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Influence of grasscutter manure, chicken manure and NPK fertilizer on the growth and yield of carrot and chemical properties of soil

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ABSTRACT: Field experiments were conducted in 2010 cropping season at the Research Centre of the College of Agriculture, Mampong Campus of the University of Education, Winneba (latitude 7° and 8° North of Equator and Longitude 1° and 24° West of the Greenwich) in the forest transitional zone of Ghana to evaluate the effect of three levels of grasscutter manure (GM), chicken manure (CM), and NPK on soil chemical properties, growth and yield of carrot. The treatments were, no fertilizer or manure (control), 300kgNPK/ha, 10tCM/ha, 3 levels of grasscutter manure (10t, 15t and 20t/ha), laid out in a randomized complete block design with 3 replications. The 3 levels of grasscutter manure and chicken manure enhanced the soil organic C, total N, available P, exchangeable K, Ca, Mg and CEC better than NPK and the control treatments. Organic matter content and percent base saturation were high in the amended plots than the control. Plant height, number of leaves, leaf chlorophyll content, root length, root diameter and root yield for the 15 and 20t/ha grasscutter manure performed better than the rest of the amendments. The study showed that among the organic manures evaluated, grasscutter manure of 15 and 20t/ha gave the improved levels of the soil chemical properties and yield of carrot.

KEYWORDS: Grasscutter manure, chicken manure, NPK, soil, chemical properties.

1 INTRODUCTION

Inorganic fertilizer has been found to increase yield of crops. Application of 300-450kg/ha NPK (15:15:15) before planting has been recommended for improved growth and yield of crops in Ghana [1]. Amjad *et al*. [2] observed that, application of NPK fertilizer increased plant height, seed yield and root yield of carrot. Hochmuth *et al*. [3] reported that the carotene content of carrot root was significantly influenced by nitrogen and potassium application.

Application of chemical fertilizers is very crucial for improving fertility of soil and have become integral part of modern crop production systems. High cost and sometimes non-availability of fertilizers at the time of sowing coupled with adulteration of some fertilizers poses a great problem [4]. Most farmers often use nitrogen alone and do not bother about the application of other macro and micro nutrients that are also essential for soil quality. Indiscriminate use of inorganic fertilizers has a myriad of problems. Generally, excessive amounts of inorganic fertilizers are applied to vegetables in order to achieve a higher yield [5] and maximum value of growth [6]; [7]; [8]. But the use of inorganic fertilizers alone may cause problems for human health and environment [7].

Organic manure can serve as alternative substitute for mineral fertilizers [9]; [10]; and [11] for improving soil structure [8] and microbial biomass [12]. In this vane, utilization of locally produced manures for vegetable production may increase crop yields with less use of inorganic fertilizer. Recently, consumers are demanding higher quality and safer food and highly interested in organic products.

Organic manure is known to contain macro and micro elements and substances that support growth, development and yield of crops and regular application improves soil structure and enhances root growth [13]; [14] and [15]. According to Zhang *et al*. [15], organic manure improves soil chemical properties including nitrogen, phosphorus, potassium, soil organic

carbon (SOC) and organic matter content. Adeleye [16] also observed an increase in pH, organic matter, total nitrogen, available phosphorus, exchangeable cations and percent base saturation due to addition of poultry manure.

Chicken manure has been widely used in various rates by both researchers and farmers. Kahangi [17] recommended the application rate of 10-20t/ha chicken manure for improved growth and yield of carrot in the tropics. Dauda *et al*. [18] reported a rate of 10, 15 and 20t/ha chicken manure for carrot growth and yield. Agyarko *et al*. [19] stated that application of chicken manure recorded heavier mean root weight, root length and root diameter in carrot were significantly better than the unamended soil. Dauda *et al*. [18] also recorded a significant increase in growth and yield of carrot for 10, 15 and 20t/ha chicken manure applied than the control.

Grasscutter (*Thryonomis swinderianus)* manure has been used to cultivate vegetables like tomatoes and cabbage and it has been found to give high yield in the western region of Ghana [20]. The yields obtained by these farmers since domestication of grasscutter can be compared to yields from chicken manure, cow dung and other manures. Grasscutter produces a lot of manure and like chicken manure, it is capable of releasing both macro and micro nutrients and improving soil conditions.

Since grasscutter domestication is in ascendancy in Ghana, most vegetable growers will continue its usage but the rate of application by farmers for vegetable crops are not often based on research recommendations perhaps since its usage is new. Due to this situation, there is the need to research into the use of grasscutter manure and its effects on soil chemical properties and yield of crops.

The objective of this study was to determine the effects of different rates of soil amendments on soil chemical characteristics and yield of carrot at Mampong-Ashanti which is a major producing area of carrot in Ghana.

2 MATERIALS AND METHODS

2.1 SITE AND TREATMENTS

The experiment was conducted at the College of Agriculture Education, University of Education, Winneba at Asante Mampong from March to July, 2010. The soil at the project site is of the Bediase series of the savannah Ochrosol. The soil exhibits all the features of sandy loam. It is well drained with thin layer of organic matter with deep yellowish red, friable and free from stones. The pH ranges from 6.5-7.0. It is permeable and has moderate water holding capacity [21]; [22]. The site has an altitude of 457.5m above sea level and occurs within latitude 7 and 8̊ North of Equator and Longitude 1 and 2̊ West [23].

A randomized complete block design was used with six (6) treatments and 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, 10t/ha chicken manure and three levels of grasscutter manure (10tGM_1/ha, 15tGM_2/ha and 20tGM_3/ha) as sole amendments, 300kgNPK/ha which was applied after thinning out and a control.

2.2 SOWING OF CARROT

Seeds of carrot *var new* improved *Kuroda* were sown by drilling to a depth of about 2cm 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 were 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. 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.

2.3 DATA COLLECTION

2.3.1 PLANT SAMPLING AND MEASUREMENTS

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. The yield of taproots from each plot was weighed with an electronic balance.

2.3.2 SOIL SAMPLING AND ANALYSIS

Soil samples were randomly taken from different spots (10 points) at a soil depth of 0-15cm from each treatment and replication. Samples from each treatment and replication were bulked, air dried and sub-sampled for analysis at the Soil Research Institute, Kumasi before planting. Soil samples were then taken six weeks after soil ammendment. Soil pH was measured using a glass electrode (pH meter) in accordance with the methods of [24] and [25]. Soil organic matter was determined by the wet combustion method [26]. Percentage total nitrogen was determined by the micro kjeldahl-technique [27]. The available phosphorus was extracted by the Bray method and determined calorimetrically [28]. Potassium was determined by flame emission photometry. The exchangeable cations, calcium, magnesium, potassium and sodium were determined as recommended by [24] using EDTA Titration after extraction with 0.1N Ammonium Acetate at pH 7. Effective Cation Exchange Capacity (ECEC) was calculated as the sum of the exchangeable bases and exchangeable acidity.

3 DATA ANALYSIS

Data collected were analyzed by Analysis of Variance (ANOVA) using GenStat Statistical Package. Significant means obtained were separated by least significant difference (LSD) method at 5% significance level.

4 RESULTS AND DISCUSSION

Table 1. Chemical properties of poultry and grasscutter manure used in field studies

Property	pH 1:1	Ca%	Mg%	P%	K%	N%
Chicken manure	9.3	0.96	1.33	1.39	0.65	2.01
Grasscutter manure	8.2	0.61	0.78	0.49	1.08	1.13

Table 2. Initial soil chemical properties at the experimental site

pH, H_2O 1:1	Org.C %	Total N %	Org. M %	Exch. Cations (me/100g)				T.E.B	Exch. A(Al+H)	ECEC me/100g	Base Sat %
				Ca	Mg	K	Na				
4.6	1.25	0.09	2.00	0.54	0.36	0.21	0.05	1.17	0.37	1.71	68.36

Table 3. Effects of amendments on nutrient levels and chemical characteristics of soil

Treatments	**pH, H_2O 1:1**	**Org.C %**	**Total N,%**	**Org.M %**	**Exch. Cations (me/100g)**				**T.E.B**	**Exch. A(Al+H)**	**E.C.E.C me/100g**	**Base Sat %**
					Ca	**Mg**	**K**	**Na**				
300kgNPK/ha	5.2	1.53	0.12	2.97	1.25	1.05	0.46	0.07	3.37	0.52	4.20	80.23
10tCM/ha	6.2	2.11	0.15	3.34	2.95	1.15	0.38	0.11	4.59	0.54	5.25	87.38
10tGM_1/ha	6.35	2.06	0.13	2.96	2.25	1.01	0.32	0.09	3.65	0.48	4.36	83.32
15tGM_2/ha	6.15	2.20	0.14	3.30	2.43	1.02	0.39	0.10	3.94	0.57	4.60	85.59
20tGM_3/ha	6.3	2.32	0.18	3.49	2.77	1.03	0.45	0.10	4.34	0.59	4.98	87.05
Control	4.6	1.25	0.09	2.00	0.54	0.36	0.21	0.05	1.17	0.37	1.71	68.36
$LSD_{0.05}$	0.43	0.22	0.02	0.15	0.41	0.08	0.09	0.03	0.43	0.09	0.24	2.33
CV%	3.5	6.0	19.0	6.1	6.5	4.2	6.5	11.6	6.0	20.5	5.9	1.3

4.1 EFFECT OF ORGANIC AND INORGANIC AMENDMENTS ON SOIL CHEMICAL PROPERTIES

Table 1 shows nutrient contents of chicken manure and grasscutter manure used in the studies. Chicken manure gave higher values of the total nitrogen (N), phosphorus (P), calcium (Ca) and magnessium (Mg), than the grasscutter manure which gave higher value of total potassium (K). The pH of the chicken manure and grasscutter manure were above neutral. From Table 2, it can be seen clearly that the soil is very acidic for the top soil (0-15cm). Organic matter content and nitrogen

levels were lower under general situations. The levels of cations in the background/initial soil recorded lower values compared with the amendments. The cations recorded low values (Ca, Mg, K and Na) which affected the total exchangeable bases (TEB) and the effective cation exchange capacity (ECEC) which indicates low base saturation of 68.36%.

Amended soils recorded increases in pH (Table 3). The manured treated plots recorded higher levels of organic carbon, percentage total nitrogen, and organic matter than the NPK alone. All the amended plots showed increase in all the nutrient levels after manure decomposition and were significantly different from the control (Table 3). The exchangeable cations, total exchangeable bases and effective cation exchange capacity in the amended soil were also significantly higher than the control. All the amended plots had higher levels of base saturation than the control.

These increases were observed due to the high organic matter and organic carbon contents observed. According to Grichs [29] and Agbede [30] organic manure act as a storehouse for plant nutrients and is a major contributor of cation exchange capacity which contribute to the desired soil chemical properties providing a better condition for growth and development of crops. The study revealed that, the organic manure applied in the soil affected the chemical conditions which improved considerably as compared to the control. Again, the study is in line with the observation made by [13] and [30] that, addition of organic manure such as chicken manure and grasscutter manure as amendment improves soil organic matter, Organic C, N, K, Ca and Mg content.

The inorganic fertilizer also had much improvements in the macro nutrients levels compared to the control. The increases influenced the growth and yield of carrot. These increases could be due the availability of nitrogen, phosphorus and potassium made available to the soil at a faster rate and needed by plants in large quantities for growth and yield. Mallareddy [31] reported that a recommended dose of NPK fertilizer alone can perform better than a control.

Addition of organic manure has been found to have increased soil microbial activity and pH [32]. The use of both grasscutter and chicken manure were found to have increased the soil pH from 4.6 to between 6.2-6.35 of the organic manure (Table 3). The increase in soil pH could be due to the increase in organic matter content and onward increasing levels of basic cations released into the soil solution during microbial decarboxylation of the manure which causes the increase in soil pH. These finding is in line with [30] on tillage and fertilizer effects on soil characteristics.

Interestingly, the NPK fertilizer improved the soil pH, organic carbon, total nitrogen and other soil chemical properties but not to the level of the grasscutter manure and chicken manure (Table 3). It may be partly due to the fast rate with which inorganic fertilizers released nutrients into the soil. The contents of some major nutrients in the soil are slightly dependable on the level of organic matter [33], [34]. Organic matter has greater capacity to retain nutrients in forms that can easily be taken up by plants over a longer period of time. The nutrients found in NPK fertilizer was in mineralized form and they were released at faster rate in soil than organic manure. These assertions have also been reported by [35] and [30].

From the results in Table 3, it could be observed that, grasscutter manure also supplied both macro and micro nutrients like the chicken manure by providing the qualities that chicken manure revealed in the study. The (macro and micro) nutrients results obtained by the grasscutter manure application (Table 3) is in accordance with [36], [37] and [16] that animal manure increases soil pH, NPK, exchangeable cations and percent base saturation.

Table 4: Plant height as affected by organic and inorganic fertilizers in 2010 season weekly (cm)

Treatments	5WAP	6WAP	7WAP	8WAP	9WAP	10WAP	11WAP	12WAP
300kgNPK/ha	11.88	18.40	25.98	37.11	42.93	45.32	46.48	48.80
10tCM/ha	16.54	24.30	33.54	43.96	49.19	50.45	52.01	53.66
10tGM_1/ha	16.23	22.21	31.44	40.54	46.77	48.22	49.91	51.56
15tGM_2/ha	19.35	27.50	35.61	44.63	52.40	54.64	55.73	57.68
20GM_3/ha	19.77	28.42	36.15	46.13	53.19	55.26	56.69	57.50
Control	8.03	12.00	16.66	22.19	28.98	32.16	35.27	40.18
LSD (0.05)	2.30	3.50	4.27	5.81	4.39	4.27	4.59	4.54
CV (%)	10.70	5.30	7.80	8.11	5.33	4.99	5.19	4.96

Table 5: Number of leaves as affected by organic and inorganic fertilizers in 2010 season weekly

Treatments	5WAP	6WAP	7WAP	8WAP	9WAP	10WAP	11WAP	12WAP
300kgNPK/ha	4.33	5.67	7.10	8.53	10.10	10.22	10.63	11.33
10tCM/ha	5.00	7.00	8.23	10.13	11.47	11.67	12.70	13.50
10tGM_1/ha	4.67	6.37	8.10	9.17	10.27	11.43	11.87	12.43
15tGM_2/ha	4.73	7.03	9.80	11.23	12.80	13.17	13.70	14.80
20GM_3/ha	5.60	7.83	10.97	11.97	13.47	14.33	14.60	14.83
Control	3.63	4.77	5.47	5.87	6.90	7.67	8.03	8.30
LSD (0.05)	0.72	1.32	1.75	2.03	2.31	2.16	2.53	2.13
CV (%)	8.73	11.72	11.87	11.97	12.04	10.91	12.25	9.91

4.2 VEGETATIVE GROWTH

4.2.1 PLANT HEIGHT

Differences in plant height was significant (p=0.05) at 5WAP to 8WAP between the organic amendments and the NPK as well as the control however, there were no significant differences between the treatments at 12WAP except the control (Table 4). Plant height tended to increase by the increasing dose of organic manure particularly the 15t and 20t/ha grasscutter manure. This was higher than the heights obtained from the chicken manure, the NPK and the control (Table 4) but there were no significant differences between them (15t and 20t/ha), chicken manure and the NPK from 9WAP to 12WAP. Throughout the growing period, all the amended plots were significantly higher than the control. This observation could be due to the higher amounts of nitrogen released from organic matter produced by the increasing amounts of grasscutter manure as asserted by [19] and [18] that increasing levels of manure increases vegetative growth especially plant height due to the corresponding increase in nitrogen from organic matter. The nitrogen released from the NPK also accounted for higher plant height than the control.

4.2.2 NUMBER OF LEAVES

Similar observations were made as reported in the plant height for number of leaves which showed significant difference with increased organic manure dose (Table 5). The amendments were significantly (p=0.05) higher than the control at 8WAP to 12WAP. The highest numbers of leaves were obtained by 15t/haGM_2 and 20t/haGM_3 with the 300kg/ha NPK recording the lowest among the amended plots for all the data from 5WAP to 12WAP. These increases could be due to the higher amounts of organic matter produced and the nutrients released into the soil for absorption due to the large amounts of manure applied to the plots as stated by [38].

4.2.3 CHLOROPHYLL CONTENT

Generally, the leaf chlorophyll content of the carrot was significantly higher in the amended treatments than the control (Table 6). Among the amendments, grasscutter manure of 15 and 20t/ha at 9WAP were higher than the rest of the sole amendments. The results obtained could be due to the improvement in soil condition such as porosity, infiltration rate, root penetrability, and the presence of other growth factors such as hormones. Apart from these soil conditions, chlorophyll formation is also aided by K, Mg, Ca, Zn and Fe as stated by [39], [40] and [14]. Therefore the organic manure was capable of releasing both macro and micro nutrients which played a vital role in increasing these nutrients for chlorophyll formation as revealed by this study.

Table 6: Chlorophyll content of carrot leaves as affected by organic and inorganic amendment (Ug/g)

Treatments	6WAP	9WAP	12WAP
300kgNPK/ha	198.41	317.31	285.72
10tCM/ha	222.55	366.14	297.87
$10tGM_1$/ha	227.36	340.59	290.22
$15tGM_2$/ha	238.38	394.84	316.44
$20tGM_3$/ha	230.12	396.60	324.00
Control	133.98	231.81	264.72
LSD (P < 0.05)	52.35	57.55	49.72
CV (%)	13.84	9.46	9.60

Table 7: Nutrient composition of carrot root (%)

Treatments	Ca	K	Mg	N	P	S
300kgNPK/ha	1.45	1.21	0.62	1.67	0.58	0.11
10tCM//ha	2.14	1.62	0.33	2.18	0.98	0.06
$10tGM_1$/ha	1.13	2.25	0.90	2.03	0.75	0.03
$15tGM_2$/ha	0.65	2.66	0.93	2.03	0.85	0.04
$20tGM_3$/ha	0.59	2.48	1.07	2.39	0.88	0.03
Control	0.38	1.14	0.16	1.12	0.38	0.01
LSD (p<0.05)	0.03	0.03	0.02	0.03	0.03	0.01
CV (%)	0.40	0.10	0.60	0.20	1.00	5.20

4.3 EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON NUTRIENT CONTENTS OF CARROT ROOT

Generally the nutrient levels of the carrot roots from the amended soils were higher than those from the control (Table 7). Carrot roots from the grasscutter treatment of 15 and 20t/ha had the

highest nutrient values for Ca, Mg, P and N, with value from the 10t/ha CM and GM as well as 300kgNPK/ha following in that order of the carrot root nutrient levels as found in Table 7. Generally, the 20t/ha GM gave higher values for Mg and P except and N while the 15t/ha GM gave highest values of Ca and K.

The increase in nutrient composition of carrot root might be due to organic materials present in soil amendments which raised the level of nutrients in the soil which gave a corresponding increase in the nutrient level of plants growing on them [41]. The soil nutrient levels of nitrogen, potassium, phosphorus, sulphur, calcium and magnesium in the amended soils were higher than the control due to the corresponding increase of the nutrients levels in the amendment used for the study (Table 7). The present study is in line with the study by [19] on the relative increase of soil nutrients in amendments with corresponding increase in carrot roots and leaves. Again, similar observation has been made by [42] in sweet potato root.

Table 8 : Effects of organic and inorganic manures on yield and yield parameters

Treatments	Yield t/ha	Root length (cm)	Root diameter (cm)	Forked root kg/ha
300kg/ha NPK (15:15:15)	9.78	15.25	3.60	0.67
10tCM/ha	10.96	15.54	3.73	1.00
10tGM/ha	12.15	15.81	3.47	0.67
15tGM/ha	15.26	16.10	3.77	0.67
20tGM/ha	15.70	17.60	4.43	0.69
Control	3.85	12.40	2.43	1.33
$LSD_{0.05}$	2.79	0.94	0.12	1.74
CV %	13.61	3.48	1.88	1.28

4.4 EFFECT OF ORGANIC AND INORGANIC AMENDMENTS ON CARROT ROOT YIELD CHARACTERISTICS

The grasscutter manure of 15tGM_2/ha and 20t/haGM_3 gave 15.26t/ha and 15.70t/ha respectively of carrot yield which were significantly higher than the yields from the rest of the amendments and the control. These yields were higher than 4.8t/ha value reported by [43] but were lower than the 30t/ha reported by [1] even though different quantities of manure were applied. The chicken and grasscutter manure applied probably improved plant growth and increased root size since the organic manure could have a positive influence in soil physical properties. Asiedu *et al*.[44] also reported increased yield of carrot with the application of chicken and sheep manure.

Root length and root diameter of the manure treatment plots were significantly different from the control treatments (Table 8). The higher root length and root diameter recorded by the amendments might be due to the higher amounts of organic matter content and the improvement in soil physical attributes which made the soil loose for smooth root penetration and enlargement.

The yield and other yield characteristics of the carrot improved relatively with the increasing levels of the amendments which followed the pattern of the changes in the nutrient levels in the soil after treatment application. This assertion supports the earlier study by [19] that yield and yield characteristics of carrot improve in relation with rising levels of nutrient amendments and tend to be affected by increasing soil nutrients.

The forked root weight of carrot was high in the control and perhaps might be due to acid nature of the soil. Sinnadurai [45] stated that rich soils produce smooth roots with a suitable pH between 5.8 and 7.0. The addition of chicken and grasscutter manure released ammonium which raised the pH (Table 8) by reducing the acidity [46] and again increased the exchangeable Ca and Mg and improved P uptake thereby reducing Al and Mn levels as asserted by [47].

5 CONCLUSION

The study showed that the application of grasscutter manure and poultry manure improved the chemical properties of the soil as well as the yield parameters of carrot than the control. The grasscutter manure of 15 and 20t/ha gave better results for almost all the parameters in the study. From the results, it could be said that grasscutter manure can serve as an alternative source of manure for nutrients for carrot production and application rate of 15-20t/ha is recommended for optimum results.

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