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*Full Length Research Paper*

# Effect of combined application of organic-P and inorganic-N fertilizers on yield of carrot

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**A study was undertaken to assess the effect of combined application of organic-P and inorganic-N fertilizers on yield and yield components of carrot (*Daucus carota* L.). The field experiment was conducted at Kombolcha ATVET College, South Wollo, Ethiopia. Seeds of carrot were sown on raised beds of a black clay soil. "Orga "and urea were used as sources of phosphorus and nitrogen, respectively, for the fertilizer treatments. The rates of fertilizers used in the experiment were, 309 kg "orga" ha$^{-1}$ combined with six rates of urea (0, 68.5, 267.2, 274,342.5 and 411 kg urea ha$^{-1}$). The field experiment was laid out in a randomized complete block design with seven fertilizer treatments, replicated five times. Yield and yield components of carrot were significantly influenced by the pre-harvest combined application of "orga" and urea treatments. Pre-harvest application of 309 kg "orga" ha$^{-1}$ combined with 274 kg urea ha$^{-1}$ increased yield of carrot by 46% compared to the control treatment. The values of yield components of carrot were also increased in response to the increased rate of combined "orga" and urea fertilizer application. The result showed that the combined application of 309 kg ha$^{-1}$ "orga"and 274 kg ha$^{-1}$ urea resulted in the maximum yield of carrot.**

**Key words:** Carrot, "orga", urea, yield, yield components.

## INTRODUCTION

Carrot is the major vegetable *Apeaceae* cultivated world-wide. The two cultivated types of carrot are Eastern (Asiatic) and Western carrots. Carrot is a biennial plant. In the first year it develops leaves and roots until the end of its growing season. When the leaves have reached their maximum length, the root will also reach its maximum length. Then, the leaves start to spread out and the root thickness increases. At the end of the growth period, the leaves start to age and turn yellow and brown, and some of them die off. In the second year the plant uses the roots as a reserve organ and forms new leaves and flowers (Martin et. al., 2004). 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 (Libner, 1989).

In addition to its role as a nutrient store, 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). Organic fertilizers are critical in enhancing soil fertility (Kaack et al., 2002; Ashraf et al., 2004). The term "orga" represents the trade name of organic fertilizer, which is locally manufactured by National Fertilizer Manufacturing pvt. Ltd. Co. (NAFMAC) and contains 1% N + 23% $P_2O_5$ which provides substantial amounts of phosphorus. Basi-cally, "orga" fertilizer is made up of bones, stomach paunch, horns and hooves by the action of phosphate solubilizing bacteria and nitrogen fixing bacteria (Active+) (NAFMAC, 2002).

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Not much work has been done in respect to effect of "orga" fertilizer on the yield of carrots and other horticultural crops. Often, research has been conducted on combining organic fertilizers and inorganic ones to enhance their efficacy (AVRDC, 2000). The distinctive-ness of this study, as compared to studies on other organic fertilizers, lies in the fact that other organic fertilizers do not have phosphorus content more than 10%. According to Jema et al. (1997), the highest P concentration in manures is 4.9 g $kg^{-1}$ (0.49%). However, "orga" contains a minimum of 23% phosphorus ($P_2O_5$) and 21% calcium oxide (CaO). In addition, most organic fertilizers are bulky and their application needs much more labour and time compared to inorganic fertilizers. Nevertheless, the application rate of "orga" is much reduced, since it has relatively high nutrient content compared to other organic fertilizers. Taye and Hoefner (1993) also reported that bone meal has a phosphorus content amounting to 26 kg $ha^{-1}$ $P_2O_5$, which is equivalent to that contained in triple super phosphate (TSP). Furthermore, the price of "orga" is lower and affordable to resource-poor farmers than the prices of inorganic fertilizers. In spite of having high content of phosphorus, "orga" has very low nitrogen content. This was the major reason for combining pre-harvest application of "orga" and inorganic N-fertilizer in this study. Therefore, the objective of this study was to determine the optimum combination of organic-P and inorganic-N fertilizer for maximum yield of carrot.

## MATERIALS AND METHODS

### Experimental site

A field experiment was conducted on black vertisol of Kombolcha ATVET College, South Wollo. Kombolcha is located in North Eastern part of Ethiopia at the latitude of 11°04′N and longitude of 39°44′ E and a distance of 380 km away from Addis Ababa. The area has the elevation of 1800 meters above sea level. Mean annual rainfall is 1046 mm while mean annual maximum and minimum temperatures are 26.5 and 12.3 °C, respectively. The average yield of carrot in the research area is about 11- 15 tons $ha^{-1}$.

### Experimental materials and design

The field experiment was conducted by combining organic-P fertilizer (309 kg "orga" $ha^{-1}$) with six rates of inorganic-N fertilizer (0, 68.5, 267.2, 274,342.5 and 411 kg urea $ha^{-1}$). The nitrogen and phosphorus contents of urea and "orga" are 46 and 23%, respectively. The applied rates of urea used for the treatment were 0, 25%, (100% - N content in "orga"), 100, 125 and 150% of the recommended rates of urea for carrots, respectively, based on the recommendation by IFA (2005). The recommended rates of "orga" (309 kg "orga" $ha^{-1}$) and urea (274 kg urea $ha^{-1}$) for carrot production were based on National Fertilizer Manufacturing pvt. Ltd. Co. (NAFMAC) (2002) and IFA (2005), respectively. A total of 7 pre-harvest fertilizer treatments, 0 + 0, 309 + 0, 309 + 68.5, 309 + 367.2, 309 + 274, 309 + 342.5 and 309 + 411 kg $ha^{-1}$ "orga" and urea, respectively, were employed under field condition.

The field experiment was arranged in a randomized complete block design (RCBD) with five replications. After thorough preparation of the land, 35 plots were made in 5 blocks. The plot size was 9 $m^2$, with a distance of 50 cm between plots and 1 m between blocks. A uniform 15 rows of carrot plant stand per plot was established, but the border rows were not included to estimate yield at the time of harvest.

Soil test was done prior to planting. Similarly, the nitrogen and phosphorus contents of the soil were determined after harvest. After ploughing and pulverizing the land, raised beds having optimum drainage and less compaction were made. The beds were also made to suit the development of maximum storage root length having smooth root surfaces.

The whole dose of "orga" fertilizer was applied on the respective treatment plots one week before sowing. Urea was applied in three split doses. The 1st split being at the time of emergence, the 2nd split 2 months after planting and the last split was applied 1 month before harvesting. The method of fertilizer placement application was row or band in which the fertilizer was applied in bands a little below and a few inches away from the plant.

Carrot seeds of the Nantes cultivar were used for the experiment. Seeds were directly sown on prepared land on 6th January, 2006. The seeds were dribbled by hand after mixing with sand at 1:1 ratio in rows of 20 cm apart. After emergence the crop was thinned out to the spacing of approximately 5 - 10 cm apart within the rows. All other agricultural practices including irrigation were kept the same between the treatments during the period of plant growth.

When the crop reached maturity after 5 months, carrots were harvested and topped in the field, and were immediately taken to the Plant Science Laboratory of Kombolca ATVET College. Harvesting, topping, and washing of carrots were made early in the morning before the temperature was too high to prevent moisture loss. Soil and dust particles were washed with tap water before packaging and transporting to reduce field heat, mechanical damage, and microbial attack and biochemical reactions.

### Days to emergence

Days after which 50% of the sown seeds emerged were recorded. Then the average of these numbers of days to emergence on each plot for the whole replications was taken as the actual number of days to emergence.

### Plant height

This was the height measured in cm from the ground level to the top of the shoot during the course of growth and development. Ten randomly selected plants per each experimental plot were tagged and used for agronomic data collection. The measurement was taken every 15 days after emergence up to the time of harvest so that the growth rate can be estimated.

### Days to maturity

The actual number of days from emergence to the day on which more than 70% of the plants attained physiological maturity was taken as the number of days to maturity. Normally, carrot shows some external appearances like yellowing of leaves at the time of reaching physiological maturity. According to Rubatzky et al. (1999) there is no defined maturity stage for carrots compared to other crop products. Determination of the appropriate harvest maturity will vary based on cultivars, intended use, market conditions and other factors. Therefore, carrots often are harvested before achieving their full potential size, weight or marketable yield. Delayed harvesting results in increased size of roots but usually at the expense of quality (Rubatzky et al., 1999).

### Leaf number

Ten randomly selected carrot plants per each experimental plot were taken for leaf counting every 15 days up to the time of harvesting. In the process, the number of true leaves were counted and recorded.

### Yield parameters

Ten randomly selected carrot samples per plot were used to obtain the measured values of yield components like average root volume, average root length, average root juice content, root base diameter and core diameter.

Immediately after harvest, the total carrot roots obtained from each treatment plot were taken and their fresh weight was measured with the help of an analytical balance. Then, mixing the replications of each treatment, ten randomly selected carrot samples from each treatment were taken to measure the fresh weight of individual roots to determine average root weight. The average root volume was measured by taking random samples from each treatment and immersing the root samples in a beaker containing known amount of water. The volume of the root was determined by observing the displacement of the water by the root and the difference was taken as the volume of the root. Samples were taken from treatment plots and the root length was measured using a ruler and expressed in centimeters. Carrot juice was extracted from the sample with a juice extractor (Type 6001 x model No. 31JE35 6x.00777 U.S.A.) and clear juice was used for measuring average root juice content. The average root base diameter was determined by measuring the base diameter of the root with the help of a verneer caliper. The cores of the roots were taken out using knives and average core diameter was determined by measuring the core of the root at the middle portion with the help of a verneer caliper.

## RESULTS AND DISCUSSION

### General growth and field performance

The seedlings grew and performed well during the early establishment of the crop in all the treatments. Growth was not as such rapid and through time better vegetative growth was evident in carrot plants treated with higher rates of N fertilizer. The best vegetative growth and well established crop stands were observed in crops treated with 309 + 274, 309 + 342.5, 309 + 411 kg $ha^{-1}$ “orga” + urea throughout the growth period (Table 1). This could be due to the effect of high nitrogen supply, which promotes vegetative growth (IFA, 2005). The control treatment exhibited poor crop stand compared to the other treatments.

Generally poor vegetative growth was observed during the growing season. This could be attributed to the poor soil structure for carrot root growth as the soil was clay and may have partly inhibited early root proliferation. The plants also appeared to show variation in color development of the leaves. The leaves of plants in the control treatments had relatively light green to yellowish color whereas those treated with higher levels of N had leaves with deep green color bearing out the direct effect of nitrogen on formation of chlorophyll and as a result leaf color development.

Although appropriate management practices were employed during the growing season, some greening was observed at the base of the root in plots especially with low above ground coverage. This could possibly be ascribed to the exposure of the root to direct sunlight. This was probably aggravated by the clayey texture and compact structure of the soil, which may have hindered easy penetration of the roots. Furthermore, susceptibility of the soil to erosion and the establishment of the crop on raised beds could also be a possible cause for the greening. Some forking of carrot roots was also evident regardless of fertilizer treatments. The clay soil was too hard for the roots to penetrate easily thereby inducing root forking.

### Average plant height

Average plant height was significantly ($P < 0.01$) affected by the pre-harvest application of organic-P and inorganic-N fertilizers during the growth period (Table 1). Numerically, but not significantly higher plant height was recorded in carrot treated with 309 kg $ha^{-1}$ “orga” compared to the control treatment. 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 (orga). According to the previous study by Hader (1986) and Henis (1986), both the deficit and excess amount of nutrients in the soil that could be caused by mineral fertilization can be compensated for by the application of organic fertilizers, which is in line with the results obtained in the current study.

Additional applications of nitrogen fertilizer in lower doses proved to be of no more significant importance in promoting plant height than application of sole “orga”. Pre-harvest fertilizer treatments with 309 + 0, 309 + 68.5, 309 + 267.2 kg $ha^{-1}$ “orga” and urea respectively did not result in significantly different plant heights compared to the plant heights observed in the control treatments (Table 1). The plant height was significantly ($P < 0.01$) promoted at higher levels of N-fertilizer application (342.5 and 411 kg $ha^{-1}$ urea). As a general trend, enhanced plant height was observed in response to successive increases in N-fertilizer application in the current study. This result is consistent with that of Robin et al. (2001) who reported higher rate of plant growth due to increased nitrogen supply.

### Average leaf number

The number of leaves counted in two weeks intervals had highly significant ($p < 0.01$) variation due to the pre-harvest treatments (Table 1). Similar to the data of plant height, a general tendency of increased leaf number of carrot was observed due to increased application of

**Table 1.** Average leaf number, average plant height, days to emergence and days to maturity of carrot as influenced by pre-harvest “orga” and urea application

| Orga + Urea (kg ha$^-$) | ALN (No.) | APLH. (cm) | DTEM (day) | DTM (day) |
|---|---|---|---|---|
| 0 + 0 | 52.67$^c$ | 13.76$^c$ | 14.60$^a$ | 135.60$^b$ |
| 309 + 0 | 54.52$^c$ | 15.53$^{bc}$ | 13.60$^c$ | 134.80$^b$ |
| 309 + 68.5 | 53.36$^c$ | 15.76$^{bc}$ | 13.80$^{bc}$ | 134.40$^b$ |
| 309 + 267.2 | 66.08$^b$ | 15.42$^{bc}$ | 14.40$^{ab}$ | 136.40$^b$ |
| 309 + 274 | 64.73$^b$ | 16.71$^b$ | 14.40$^{ab}$ | 137.40$^b$ |
| 309 + 342.5 | 71.75$^{ab}$ | 19.27$^a$ | 14.20$^{abc}$ | 141.60$^a$ |
| 309 + 411 | 73.98$^a$ | 20.44$^a$ | 14.00$^{abc}$ | 143.00$^a$ |
| Significance | ** | ** | * | ** |
| CV (%) | 8.91 | 7.18 | 3.31 | 1.62 |

*, ** significant at P < 0.05 or 0.01, respectively.
Means followed by the same letter(s) within a column are not significantly different according to Duncan’s Multiple Range Test.
ALN, Average leaf number; APLH, average plant height; DTEM, days to emergence; and DTM, days to maturity.

nitrogen. Comparatively, average leaf numbers counted on carrot plants subjected to the pre-harvest 309 + 411 kg ha$^{-1}$ “orga” and urea treatment was significantly (p < 0.01) higher. Both the application of “orga” alone and integrating “orga” with lower level of N- fertilizer (68.5 kg ha$^{-1}$ urea) had no significant effect on the plants compared to the control treatments. This could be due to poor N content of “orga”, since nitrogen is responsible for better vegetative growth (Koch et al, 1988; Robin et al, 2001; NAFMAC, 2002). Pre-harvest application of 309 + 267.2, 309 + 274, 309 + 342.5 kg ha$^{-1}$ “orga” and urea respectively exhibited no mutually significant differences on leaf numbers of carrots. However, the application of these fertilizers had significant (P <0.01) effect on leaf numbers of the plants when compared with the control treatments (Table 1). The highest average leaf number was recorded for carrot plants treated with pre-harvest combined application of 309 kg “orga” ha$^{-1}$ with 411 kg urea ha$^{-1}$, which could be explained by the enhanced vegetative growth of crops with increased nitrogen application. The present finding is in agreement with the previous report of Robin et al. (2001).

## Days to emergence

Significant variation (P <0.05) in days to emergence of carrot was observed among the different pre-harvest fertilizer treatments (Table 1). Plants in the control treatment took relatively longer days to emerge whereas plants treated with 309 kg ha$^{-1}$ “orga” took the shortest days to emerge, followed by plants treated with 309 + 68.5 kg ha$^{-1}$ “orga” and urea, respectively (Table 1). Apparently, increased rate of N fertilizer application did not result in reduced days to emergence. This could be attributed to less effect of the inorganic fertilizer on improving soil structure and water holding capacity, thereby having less impact on promoting early germination and emergence. On the other hand, application of organic fertilizer enhanced early emergence. This could be attributed to the increased infiltration and water holding capacity of the soil due to improved soil structure (Bulluck et al., 2002; Edmeades, 2003). Furthermore, the positive effect of phosphorus on germination of seeds as compared to that of nitrogen may also be another reason. Hole et al. (1984) observed initiation of the cambium at 11 days after sowing which is directly related to the emergence of the first leaves, and completion of the cambial ring at 20 days after sowing in a controlled environment. Hole et al. (1987b) also observed that under field conditions, initiation and completion of the cambium occurred ten days later.

## Days to maturity

Days to maturity of carrot subjected to different pre-harvest fertilizer treatments are shown in Table 1. There was a significant (P < 0.05) difference in days to maturity due to pre-harvest fertilizer treatments. The shortest days to maturity were recorded for pre-harvest fertilizer treatment with 309 + 68.5 kg ha$^{-1}$ “orga” and urea, but were not significantly different from days to maturity observed for the control treatment. Days to maturity of carrots treated with 309, 309 + 68.5, 309 + 267.2, 309 + 274 kg ha$^{-1}$ “orga” + urea were not significantly (P <0.05) different from the control treatment. Although the difference was non-significant, increased rate of N fertilizer application resulted in longer days to maturity. Carrot plants treated with 342.5 and 411 kg ha$^{-1}$ in addition to 309 kg ha$^{-1}$ “orga” resulted in significantly (P < 0.01) delayed days to maturity. This could possibly be ascribed to enhanced vegetative growth due to high rate of nitrogen and hence extended maturity stage. This result is in

**Table 2.** Root weight, root volume, juice content and yield of fresh market carrot (Nantes) as influenced by the Pre-harvest "orga" and urea application.

| Orga + Urea (kg ha$^{-}$) | Root weight (g) | Root volume (cm$^3$) | Juice content (%) | Yield (t ha$^{-1}$) |
|---|---|---|---|---|
| 0 + 0 | 48.80$^{c}$ | 46.80$^{c}$ | 43.70$^{b}$ | 13.70$^{b}$ |
| 309 + 0 | 56.64$^{bc}$ | 53.00$^{bc}$ | 50.50$^{ab}$ | 14.06$^{b}$ |
| 309 + 68.5 | 72.36$^{abc}$ | 71.14$^{abc}$ | 43.34$^{b}$ | 16.06$^{ab}$ |
| 309 + 267.2 | 85.79$^{ab}$ | 82.58$^{ab}$ | 48.04$^{ab}$ | 18.17$^{ab}$ |
| 309 + 274 | 92.63$^{a}$ | 90.34$^{a}$ | 55.66$^{a}$ | 20.00$^{a}$ |
| 309 + 342.5 | 57.13$^{bc}$ | 55.52$^{bc}$ | 44.98$^{b}$ | 15.27$^{b}$ |
| 309 + 411 | 78.02$^{abc}$ | 75.20$^{abc}$ | 46.40$^{ab}$ | 15.97$^{ab}$ |
| Significance | ** | ** | ** | * |
| CV (%) | 24.25 | 25.72 | 10.64 | 19.09 |

*, ** Significant at P < 0.05 or 0.01, respectively.
Means followed by the same letter(s) within a column are not significantly different according to Duncan's multiple range test.

agreement with that of Koch et al. (1988) who reported that N deficient plants are known to have higher specific leaf weights, shortened vegetative growth stages and often a tendency to mature earlier, compared with well-nourished plants.

## Root weight

The root weight of carrot treated with 309 kg "orga" ha$^{-1}$ + 267.2 kg urea ha$^{-1}$ was significantly (P <0.01) higher compared to the root weight obtained from the control treatment (Table 2). The maximum and lowest root weights were recorded in carrot crops treated with 309 kg ha$^{-1}$ "orga" + 274 kg ha$^{-1}$ urea and the control treatment, respectively. A general trend of increase and then decrease in carrot root weight was evident due to increased rate of N-fertilizer application (Table 2). Hole et al. (1987a) reported that partitioning of leaf production at an early stage resulting in higher shoot to root ratio apparently ensures a potential for high biomass production and high root weight of carrot. The current result confirms the indirect effect of N- fertilization on increased root weight in carrot. This root weight augmentation could be due to the increased vegetative growth and hence increased food production and assimilation in to parts. But with excess application of N- fertilizer, more of above ground vegetative growth is favored than root growth, so that low root weight could result.

During the growth period, application of "orga" resulted in 16.1% rise in root weight than the control treatment. The application of 309 + 274 kg ha$^{-1}$ "orga" + urea resulted in almost 89.8% increase in root weight compared to the control treatment. Therefore the result of the current study appears to suggest combined application of orga and urea at the rate of 309 274 kg ha$^{-1}$and 274 kg ha$^{-1}$, respectively, is the best to produce high root weight in carrot.

## Root volume

Pre-harvest organic and inorganic fertilizer treatments significantly (P <0.01) affected the root volume of carrot (Table 2). Similar to that of root weight, statistically lowest (P <0.01) root volume of carrot was observed in control treatments and the highest one in carrot roots treated with 309 + 274 kg ha$^{-1}$ "orga" + urea. More root volume (93%) was obtained from the pre-harvest application of "orga" and urea at the rate of 309 + 274 kg ha$^{-1}$ than the control treatment. This result could possibly be attributed to the poor nutrient content of the soil, the unfavorable soil condition for growth and development of the root and the high growing temperature during the establishment of the crop. The result supports the previous results of Hole (1996) that suggests high temperature is more favorable for shoot growth than for storage root growth.

Generally, the root volume increased with increasing N-fertilizer application in addition to "orga", substantiating the significance of both nitrogen and phosphorus supply for increased root volume in carrot production. Excess application of inorganic N- fertilizer did not improve root volume (Table 2). Conversely, a decrease in root volume was observed due to excess N- fertilizer application above the recommended rate. This could also be associated with the enhanced vegetative growth of carrot rather than root development due to high rate of N-fertilizer. Similarly, previous reports showed that under high nitrogen application the plant grew well but had low yield because the vegetative growth was favoured over root growth (Wudiri and Henderson, 1985)

## Juice content

The juice content of carrot was highly (P <0.01) affected by pre-harvest "orga" and urea treatments (Table 2). The highest juice content was obtained from the carrot plants

**Table 3.** Base diameter, core diameter, root length and root texture and marketability of fresh market carrot as influenced by pre-harvest application of "orga" and urea.

| Orga + Urea (kg ha$^{-}$) | Base diameter (cm) | Core diameter (cm) | Root length (cm) |
|---|---|---|---|
| 0 + 0 | 2.29$^{d}$ | 1.41 | 12.55 |
| 309 + 0 | 2.69$^{bcd}$ | 1.30 | 12.31 |
| 309 + 68.5 | 3.01$^{abc}$ | 1.19 | 13.67 |
| 309 + 267.2 | 3.18$^{ab}$ | 1.44 | 13.88 |
| 309 + 274 | 3.36$^{a}$ | 1.33 | 14.74 |
| 309 + 342.5 | 2.80a$^{bcd}$ | 1.29 | 14.30 |
| 309 + 411 | 2.40c$^{d}$ | 1.62 | 14.64 |
| Significance | ** | NS | NS |
| CV (%) | 12.10 | | |

NS, ** Non-significant or significant at P < 0.01, respectively.
Means followed by the same letter (s) within a column are not significantly different according to Duncan's multiple range test.

treated with 309 + 274 kg "orga" + urea ha$^{-1}$. This may be due to improved soil structure and easy movement of water and nutrients in response to organic fertilizer application. Although it was not significant, in the current study, application of 309 kg orga ha$^{-1}$ improved the juice content of carrot by 15.6% compared to the control treatment. The highest juice content of carrot was observed in crops treated with the combination of "orga" and urea at 309 and 274 kg ha$^{-1}$, respectively. Carrots in this treatment had almost 27.4% more juice content when compared to the juice content of carrots which received no fertilizer treatment. Similar to weight and volume of the root, excess N- fertilizer had declining effect on the juice content of carrots. Therefore, the present finding seems to suggest pre-harvest "orga" and urea application at 309 and 274 kg ha$^{-1}$ respectively, for better juice content of carrot.

## Base diameter

The base diameter of carrot was significantly (P <0.01) affected by the pre-harvest fertilizer treatments (Table 2). "Orga" treatment resulted in 17.5% increase in base diameter of carrot compared to the base diameter of the control treatment. As a general trend, the base diameter of carrot increased with increased application of inorganic N in addition to the recommended rate of "orga". Carrot roots treated with "orga" and urea at 309 and 274 kg ha$^{-1}$, respectively, increased the base diameter by 46.7 % compared with control treatment. However, the further increase in N- fertilizer caused the reduction in base diameter of carrot (Table 3). Generally, the base diameter and the yield of carrot was poor during the study period possibly due to poor fertility status of the soil and high temperature during the growing season. Rubatzky et al. (1999) also indicated that both high growing temperature and poor fertility status of the soil are detrimental to growth and development of carrot roots.

The core diameter was not significantly affected by the pre-harvest treatments (Table 3). Preharvest application of "orga" + urea at the rates of 309 + 0, 309 + 68.5, 309 + 274 and 309 + 342.5 kg ha$^{-1}$ resulted in lower core diameter compared to the control treatment. The variation in root length was also non-significant (P <0.05) as a result of pre-harvest "orga" and urea application. The root length was between 12.55 - 14.64 cm due to the control treatment and combined application of 309 kg "orga" ha$^{-1}$ with 411 kg urea ha$^{-1}$. The difference in root texture of carrot due to pre-harvest fertilizer treatments was non-significant (P <0.05). Application of phosphorus was uniform in the current study. The non-significant difference obtained in root texture of carrot could partly be attributed to balanced application of phosphorus fertilizer.

## Yield

Pre-harvest "orga" and urea treatment significantly (P < 0.01) affected the yield of carrot (Table 2). During the period of the study, the highest yield of carrot was obtained from pre-harvest "orga" and urea treatment at the rates of 309 and 274 kg ha$^{-1}$, respectively. The lowest yield was recorded in the control treatment. Although it was not statistically significant, application of 309 kg ha$^{-1}$ sole "orga" resulted in enhanced yield as compared to the yield obtained from the control treatment, which signifies the positive effect of phosphorus on the yield of carrot. Consistent with this result, Dechassa et al. (2003) reported increased yield of carrot due to phosphorus application. The general trend of increase in root yield of carrot due to increased rate of N fertilizer application was observed (Table 2). Nevertheless, this was apparent only up to the recommended rate of 309 kg "orga" ha$^{-1}$ and 274 kg urea ha$^{-1}$ applications. However, further increase in urea application decreased root yield rather than enhancing it.

Pre-harvest application of "orga" and urea at the rates of 309 kg $ha^{-1}$ and 274 kg $ha^{-1}$ respectively, increased root yield by 46% compared to the unfertilized control treatment proving the significance of preharvest application of both "orga" and urea at the recommended rates for maximum carrot root yield.

As a general overview, the yield of carrot obtained during the study period was low. This may be due to the unfavorable growing condition regarding both the soil and temperature of the growing region. The influence of temperature on root growth and performance of carrot was reported by Rosenfeld et al. (1998b). However, many research reports suggested different ranges of temperature as optimum range for carrot production. Carrot is classified as a cool-season crop, the minimum temperature for growth being 5°C and the optimum temperature being 18 - 25°C (Krug 1997). Barnes (1936) found that the optimum temperature for carrot growth is 16-21°C. Rosenfeld et al. (1998b) grew carrots at constant temperatures of 9, 12, 15, 18 and 21°C and observed the highest root weight at 12 and 15°C. According to Rubatzky et al. (1999), above 25°C the increased rate of plant respiration tends to limit root yields in carrot. Hence, the reports in general suggest lower growing temperature for optimum production of carrot, which is supported by the result of the current study, since the temperature range during the growing season was 7.5 - 29.0°C.

The soil was also black clay with low organic carbon, total nitrogen and available phosphorus. Therefore, compact soil structure may have inhibited easy penetration and proliferation of the roots particularly during early growth period. Rubatzky et al. (1999) reported that clay soils are usually less adapted to intensive vegetable production because of possible aeration and drainage limitations that may restrict nutrient acquisition and root development. Formation of crust due to poor infiltration capacity of the soil during irrigation could also contribute towards low root yield. Nevertheless, pre-harvest application of 309 + 274 kg $ha^{-1}$ (orga + urea) seems to be one of the most recommended practices for better yield of carrot for it enhances soil nutrient status as well as improves soil structure under the afore-mentioned environment and soil conditions.

## Conclusion

Vegetables produced by using organic farming were shown to be of higher quality than vegetables produced by the use of chemical fertilizers whereas higher yields were reported to occur due to the use of chemical fertilizers. However, difficulty in handling organic fertilizers owing to their bulkiness remained a basic constraint of production. In addition, the low nutrient content of organic fertilizers was reported to be among the limitations of organic farming. The manufactured organic fertilizers (orga), which can supply half of the phosphorus content in DAP at the same rate of application can solve the above-mentioned drawbacks of organic farming. Nevertheless, orga is poor in nitrogen and needs to be combined with other nitrogen fertilizers to optimize yield. Carrot yield was significantly affected by the pre-harvest treatment combinations. The highest yield was obtained from the pre-harvest application of 309 kg "orga" $ha^{-1}$ combined with 274 kg urea $ha^{-1}$. Similarly, root weight, root volume, juice content and root base diameter were significantly ($p<0.01$) influenced by the pre-harvest fertilizer treatments. The influence of pre-harvest fertilizer treatments on yield components of carrot was similar to the effect observed on yield. The highest values of yield components were obtained from pre-harvest application of 309 kg "orga" $ha^{-1}$ combined with 274 kg urea $ha^{-1}$. The average leaf number, average plant height, days to emergence, and days to maturity were significantly affected by pre-harvest treatments. It could, thus, be concluded that the combined application of 309 kg $ha^{-1}$ "orga" and 274 kg $ha^{-1}$ urea resulted in the maximum yield of carrot, and could be recommended for the study site for high yield of the crop plant.

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