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Influence of Grasscutter, Chicken Manure and NPK Fertilizer on the Physical Properties of a Chromic Luvisol, Growth and Yield of Carrot (*Daucus carota)*

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Authors' contributions

This work was carried out by the author KA under the supervision of author KA. Author EKA provided valuable materials and procedure for the laboratory work for soil physical properties. Author KA did the analysis. Authors EKA and KA painstakingly went through the manuscript. The final correction was done by author KA. All authors went through the manuscript and approved.

Original Research Article

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ABSTRACT

A field experiment was conducted to evaluate the effect of grasscutter manure (GM), chicken manure (CM), and NPK on soil physical properties, growth and yield of carrot. The treatments were; no fertilizer or manure (control), 300kgNPK/ha (15:15:15), 10tCM/ha, 3 levels of grasscutter manure (10t, 15t and 20t/ha), laid out in a randomized complete block design with 3 replications. Soil bulk density was highest in the control plot while the sole manure treatments had low soil bulk densities, with the 20t/haGM_3 having the lowest value. The 20t/haGM_3 treatment also recorded the highest values for the gravimetric moisture content and the total soil porosity. Plant height, number of leaves, root length, root diameter and root yield in the amended treatments were better than the control. Values for the growth and yield parameters of the carrot plant from the 20t/haGM_3 treatment were in most cases significantly (P=.05) higher than the rest of the treatments, and the 10tGM/ha treatment had better impact on the parameters than the 10tCM/ha treatment. The highest economic benefit was realized for the 20t/haGM_3 treatment.

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1. INTRODUCTION

Soil fertility restoration is necessary if maintenance of high crop yield is to be achieved. Inorganic fertilizers have been used in this regard for good crop performance especially shoot length and diameter of root crop such as carrot [1]. Inorganic fertilizer has been found to increase yield of crops including carrot. Application of 300-450kg/ha NPK (15:15:15) before planting has been recommended for improved growth and yield of crops in Ghana [2]. Amjad et al. [3] observed that, application of NPK fertilizer increased plant height, seed yield and root yield of carrot. Hochmuth et al. [4] reported that the carotene content of carrot root was significantly influenced by nitrogen and potassium application. Meanwhile, the high cost of inorganic fertilizers and the subsequent adverse effects of continuous application on soil productivity necessitate the need for alternative sources for improving soil fertility.

An alternative to the use of inorganic fertilizers is the application of organic soil amendment. Application of organic manure improves soil structure, water holding capacity, porosity, bulk density, moisture retention, microbial activity and eventual growth and yield [5]. The use of manure in the production of vegetables has been successful. Organic manure is known to contain macro and micro elements and substances that support growth, development and yield of crops [6]. Chicken manure has been widely used in various rates by both researches and farmers. Kahangi [7] has recommended the application rate of 10-20t/ha chicken manure for improved growth and yield of carrot in the tropics.

Dauda et al*.* [8] recorded significantly higher increases in growth and yield of carrot after applying 10, 15 and 20t/ha chicken manure than the control. Agyarko et al. [9] stated that application of chicken manure recorded heavier mean root weight, root length and root diameter of carrot and were significantly better than the unamended soil.

There has been a continuous use of grasscutter manure (*Thryonomis swinderianus)* to fertilize crops by some farmers in Ghana with no or limited official documentation on performance. According to Annor et al. [10] proper disposal of grasscutter faeces and waste is a big challenge to grasscutter farmers both in Ghana and in other West African countries having grasscutter farms. There is the need to research into the contribution of grasscutter manure as a fertilizer source for growth and yield of crops.

The objective of this study was to evaluate the impact of grasscutter manure, poultry manure and NPK fertilizers as soil amendments on physical properties of a Chromic Luvisol, growth and yield of carrot.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The experiment was conducted between March and July 2010 at the Multipurpose Crop Nursery of the College of Agricultural Education, University of Education, Winneba at Asante Mampong Campus, Ghana (Lat. 07º, 04'N; Long. 01º, 24'W). The soil at the project site has been classified by [11] legend as Chromic Luvisol and locally as the Bediesi series [12]. The Meteorogical data during the research period as recorded by [13] are as follows: The maximum and minimum temperatures were 32.2°C and 22.8°C respectively with Rainfall of 547.5m. The maximum and minimum relative humidity were 96% and 62% respectively.

2.2 Methodology of Investigation

A randomized complete block design (RCBD) was used with six (6) treatments with three replications on beds. Each bed measured 2.0m x 1.5m and was prepared with a hoe to a height of 25cm. Well decomposed chicken manure (CM) and grasscutter manure (GM) were thoroughly incorporated separately into the beds before leveling with rake. The treatments were 300kgNPK/ha, 10t chicken manure and three levels of grasscutter manure (10tGM_1/ha, 15tGM_2/ha and 20tGM_3/ha) as sole amendments and a control.

Water Holding Capacity (WHC) was carried out using the funnel method [14]. Bulk density was taken two weeks after manure application. The soil samples were taken by driving aluminium cylinder of known volumes into the soil at 0-15cm depth by means of augur. Samples taken from each plot were then oven-dried at 100ºC to a constant weight. It was calculated using the relation:

$$\text{Bulk density} = \frac{\text{Weight of oven dry weight}}{\text{Volume of soil}}$$

Total Porosity:

Soil porosity was determined using the formula

$$f = (1 - BD/PD) \times 100$$

where f = Total porosity
BD = bulk density
PD = particle density = 2.65g/cm^3 [14,15].

Laboratory analysis of the grasscutter and chicken manure using pH of 1:5 showed the following: Chicken manure: pH 8.2, Ca% 0.96, Mg% 1.33, P% 1.39, K% 0.65 and N% 2.01. Grasscutter manure: pH 9.3, Ca% 0.61, Mg% 0.78, P% 0.49, K% 1.08 and N% 1.13

Seeds of carrot (*Kuroda*) were sown by drilling to a depth of about 2mm and at 25cm between rows on each bed. The beds were covered with straw to prevent excessive heat and possible falling of the tiny seeds and was later watered. Germination was observed six days after sowing. The seedlings were thinned out 21days after germination to intra-row spacing of 10cm. Weed control was carried out by handpicking. The paths between the blocks and plots were weeded with cutlass and hoe four times during the experiment. Earthening-up was done every two weeks after thinning out to check exposure of roots by watering. The interows were stirred up with hand fork at two weekly intervals throughout the growing period to improve aeration for enhancement of growth of the crop. Twenty plants were randomly selected from the middle rows and tagged for record taking. Plant height and number of leaves were taken from 5 weeks after planting (5WAP) to 12 WAP. Root length and root diameter at 2cm from the top were recorded immediately after harvest with the aid of metre rule and veneer calipers respectively. Plant height was taken with a long plastic rule from the soil level to the tip of the longest leaf whilst number of leaves per plant were counted.

Data collected were analyzed by Analysis of Variance (ANOVA) using Gen Stat Statistical Package. Significant means of results were separated by the Least Significant Difference (LSD) method at 5% significance level.

Cost/benefit analysis was done to determine the relative economic returns on the applied treatments using 2010 annual market prices. The total yield and cost benefit analysis were determined using all the harvest from the central bed (1m²) of each plot. Costs of farm services were taken at Mampong market in the Sekyere West District of the Ashanti region of Ghana. CIMMYT [16] Agronomic data to Farmer Recommendation Economic Training Manual served as guidelines in working out the cost/benefit analysis.

3. RESULTS AND DISCUSSION

3.1 Soil Physical Properties

Table 1 shows the physical properties of the soil as affected by the soil amendment with organic and inorganic fertilizers. The 300kgNPK ha^{-1} (15:15:15) treatment recorded the highest bulk density among all the amended plots with the 20tGM ha^{-1} recording the lowest. All the amended plots recorded significantly (*P* = .05) lower bulk densities than the control. The 300kgNPK ha^{-1} (15:15:15) treatment also recorded the lowest total porosity among the amended plots while the 20tGM ha^{-1} treatment recorded the highest among all the treatments. The highest gravimetric moisture among the treatments was recorded by the 20tGM ha^{-1}. Among the amended plots, the 300kgNPK ha^{-1} (15:15:15) treatment recorded the lowest value of the gravimetric moisture. The control recorded significantly (*P* = .05) lower values for the porosity and the gravimetric moisture than the amended soil. The 10tGM ha^{-1}treatment recorded higher values of total soil porosity and gravimetric soil moisture and bulk density than the 10tCM ha^{-1} treatment.

Young [17], reported improved structural stability, lower bulk density and improved soil moisture properties with the addition of organic matter. Lombin et al. [18], Mbah et al. [19] and Adeleye et al. [20] shared similar views on reduced soil bulk density. Russel and Morsah [5], reported that soils amended with animal manure tended to have lower bulk densities and higher porosities. Bulk density is important to water infiltration, root distribution and root function which in turn affect plant water uptake and growth. This reduction in soil bulk density could make appreciable difference in the root growth of carrot. Improvement in soil total porosity due to manure application might be as a result of the improved soil particle aggregation brought about by the improved soil organic matter content of the plots amended with manure. This assertion is also supported by [18]. The quantity of the manure added had relative influence on the physical parameters, as the highest level of the manure treatment ($20tGM_3$/ha) recorded the lowest bulk density, the highest gravimetric soil moisture content and the highest percentage soil pores, with the 15tGM ha^{-1} and 10tGM ha^{-1} treatments following in that order.

Table 1. Soil physical properties as affected by soil amendment with organic and inorganic fertilizers

Treatments ha^{-1}	Bulk Density (g/cm^3)	Total Porosity (%)	Gravimetric Moisture Content (%)
300kgNPK(15:15:15)	1.41	46.59	10.47
10tCM	1.35	47.34	10.72
10tGM	1.31	49.54	11.00
15TGM	1.29	49.52	11.25
20tGM	1.24	51.52	11.52
Control	1.50	42.80	9.30
$LSD_{0.05}$	.03	1.25	.91
CV%	1.20	8.20	2.50

GM: Grasscutter manure, CM: Chicken manure

3.2 Growth and Yield of Carrot

Table 2 indicates soil amendment effect on some growth and yield parameters of carrot. Plant height and number of leaves were significantly (*P*=.05) higher in the amended soil treatments than the control treatment. Among the amended treatments, the chicken and grasscutter manures had higher figures for the plant height and number of leaves of carrot than values obtained from the inorganic amended soil treatment. The 20tGM ha^{-1} treatment had the highest figures though not significant for the parameters among the amended treatments. The 15tGM ha^{-1} treatment had the next highest figures. Similar to the trend observed for the growth parameters, the amended soil treatments recorded significantly (*P*=.05) higher figures for the root length, diameter and yield of carrot than the control treatment. The animal manure treatments had higher figures than the yield parameters from the inorganic treated soil. The 20tGM ha^{-1}treatment had significantly (*P*=.05) the highest figures among the treatments for these parameters. As observed for the growth parameters, the 15tGM ha^{-1} treatment had the next highest figures for the root length, diameter and yield of carrot.

Soils amended with inorganic and organic manures have been found to produce better growth and yield parameters of carrot than control treatments with the performance having positive relationship with the quantity of the manure applied [9]; [8] as observed in the current study where the growth and yield parameters have decreasing values relative to following order of treatments: 20tGM ha^{-1} > 15tGM ha^{-1} > 10tGM ha^{-1}.

Poultry manure has proven to be superior in many instances to produce higher yield of crops than other manures, however, in the study the 10tGM ha^{-1}treatment recorded higher carrot yield levels than the 10tCM ha^{-1} treatment, which might be due to the better physical conditions (Table 2) produced by the 10tGM ha^{-1}treatment.

Table 2. Growth and yield parameters of carrot as affected by soil amendment

Treatments (ha^{-1})	Plant Height (cm)	Number of leaves	Root length (cm)	Root Diameter (cm)	Root Yield ($t\ ha^{-1}$)
300kgNPK (15:15:15)	45.09	10.93	15.25	3.60	9.78
10tCM	45.97	13.40	15.54	3.73	10.96
10tGM	46.63	12.73	15.81	3.47	12.15
15tGM	47.86	13.70	16.10	3.77	15.26
20tGM	47.96	14.00	17.60	4.43	15.70
Control	36.11	8.87	12.40	2.43	3.85
$LSD_{0.05}$	5.04	3.00	.94	.12	2.79
CV%	6.42	14.10	3.48	1.88	13.61

GM: Grasscutter manure, CM: Chicken manure

3.3 Cost Benefit Analysis

Significantly, higher cost of production (*P*=.05) was incurred relative to the quantity of the grasscutter manure and poultry manure applied as compared to the NPK and the control (Table 3). The significant differences observed might be due to the large quantities of grasscutter manure and chicken manure applied and the cost of application. The income and profit obtained from the application of manures were, however, significantly higher than the NPK treatment and the control. The cost of production increased with the rate of manure application. The high levels of the manure in the treatments, especially the 20tGM ha^{-1} treatment proved to be more cost effective in the production of carrot than the rest of the treatments. This is so because as the quantity of manure increases, it has a corresponding increase in yield which translated to the profit gained compared with the yield recorded by other treatments. Dauda *et al*. [8] reported that 20t/ha Chicken manure (CM) gave higher yield which translated into higher profit than the 15t/ha and 10t/ha CM. Again, Usman *et al*. [21] recorded higher profit in terms of cost benefit ratio of 20t/ha Farm Yard Manure and Poultry manure than the control. Comparatively, the 10tGM/ha treatment seemed to be more cost effective in the production of carrot than 10tCM/ha treatment.

Table 3. Economic analysis of treatment and yield of carrot

Treatments	Cost of production (GHc/ha)	Income (GHc/ha)	Profit (GHc/ha)
300kg NPK/ha (15:15:15)	1448	15404	13956
10tCM/ha	2511	17255	14744
$10tGM_1$/ha	2511	19145	16634
$15tGM_2$/ha	3448	23975	20527
$20tGM_3$/ha	4574	27475	22890
Control	1400	6072	4672
$LSD_{0.05}$	15.60	1.46	1.26
$CV_{\%}$	.3	.01	.01

GM: Grasscutter manure, CM: Chicken manure

4. CONCLUSION

The study showed that the application of grasscutter manure and poultry manure improved more the physical characteristics of the soil and increased the vegetative and yield parameters of carrot than the NPK and the control. The quantity of the manure added had relative influence on the parameters. The 20t/ha GM rate however, gave higher performance for all the parameters in the study. Comparatively, the 10tGM/ha treatment had better results than the 10tCM/ha treatment. The application of the grasscutter manure of 20t/ha was found to be more cost effective in the production of carrot than the rest of the treatments. Grasscutter manure could be an alternative source of manure for crop production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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