.8**	**0.15**	**3.14**	**2.72**	**1.02**	**0.41**	**0.07**	**5.00**	**72.4**	[illegible]
$7.5tGM_2$/ha+ 150kgNPK/ha	**6.7**	**2.2**	**0.16**	**3.3**	**2.16**	**1.07**	**0.35**	**0.08**	**4.25**	**74.29**	**13.52**
$10tGM_3$/ha+	**6.2**	**1.88**	**0.173**	**3.59**	**2.92**	**1.08**	**0.47**	**0.09**	**5.2**	**74.31**	**13.68**

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150kgNPK/ha											
Control	**4.6**	**1.3**	**0.13**	**2.26**	**0.59**	**0.43**	**0.22**	**0.07**	**2.04**	**53.12**	**11.19**
L.S.D(P<0.05)	**0.215**	**0.29**	**0.019**	**0.169**	**0.216**	**0.173**	**0.031**	**0.016**	**0.356**	**2.19**	**0.356**
CV (%)	**1.0**	**2.6**	**2.0**	**1.7**	**2.0**	**6.0**	**1.8**	**5.9**	**2.3**	**0.4**	**4.0**

3.2 Soil Chemical Properties

The application of the treatments brought changes in the soil nutrient levels. The nutrient levels of the amended soils were all higher than the control. The combined treatments recorded significantly (P=0.05) higher values of total percentage nitrogen and organic matter than the control. The sole NPK fertilizer recorded the highest exchangeable cations and were significantly different from the treatment combinations except ~~sodium~~Na content. The effective cation exchange capacity (ECEC) which was reflection of the exchangeable cations was also significantly highest in the sole NPK fertilizer and the treatment combinations than the control. For available P and K, there were no significant difference between the sole NPK fertilizer and the treatment combinations. Organic carbon (OC) was higher in treatment combinations than the NPK and the control.

Chemical fertilizers alone according to [28] most of the time increases soil acidity, nutrient leaching and degradation of soil physical properties and organic matter status. According to Cooke [31], the association between ~~contribution of~~ organic manure and inorganic fertilizer can provides best values of total acidity, vitamin content, dry matter, NPK, Fe, Me, Zn Cu, Ni and Pb contents of fruits. In an experiment to compare the evaluation of organic manure and NPK fertilizer on soil physical and chemical properties, growth and yield of yam in south western Nigeria was revealed that, there were significant increase in soil organic carbon (SOC), N, P, K, Ca, and Mg as well as leaf N, P, K, Ca and Mg concentrations than manure or inorganic fertilizers alone and the control. In the present study, the treatment combinations recorded appreciable levels of exchangeable cations, SOC~~soil organic carbon~~, available K and P than the control which made adequate nutrient available for plant use for growth and yield. Zhang *et al.* [32] observed that regular application of organic manure improves soil physical and chemical properties and increases ~~nitrogen~~N, ~~phosphorus~~P, ~~potassium~~ K and ~~soil organic carbon~~SOC ~~(SOC)~~.

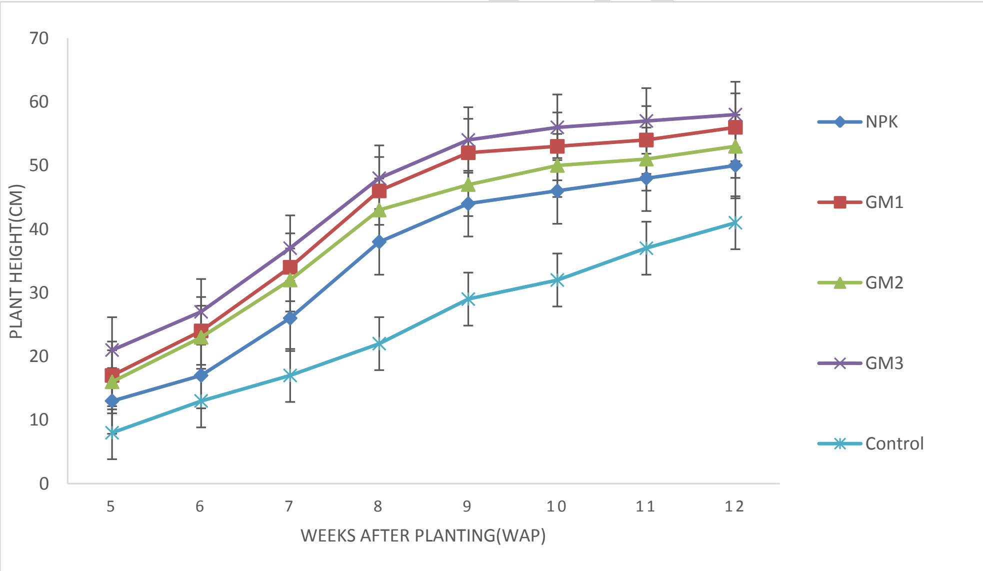

Figure 1: Changes in plant height as affected by treatments

***KEY: NPK=300kgNPK/ha, Control= Control, GM1 means GM_1+NPK=5tGM_1/ha+150kgNPK/ha, GM2 means GM_2+NPK= 7.5tGM_2/ha+150kgNPK/ha, GM3 means GM_3+NPK= 10tGM_3/ha+150kgNPK/ha.**

3.3 Plant height

From the results Figure 1, there was a steady growth in plant height of all the treatments from 5 weeks after planting to 12 weeks after planting. It was observed that, by the 12 week after planting there were significant (P = 0.05) differences among the treatment combinations and the sole NPK fertilizer treatment and the control. The 10tGM$_3$/ha + 150kgNPK/ha had the highest plant height while the control recorded the least value. The observed results could have been as a result of all the combination treatments recording relatively higher ~~nitrogen~~N, ~~phosphorous~~ P and organic matter (OM) content than both the control and the sole NPK fertilizer application which in turn resulted in the carrot plants receiving adequate nutrition for plant growth. Also the relatively higher ~~organic matter~~OM content could have served as colloids providing places of attachment for nutrients which are made available for plant growth. This affirms the assertion that regular application of organic manure improves soil physical and chemical properties and increases ~~nitrogen~~N, ~~phosphorus~~P, ~~potassium~~ K and SOC~~Soil Organic Carbon (SOC)~~ [32]. The relatively lower bulk densities, higher total porosities and higher gravimetric moisture content recorded by the combination treatments which are all good indices for good plant growth could have resulted into significant plant height difference between the combination treatments and both the control and the sole application of NPK.

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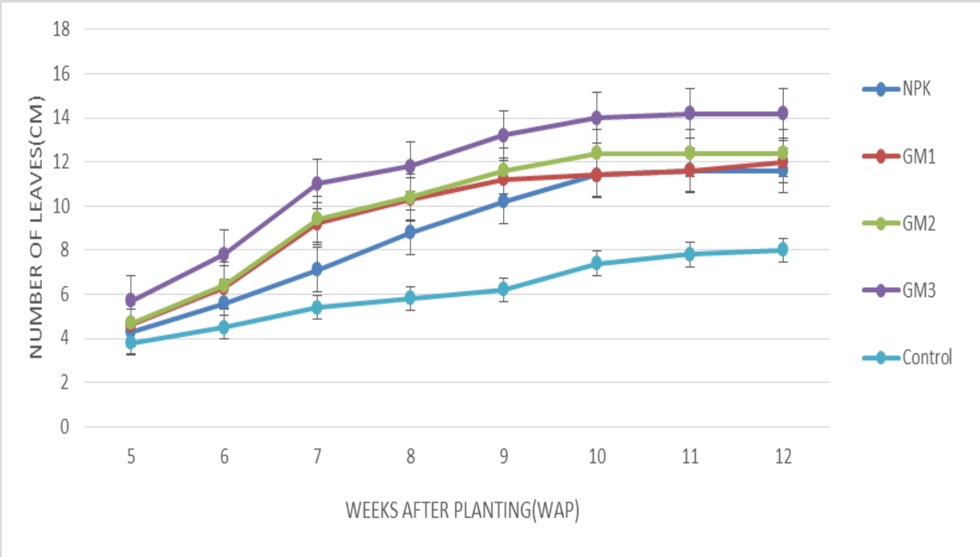

Figure 2: Changes in number of leaves as affected by treatments

***KEY: NPK=300kgNPK/ha, Control= Control, GM1 means GM_1+NPK=5tGM_1/ha+150kgNPK/ha, GM2 means GM_2+NPK= 7.5tGM_2/ha+150kgNPK/ha, GM3 means GM_3+NPK= 10tGM_3/ha+150kgNPK/ha.**

3.4 Number of branches

From Figure 2, there was a steady growth in number of leaves for all the treatments from 5 weeks after planting to 12 weeks after planting. There were significant (P = 0.05) differences among the treatments and the control. The 10tGM_3/ha + 150kgNPK/ha had the highest leaf number followed by 7.5tGM_2t/ha + 150kgNPK/ha, 5tGM_3/ha + 150kgNPK/ha and NPK 300 Kg/ha while the control recorded the least value. This observation could be attributed to the combination treatments recording relatively higher nitrogenN, phosphorous P and OMorganic matter content than both the control and the sole NPK fertilizer application which in turn resulted in the carrot plants receiving adequate nutrition for plant growth as observed for the plant height [32]. According to Wolf [33], adequate amounts of ~~nitrogen~~ N may be obtained from reasonable amounts of ~~organic matter~~OM applied to the soil and is directly responsible for vegetative growth of plants. Nitrogen functions in plants by being part of chlorophyll which is responsible for photosynthesis, helps plants with rapid growth, and improves the quality of leaf.

Table 3: Mean Root Length, Root Diameter and Carrot Root Yield/ha as Influenced by Organic and Inorganic Fertilization

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Treatments	Root Length	Root Diameter	Yield per hectare (t/ha)
300kgNPK/ha	15.18	3.6	9.78
$5tGM_1$/ha + 150kgNPK/ha	15.41	3.65	12.45
$7.5tGM_2$/ha +	15.98	4.5	12.00

150kgNPK/ha			
$10tGM_3$/ha + 150kgNPK/ha	17.52	3.9	14.67
Control	12.4	2.43	3.85
LSD (P < 0.05)	0.589	0.251	1.049
CV (%)	2.0	3.7	5.3

*** GM: Grasscutter Manure**

3.5 Yield and yield components

The application of $10tGM_3$/ha + 150kgNPK/ha recorded the highest root length while the control recorded the least value (Table 3). The combined treatments $10tGM_3$/ha + 150kgNPK/ha and $7.5tGM_2$/ha + 150kgNPK/ha were significantly (*P* =0 .05) different from both the sole NPK application and the control. For root diameter, it was observed that all the combined treatments and the sole application of NPK fertilizer were significantly (P= .05) different from the control. The combined treatments significantly (P=0 .05) recorded higher yield per hectare of carrots than the sole NPK fertilizer treatment and the control. Also the higher yield from $10tGM_3$/ha + 150kgNPK/ha treatment was significantly (P = 0.05) different from $7.5tGM_2$/ha + 150kgNPK/ha and $5tGM_2$/ha + 150kgNPK/ha treatments. However, the carrot yield from the $7.5tGM_2$/ha + 150kgNPK/ha and $5tGM_2$/ha + 150kgNPK/ha treatments were not significantly (P=0 .05) different from each other. The increase in yield recorded for the treatment combinations might be due to the improvement of the physical structure of the soil and nutrients supplied by their combinations as stated by [34] and [35]. The addition of organic amendments increased the total porosity which decreased bulk density there by increasing root penetrability. This improved nutrient exploration by plants for better growth and yield. The decrease in bulk density made the soil to hold enough moisture which led to effective root development of carrot. The combined effect of the use of organic and inorganic fertilizers does not only reduce bulk density and water holding capacity but allows nutrient to be available throughout the growing period and reduces leaching. –In this wise, as the inorganic fertilizers quickly release the major nutrients, the organic manure releases both major (NPK) and micro-nutrients, gradually, –and other growth promoting substances for continuous growth. These growth promoting substances bind the soil together to retain a lot of moisture which improves soil productivity including improving water infiltrability, soil structure and soil moisture retention.

Adeleye *et al*. [36] reported that the addition of organic manure to the soils improves their physical properties, lowers bulk density, improves moisture storage, aeration and increases the absorption of nutrients by plants. This situation might be the reason behind the higher yield and yield components of carrot recorded in the grasscutter manure additions than the sole NPK and the control in the current experiment.

Table 4: Carrot root nematode rating and deformed root as influenced by organic and inorganic amendment

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Treatments	Nematode Rating	No. of Deformed root
300kgNPK/ha	1.9	10.00
$5tGM_1$/ha + 150kgNPK/ha	1.7	7.00
$7.5tGM_2$/ha + 150kgNPK/ha	2.24	7.33
$10tGM_3$/ha + 150kgNPK/ha	1.61	7.33
Control	3.86	15
LSD (P < 0.05)	0.043	1.549
CV (%)	10.0	8.8

***GM: Grasscutter Manure**

3.6 Nematode Rating

Generally, for root nematode and number of deformed roots which are not desirable qualities, the control recorded the highest value while the $10tGM_3$/ha + 150kgNPK/ha treatment recorded the least value (Table 4). All the combined treatments had lower values of nematode rating and number of deformed carrot roots than the sole NPK fertilizer application as observed in Table 4. This observation was as a result of the ability of the grasscutter manure to control nematodes which in effect causes damaged roots of carrots. This supports [37] findings where they reported that the application of beef, horse, swine and poultry manure did reduced the total number of nematodes in the soil. Again, [38] also reported of the suppression of nematodes by animal manure in combination with neem extracts in carrot production.

4.0 CONCLUSION

The results of the study showed that application of grasscutter manure in combination with NPK fertilizer ~~had~~ promoted great improvement in soil physical properties such as lower bulk density, high moisture content and improved total porosity. Chemical properties were also enhanced with the application of grasscutter manure in combination with NPK fertilizer. Yield and yield components of carrot as well as soil physico-chemical properties of soil was greatly improved than NPK alone and the control. This implies that grasscutter manure in combination with NPK fertilizer could serve as alternative use of other organic manures in combination with inorganic fertilizer.

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