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TITHONIA MANURE IMPROVES CARROT YIELD AND QUALITY

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ABSTRACT

A study on the effect of decomposed tithonia manure on growth, yield and quality of Carrot (*Daucus carota* L.*)* was undertaken in the Horticulture, Research and Teaching field, Egerton University for two seasons. The field experiment was laid out in a Randomized Complete Block design (RCBD), with 3 replications. The treatments consisted of four levels of decomposed tithonia manure (0, 1.5, 3.0 and 4.5 t/ha). Data was subjected to Analysis of Variance (ANOVA) and significant treatment means separated using the Turkey's Honestly Significant Difference Test at $P \leq 0.05$. Application of *Tithonia diversifolia* manure resulted in increase in total fresh root weight, dry root and shoots biomass and root volume compared to the control. Total yield of carrots subjected to 3.0 t/ha increased by 33% and 18% in season 1 and 2 respectively compared to control. The sweetness of carrot was influenced at the highest level of tithonia.

Key words: Nutrient, Carrot yield, quality, brix content, biomass.

INTRODUCTION

Carrot (*Daucus carota* L.*)* is a cool season crop and belongs to Apiaceae family. It is one of the most important crops cultivated throughout the world for its edible roots. Carrot is an excellent source of carotene a precursor of vitamin A and fibre in the diet (Handelman, 2001). It also contains abundant amounts of nutrients such as protein, carbohydrates, fibre and sodium (Ahmad *et al.*, 2004). Carrot fleshy roots are used as vegetables for salads, soups and are also steamed or boiled in other vegetable dishes (Anjum and Amjad, 2002). Besides food value different parts of carrot can be used for different medicinal purposes due to a wide range of reported pharmacological effects (Pant and Manandhar, 2007; Rossi *et al*., 2007; Tavares *et al*., 2008).

Although carrot has been widely cultivated in most developing countries since long, its production is still below the recommended world average. The main reason for low yields is lack of proper knowledge on new production methods. Generally, most carrot growers use inorganic fertilizers to realize higher yields (Dauda *et al*., 2008). The use of inorganic fertilizers as a source of nutrient has however, been associated with human health problems and environment degradation (Arisha and Bardisi, 1999). In addition, the rising costs of inorganic fertilizers have made them too expensive to most resource-poor small scale growers.

Manures and composts can provide significant quantity of nutrients and have a constant effect on the soil for a long time. Eghball et al., 2004 documented increased corn yield and improved soil properties for several years after application of compost and manures. Organic manure and compost increases soil organic carbon (Akanbi *et al.*, 2007) improves soil moisture (Adeleye *et al.,* 2010) and soil N, P, K, Mg and Ca (Olubukola *et al*., 2010).

Tithonia diversifolia green biomass is an effective source of nutrients and has been used successfully to improve soil fertility and crop yields in Kenya (Jama *et al*., 2000). Aguyoh *et al.*, (2010) reported a significant and positively correlated increase in total yield of watermelon with increasing application rates of *T. diversifolia* manure. In this study, tithonia application enhanced the total yield of watermelon by between 8.5% and 31% compared to the control. Similarly, Gachengo (1996) and Sangakkara *et al*., (2004) demonstrated increased maize yield following incorporation of fresh tithonia biomass.

Tithonia accumulates large amounts of nitrogen and phosphorus from the soil and when cut and incorporated into the soil, it releases nearly all its nitrogen to the soil very quickly, even though its not a legume (Gachengo, 1999). This makes it an important source of nutrients and organic matter for soil rejuvenation (Jama *et al*., 2000). Little has been done on the use of decomposed tithonia manure on carrot production. This study therefore aimed at investigating the potential use of decomposed tithonia manure to enhance carrot productivity.

MATERIALS AND METHODS

Study Site

The present research was conducted at Horticulture, Research and Teaching Field, Egerton University, Njoro. The farm lies at a latitude of 0° 23' South, longitudes 35° 35' East and 2,238 meters above sea level in agro ecological zone Lower Highland 3 (Jaetzold and Schmidt, 1983). The amount of rainfall received at the experimental site was 228.4mm during the first growing season (Oct-Jan 2010 to 2011) and 328.8mm during the second growing season (Feb to May 2011) with mean temperatures of 21.3°C in season 1 and 19.3°C in season 2. The soils at the site are classified as vitric mollic Andosols (Kinyanjui, 1979).

Compost Manure Preparation

Plastic barrel measuring 2.5 m diameter and 3 m long with 9 holes perforated at intervals of 30 cm apart on the bottom sides was used for composting. Aeration was provided passively through open-ended air intake plastic pipes (5.0cm in diameter) inserted into the holes through which fresh air flowed. Another plastic pipe was inserted vertically, half way into the plastic barrel to enable warm air generated through biological oxidation to escape. *Tithonia diversifolia* fresh biomass was moistened and placed into the plastic barrel and complete decomposition was ascertained when temperature stabilized.

Soil and Manure Analysis

Soil was sampled from the top 0-15 cm of the soil profile following a zigzag sampling design at various points across the entire experimental field using a soil auger, after which a composite sample was derived for the initial soil chemical analysis. Another set of soil samples were taken from each plot at the end of each planting season. The soil and manure samples were air-dried, sieved and chemically analysed. The soil pH was determined using pH meter (Fisher Accument ®) in a 1:2 soil-water ratio. Organic carbon content was determined by Walkley-Black dichromate oxidation method. Total N was determined by the Kjeldah method as described by Okalebo *et al.* (2002). Available P was extracted by the Bray-1 method and determined calorimetrically. Available potassium from soil and manure were determined by use of an Atomic Absorption Spectrophotometer (AAS) as described by Okalebo *et al.* (2002). Soil analysis was conducted at Egerton University and Kenya Agricultural research Institute (KARI) Njoro Soil Analysis Laboratories.

Design and Treatment Application

The experiment was set in a Randomized Complete Block design (RCBD), with three replications. Treatment comprised four levels of decomposed *Tithonia diversifolia* (0, 1.5, 3.0 and 4.5 t/ha). These rates were attained after putting into consideration the recommended nitrogen rate for carrots of 75 kg N/ha, initial soil chemical analysis (0.23% N) and chemical composition of decomposed tithonia manure (2.50% N).

Land Preparation and Planting

Land preparation was done one month before sowing by clearing the weeds followed by ploughing to a depth of 30 cm. The field was harrowed to create a fine tilth and raised beds measuring 1.5 m by 1 m and 15cm high were prepared. Decomposed tithonia manure (0, 0.56, 1.12 and 1.68 kg/plot) were spread on each plot before being worked in/incorporated thoroughly into the soil. The soil was then moistened to field capacity. Leveling was done using a rake. Carrot seeds sourced from Kenya seed company suppliers, were then drilled to a depth of 1 cm in rows spaced at 20 cm apart. Thinning was done two weeks after the emergence of the crop to attain recommended spacing of 5 cm between the plants (Sarkindiya and Yakubu, 2006), giving a total of 78 plants per plot.

Crop Maintenance in the Field

Water was continuously applied to field capacity during the growth period on need basis. Continuous weeding by hand pulling was performed to ensure clean fields. Pests and diseases were controlled using recommended chemicals. Earthing up of carrot shoulders was done frequently to prevent them from direct sunlight which causes undesirable green colouration.

Data Collection

Growth Parameters

Height of five carrot plants was measured using a ruler from the ground level to the top of the shoot fortnightly from the time of final thinning and recorded in centimeters. The numbers of fully expanded leaves of carrots were also counted on similar plants where plant height was collected.

Biomass Variables

Five carrot plants were randomly selected after harvest from each plot to determine total biomass. This was done by detaching the harvested plants shoots from the roots and oven drying them separately at 70°C to constant weights. Thereafter, the roots and shoots were weighed using an electronic balance (CTG.1.2S, India Mart Inter Mesh limited) and readings recorded in grams per plant (g/plant).

Yield Variables

Twenty carrot roots obtained from each treatment plot were taken and their fresh weight was measured using a weighing scale balance (NSR-Zhongshan Camry Electronic Limited). Obtained weights were recorded in kg/plot and later converted to ton/hectare. A sample of five carrot roots randomly selected from the samples of twenty carrot roots used to determine fresh weight were used to obtain root volume. The root volume was determined using water displacement method and the volume recorded in cm^3.

Quality Variables

Quality parameters considered in this study were root length, shoulder and core diameter and total soluble solids (ºBrix). Five carrot roots were picked at random per plot after harvest and their root length was determined using a ruler starting from the shoulder to the end of the root tip. The shoulder and core diameter of carrot roots were also measured at 0.5 cm from the top of the shoulder using a vernier caliper and a ruler, respectively and measurements recorded in centimeters. Total soluble solids were measured using a hand-held refractometer (0-30 % Brix) from similar five carrot roots from each plot used to measure other quality parameters and values obtained were recorded in percent.

Data Analysis

The data obtained were subjected to Analysis of Variance (ANOVA) using Proc GLM code of SAS (SAS Institute, 2002) and significant treatment means separated using the Tukey's Honestly Significant Difference Test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Soil and Manure Analysis

Soil properties at the top 15 cm of soil done before the start of the experiment were: pH = 5.68, total organic carbon = 1.73%, total N = 0.23%, available P = 0.16% and exchangeable K= 0.10%. Chemical composition of decomposed tithonia manure was pH of 7.89, organic carbon of 29.44%, total N of 2.50%, total P of 0.32% and total K of 3.2%.

Growth Parameters

In response to manure levels, a general trend of increase in growth parameters with successive increase in tithonia manure application was observed (Figure 1). Except for plant height in season 2 that was not influenced by tithonia application, plant height and leaf numbers were significantly higher for plants treated with 4.5 t/ha of tithonia over the control treatment in this study period (Figure 1). Plants treated with 1.5 and 3.0 t/ha of tithonia also tended to be taller than control plants, although the difference was not significant.

Taller plants and more leaf numbers recorded in the current study as a result of tithonia manure application could be ascribed to enhanced levels of major nutrients (NPK) in tithonia manure as revealed by improved nutrient levels in the soil at the end of each growing season. The ability of organic manures to supply the essential plant nutrients, improve soil structure and water holding capacity, increase microbial population has also been shown to promote plant growth (Dauda *et al*., 2008). Similar to the findings of this study, Liasu *et al.*, (2008) observed increased okra plant height in soils supplemented with fortified tithonia mulch which they attributed to improved soil conditions through replenishment of soil nutrients. Mbatha (2008) similarly observed increased plant height and leaf numbers of carrot subjected to higher rates of different organic fertilizers (chicken, kraal and compost) which she attributed to enhanced nutrients availability, moisture retention and uptake as a result of manure application.

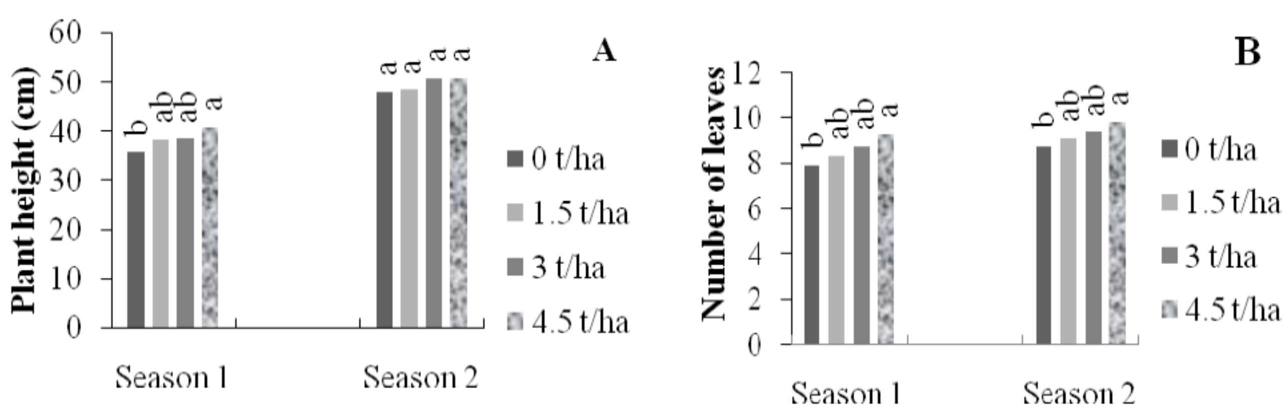

Figure 1. Influence of tithonia manure levels on plant height (A) and leaf numbers (B) of carrot

Biomass and Yield Parameters

Yield and yield components of carrot plants were generally influenced by tithonia manure levels in both seasons (Table 1). Higher shoot dry biomass was recorded for plants treated with tithonia compared to control plants although the difference was significant only in season 2. An increase of 12.04% and 24.09% of shoot dry biomass was registered in season 1 and 2, respectively following application of the highest level (4.5 t/ha) of tithonia compared to the control treatment.

Root dry biomass of plants treated with 3.0 t/ha and 4.5 t/ha tended to be higher compared to control plants in season 1, resulting in a 16.5% and 14.7% increase. In season 2, 4.5 t/ha of tithonia produced highest root dry biomass, registering a 16.3% increase compared to control plants. Similar to other yield components, root volume was also influenced by tithonia manure levels. Subjecting plants to 3.0 t/ha of tithonia resulted in 14.6% increase in root volume than control in season 1. In season 2, plants that received higher levels (3.0 t/ha and 4.5 t/ha) of tithonia manure had more root volume by 10.80% and 11.90% than control plants

A general tendency of increase in total root yield with successive increase in tithonia application was observed during this study period. In both seasons, the highest yield of carrot was obtained from plants treated with 3.0 t/ha and 4.5 t/ha of tithonia while the lowest yields was recorded in control treatments. Subjecting plants to 3.0 t/ha and 4.5 t/ha of tithonia increased carrot yields by 32.6% and 31.7% in season 1 and by 18.1% and 19.9% in season 2, respectively compared to control plants. Plants treated with 1.5 t/ha of tithonia yielded more than control, although the difference was not significant.

The observed increase in biomass and yield of carrot with subsequent increase in tithonia manure level could be attributed to increased nitrogen, phosphorous and potassium in tithonia manure which was later reflected in the growing medium at the end of each growing season. This findings are in agreement with those of Aguyoh *et al.*, (2010) who reported a significant and positively correlated increase in total yield of watermelon with increasing application rates of *Tithonia diversifolia* manure with yields enhanced by between 8.5% and 31% in plants subjected to the highest level (5.4 t/ha) of tithonia compared to the control. Similar trends in yield increase with increase in manure application have been reported with carrots (Mbatha, 2008) and maize (Sangakkara *et al*., 2004). Apart from increased nutrient supply, the higher root volume, fresh yield and dry biomass recorded for carrot plots treated with tithonia could also be attributed to the effect of organic manures on soil conditions. According to Adeleye *et al.*, (2010) organic manures provide more conducive soil conditions which enhance root expansion and development.

Table 1. Yield components and yield of carrot as influenced by tithonia manure levels

Tithonia (t/ha)	Shoot dry biomass (t/ha)	Root dry Biomass (t/ha)	Root volume (cm^3)	Total yield (t/ha)
Season 1				
0.0	1.66a*	4.90b	63.04c	33.42b
1.5	1.70a	5.33ab	68.77bc	41.64ab
3.0	1.71a	5.71a	72.27a	44.32a
4.5	1.86a	5.62a	68.62ab	44.07a
Season 2				
0.0	3.03b	5.47b	70.62b	52.34b
1.5	3.03b	5.58ab	72.70ab	59.42ab
3.0	3.31ab	5.98ab	78.25a	61.77a
4.5	3.76a	6.36a	79.05a	62.75a

*Means within a column and a season followed by the same letter are not significantly different according to Tukey Honestly Significantly Difference Test at ($P \leq 0.05$).

Quality Attributes

Apart from shoulder diameter which was not influenced in both seasons and core diameter in season 1 by tithonia manure application. All other quality parameters measured were affected during the study period (Table 2). Application of tithonia manure at 3.0 t/ha and 4.5 t/ha resulted in a 19.5% and 11.5% increase in root length compared to the control in season 1 and 2 respectively. The largest core diameter was recorded in plants treated with highest level (4.5 t/ha) of tithonia, although the difference was not significant with other levels in season 1. However, in season 2, 4.5 t/ha of tithonia resulted in 22.1% increase in core diameter compared to the control treatment. The observed effect of tithonia manure on root length, shoulder and core diameter attribute to the effect of manures in increasing water holding capacity, reduction of soil bulk density, hence, better root growth and expansion. Similar findings have been reported by Sangakkara with maize using tithonia manure, Maerere et al., 2001 with amaranthus using poultry manure and Mbatha 2008 with carrots using different organic fertilizers (kraal, chicken and compost).

Tithonia manure applied at 4.5 t/ha resulted in increased total soluble solids of carrot roots with the highest total soluble solids of 12.73 and 11.56 observed in season 1 and 2 respectively compared to control. The enhanced total soluble solids observed following application of higher levels of tithonia in this study could be attributed to the better levels of macronutrients and micronutrients in manures required for growth and quality. Potassium which is the key element in influencing quality of fruits and vegetables might have enhanced carrot total soluble solids. Aguyoh *et al.,* (2010) observed an increase in total soluble solids content of watermelon supplied with higher levels of tithonia manure and Ahmad *et al.,* (2005) also reported positive effect of farmyard manure on total soluble solids content of carrots compared to the control.

Table 2. Influence of tithonia manure levels on quality attributes of carrot

Tithonia (t/ha)	Root length (cm)	Shoulder diameter (cm)	Core diameter (cm)	Total soluble Solids (%)
Season 1				
0.0	16.49b	2.30a	1.13a	11.23b
1.5	17.86ab	2.35a	1.09a	12.00ab
3.0	19.70a	2.34a	1.09a	12.70a
4.5	18.11ab	2.34a	1.17a	12.73a
Season 2				
0.0	19.02b	2.73a	1.36c	10.37b
1.5	20.41ab	2.80a	1.42b	10.78ab
3.0	20.75ab	2.95a	1.49ab	10.96ab
4.5	21.22a	2.99a	1.66a	11.56a

*Means within a column and a season followed by the same letter are not significantly different according to Tukey Honestly Significantly Difference Test at ($P \leq 0.05$).

Selected Soil Nutrients Properties

Apart from soil phosphorous that was not significantly affected by the different levels of tithonia manure application in seasons, soil nitrogen and potassium were influenced. The highest level (4.5 t/ha) of tithonia manure led to better retention of nitrogen, phosphorous and potassium by 25.8%, 35.5% and 9.0% in season 1 and by 55.6%, 30.3% and 4.5% and in season 2, respectively. Although plots subjected to 1.5 t/ha of tithonia retained more nutrients than control plots, the difference was not significant with most of the nutrients tested in both seasons. Control plots generally retained the lowest nutrients in both seasons. The better retention of macronutrients could be attributed to the ability of tithonia manure to supply humus to the soil thereby enhancing the water holding capacity and nutrient retention in the soil. In line with these findings, Olubukola et al., (2010) reported that use of tithonia as soil amendment for growth of Celosia argentea led to the retention of more N, P, K, Mg and Ca compared to the control. Similar results were also reported by Adeleye et al., (2010) on soils treated with poultry manure.

Table 3. Selected soil nutrients properties as influenced by tithonia manure levels

Tithonia (t/ha)	Nitrogen (%)	Phosphorous (%)	Potassium (%)
Season 1			
0.0	0.310c	0.0031	0.0131c
1.5	0.341bc	0.0034	0.0137bc
3.0	0.361ab	0.0045	0.0138b
4.5	0.392a	0.0042	0.0144a
Season 2			
0.0	0.361c	0.0033	0.0133b
1.5	0.431bc	0.0041	0.0136ab
3.0	0.412b	0.0034	0.0139a
4.5	0.563a	0.0043	0.0139a

*Means within a column and a season followed by the same letter are not significantly different according to Tukey Honestly Significantly Difference Test at ($P \leq 0.05$).

CONCLUSION

Treating soils with tithonia manure improves the vegetative growth, fresh root yield and quality of carrots. The highest rate (4.5 t/ha) of tithonia manure showed to be the best in improving the vegetative growth, fresh root yield and quality of carrots.

RECOMMENDATION

Farmers are advised to use tithonia manure for enhanced yield and quality of carrots**.**

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