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Effects of Combined Application of Organic –P and Inorganic N Fertilizers on Yield of Carrot (*Daucus Carrota L.*)

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Abstract

A field experiment was conducted during the 2015 growing season from March to June of 2015 to study the effects of combined applications of organic- P and inorganic –N fertilizers on yield of carrot (*Daucus carrota L.*) at Menschen fur Menschen Foundation Agro ecology Department Demonstration Site. Factorial combinations of organic –P fertilizer (309kg orga ha^{-1} with three rates of inorganic N fertilizer (0, 68, and 411 kg Urea ha^{-1}) were used. Treatments were laid down in a randomized Complete Block Design (RCBD) in a factorial combination with three replications. The result of this study revealed that the application of organic –P fertilizer and inorganic- N fertilizer showed a significant differences ($P<0.05$) on root weight, root volume, and yield while a non significance ($P>0.05$) difference result was recorded for emergency date and leaf number. The application of 309kg/ha orga + 411kg N/ha as a source urea and 309kg/ha orga + 68kgN/ha as source urea increase plant height by 145.15% and 143.70% over control. Similarly, the application of 309kg/ha orga + 411kgN/ ha as source urea, 309kg/ha orga + 68kg N/ha as source urea, 309kg/ha orga +0 kgN/ha as source urea increased root weight by 174.33%, 149.23% and 129.26% over control. There was also an increase root volume by 170.4%, 150.41% and 145.13% over control for the application of 309kg/ha orga +411kg N/ha as urea, 309kg/ha orga +68kgN/ ha as source urea and 309kg orga + 0 kgN/ha as urea respectively. The experimental results also shown an increase in leaf weight by 211.98% and 160.25% over the control for the application of 309kg/ha orga +411kg N/ha as source urea and 309kg/ha orga +68kg N/ha as source urea. There was also an increased in yield (t/ha) over the control for the application of 309kg/ha orga + 411kg N/ha as source urea, 309kg/ha orga + 68kgN/ha as source urea and 309 kg/ha orga + 0kg N/ha as source urea increased by 231.22%, 118% and 149.08% respectively. This study recommended farmers to apply 309kg/ha orga + 411kg N/ha as source urea.

Keywords: *Daucus carrota L.*; Plant height; Nutritious

Abbreviations: ALN: Average Leaf Number; ANOVA: Analysis of Variance; DM: Days to Maturity; ha: Hectare; m.a.s.l: Meter above sea level; mg: Milligram; ml: Millilitre; MSE: Mean Square Error; NP: Nitrogen and Phosphorus; P: Probability Level; PLH: Plant Height; RH: Relative Humidity; RT: Room Temperature; t: Tone; TA: Titratable Acidity

Introduction

Carrot (*Daucus carrota L.*) is a highly nutritious cool season root crop. It contains appreciable amount of carotene, thiamin, riboflavin and iron [1]. It is a biennial vegetable crop. In the first season, it develops leaves and roots until the end of its growing season. When the leaves have reached 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 [2]. Carrots are relatively tolerant to a wide variety of temperatures but prefer cooler agro-climatic conditions where temperature varies between 15.6 and 21.1 oc [3]. Carrots are produced in a wide range of agro-ecologies from the lowlands to the highlands of Ethiopia. They are frost tolerant and have become one of a few alternative crops that can be grown in the frost prone highlands around 3000 m.a.s.l. They grow in well drained alluvial and sandy loam soils with pH of 6.6-7.1 but not in heavy clay and water-logged soils. Carrots are usually grown on small plots in the backyards of town and peri-urban dwellers for family consumption; however, some farmers grow carrots on up to 0.25 to 1 ha as a means of income. Carrots can be grown throughout the year if rain and irrigation water is available [4]. Currently, about 12345.8 t of carrot is produced in Ethiopia on 2215 ha of land [5]. Although the production trend is not consistent from year to year, the production of carrots has doubled between 2004/5 and 2010/11 [4] mainly due to increasing urbanization and the recognition of carrots as an income and nutrition source. Farmers in Hararghe area also generate foreign currency from exporting carrots to neighboring Djibouti and Somalia.

Moreover, foreign currency income obtained from exporting fresh or chilled carrots and turnips increased from a mere 581 USD in 1997 to 517,172 USD in 2011[4]. It is also reported that from adaptation trials undertaken at various agro-ecological zones between 1983 and 1988, Nantes and Chantenay varieties of carrot gave a root yield of 19.6 and 21.7 t/ha in the highlands (2201 to 3000 m.a.s.l), 23.2 and 24.1 t/ha in the mid-altitudes (1701 to 2200 m.a.s.l), and 21.2 and 19.7 t/ha in the lowlands (500 to 1700 m.a.s.l), respectively [6].

The optimum rates of fertilizers to be applied for maximum carrot yield in Eastern Hararghe of Ethiopia are 46 kg P_2O_5 or 100 kg DAP and 64 kg N or 100 kg Urea (18% N from100 kg DAP), however, there is no information on utilization of orga fertilizer and its recommended rates [7]. Organic fertilizers are critical in enhancing soil fertility besides improving of crops [10] [8] In addition to its role as nutrient store, organic fertilizers improve soil structure, stimulate soil biological activity and enhance the solubility of phosphorus applied as fertilized in the soil [18] [9]. 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 prominent level of phosphorus. Basically orga fertilizer is made up of bones, stomach paunch, horns and hooves by the action of phosphate solubilizing bacteria and nitrogen fixing bacteria [8] [10]. Conversely, there was no much work done on orga fertilizer in relation to yield and quality of horticultural crops. According to the progress report of [22] [11], the field evaluation of orga fertilizer and TSP (Triple Super Phosphate) as a source of phosphorus was carried on some crops (wheat, teff and potato).

According to Jema B et al. [9], the highest P concentration in manure 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, application of most organic fertilizer is much bulky since they have low P content. But the application rate of orga is much more reduced since it has relatively high nutrient content compared to other organic fertilizers. [21] [12] Also assured that bone meal has a phosphorus nutritive value equivalent to 26kg ha^{-1} P_2O_5 in TSP (Triple Super Phosphate). Despite the fact that orga is rich in phosphorus and other macro and micronutrients, it has very low nitrogen content; the reason why in this study, preharvest application of orga and inorganic N-fertilizer are combined.

The rate of preharvest fertilizer application can seriously affect the postharvest quality of carrot [13]. On the other hand, increased use of chemical fertilizers could result in reduced postharvest quality of carrot; whereas high organic fertilizer application has no negative impact on quality of the crop [14]. However, combining organic and inorganic fertilizers in carrot production could reduce the negative impact of chemical fertilizers. Therefore, the present study was initiated to determine the optimum combination of orga with inorganic N-fertilizer and its effect on yield of carrot. Thus, the objective of this study was to determine the optimum combination of organic-P and inorganic-N fertilizers on the yield of carrot.

Materials and Methods

Description of the Study Site

A field experiment was conducted at Menschen fur Menschen Foundation Agro -Technical and Technology College of Agro ecology Department Demonstration site. The field experiment was conducted from March to June of 2015. The experimental site is located at the geographical coordinates of latitude 9020'north and longitude 42009' east. The altitude of the site is around 1900m.a.s.l. The mean annual rainfall of the area is 450-1110mm while the mean annual maximum and minimum temperatures are 280C and 110C respectively.

Experimental Procedure

Source of seed: Carrot (*Daucus carota L.*) seed was obtained from Fedis Agricultural Research Centre of the Oromya Regional state of Ethiopia.

Soil preparation: The experimental field was ploughed and well prepared by the students before planting the seed.

Treatment and experimental design: The treatments consisted of a factorial combination of three rates of nitrogen (0, 68, 411 kg N ha^{-1}) and organic phosphorus fertilizer (309kg as source orga $ha^{-1)}$. The sources of N and P were urea (46% N) and orga respectively. A total of four preharvest fertilizer treatments, 0+0, 309 +0, 309+68 and 309+411kg ha^{-1} orga and urea respectively were employed under field condition. The experiment was laid out in a randomized complete block design with three replications. After thorough preparation of the land, 12 plots were made in three blocks. The plot size was $4m^2$ with a distance of 50cm between plots and 1m between blocks. A uniform 10 rows of carrot plant stand per plot was established but the border rows were not included to estimate yield at the time of harvest. The land was ploughed well prior to crop establishment in order to loosen the soil since carrot prefer deep and well drained soils. Soils were bedded (formed into a raised bed) to obtain optimum drainage, maximum root length and smoothens and to reduce soil compaction. Since carrot seeds are very small in size the beds were smothered before planting.

The whole orga fertilizer was applied on during sowing. Urea was applied in two split doses, the first split being at the time of sowing and the 2nd split 6weeks after plant emergence. The method of fertilizer application was row placement in which fertilizer was applied in bands a little below and 5cm away from the plant. The method of planting was dropping the seeds after mixing with sand at 1:1 ratio on the rows of 20cm apart. After emergence the crop was thinned out to the spacing of 10cm apart. The agricultural practices including irrigation, weeding, disease and pest control (Table 1).

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Table 1: Treatments.

Treatments	Descriptions
T1	N_0P_0
T2	N_0P_{309}
T3	$N_{68}P_{309}$
T4	$N_{411}P_{309}$

Crop data collection

Days to emergence: Days to 50% emergence were recorded during the course of the study.

Leaf number: Ten randomly selected carrot plants per experimental plots were taken for leaf counting every 15days 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.

Fresh root weight: Immediately after harvest the total carrot roots obtained from each treatment plot were taken and their fresh weight was measured with the help of 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.

Average root volume: The average root volume was measured by taking random samples from each treatment and immersing 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, so that the difference was taken as the volume of the root.

Statistical analysis

Analysis of variance (ANOVA) was performed for parameters of plant height, shoot weight, root weight, root shoot, root diameter, root crown diameter, leaf number, root length, root core diameter and marketable and unmarketable root yield. Mean differences were separated using the least significant difference (LSD) procedure at 5% level of probability.

Results and Discussion

General growth and field performance

Good seedling performance was observed during the early establishment of the crop in all the treatments. Better vegetative growth and well established crop stand was observed in crops treated with 309+68, 309+411kg ha^{-1} orga + urea throughout the growth period (Table 2). This could be due to the effect of high nitrogen application which promotes vegetative growth [15]. Relatively the control treatment showed light green to yellowish color of leaves whereas those treatments with high rate of N fertilization became deep green in appearance bearing out the direct effect of nitrogen in formation of chlorophyll and as a result leaf color development.

Table 2: Average Leaf Number, average plant height, days to emergence and days to maturity of carrot as influenced by preharvest orga and urea application.

S.No	Treatments	LN(No.)	PLH(cm)	DTEM(day)	DTM(day)
	Orga + urea(kg/ha)				
1	0+0	10.53c	30.5b	14.6a	185.66c
2	309 kg/ha orga +0kg N/ha as source urea	10.00c	34.67b	13.60c	190.66c
3	309 kg/ha orga +68kg N/ha as source urea	10.93c	43.83ed	13.80bc	178c
4	309 kg/ha orga +411kg N/ha as source urea	10.93c	44.27dc	14.00abc	175.3c
	Cv%	14.31	10.54	3.31	5.29

Although appropriate management practices were employed during the growing season, some greening at the base of the root was observed in plots especially with low above ground coverage. This could possibly be due to the exposure of the root to direct sunlight. This was probably aggravated by the nature 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 bed could also be possible causes. Some forking of carrot roots was also evident regardless of fertilizer treatments. The clay soil was too hard for the roots for easy penetration during growth.

Vegetative growth

Average plant height: Preharvest organic –P and inorganic –N fertilizers application resulted in significant difference($P<0.05$) in average plant height during the growth period (Table 2).Numerically but not significantly higher plant height was recorded in carrot treated with 309kg ha-1 orga compared to the control treatment. This could be due to the improvement of sol structure and improved nutrient and moisture status of the soil in favor of plant growth due to application of organic fertilizer (orga) (Table 2).

Preharvest fertilizer treatments with 309 +68, 309 +411kg/ha orga and urea respectively were significantly different from the control regarding plant height (Table 2). The plant height was significantly different ($P<0.05$) promoted at higher levels of N- fertilizer application of 309 +411kg/ha orga and urea. As a general trend increasing plant height was observed due to continuous increase in N-fertilizer application in the current

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study. Similarly Kaack KM et al. [8] reported higher rate of plant growth due to increased rate of nitrogen supply.

Average leaf number: The number of leaves counted showed a non-significant (P<0.05) variations due to the preharvest treatments (Table 2). Similar to the data of plant height, a general tendency no more increased leaf number of carrot was observed due to increased application of nitrogen.

Days to emergence: Significant variation (P<0.05) in days to emergence of carrot was observed among the different preharvest fertilizer treatments (Table 2). The control treatment took relatively longer days to emerge whereas the shortest days to emerge were taken by the preharvest fertilizer treatment with 309kg/ha orga which was followed by 309+68kg/ha orga and urea respectively (Table 2). However, increased the rate of N fertilizer application didn't result in reduced days to emergence. This could be attributed to the increased infiltration and water holding capacity of the soil due to organic fertilizer [16].

Days to maturity: The result of this study indicated that there was a non-significant difference among treatments tested. The present study was contrary to [17-19] who found a significant difference on different rates of orga and urea treatments.

Yield and yield components

Root weight: The root weight of carrot treated with 309kg/ha orga +68kg/ha urea and 309kg/ha orga +411kg/ha urea were significantly different (P<0.05) over control (Table 3). [20] reported that partitioning to 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 conform the indirect effect of N-fertilization for increased root weight in carrot. The root weight augmentation could be due to the increased vegetative growth and hence increased food production and assimilation into 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.

Table 3: Root weight, root volume and yield of fresh carrot as influenced by preharvest application of orga and urea application

S.No	Treatments	Root weight(g)	Root volume(cm^3)	Yield(t/ha)
1	0 +0	60.5ec	56.73fg	4.9c
2	309kg orga +0kg N/ha as source urea	78.2cd	82.33e	7.6d
3	309kg orga +68kg N/ha as source urea	90.32bd	85.33de	9.57de
4	309kg orga +411kg N/ha as source urea	105.47d	96.67db	11.33be
	CV%	17.4	10.8	5.57

Root volume: The present study resulted in a significant differences (P<0.05) among treatments tested. The highest root volume (96.67cm^3) was obtained from the application of 309kg/ha orga +411kg/ha urea (85.33cm^3) followed by 309kg/ha orga +68kg/ha urea respectively over the control (56.73cm^3). The results of the present study were in line with [19] who found a significance differences due to the application of different rates of orga urea.

Yield: Preharvest orga and urea treatment significantly (P<0.05) affected the yield of carrot (Table 3). During the period of the study the highest yield (11.33t/ha) of carrot was obtained due to preharvest orga and urea treatment at the rates of 309 and 411kg/ha respectively while the lowest yield was recorded in the control treatment (4.9t/ha). Although it was not statistically significant, application of 309kg/ha orga alone showed better yield (7.6t/ha) than the control treatment which proves the contribution of phosphorus towards increased yield of carrot. Similarly Nigussie D et al. [20] 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 3). Nevertheless this was apparent only up to the recommended rate of both orga and urea application (309kg/ha and 411 kg/ha respectively, increased root yield compared to the unfertilized control treatment proving the significance of preharvest application of both orga and urea at the recommended rates for optimum carrot root yield (Table 3).

It is also 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 developments. Formation of crust due to poor infiltration capacity of the soil during irrigation could also contribute towards low root yield. Nevertheless, preharvest application of 309 +411kg ha^{-1} (orga + urea) seems to be most recommended for better yield of carrot as well as improvement of soil status under the mentioned environment and soil condition [3,21,22].

Conclusion

From the production as well as economic points of view a combination of 309kg/ha orga +411kg N/ha as source urea may be suggested for maximizing carrot production under Menschen fur Menschen Agro ecology department demonstration farm condition. Since the present study was conducted in only one agro ecological zone, further investigations are needed to be carried out in other Agro ecological zones of Ethiopia.

Dedication

This senior research manuscript is dedicated to our late father Dr. Karlheinz Bohm who devoted his entire life until he rest for disadvantaged Ethiopian People.

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