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Differential Response of Carrot Genotypes to Organic and Inorganic Fertilizer Applications in Derived Guinea Savanna Characterized with Galvanized Soil

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Abstract: Performance of carrots varies with levels of fertilizer application. As a root crop, maintaining high root yield requires knowledge of the optimal fertilizer requirement, especially, when production soil type is characterized by gravels indicating low moisture retention ability. Reduction in the loading of galvanized soil with inorganic fertilizer is crucial in enhancing soil moisture retention and growing healthy food crops with minimal chemical residue. This study was conducted at Landmark University during growing season of 2015 and 2016 to assess the differential response of three carrot genotypes to different levels of organic and inorganic fertilizer application in Southern Savanna Zone. The experiments were conducted using a randomized complete block design with three replications. Data collected on leave number, fresh leave weight, plant height and fresh root weight were subjected to analysis of variance. Difference between means were partitioned using duncan multiple range test at 5% probability level (p = 0.05). The study revealed that at application of 1 t/ha of organic fertilizer, the three carrot genotypes responded differently and significantly for fresh root yield. At all levels of both organic and inorganic fertilizer applications, the three carrot genotypes responded differentially for root yield either significant or non-significant at different levels of fertilizer application. This study identified that growing ibaka oma and ohama oma carrot genotypes under the organic manure regime (1 and 2 t/ha) highest root yields of 40.87, 41.48 and 41.58 t/ha. These identified genotypes can be grown organically for health benefits in guinea savanna ecology.

Key words: Carrot, genotypes, organic manure, gravanized soil, fertilizer, health benefits

INTRODUCTION

Guinea savanna ecology, especially, the Northern guinea zone is characterized by lateritic soil texture which are loaded with gravels. This soil texture do not retain sufficient soil moisture to support optimal crop performance. Carrot (*Daucas carota* L.) root production in low soil moisture retention environment poses a challenge for underground rooting. Application of organic fertilizer plays a fundamental role in creating water retention sites within the soil. In addition, inorganic manure supports leafiness for photosynthetic activities. A combination of both organic and inorganic fertilizer is expected to improve the water retention ability as well as enhance both vegetative and root growth for maximum yield.

Carrot is one the major vegetables cultivated world- wide under humus and sandy loamy soil. The two cultivated types of carrot are Eastern (Asiatic) and Western carrots (Martin *et al*., 2004). Carrot is a member of the Umbelliferae family. Carrot is one of the most popular and ancient vegetable crops in the world with myriad of medicinal purposes including stomach ulcers, abscesses, bladder, liver and kidney problems to aid in childbirth and even as aphrodisiacs.

It is a biennial plant but grown as annual which has a hollow, erect, very short stem and quadripinnate leaves which can grow up to 30 cm in length. Carrot has a main tap-root which becomes tuberous with absorbent hairs but without secondary roots. The roots may grow up to 20cm in length and attain a diameter of 3-4 cm. It is made up of a central cylinder (core) which is more or less fibrous and an external part (cortex) which is tender and of a deeper colour than the inner core (De Lannoy, 2001). Carrots are relatively tolerant of a wide variety of temperatures but prefer cooler agro-climatic conditions where temperature varies between 15.6 and 21.1°C during growth period (Rubatzky *et al*., 1999). High temperature favors increased shoot growth at the expense of root growth. However, when air temperature rises above 28°C, top growth is reduced and roots may become stronger in flavor (Nonnecke, 1989).

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Hot, sunny days can injure or kill young plants. Long periods of hot weather may depress carrot yields, cause bitter taste in roots and result to short and blunt roots.

Muck soils or loose, friable sandy loam soils are ideal for carrot production. Although, heavier soils are not ideal, carrots can successfully be grown on heavy-textured soils under soil amelioration measures and irrigated conditions. Short, blunt types are often grown on heavier soils. Sandy loam soils allow proper growth and development of a long, smooth, straight root. Soils with excessive stones, pebbles and debris can cause forked or misshapen roots. Soils should also be well drained as carrots will not perform well under water-logged conditions. Sites should be selected that have loose, friable soils to a depth of 30-35 cm without pebbles. Deep sandy soils can also be used, although, they may require more frequent irrigation.

Carrot is among the profitable vegetable product to promote due to its high nutritional value. However, its productivity is reduced slowly due to poor soil condition and lack of sufficient manure, poor agronomic practices, diseases and attack of some insects (Rhoda, 2008). Carrot has relatively high demand for soil nutrients, especially, potassium and nitrogen (Bendel *et al*., 1992) the increased production in Nigeria has become feasible by the application of sufficient plant nutrients to depleted soils to improve soil fertility.

Both organic and inorganic fertilizers play major contributory roles on the growth and yield of carrot. Indiscriminate use of inorganic fertilizer changes physical, chemical and biological properties of soil and can cause health hazards due to the toxic residual effects. However, organic fertilizer improves soil structures, stimulates soil biological activity and enhance the solubility of phosphorus applied as fertilizer in the soil (Stevenson and Ardakani, 1972). However, the main constraint in using organic fertilizer in most part of the world is the determination of appropriate rate for a specific variety of crop, so that, it remains with acceptable yield quantity and quality (Allemann and Young, 2001).

The purpose of this study, therefore were to compare the differential response of three carrot genotypes to organic and inorganic sources of manure. Determine appropriate rate of organic manure for each of the tested carrot genotypes for high yield performance.

MATERIALS AND METHODS

The field experiment was conducted at the Teaching and Research Farm of Landmark University during the period of 2015 and 2016 at Omu-Aran, Kwara State (Latitude 8° 9° 0" N and Longitude 5° 61° 0" E) located at the Southern Guinea Savannah Zone of Nigeria. The area has maximum temperature of 36-330°C and the minimum temperature of 28-220°C. The humidity of the area is high (47-43%) all year round except in January when the dry wind blows from the North. It has an annual rainfall pattern which extends between the months of April and October with average annual rainfall of between 600 and 1500 mm. The peak rainfall is in May to June and September to October while the dry season is between November and March. This study was conducted at Landmark University during the period of 2015 and 2016 to assess the differential response of three carrot genotypes to different levels of organic and inorganic fertilizer application in Southern Savanna Zone.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each plot was three rows, 2 m long, 50 cm between and within row spacing, respectively. There were total of 18 plots all together where organic manure were randomly allotted. The application of manure were carried 2 weeks before the carrot seedlings were transplanted. Soil analysis were carried out before manure application and transplanting to determine the inherent soil fertility status.

The following varieties of carrot were used for the study; Alheri noma, Albaka noma and Rahama noma. The treatment combination used for the inorganic fertilizer application includes Alheri noma +0 kg/ha of NPK 15:15:15 fertilizer (T1), Albaka noma +0 kg/ha of inorganic fertilizer (T2), Rahama noma +0 kg/ha of NPK 15:15:15 fertilizer (T3), Alheri noma +35.8 kg/ha of NPK 15:15:15 NPK 15:15:15 (T4), Albaka noma +35.8 kg/ha of NPK 15:15:15 fertilizer (T5), Rahama noma +35.8 kg/ha of NPK 15:15:15 fertilizer (T6), Alheri noma +71.6 kg/ha of NPK 15:15:15 fertilizer (T7), Albaka noma +71.6 kg/ha of NPK 15:15:15 fertilizer (T8), Rahama noma +71.6 kg/ha of NPK 15:15:15 fertilizer (T9). While those for organic treatment combinations were as follow; Alheri noma +0 kg/ha of poultry manure (T1), Albaka noma +0 kg/ha of poultry manure (T2), Rahama noma +0 kg/ha of poultry manure (T3), Alheri noma +1 t/ha of poultry manure (T4), Albaka noma +1 t/ha of poultry manure (T5), Rahama noma +1 t/ha of poultry manure (T6), Alheri noma +2 t/ha of poultry manure (T7), Albaka noma +2 t/ha of poultry manure (T8), Rahama noma +2 t/ha of poultry manure (T9).

Cultural practices: These are the following activities that took place for both the inorganic and organic manure experimentation on the field.

Carrots seeds were nursed in the nursery 4 weeks before transplanting them to main the site. Poultry manure were applied 2 weeks before the carrot seedlings were transplanted. Hand weeding were carried out regularly. The field were irrigated twice daily till maturity period.

Data were carried out on

Plant height: The height of the plants per plot were measured in centimetre at 50, 70 and 90 days after transplanting using meter rule from ground level to the tip of the highest growing point and the means were recorded.

Number of leaves: Ten randomly selected carrot plants per each experimental plot were taken for leave count at 50, 70, 90 days after transplanting. The average number of leaves counted were recorded.

Fresh root weight: Immediately after harvest, the total carrots roots obtained from each treatment plot were taken and their fresh weight were measured with the help of a beam balance.

Fresh leaf weight: After harvest, leaves were detached manually with hands and fresh weight was measure and average weight was measured per plant.

Proximate analysis of carrot roots: Proximate analysis of the roots of carrots were carried out at the central Laboratory of Landmark University, Omuaran, Nigeria. Samples of the carrot roots were oven dried, grinded and analyzed for nutritional component under the pattern D analyzer.

Data analysis: Data collected were subjected to Analysis of Variance (ANOVA) using SAS, 2000, the significant treatment means were compared using Duncan Multiple Range Test (DMRT) at 0.05 level of probability.

RESULTS AND DISCUSSION

The pre-planting soil analysis is as shown in Table 1. The pH of the soil was slightly acidic, the nitrogen content of the soil was very low, the available phosphorus was high and the exchangeable K was at moderate while the exchangeable Na, Ca and Mg are all suitable. The organic carbon and organic matter are adequate. The soil is highly sandy with relatively low values of both silt and clay, hence, the textural class is sandy loam.

Table 2 showed the mean fresh leave weight per plant of three varieties of carrot under two levels of organic and inorganic fertilizer and control. All the three carrot varieties Alheri noma, Rahama noma and Albaka noma significantly responded differentially to the two levels of inorganic manure and the control (35.80, 71.60 and 0 kg/ha) of NPK 15:15:15, respectively for fresh leave weight per plant. However, highest fresh leave weight per plant was obtained by variety Albaka noma under the application of 71.60 kg/ha of NPK 15:15:15. Similarly, under the organic manure application regimes, the three carrots varieties responded significantly and differentially for fresh leave weight at application of 1 t/ha of poultry manure. The same variety produce the highest leave weight per plant (Albaka noma) under the application of both inorganic and organic fertilizer application. This is an indication that different carrot varieties behave differently at different level of fertilizer application in relation to vegetative growth. Across the three carrot varieties, doubling of both organic and inorganic manure application did not proportionally increase the leave

Table 1: Soil physical and chemical properties prior to planting (0-15 cm)

Parameters	Values
Particle size	
Sand (%)	76.12
Silt (%)	12
Clay (%)	11.88
Textural class	Lateritic
pH (H_2O) 1:1	5.25
Total nitrogen (%)	0.16
Organic carbon (%)	1.88
Organic matter (%)	3.24
Exchangeable bases	
K (cmol/kg)	0.23
Na (cmol/kg)	0.66
Ca (cmol/kg)	3.97
Mg (cmol/kg)	1.32
$Al^{+}H$ (cmol/kg)	0.07
ECEC (cmol/kg)	6.25
Available phosphorus (mg/kg)	21.12

Table 2: Mean fresh leave weight of three varieties of carrot under two levels of organic and inorganic fertilizer and control

	Varieties of carrot		
Treatments	Alheri noma (g/plant)	Albaka noma (g/plant)	Rahama noma (g/plant)
Inorganic/level of application (kg/ha)			
0.00	43.02^{c}	44.45^{c}	42.04^{c}
35.80	51.58^{ab}	59.04^{ab}	55.73^{ab}
71.60	59.47^{a}	63.96^{a}	57.30^{a}
Organic manure/level of application (t/ha)			
0.00	43.44^{c}	45.73^{c}	43.23^{c}
1.00	54.56^{ab}	60.32^{a}	55.54^{ab}
2.00	60.43^{a}	62.01^{a}	59.34^{a}

$^{a-c}$Means followed with the same letter (s) within a column are not significantly different according to Duncan's multiple range test

Table 3: Mean leave number of three varieties of carrot per plant under two levels of organic and inorganic fertilizer application and the control

	Varieties of carrot		
Treatments	Alheri noma (no)	Albaka noma (no)	Rahama noma (no)
Inorganic/level of application (kg/ha)			
0.00	11.76^{ab}	11.33^{ab}	10.90^{a}
35.80	12.23^{ab}	12.30^{ab}	13.76^{ab}
71.60	15.22^{a}	14.80^{ab}	15.90^{a}
Organic manure/level of application (t/ha)			
0.00	11.33^{ab}	10.58^{b}	11.49^{ab}
1.00	17.82^{a}	16.23^{a}	18.70^{a}
2.00	16.65^{a}	16.33^{a}	15.54^{a}

$^{a, b}$Means followed by the same letter (s) within a column are not significantly different according to Duncan's multiple range test

Table 4: Mean plant height of three varieties of carrot under two levels of organic and inorganic fertilizer application and the control

	Varieties of carrot		
Treatments	Alheri noma (cm)	Albaka noma (cm)	Rahama noma (cm)
Inorganic/level of application (kg/ha)			
0.00	35.63^{a}	36.58^{a}	34.36^{c}
35.80	43.30^{ab}	41.83^{ab}	44.90^{ab}
71.60	54.05^{a}	52.25^{a}	50.03^{a}
Organic manure/level of application (t/ha)			
0.00	37.35^{a}	36.52^{b}	36.33^{b}
1.00	45.23^{ab}	47.51^{ab}	48.23^{a}
2.00	52.23^{a}	51.78^{a}	51.55^{a}

$^{a, b}$Means followed by the same letter (s) within a column are not significantly different according to Duncan's multiple range test

weight. This study revealed that the additional application of both organic and inorganic may not proportionally increase the vegetative parts.

Comparatively, average leaf numbers counted on carrot plants under the application 71.60 kg/ha of NPK 15:15:15 was significantly ($p<0.05$) higher than control for variety Alheri noma (Table 3). However, the were no significant differential response for variety Albaka noma under the two levels of inorganic fertilizer application and the control. The mean number of leaves counted on carrot plants under application of 1 and 2 t/ha organic fertilizer were significantly higher than control for the three varieties of the carrots. However, there were non-significant differential response by the three carrots varieties to the two levels of Organic fertilizer application and the control, however, numerically, there were differential response to the application of both Inorganic and organic manure by the three carrot varieties. Higher and significant number of leave counts were recorded by the three carrots varieties under the two levels of organic fertilizer application and the control compare to inorganic manure application. The number of the leaves of the three varieties of carrot increased differentially with increase in both organic and inorganic fertilizer application (IFA., 2005).

Mazed *et al.* (2015) also observed that the application of these fertilizers had significant effect on leaf numbers of the plants when compared with the control treatments. The researcher further explained that the increase in vegetative carrot plant could attributed to the effect of high nitrogen supply which promotes vegetative growth.

The three carrot varieties did not significantly respond differentially to the two different levels of inorganic fertilizer application for plant height (Table 4). However, numerically but not significantly, higher plant height were differentially obtained by the three carrot varieties under the two levels of organic manure application. All the three varieties of carrot recorded differential increase in plant height with increase in organic manure application per hectare. There were continuous increase in plant height among the three carrot varieties with increase in organic manure application per hectare. Mazed *et al.* (2015) also observed that carrot plant height was significantly influenced by the effect of organic manure application. This could be due to the improvement in soil structure and enhanced nutrient and moisture availability and uptake that may have favored plant growth due to application of organic fertilizer. The three carrot varieties also significantly responded differently to organic manure application at the two levels of treatments and the control.

All the three carrots varieties responded differentially to both organic and inorganic manure application for root yields (Table 5). Highest root yield (39.35 kg/ha) was recorded by variety Albaka noma at application of 71.60 kg/ha of NPK 15:15:15 while variety Alheri noma ranked second with 39.08 kg/ha root yield under the same application regime. Carrot root yield increased among three carrot varieties by increasing the NPK application from 0-71.60 kg/ha. This is an indication that the three carrot varieties responded to increase in fertilizer application. Moreover, under the application of organic

Table 5: Mean fresh root weight of three varieties of carrot under two levels of organic and inorganic fertilizer application and the control (2015 and 2016)

	Varieties of carrot		
Treatments	Alheri noma (t/ha)	Albaka noma (t/ha)	Rahama noma (t/ha)
Inorganic/level of application (kg/ha)			
0.00	32.50^{b}	31.40^{b}	30.70^{b}
35.80	33.80^{b}	36.48^{ab}	33.34^{b}
71.60	39.08^{a}	39.35^{a}	38.74^{a}
Organic manure/level of application (t/ha)			
0.00	32.30^{b}	31.90^{b}	31.90^{a}
1.00	35.68^{ab}	38.66^{a}	41.58^{ab}
2.00	38.98^{a}	41.48^{a}	40.87^{a}

$^{a, b}$Means followed by the same letter (s) within a column are not significantly different according to Duncan's multiple range test

Manure, the three carrot varieties responded differential and significantly to different levels of organic manure application. It was also, observed that increase in application of the organic manure resulted to increase in root yield per hectare among the three carrots varieties. Contrary to what was observed under inorganic fertilizer regime, highest root yield per hectare was obtained by variety Rahama noma at application of 1t/ha of organic fertilizer while the variety Albaka noma that ranked first under inorganic fertilization regime now ranked second under organic manure application. This is an indication that carrot respond differently to organic and inorganic manure application. The study also revealed that different carrot varieties will perform differently at different levels of both organic and inorganic fertilizer application. However, among the three carrot varieties tested, doubling of both organic and inorganic manure application did not result to proportional increase in carrot root yield. This is an indication that continuous application of fertilizer with attain a particular level when the additional application may not proportionally increase carrot root yield. Similarly, observation was made by Hailu *et al*. (2008) that further increase in the fertilizer application of urea fertilizer above certain level decreased root yield rather than enhancing it.

The right diagonal showed the association between carrot root weight and other agronomic traits under inorganic fertilizer application while the left diagonal present relationship between root yield and other characters under organic fertilizer application.

The correlation between root weight and leave weight was high and significant under organic manure regime, however, under inorganic manure regime, highest and significant correlation was recorded between root weight and root number (Table 6). The association between other traits and root weight under organic and inorganic manure application were high but not significant. There is an indication that organic manure appeared to favor increase in leave weight which also corresponded to high carrot root yield. However, increase in the number of leaves per plant were favored by the application of inorganic manure which also corresponded to an increase in carrot root yield. It is an indication that increase in leaves has increased the photosynthetic rate which has also be partitioned to carrot formation. Similarly, Hailu *et al*. (2008) reported that the root weight augmentation could be due to the increased in vegetative growth and hence, increased food production and assimilation in to parts. Plant height has also contributed, though not significant, to carrot root yield under both organic and inorganic environment.

Table 6: Correlation between carrot root weight and other agronomic characteristics under organic and inorganic manure regime

Characteristics	RW	PLH	LN	LW
RW		0.997	0.999*	0.935
PLH	0.993		992	961
LN	0.992	0.863		917
LW	1.00*	0.995	0.909	

*, ** Significant at $p<0.05$ or 0.01, respectively; RW, Root Weight; PLH, Plant Height; LN, Leave Number; LW, Fresh Leave Weight

CONCLUSION

From this study, it is apparent that the recommendation of fertilizer for optimum yield of carrot root should not be limited to crop per se. but on the varietal bases. It also evidence from this that further application of fertilizer above certain level or recommended level may not proportional increase the yield or may even lead to a reduction in carrot root yield. Moreover, variety Albaka and variety Rahama recorded the highest carrot root weight under inorganic and organic manure, respectively, among the three varieties tested.

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