

Full Length Research Paper

Integrated effect of nitrogen and vermicompost levels on yield and yield components of carrot (*Daucus carota* L.) at Woreta, Northwestern Ethiopia

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The N fertilizer or organic resources alone may not provide sufficient amounts or may be unsuitable for improving specific constraints to crop production. In view of this, a field trial was conducted at Woreta ATVET College horticultural farm, Ethiopia to determine integrated effect of nitrogen and vermicompost levels on yield and yield components of carrot, Nantes type, during 2017 main rainy season. Nine treatments comprising a factorial combination of three levels of nitrogen (0, 50, and 100 kg N ha⁻¹) and vermicompost (0, 3 and 6 ton vermicompost ha⁻¹) were laid out in a randomized complete block design (RCBD) with three replications. Data were collected on growth factors, root yield and yield components. The results revealed that the main and interaction effects of treatments did not have any significant ($P > 0.05$) effect on plant height and root length. However, main effects of nitrogen affected leaf number and total fresh biomass. Combined application of 50 kg N ha⁻¹ and 6 ton vermicompost ha⁻¹ significantly ($P \leq 0.05$) increased total root yield (t/ha), dry root weight (g/plant), harvest index and fresh root weight (g/plant). At this combination, highest total root yield (60 t/ha), harvest index (51%) and fresh root yield (79.8 g/plant) were recorded. It can, thus, be concluded that maximum yield of carrot can be obtained from the combined application of 50 kg N ha⁻¹ and 6 t vermicompost ha⁻¹.

Key words: Carrot, Nantes, nitrogen, vermicompost, root yield, interaction effect.

INTRODUCTION

Carrot (*Daucus carota* L.) belongs to the family Apiaceae (previously Umbelliferae). Its root is valued as food (salads, soups, steamed or boiled in other vegetable dishes) mainly for its high carotene content. Carrots have gained worldwide acceptance due to their high vitamin A content, acceptable taste, ease of production and relatively long storage life at low temperature (Ali et al., 2006). In Ethiopia, carrots are usually grown on small

plots in the backyards of town and peri-urban dwellers mainly for family consumption. According to Ethiopian Central Statistical Agency (2017/18), carrot total production in the country was 17,333.43 tons produced in 4,902.90 ha of land with 3.5 ton/ha productivity despite its suitable agroclimate for carrot production. This productivity is relatively very low compared to world average (21 t/ha) and other carrot producing countries

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Table 1. Treatments' description.

Treatments	Description	Remark
T1	Control	N ₀ V ₀
T2	Zero N + HRV	N ₀ V ₁
T3	Zero N +FRV	N ₀ V ₂
T4	HRN+ Zero vermicompost	N ₁ V ₀
T5	FRN + Zero vermicompost	N ₂ V ₀
T6	HRN+ HRV	N ₁ V ₁
T7	HRN +FRV	N ₁ V ₂
T8	FRN +HRV	N ₂ V ₁
T9	FRN + FRV	N ₂ V ₂

N= nitrogen, V= vermicompost, N₀=control, N₁ = 50kg/ha /half recommended nitrogen (HRN), N₂ =100kg/ha Full recommended nitrogen (FRN), V₀ = control, V₁=3 ton/ha/half recommended vermicompost (HRV) , V₂ = 6 ton/ha Full recommended vermicompost (FRV).

like Switzerland, Denmark, UK, Sweden, Austria and Israel, where the average per hectare yields are reported to be 40.88, 42.67, 51.88, 54.35, 56.7 and 64.2 tones, respectively (Kahangi, 2004; FAO, 2000). In view of this, a lot of work has to be done in Ethiopia to improve carrot productivity. Integrated nutrient application is useful to fill this gap as imbalanced use of fertilizers leads to loss of soil fertility and adversely impacted agricultural productivity as well as causes soil degradation (Patil et al., 2016; Thiruneelakandan and Subbulakshmi, 2014; Vithwel and Kanaujia, 2013).

Although inorganic fertilization is very important for the healthy plant growth and development, the organic source of nutrients has the advantage of consistent and slow release of nutrients, maintaining ideal carbon:nitrogen (C:N) ratio, improvement in water holding capacity and microbial biomass of soil profile, without any adverse residual effects (Kiros et al., 2018; Yadav et al., 2010). One of the appropriate processes for organic fertilizer production is vermicomposting which converts organic materials (usually wastes) into a humus-like, fine-divided, nutrient rich material known as vermicompost. Vermicomposting technology, using earthworms as versatile natural bioreactors for effective recycling of organic wastes to the soil, is an environmentally acceptable means of converting waste into nutritious composts for crop production. Earthworms make the soil 'soft and porous' by its burrowing actions and excretions containing nutrients with beneficial soil microbes to improve its natural fertility and productivity. In Ethiopia, vermicompost application is getting more emphasis accounted for ease of preparation, input and labor availability, better nutrient composition as well as low cost as compared to inorganic fertilizer (Shanu et al., 2019; Almaz et al., 2017; Girma and Zeleke, 2017; Tesfaye, 2017; Devi et al., 2007). The basic concept pertinent to the principles of integrated nutrient management is the maintenance and possible management of soil fertility for

sustaining crop productivity on a long term basis (Hedge and Srinivas, 1989). Therefore, judicious and proper use of organic and inorganic fertilizers is very essential not only for obtaining higher yield and quality but also to maintain soil health and sustainability for longer period. Since integrated nutrient management for the crop is lacking in the study area, this study aimed to evaluate the integrated effect of nitrogen and vermicompost levels on yield and yield components of carrot.

MATERIALS AND METHODS

The field experiment was conducted at Woreta Agricultural Technical Vocational Education and Training College, northwest, Ethiopia during June to September 2017 rainy season. The study area is characterized by uni-modal rainfall pattern with annual average rainfall of 1259 mm. The mean maximum, mean minimum and annual average temperatures are 28.2, 11.5 and 19.9°C. The field soil and vermicompost samples of the experiment were analyzed and documented (Table 2). Two different factors were considered in the study. They were three nitrogen (0, 50,100, kg ha⁻¹) and vermicompost levels (0, 3 and 6 ton ha⁻¹) arranged in factorial RCBD design with three replications. Vermicompost inputs were using green leaf, cow dung and soil with 5:1:0.2 proportions respectively. There were 9 treatments for these factor combinations (Table 1). A carrot type known as "Nantes" was used for the experiment. The size of each plot was 1 m × 1 m = 1 m² with a net plot area of 0.64 m². The seeds were drilled and covered lightly with soil (Jeptoo et al., 2013). A distance of 1 m was maintained between plots and blocks. There were 5 rows per plot having 20 plants per row with the spacing of 20 × 5 cm. Thinning was done 30 and 40 days after emergence of the plants to maintain the recommended spacing of 5 cm between plants (Vithwel and Kanaujia, 2013; Mehedi et al., 2012). Before planting, beds were prepared to fine tilt by ploughing and disking using tractor. Since nitrogen is a mobile element, urea was applied in split; 50% during planting and the other 50% thirty five days after emergence. Vermicompost was incorporated into the experimental plots one week before sowing. It was applied in trenches of about 5-15 cm depth and thoroughly mixed with the soil and buried. Other cultural practices were done as required.

In the study, growth parameters such as average leaf number per plant, plant height (cm), root length (cm), root girth (cm), yield of fresh biomass yield (g/plant), fresh root weight (g/plant), dry root weight (g/plant), total root yield (t/ha), harvest index (hi%) and total yield of dry biomass (g/plant) were collected and analysed. Data were subjected to analysis of variance using SAS software (2003).

RESULTS AND DISCUSSION

Growth parameters

Leaf number

Statistically, there was significant difference in main effects of nitrogen for this parameter (P<0.05) while vermicompost and interaction effects did not show statistical significant difference. As far as nitrogen is concerned, the highest leaf number (10.3) was recorded at 50kg N/ha which was in par with nitrogen at 100 kg N/ha (Table 3). Whereas, the lowest leaf number (8.6)

Table 2. Laboratory results for analyzed field soil and vermicompost samples.

Parameter	Soil and vermicompost sample	
	Field soil	Vermicompost
pH	6.28	7.22
EC	67.8 mS/cm	3.07 mS/cm
Soil texture	Clay loam	Sandy loam
% Organic matter	4.1	27
% Organic carbon	2.4	16
Total N (%)	2.05	135
Ava. P (Olsen)	24	597
Exchangeable potassium (K, cmol/kg))	1.0	7.9
Exchangeable sodium (Na, cmol/kg))	0.2	1.7

EC= electrical conductivity; N=nitrogen; Ava.P= available phosphorus, Exc K =exchangeable potassium; Exc.Na= exchangeable sodium.

Table 3. Plant height of carrot as influenced by the main effects of nitrogen.

Nitrogen levels (kg/ha)	Leaf number
0	8.6 ^b
50	10.3 ^a
100	9.7 ^{ab}
LSD	0.98
CV	10.10

Means with the same letter(s) in the table were not significantly different at 5% probability level according to least significant difference. LSD (5%) = least significant difference at P = 0.05, CV (%) = Coefficient of variation in percent.

was recoded at the control. Application of urea might have provided adequate N which is associated with high photosynthetic activity and vigorous vegetative growth.

Plant height (cm)

Data regarding plant height depicted non- significant differences for main and interaction effects. Numerically, the tallest plant height (56.2 cm) was recorded on plots that receive 50 kg N /ha and 3ton vermicompost/ha followed by (54.6 cm) on plots where 100 kgN/ha and zero vermicompost was applied (Table 4).

Root length (cm) and root girth (cm)

Applications of urea and vermicompost levels neither alone nor in combination had a significant ($P < 0.05$) for root length. Despite this fact, the tallest root length (16.6 cm) followed by (13.0 cm) was obtained on plots which

received 50 kgN/ha and 6 ton vermicompost/ha and the control (Table 4). In contrast, there was significant difference in interaction effects for root girth ($P < 0.01$). The highest root girth (11.6cm) was recorded at combination of 50kg N/ha with 6ton vermicompost/ha while the lowest root girth (7.5 cm) was recorded at the control. The results are in agreement with Mehedi et al. (2012) who reported that the application of organic matter with NPK increased the diameter of carrot root.

Yield parameters

Total fresh biomass (g/plant) and fresh root weight (g/plant)

Statistically, there was no significant difference for main and interaction effects of treatments for this parameter. Despite this fact, the highest total fresh biomass (237.5 g/plant) was recorded at combination of 50 kg N/ha with 6 ton vermicompost /ha while the lowest (114.7 g/plant)

Table 4. Effect of nitrogen and vermicompost levels on carrot growth parameters.

Ts	Treatment combination	Growth parameter		
		Plant height (cm)	Root length (cm)	Root girth (cm)
T ₁	Control	48.2	13.0	7.5 ^b
T ₂	Zero N + HRV	50.50	15.9	8.3 ^b
T ₃	Zero N +FRV	54.4	13.4	8.3 ^b
T ₄	HRN+ Zero vermicompost	51.7	13.5	8.4 ^b
T ₅	FRN + Zerovermicompost	54.6	15.1	8.5 ^b
T ₆	HRN+ HRV	56.2	13.9	9.1 ^b
T ₇	HRN +FRV	54.1	16.6	11.6 ^a
T ₈	FRN +HRV	52.8	15.3	8.5 ^b
T ₉	FRN + FRV	48.9	16.1	8.2 ^b
CV ()		6.41	12.38	9.42
Sig.		ns	ns	**

* and ** indicates significant difference at probability level of 5% and 1% respectively. Ns = non-significant, CV= coefficient of variation.

Table 5. Effect of nitrogen and vermicompost levels on carrot yield parameters.

Treatments	Yield parameter					
	Total fresh biomass (g/plant)	Fresh root weight (g/plant)	Total dry biomass (g/plant)	Dry root weight (g/plant)	Harvest index	Total root yield (t/ha)
T1	114.7	49.5 ^d	61.7	6.0 ^c	34.5 ^c	22.6f
T2	154.8	51.5 ^{abc}	92.7	7.2 ^{bc}	37.2 ^{bc}	29.9e
T3	152.1	71.9 ^{abc}	90.8	7.7 ^{bc}	38.4 ^{bc}	34.6 ^d e
T4	164.4	73.5 ^{abc}	74.9	8.1 ^{bc}	40.5 ^{bc}	41.3 ^{bcd}
T5	169.4	55.2 ^{bcd}	76.2	8.7 ^b	40.9 ^{bc}	43.4 ^{bc}
T6	221.9	77.3 ^{ab}	82.3	8.6 ^b	43.2 ^b	48.1 ^b
T7	237.5	79.8 ^a	99.6	11.2 ^a	51.3 ^a	60.8 ^a
T8	168.2	64.2 ^{abcd}	87.9	7.8 ^{bc}	39.2 ^{bc}	36.7 ^{cd} e
T9	153.7	74.5 ^{ab}	92.3	8.4 ^b	40.0 ^{bc}	37.3 ^{cd}
CV	9.12	12.56		10.38	5.90	5.19
Sig.	ns	*	ns	*	**	***

Means with the same letter(s) in the table were not significantly different. *, ** and *** indicates significant difference at probability level of 5, 1 and 0.1%, respectively. Ns = non-significant.

was recorded at the control (Table 5).

The interaction effect of nitrogen fertilizer and vermicompost ($P < 0.05$) had also pronounced on

Table 6. Total dry biomass weight of carrot as influenced by the main effects of nitrogen.

Vermicompost (t/ha)	Total dry biomass weight (g/plant)
0	70.9 ^b
3	87.6 ^{ab}
6	94.2 ^a
LSD	0.98
CV	12.55

Means with the same letter(s) in the table were not significantly different at 5% probability level according to least significant difference. LSD (5%) = least significant difference at $P = 0.05$, CV (%) = Coefficient of variation in percent.

effect on fresh root weight. The highest fresh root weight (79.8 g/plant) when 50 kg N/ha was combined with 6 ton vermicompost per ha followed by T6 which was in par with T9, T4, T3, and T8 (Table 5). While the lowest (49.5 g) fresh root weight was recorded at the control (Table 4). Chatterjee et al. (2014) on their study on evaluation of vegetable wastes recycled for vermicomposting and its response on yield and quality of carrot reported that vermicompost from wastes from non-legume and legume family at 2:1 ratio resulted in high root weight.

Rani and Mallareddy (2006) in their study on effect of different organic manures and inorganic fertilizers on growth, yield and quality of carrot documented that maximum fresh carrot weight (55.23 g) was significantly higher with integration of neem cake /4t ha⁻¹/ and half the recommended dose of NPK treatments. Zakir et al. (2012) on their study about influence of commercially available organic vs inorganic fertilizers on growth yield and quality of carrot reported that recommended dose of inorganic fertilizers (RDIF) (197.6, 148.2, 148.2 and 98.8 kg ha⁻¹ urea, triple super phosphate (TSP), muriate of potash (MOP) and gypsum, respectively and recommended dose of Biomeal (RDB) (6 t ha⁻¹) gave maximum fresh root weight (66.89 g/plant). Vithwel and Kanaujia (2013) studying integrated nutrient management on productivity of carrot and fertility of soil reported that application of 50% NPK (40:20:20 kg ha⁻¹) + 50 % farm yard manure (FYM, 10 t/ha) + biofertilizers/Azospirillum and Phosphotika/ recorded maximum values of all yield attributing characters such as root length (18.88 cm), root diameter (4.14 cm), root weight (90.37 g). Similarly Mehedi et al. (2012) reported that combined application of 150 kg N ha⁻¹ and 15 t cow dung ha⁻¹ gave highest fresh root weight. The study is also in line with works of different researchers (Rahman et al., 2018; Yourtchi et al., 2013).

Dry root weight (g/plant)

For dry root weight, both main and interaction effects of treatments resulted in statistically significant difference

($P < 0.05$). The highest dry root weight (11.2 g) was obtained from combination of 50 kgN/ha with 6ton/ha vermicompost followed by T5 which was in par with T6, T9, and T4 treatments. While the lowest (6.0 g) dry root weight obtained was from control (Table 5).

This result is consistent with the findings of different researchers. Rani and Mallareddy (2006) in their study on effect of different organic manures and inorganic fertilizers on growth, yield and quality of carrot stated that dry root weight of carrot reported that maximum dry root weight (6.8 g) was observed with castor cake (4 t/ha) in combination with half the recommended dose of NPK(50:30:40). Zakir et al. (2012) on their study about influence of commercially available organic vs inorganic fertilizers on growth yield and quality of carrot reported that recommended dose of inorganic fertilizers (RDIF) (198 148, 148 and 99 kg ha⁻¹ urea, TSP, MOP and gypsum, respectively and recommended dose of Biomeal (RDB) (6 t ha⁻¹) resulted in the highest dry root weight (9.97 g).

Total dry biomass (g/plant)

The effect of vermicompost was statistically significant ($P \leq 0.05$) on total dry biomass (Table 6). The highest and lowest amounts of this trait were recorded at 6 t ha⁻¹ and 0 t ha⁻¹, with 94.2 and 70.9 g, respectively. The results showed that vermicompost had the best response on this parameter. The results are in conformity with the findings of many works on carrot (Tomar et al., 1998) and potato (Alam et al., 2007).

Total root yield (t/ha)

Significant variation was found in respect of gross yield of root due to main and interaction effects ($P < 0.01$). The highest root yield (60 t/ha) was recorded at treatment combinations of half recommended nitrogen (50 kg N per ha) and full recommended vermicompost (6 ton/ha) followed by T6 which was in par with T5 and T4. The lowest total root yield (22.6 t/ha) was recorded at the

control (T1). This yield increment could be attributed to increased growth parameters at this treatments combination (Table 5). The better efficiency of vermicompost in combination with inorganic fertilizers might be also due to the fact that vermicompost would have provided the micronutrients in an optimum range to the plant. It would have enhanced the metabolic activity through the supply of such important micronutrients in the early growth phase which in turn must have encouraged the overall growth and due to the cumulative effect of all yield components *viz.*, root length, root diameter, fresh and dry weight of root. The slow release of nutrients from vermicompost and their better utilization by carrot throughout the growing period might have also resulted in higher root yields of carrot. Several other works have also reported the highest plant growth due to the combined application of organic manures and chemical fertilizers in tomato (Kiros et al., 2018; Mebrahtu and Solomun, 2018; Kumar and Venkatasubbaiah, 2017; Patil et al., 2016; Tripathi et al., 2015; Prativa and Bhattarai, 2011; Alam, 2006).

Other studies also reported positive influence of integrated nutrient management on carrot. Rani and Mallareddy (2006) in their study on effect of different organic manures and inorganic fertilizers on growth, yield and quality of carrot stated that root yield of carrot was significantly affected with integrated nutrient management practices. According to these authors, maximum root yield was observed with castor cake (4t/ha) in combination with half the recommended dose of NPK (50:30:40).

Sylvestre et al. (2015) on their study on effect of poultry manure and NPK (17-17-17) on growth and yield of carrot stated that maximum carrot yield was found by integrating 5tha⁻¹ poultry manure with 150 kgha⁻¹NPK which was in par with sole application of 10 tha⁻¹ poultry manure. Mehedi et al. (2012) on their part found that combination of 150 kg N ha⁻¹ and 15 t cow dung ha⁻¹ resulted in the best performance in gross yields of carrot (51.22 t ha⁻¹). The highest gross carrot yield (67.47t ha⁻¹) was obtained from the treatment of inorganic fertilizers (290 kg Urea, 225 kg TSP and 250 kg MP) plus 5t mustard oil cake ha⁻¹ (Alom, 2004). Vithwel and Kanaujia (2013) reported that integrated application of chemical fertilizers, organic manures and biofertilizers alone or in combination significantly increased the yield and yield attributing characters of carrot compared to control (50 % NPK + 50% FYM + biofertilizers). In agreement with this study, Subenthung et al. (2012) also reported that combined application of 50% pig manure + 50% NPK recorded maximum plant height (50.16 cm), number of leaves (14.43), leaf area (185.86 cm²) and root yield (522.51 t ha⁻¹).

In general, fertilizer integration positive effect on yield could be attributed to the positive effect of all the yield components *viz.*, root girth, fresh weight and dry weight of root. Furthermore, this increased yield may be due to

better availability and uptake of nitrogen and other nutrients in combination of vermicompost which might have led to the balanced C/N ratio and increased activity of plant metabolism. Combined usage of organic fertilizers with inorganic fertilizers not only helps to improve the yield and quality of carrot but also help in conserving the soil health.

Harvest index (HI)

For this parameter, there was statistically significant difference for nitrogen and vermicompost main effects as well as their integration (P<0.01). The highest harvest index (51.3) was recorded at treatment combinations of half recommended nitrogen (50 kg N per ha) and full recommended vermicompost (6 ton/ha). The next rank was occupied by T6, T5, T4, and T9 treatments having similar statistical implication. The lowest (34.5) harvest index was recorded at T1 (control) treatment. Sylvestre et al. (2015) in their study on effect of poultry manure and NPK (17-17-17) on growth and yield of carrot stated that maximum carrot harvest index was found by integrating 5 tha⁻¹ poultry manure with 150 kg ha⁻¹NPK which was similar with sole application of 10t ha⁻¹ poultry manure. The current study is also in line with the work of Yagoub et al. (2012).

Conclusion

The results of this experiment indicated that combination of nitrogen and vermicompost nutrition played an important role on growth, yield and yield contributing characters of carrot. It was found that most of the characters that govern the production of carrot were influenced and increased the yield. From production, sustainability and environmental points of view, a combination of 50 kg N ha⁻¹ with 6 ton vermicompost ha⁻¹ may be suggested for maximizing carrot production under Woreta Agricultural College farm condition. Since the present study was conducted in only one agro ecological zone and season, further investigations need to be carried out in other agro- ecological zones of Ethiopia.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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