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Full Length Research Paper

Nutritional quality of carrot (*Daucus carota* L.) as influenced by farm yard manure

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An experiment was conducted at the University of Rwanda, college's farm located in Northern Rwanda in 2013. The main objective was to determine the effectiveness of farm yard manure on carrot nutritional quality. The experimental design applied was randomized complete block design (RCBD) with three replicates for each treatment. The treatments comprised five levels (0, 5, 10, 15 and 20 tha^{-1}) of decomposed farm yard manure. The quality parameters namely, ß-carotene, vitamin C and total soluble sugars were analyzed in harvested carrots for each treatment using standard methods. The results showed that farm yard manure had a positive effect on ß-carotene whereby the highest content of 11188 µg/100 g was recorded from the 20 tha^{-1} treatment, while the lowest content of 10287 µg/100 g was recorded from the carrots that did not receive any farm yard manure. The results on vitamin C showed that its content increased with the application rate of 20 tha^{-1} recording 7.980 g/100 g, while the lowest content was recorded in plots that did not receive any fertilization. However, FYM did not influence significantly total soluble sugars content in carrots whereby the highest TSS of 10.267% was obtained in plots without FYM, while the lowest TSS of 9.997% was obtained in carrots from the 20 tha^{-1} treatment. On the basis of the results of this study, a range of 15-20 tha^{-1} of FYM is therefore recommended because it improved the nutritional quality of carrots.

Key words: Carrot, nutritional quality, ß-carotene, vitamin C, total soluble sugars.

INTRODUCTION

Carrot (*Daucus carota* L.*)* is an essential root vegetable commonly used in the diet of human beings. It is greatly treasured as food mostly because it is the best source of carotene; a precursor of Vitamin A (Zeb and Mahmood, 2004). Beta carotene is one of hydrocarbon carotenoids while the oxygenated derivatives of these hydrocarbons are known as Xanthophylls. For many communities in developing countries, the major source of vitamin A in the diet is carotenoids especially Beta carotene (Britton, 1995).

Furthermore, carrot contains also abundant quantities of nutrients and minerals (Handelman, 2001; Nicolle et salads, steamed or boiled in vegetables and may also be prepared with other vegetables in the preparation of soups and stews (Anjum and Amjad, 2002). Carrot in combination with other vegetables can produce especially healthful, tasty and refreshing drinks.

Besides being food, different parts of carrot can be used for different medicinal purposes. Carrot roots are used as refrigerant and seeds as aromatic, stimulant and carminative. They are useful in the kidney diseases, in dropsy, nervine tonic, aphrodisiac and given in uterine pain.

Carrot increases the quantity of urine and large amount of carrot to the diet has a favorable effect on the nitrogen balance (Pant and Manandhar, 2007; Anjum and Amjad, 2002). Carrot production can be a favorite enterprise for most small scale, resource poor farmers, since carrot is a

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short duration crop and higher yields can be obtained per unit area, hence profitable (Ahmad et al., 2005).

In most developing countries, however, carrot yields per unit area still remain below the recommended world average. One of the reasons advanced for such low yields is low skills in technical methods of production (Muendo and Tschirley, 2004). In order to obtain high and quality yields of carrots, good soil fertility and constant growth is required to facilitate the production and translocation of carbohydrates from leaves to roots.

The key limiting factors in crop growth, development and yield are the essential nutrients (nitrogen, phosphorous and potassium) and water (Glass, 2003; Parry et al., 2005). In most cases, carrot growers use synthetic fertilizers as the major supply of nutrients in order to attain higher yields and growth (Stewart et al., 2005; Dauda et al., 2008).

The use of inorganic fertilizers has, however, been associated with human health problems and environment degradation (Arisha and Bardisi, 1999). Moreover, the increasing costs of inorganic fertilizers have rendered them unaffordable to most resource-poor small scale growers.

Organic manure can serve as a substitute to mineral fertilizers. Manures supply the required nutrients, improve soil structure, increase microbial population and at the same time maintain the quality of crop produce (Wong et al., 1999; Nehra et al., 2001; Suresh et al., 2004; Dauda et al., 2008).

Despite the large quantities of plant nutrients contained in inorganic fertilizers as compared to organic nutrients, the presence of growth promoting agents in organic fertilizers make them important for enhancement of soil fertility and productivity (Sanwal et al., 2007). Several authors have reported the importance of organic manure as a source of nutrients and a means of soil rejuvenation (Adeleye et al., 2010).

FYM, the residual generated through anaerobic decomposition of various organic materials is considered as a quality organic fertilizer (Islam, 2006). This residual manure is normally rich in macro and micro nutrients (Islam, 2006; Thu, 2007). The use of decomposed FYM in carrot production has not been tested in many carrot growing areas (Jepto et al., 2012).

Continuous cultivation of farms has led to decline in soil fertility due to constant removal of nutrients leading to reduction of carrot (*D. carota* L.) yields. Thus the mineral nutrients, especially nitrates, in fertilizers can cause problems for natural habitats and for human health if they are washed off soil into watercourses or leached through soil into groundwater (Stewart et al., 2005). Therefore, the ultimate test of the nutritional value of food depends on its ability to support health, growth, and reproduction over successive generations of animals or humans.

Win et al. (2008) and other authors reported that the use of chemical fertilizers is a critical factor limiting carrot production by poor farmers due to their high prices and generally farmers use their own animals by the application of organic manures. The problem that farmers are faced with, is to know how much organic fertilizer to apply for a specific crop so that it remains with acceptable yield quality (Oelhalf, 1978; Allemann and Young, 2001; Gontcharenko, 1994).

Therefore, a field study was carried out in ISAE farm (from January to May 2013) with the aim of evaluating the effects of decomposed cattle Farmyard manure on nutritional quality of carrot (*D. carota* L.).

The main objective of this study is to evaluate the effect of FYM on nutritional quality of carrots. The specific objectives are:

(i). To determine the effect of different FYM levels on ascorbic acid (vitamin C) content in carrots;
(ii). To determine the effect of different FYM levels on β carotene content in carrots;
(iii). To determine the effect of different FYM levels on total soluble sugars content in carrots.

The hypotheses of the study are:

(i). Vitamin C content obtained after fertilization of carrots with different FYM levels remains the same.
(ii). There is no significant difference in $\beta -$ carotene content of carrots fertilized with different levels of FYM.
(iii). There is no significant difference in TSS of carrots fertilized with different levels of FYM.

MATERIALS AND METHODS

Experimental site

The field in which the experiment was conducted is located at College of Agriculture, Animal Sciences and Veterinary Medicine farm located in Busogo Sector, Musanze District, Northern Province of Rwanda. The climate of the site is characterized by a drought season of 4 to 5 months and a long period of rain of 7 to 8 months. This region has a volcanic soil with a pH which varies from 5.1 to 5.3 and the rainfall that ranges between 1800 to 2000 mm. The relative humidity is 86% and the altitude of this region is 2200 m above sea level and the average temperature ranges between 16 and 17°C (Doyle, 2008).

Test plant

The carrot variety used in this study was Nantes, from Agrotech at Musanze, District.

Experimental design

The experimental design was RCBD with 3 replications. Treatments comprised five levels (0, 5, 10, 15 and 20 t/ha) of decomposed FYM. Each plot measured 1.5 m^2 and the required area was 73.5 m^2 which means that the total width was 7 m and length of 10.5 m.

Farm yard manure preparation

FYM from UR-CAVM animal farm was weighed by using a balance and then applied onto each plot at the required amount.

Land preparation and planting

Land was ploughed to a depth of 30 cm and prepared into fine soil particles using rakes. Raised beds of 1.5 m long, 1 m wide and 15 cm height were prepared. Decomposed farmyard manure (0, 5, 10, 15 and 20t/ha) were spread on each plot before being incorporated thoroughly into the soil. Carrot seeds sourced from Agrotech suppliers were then drilled to a depth of 1 cm in rows spaced at 20 cm apart. Thinning was done two weeks after emergence of the carrots to attain the recommended spacing of 8 cm between plants (Sarkindiya and Yakubu, 2006).

Routine plant maintenance practices

Cultural practices were applied uniformly to all the plots throughout the growing period. Continuous weeding by hand pulling was performed to ensure clean fields. We controlled *Alternalia* leaf blight using Dithane (mancozeb 75%). Earthing up of carrot shoulders was done frequently to protect them from direct sunlight which could cause undesirable green coloration.

Harvest and laboratory analysis of the carrots

Fifteen samples were collected after harvesting (105 days after sowing) with respect to treatments and replications. They were packaged in the envelopes and then stored in laboratory. Beta carotene, Ascorbic acid and TSS were analyzed in the following procedures (Kilyobo, 2009).

Determination of beta-carotene content of carrots

Two grams of fresh carrots were weighed and mixed with 50 ml of acetone in a mortar. The mixture was grinded with a pestle and the juice was recuperated. Twenty five milliliters of acetone were added to the residues and grinded together to extract totally the carrot juice. The residues were grinded again until their colour turned into white.

Petroleum ether (20 ml) was put in a separatory funnel and the acetone extract was added. Distilled water was added slowly, and letting it flow along the walls of the funnel and this was done five times in order to remove acetone completely.

The lower phase that contained acetone was discarded, then the petroleum ether phase was collected in a volumetric flask and topped up to 100 ml with petroleum ether. The absorbance of the extracts was read using colorimeter at wavelength of 430 nm, the extracts were placed in cuvette and readings were taken. The operation was repeated 5 times for each sample and average readings were recorded. The readings of absorbance for carotenoid content with ethereal extract at 430 nm were used to calculate total beta carotene content using the following formula:

$$\beta-\text{carotene}\ (\mu g/gr) = \frac{(\text{A}-\text{Bl})\times \text{Volume (ml)}\times 10^{4}}{\text{A}_{1\text{cm}}^{1\%}\times \text{sample weight (g)}}$$

A= absorbance; $A_{1cm}^{1\%} = 2592$

Determination of vitamin C content of carrots

The concentration of ascorbic acid in fresh carrot was obtained by titrimetric method. The samples (2 g each) were weighed and then grinded with a pestle and mortal. After that, 25 ml of distilled water were added to the grinded samples and then filtered with the aid of filter paper in order to separate residues from juice. Distilled water was added up to 100 ml. After, the second dilution were done by taking 5 ml of carrot juice and add distilled water up to 100 ml. Five drops of 0.1% Phenolphthalein were added to each sample in a volumetric flask and it is from the second dilution that titration were performed using NaOH 0.01N. A number of NaOH drops were put into the samples until persistent rose color of vitamin C in extracts appears. The amount of NaOH to change the color of juice were recorded and used in the formula to calculate vitamin C concentration in carrot juice:

$$\text{Vit C}\ (\frac{\text{g}}{100\text{g}}) = \frac{(\text{Vol NaOH}-\text{Bl})\times \text{N}\times \text{TVafter1}^{\text{st}}\,\text{dilution}\times 100\times \text{MW of vit C}\times 10^{-3}}{\text{Vol used for }2^{\text{nd}}\,\text{dilution}\times \text{sample weght}}$$

MW= 176.13 g/mol

Determination of total soluble sugar (TSS) content of carrots

Ten milligrams of dried sample were grinded using mortar and pestle and then distilled water up to 25 ml was added and were agitated for 20 min with an electric agitator at 250 rpm and then they were filtered with the aid of filter paper. One milliliter of the extract were mixed with 2 ml of $ZnSO_4$ 2% and 2ml of Ba $(OH)_2$ 1.8%, afterward they were centrifuged for 15 min. After centrifugation, 1 ml of centrifuged extract was mixed with 1 ml of phenolphthalein 5% and 5 ml of H_2SO_4Cl. The absorbance was read using a colorimeter at 490 nm and then recorded. To be sure, from the readings, data were recorded four times for each sample and the mean were calculated before using absorbance in the formula:

$$\% \text{ TSS} = (\text{A} - \text{Bl}) \times \text{FC} \times \text{FD} \times \frac{100}{\text{sample weight (g)}} \times 10^{-6}$$

FC=1
FD=875

RESULTS

Effect of FYM levels on beta carotene in carrots

The results in Table 1 showed that the maximum Beta carotene (11188 µg/100 g) content was obtained when 20 tha^{-1} of FYM were used on carrots. The mean of 10995 µg/100 g followed and it was obtained when 15 tha^{-1} of FYM were applied. Carrots fertilized with 10tha^{-1} of FYM gave 10866 µg/100 g, followed by 10673 µg/100 g in carrots that received 5 tha^{-1} of FYM. The lowest beta carotene (10287 µg/100 g) was obtained in carrots that did not receive any fertilizer.

The results from analysis of variance (ANOVA) showed a significant difference between treatments. Means for the factors which do not differ according to Duncan multiple range test at P≤ 0.05 are marked with the same letters.

Effect of FYM levels on vitamin C in carrots

The highest vitamin C content (7.98 g/100 g) was obtained in the carrots that received 20 tha^{-1} of FYM, followed by 7.84 g/100 g obtained in carrots fertilized by 15 tha^{-1} of FYM. Thus carrots fertilized with 10 tha^{-1} of FYM resulted in 7.747 g/100 g of vitamin C. The application of 5 tha^{-1} of FYM resulted in 7.67 g/100 g of vitamin C. The lowest vitamin C was obtained in carrots that did not receive any fertilizer (Table 2).

Effect of FYM on total soluble sugar (TSS) of carrots

The results of TSS varied between 9.9 and 10.27% from the treatments with higher farmyard manure rate to the ones with no farmyard manure application, respectively (Table 3). The highest TSS (10.27%) was obtained in carrots that did not receive any fertilizer. TSS (10.27%) was obtained in the carrots that received the lowest FYM level (5 t/ha). The application of 10 tha^{-1} of FYM in carrots resulted in 10.03% of TSS. This was followed by 9.92% TSS which was obtained in carrots that received 15 tha^{-1} of FYM. The lowest TSS (9.9%) was obtained when 20 tha^{-1} of FYM were applied in carrots (Table 3).

The analysis of variance (ANOVA) showed a significant difference between treatments. Thus the means for factors which do not differ according to Duncan multiple range tests at P≤ 0.05 are marked with the same letters.

Table 1. Mean value of Beta carotene content of carrots.

Treatments	FYM application rate(t/ha)	Beta carotene (µg/100 g)
0	0	10287d
1	5	10673c
2	10	10866b
3	15	10995b
4	20	11188a

Table 2. Mean value of vitamin C in carrots.

Treatments	FYM application rate (t/ha)	Vitamin C (g/100g)
0	0	7.38d
1	5	7.67c
2	10	7.75c
3	15	7.84b
4	20	7.98a

Table 3. Mean value of total soluble sugar content.

Treatments	FYM application rate (t/ha)	Total soluble sugar (%)
0	0	10.27a
1	5	10.09b
2	10	10.03bc
3	15	9.92c
4	20	9.9c

DISCUSSION

Effect of FYM levels on ß-carotene content of carrots

Carrot (*D. carota* L.) was analyzed for Beta carotene content because it is the precursor of vitamin A and eaten in both raw and cooked form by humans in daily life (Sarhad, 2007). The results of the current study proved that the highest mean for the quantity of beta carotene (11188 µg/100 g) was obtained on carrots fertilized with 20 tons of FYM per hectare. On the other hand, the lowest quantity of beta carotene (10287 µg/100 g) was obtained for treatment with no farmyard manure application. Statistically, the beta carotene in carrots fertilized with 10 tha^{-1} and those fertilized with 15 t/ha of farmyard manure showed no significant difference (Table 2).

Therefore, the result showed that as the higher Farmyard manure rate is increased, the higher the quantity of beta carotene is obtained. This is in agreements with the findings of Kipkoskei et al. (2000) who reported that the content of beta carotene increases with increasing levels of fertilizers. These results are also in the same range with those reported by Sarhad (2007) in which beta carotene content in carrot was 11210 µg/100 g and those reported by Higdon and Bendish (2004) who reported that the quantity of beta carotene in carrot was 10110 µg/100 g. However, the beta carotene content obtained during this study was higher than that obtained by Agte et al. (2000) who analyzed 24 green vegetables for different macro nutrients contents including ß- carotene. According to their analysis, ß-carotene in carrots was 5340 µg/100 g.

Effect of FYM levels on vitamin C content of carrot

FYM increased significantly the vitamin C in carrots. Duncan multiple range test showed that there was no significant difference for vitamin C between carrots that received 5 - 15 tha^{-1} of FYM, but a significant difference occurred between carrots that did not receive a fertilizer and those that received 20 tha^{-1} of FYM (Table 3). The highest vitamin C content (7.98 g/100 g) was obtained in carrots that received highest FYM level (20 t/ha) while the lowest vitamin C (7.38 g/100 g) where obtained in carrots that did not receive any fertilizer. In this study, the increase in FYM level resulted in an increase of vitamin C content. This is in accordance with Kipkoskei et al. (2003) who reported that vitamin C increased at 15-20 tons/ha of FYM. However, this is different from those reported by FAO (2011) where they reported that the vitamin C content in carrots was 5.9 mg/100 g. Matejkova and Petrova (2010) also reported that vitamin C in carrots was 12%. The slight variation in the data compared to others may be due to difference in experimental conditions, storage conditions of carrots, extraction procedures and materials used. This may also be attributed to the different solvent used, temperature during analytical process because all these have a tremendous effect on results (Sarhad, 2007).

Effect of FYM levels on total soluble sugar (TSS) content of carrots

The highest TSS (10.27%) were obtained in carrots planted in plots that did not receive FYM, while the lowest TSS (9.9%) were obtained in carrots with highest FYM application (20 t/ha). Zakir et al. (2012) reported that the highest TSS in carrot was 10.51%. Therefore, the results showed that the TSS reduced with the increase of FYM levels. This is in fair agreements with Mbatha (2008) who reported that the TSS of carrot that received chicken manure at different rates was significantly lower than those that did not receive any fertilizer. This reduction of TSS in carrots may be caused by the increase of Nitrogen, Phosphorus and potassium in soil which have negative effect on plant sugars (Hochmuth et al., 1998).

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