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Assessment of Growth, Yield and Quality of Carrot (*Daucus carota* L.) var. Pusa Kesar under Integrated Nutrient Management

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A B S T R A C T

Carrot (*Daucus carota* L.) is one of the most important root vegetables of both tropical and temperate countries. Proportion of organic food consumers is increasing with the increasing awareness of health and food safety concerns. There is a widespread belief that organic food is substantially healthier and safer than conventional food and consumers are willing to pay significant price premiums to obtain it. Vegetables that are produced by using organic manures are gaining more importance because of less chemical residues and better taste. This experiment was conducted to study the effect of Integrated Nutrient Management (INM) on growth, yield and quality of carrot (*Daucus carota* L.) var. Pusa Kesar at main Experimental Station, Department of Horticulture, BFIT Group of Institutions, Sudhowala, Dehradun, Uttarakhand (U.K), during the rabi season of 2018-19. The experiment was laid out in Randomised Block Design (RBD) with 12 treatment combination of organic and inorganic sources of nutrients. During experiment, growth parameters *viz.*, plant height, number of leaves per plant, root length and root diameter was highest in treatment T_{11} (FYM 10t/ha + vermicompost 2.5t/ha + biofertilizer 2 kg/ha + 50% NPK) at 40, 60 and 80 DAS. The root yield per hectare and dry weight of root was also recorded highest. The quality characters TSS was recorded maximum in treatment T_1 (FYM 20t/ha). On the basis of the investigation, it was concluded that carrot variety Pusa Kesar responded well in terms of growth, yield and quality, by the application of combination of organic manures and inorganic fertilizers in the respective treatments.

Introduction

Carrot (*Daucus carota* L.) is one of the most important root vegetables of both tropical and temperate countries. It belongs to the family Apiaceae having chromosome number 2n=18. The primary centre of origin of carrot ranges from Afghanistan to Mediterranean region and South-west Asia is the secondary centre of origin. Carrot is used as a salad, cooked as vegetables preferably with potatoes and peas. It is cultivated all over India for both forage and human consumption. They have been used to control ulcers, eczema, boil and are used in cosmetics preparations to fight wrinkles. It improves brain health, treating wounds, supporting better digestion, maintaining healthy hair and skin and

lowering the risk of diabetes. Vitamin A in carrot helps to prevent vision loss. It contains appreciable amount of beta carotene (60-500ppm); a precursor to vitamin A which prevents infection, some forms of cancer and improves vision, lycopene (50-100ppm) and lutein (1-5ppm). The anthocyanin content of black carrot ranges from 1750mg/100g. They also contain vitamin C, B_1 (thiamine) and B_2 (riboflavin). Proportion of organic food consumers is increasing with the increasing awareness of health and food safety concerns. There is a widespread belief that organic food is substantially healthier and safer than conventional food. However carrot yield and nutritional quality are affected by the types of fertilizers applied. Among the chemical constituents of the fertilizers, N plays a dominant role in affecting the nutritional quality. Carrot root yield was improved by hundred percent recommended doses of N, P and K fertilizers compared to application of organic fertilizer alone.

As the root vegetables are an exhaustive crop, organic manures alone may not be able to supply the desired amount of nutrients to the crop. So it has been found that neither the chemical fertilizers nor the organic manures alone can help to achieve sustainable crop production. Instead of this, combined usages of organic manures and inorganic fertilizers *i.e.,* INM (Integrated Nutrient Management) practices will help to improve the soil health and nutrient availability, increase production and help to improve the quality of carrot. (Ahmad *et al.,* 2015) The basic principle of INM is "to use the land without abusing it". Integrated nutrient system is a holistic system approach focusing on the cropping system rather than an individual crop. It not only involves identification and application of improved technologies but also the successful management of natural and renewable resources.

Materials and Methods

The present investigation pertaining to the studies on the "Assessment of growth, yield and quality of carrot (*Daucus carota* L.) var. Pusa Kesar under Integrated Nutrient Management" was conducted during 2018-2019 at main Experimental Station, Department of Horticulture, BFIT Group of Institution, Sudhowala, Dehradun, Uttarakhand. The experiment was conducted in Randomized Block Design (RBD) with three replications and 12 treatment combinations of organic and inorganic sources of nutrients i.e., T_1 (FYM 20t/ha), T_2 (Vermicompost 5t/ha),T_3 (FYM 10t/ha + Vermicompost 2.5t/ha), T_4 (FYM 10t/ha + 50% NPK + biofertilizer), T_5 (Vermicompost 2.5t/ha + 50% NPK + biofertilizer), T_6 (FYM 10t/ha + biofertilizer), T_7 (Vermicompost 2.5t/ha + biofertilizer), T_8 (FYM 10t/ha + Vermicompost 2.5t/ha + biofertilizer), T_9 (FYM 10t/ha + biofertilizer (5kg/ha) + 50% NPK), T_{10} (Vermicompost 2.5t/ha + biofertilizer (5kg/ha) 50% NPK), T_{11} (FYM 10t/ha + Vermicompost 2.5t/ha + biofertilizer (2kg/ha) + 50% NPK), T_{12} (Full dose of NPK (60:80:75kg/ha). The variance of the measure of the variability and is defined as the average of the square deviation from the mean. The analysis of variance was carried out as per methods suggested by Panse and Sukhatme (1989).

Results and Discussion

Various treatments showed significant variations in growth attributes viz., plant height, number of leaves per plant, days to first root harvest, root length and root diameter. The data on plant height and number of leaves per plant, recorded at different intervals revealed that these parameters in general progressively increased with the increase in age of crop till maturity.

Effect of organic fertilizers

Maximum plant height 19.00cm, 41.61cm and 85.87cm was observed in treatment T_8 (FYM 10t/ha + vermicompost 2.5t/ha + biofertilizer 2kg/ha) at 40, 60 and 80 DAS (table 1). Increase in number of leaves per plant 4.41, 10.49 and 18.03 was observed in treatment T_8 (FYM 10t/ha + vermicompost 2.5t/ha + biofertilizer 2kg/ha) at 40, 60 and 80 DAS (table 2). Number of leaves per plant was increased significantly at 60 and 80 DAS, but not much effect was seen at 40 DAS. Early maturity (81 days) to first root harvest was observed in treatment T_2 (vermicompost 5t/ha) and T_3 (FYM 10t/ha + vermicompost 2.5t/ha) as compared to other treatments (table 3). Among the various treatments of organic manure, T_8 (FYM 10t/ha + vermicompost 2.5t/ha + biofertilizer 2kg/ha) showed maximum root length (24.88 cm; table 3), root diameter (4.78 cm; table 4), root weight (119.75 g; table 5), root yield per plot (25.53 kg; table 6), root yield per hectare (312.76 q/ha; table 6) and dry weight of root (7.56 g; table 7). Maximum T.S.S (9.66^0brix) was observed in treatment T_1 (FYM 20t/ha) (table 7). The minimum root forking percentage (5.23%) was recorded in treatment T_7 (vermicompost 2.5t/ha + biofertilizer 2kg/ha) (table 4). The minimum root cracking percentage (0.66%) was observed in the treatment T_6 (FYM 10t/ha + biofertilizer 2kg/ha) (table 5).

Effect of inorganic fertilizers

A significant increase in the plant height was observed as 16.55 cm, 35.99 cm and 75.88 cm in treatment T_{12} (60:80:75kg NPK/ha) at 40, 60 and 80 DAS (table 1). The number of leaves per plant was recorded as 4.69, 11.57 and 18.86 in treatment T_{12} (60:80:75kg NPK/ha) at 40, 60 and 80 DAS (table 2). Significantly late maturity (84.08 days) to first root harvest was observed by the application of 60:80:75kg NPK/ha (treatment T_{12}) when compared with other treatments (table 3). Root length (23.72 cm; table 3), root diameter (4.39 cm; table 4), root weight (118.10 g; table 5), root yield per plot (20.183 kg; table 6), root yield per hectare (280.14 q/ha; table 6) and dry weight of root (6.83 g; table 7) was observed by the application of 60:80:75kg NPK/ha (treatment T_{12}). The T.S.S is recorded as 7.83^0Brix by the application of inorganic fertilizer treatment T_{12} (60:80:75kg NPK/ha) (table 7). Root forking and root cracking percentage observed in treatment T_{12} (60:80:75kg NPK/ha) was 3.80 % (table 4) and 2.73 % (table 5).

Effect of organic and inorganic sources of nutrients

The maximum plant height was recorded as 20.30 cm, 43.97 cm and 89.67 cm in treatment T_{11} (FYM 10t/ha + vermicompost 2.5t/ha + biofertilizer 2kg/ha + 50% NPK) at 40, 60 and 80 DAS (table 1). The maximum number of leaves per plant was recorded as 4.73, 16.28 and 19.86 in treatment T_{11} (FYM 10t/ha + vermicompost 2.5t/ha + biofertilizer 2kg/ha + 50% NPK) at 40, 60 and 80 DAS (table 2). Among the treatment combinations, T_4 (FYM 10t/ha + 50% NPK + biofertilizer 2kg/ha) was found to exhibit significantly early maturity (82.33 days) to first root harvest when compared with other treatment combinations (table 3). Root length (28.52 cm; table 3), root diameter (5.40 cm; table 4), root weight (122.86 g; table 5), root yield per plot (28.00 kg; table 6), root yield per hectare (388.63 q/ha; table 6) was observed in treatment T_{11} (FYM 10t/ha + vermicompost 2.5t/ha + biofertilizer 2kg/ha + 50% NPK). Dry weight of root (9.60 g) was observed in treatment T_{11} (FYM 10t/ha + vermicompost 2.5t/ha + biofertilizer 2kg/ha + 50% NPK) (table 7). Maximum T.S.S was observed as 9.00^0Brix in treatment T_{11} (FYM 10t/ha + vermicompost 2.5t/ha + biofertilizer 2kg/ha + 50% NPK) (table 7).

Table.1 Plant height as affected by different treatments of organic and inorganic sources of nutrients at 40, 60 and 80 DAS

Symbol	Treatments	Plant height (cm) 40 DAS	Plant height (cm) 60 DAS	Plant height (cm) 80 DAS
T_1	FYM 20t/ha	13.40	28.86	69.61
T_2	Vermicompost 5t/ha	14.77	31.29	70.17
T_3	FYM 10t/ha + Vermicompost	15.17	34.07	72.63
T_4	FYM 10t/ha + 50% NPK + biofertilizer (2kg/ha)	15.20	34.79	73.96
T_5	Vermicompost 2.5t/ha + 50% NPK + biofertilizer (2kg/ha)	16.33	37.17	77.72
T_6	FYM 10t/ha + biofertilizer (2kg/ha)	15.67	34.26	73.83
T_7	Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	17.33	35.20	70.02
T_8	FYM10t/ha + Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	19.00	41.61	85.87
T_9	FYM10t/ha + biofertilizer (5kg/ha) + 50% NPK	17.20	36.58	76.57
T_{10}	Vermicompost 2.5t/ha + biofertilizer (5kg/ha)+50% NPK	17.00	35.68	77.99
T_{11}	FYM 10t/ha + Vermicompost 2.5t/ha + biofertilizer (2.Kg/ha) + 50% NPK	20.30	43.97	89.67
T_{12}	Full dose of NPK (60:80:75Kg/ha)	16.55	35.99	75.88
GM		**16.49**	**35.79**	**76.16**
SEm±		**0.45**	**0.81**	**1.26**
CD at 5%		**1.33**	**2.37**	**3.68**

Table.2 Number of leaves per plant as affected by different treatments of organic and inorganic sources of nutrient at 40, 60 and 80 DAS

Symbol	Treatments	Number of leaves/plant 40 DAS	Number of leaves/plant 60 DAS	Number of leaves/plant 80 DAS
T_1	FYM 20t/ha	4.08	7.47	14.63
T_2	Vermicompost 5t/ha	3.87	7.92	15.00
T_3	FYM 10t/ha + Vermicompost	4.13	8.63	15.00
T_4	FYM 10t/ha + 50% NPK + biofertilizer (2kg/ha)	4.37	9.52	15.00
T_5	Vermicompost 2.5t/ha + 50% NPK + biofertilizer (2kg/ha)	4.38	9.78	17.16
T_6	FYM 10t/ha + biofertilizer (2kg/ha)	4.22	8.66	15.33
T_7	Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	4.27	8.82	15.40
T_8	FYM10t/ha + Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	4.41	10.49	18.03
T_9	FYM10t/ha + biofertilizer (5kg/ha) + 50% NPK	4.42	10.56	18.10
T_{10}	Vermicompost 2.5t/ha + biofertilizer (5kg/ha) + 50% NPK	4.71	12.20	19.30
T_{11}	FYM 10t/ha + Vermicompost 2.5t/ha + biofertilizer (2.Kg/ha) + 50% NPK	4.73	16.28	19.86
T_{12}	Full dose of NPK (60:80:75Kg/ha)	4.69	11.57	18.86
GM		**4.36**	**4.36**	**16.87**
SEm±		**0.43**	**0.43**	**1.11**
CD at 5%		**NS**	**NS**	**3.27**

Table.3 Harvest Index and root length (cm) as affected by the different treatments of organic and inorganic sources of nutrients

Symbol	Treatments	Days to first root harvest (days)	Roof length (cm)
T_1	FYM 20t/ha	83.00	21.60
T_2	Vermicompost 5t/ha	81.00	21.98
T_3	FYM 10t/ha + Vermicompost	81.00	22.50
T_4	FYM 10t/ha + 50% NPK + biofertilizer (2kg/ha)	82.33	24.55
T_5	Vermicompost 2.5t/ha + 50% NPK + biofertilizer (2kg/ha)	84.00	26.36
T_6	FYM 10t/ha + biofertilizer (2kg/ha)	84.33	22.53
T_7	Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	84.66	23.27
T_8	FYM10t/ha + Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	82.00	24.88
T_9	FYM10t/ha + biofertilizer (5kg/ha) + 50% NPK	86.00	25.26
T_{10}	Vermicompost 2.5t/ha + biofertilizer (5kg/ha)+50% NPK	86.33	26.94
T_{11}	FYM 10t/ha + Vermicompost 2.5t/ha + biofertilizer (2.Kg/ha) + 50% NPK	88.00	28.52
T_{12}	Full dose of NPK (60:80:75Kg/ha)	84.08	23.72
GM		**83.89**	**24.34**
SEm±		**1.09**	**0.34**
CD at 5%		**3.21**	**1.00**

Table.4 Influence of different treatments of organic and inorganic sources of nutrients on root diameter (cm) and root forking percentage

Symbol	Treatments	Root diameter (cm)	Root forking percentage
T_1	FYM 20t/ha	3.46	6.03
T_2	Vermicompost 5t/ha	3.50	7.76
T_3	FYM 10t/ha + Vermicompost	3.54	7.53
T_4	FYM 10t/ha + 50% NPK + biofertilizer (2kg/ha)	4.59	6.80
T_5	Vermicompost 2.5t/ha + 50% NPK + biofertilizer (2kg/ha)	5.04	8.46
T_6	FYM 10t/ha + biofertilizer (2kg/ha)	4.10	7.66
T_7	Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	4.13	5.23
T_8	FYM10t/ha + Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	4.78	5.90
T_9	FYM10t/ha + biofertilizer (5kg/ha) + 50% NPK	4.88	6.70
T_{10}	Vermicompost 2.5t/ha + biofertilizer (5kg/ha)+50% NPK	5.23	9.36
T_{11}	FYM 10t/ha + Vermicompost 2.5t/ha + biofertilizer (2.Kg/ha) + 50% NPK	5.40	5.53
T_{12}	Full dose of NPK (60:80:75Kg/ha)	4.39	3.80
GM		**4.42**	**6.75**
SEm±		**0.25**	**NS**
CD at 5%		**0.76**	**NS**

Table.5 Effect of different treatments of organic and inorganic sources of nutrients on root cracking percentage and root weight (g)

Symbol	Treatments	Root cracking percentage	Root weight (g)
T_1	FYM 20t/ha	3.45	102.84
T_2	Vermicompost 5t/ha	2.60	106.80
T_3	FYM 10t/ha + Vermicompost	2.03	107.34
T_4	FYM 10t/ha + 50% NPK + biofertilizer (2kg/ha)	2.20	118.52
T_5	Vermicompost 2.5t/ha + 50% NPK + biofertilizer (2kg/ha)	3.75	120.78
T_6	FYM 10t/ha + biofertilizer (2kg/ha)	0.66	112.59
T_7	Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	2.11	112.62
T_8	FYM10t/ha + Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	1.59	119.75
T_9	FYM10t/ha + biofertilizer (5kg/ha) + 50% NPK	2.51	120.14
T_{10}	Vermicompost 2.5t/ha + biofertilizer (5kg/ha)+50% NPK	2.61	121.46
T_{11}	FYM 10t/ha + Vermicompost 2.5t/ha + biofertilizer (2.Kg/ha) + 50% NPK	2.63	122.86
T_{12}	Full dose of NPK (60:80:75Kg/ha)	2.73	118.10
GM		**2.40**	**115.33**
SEm±		**NS**	**1.15**
CD at 5%		**NS**	**3.39**

Table.6 Root yield per plot (kg) and root yield per hectare (q/ha) as influenced by the different treatments of organic and inorganic sources of nutrients

Symbol	Treatments	Root yield per plot (kg)	Root yield per hectare (q/ha)
T_1	FYM 20t/ha	14.433	200.33
T_2	Vermicompost 5t/ha	16.150	224.16
T_3	FYM 10t/ha + Vermicompost	16.896	234.52
T_4	FYM 10t/ha + 50% NPK + biofertilizer (2kg/ha)	21.466	297.95
T_5	Vermicompost 2.5t/ha + 50% NPK + biofertilizer (2kg/ha)	24.333	337.74
T_6	FYM 10t/ha + biofertilizer (2kg/ha)	18.316	254.23
T_7	Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	18.816	261.17
T_8	FYM10t/ha + Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	25.533	312.76
T_9	FYM10t/ha + biofertilizer (5kg/ha) + 50% NPK	22.866	317.38
T_{10}	Vermicompost 2.5t/ha + biofertilizer (5kg/ha)+50% NPK	26.450	367.12
T_{11}	FYM 10t/ha + Vermicompost 2.5t/ha + biofertilizer (2.Kg/ha) + 50% NPK	28.000	388.63
T_{12}	Full dose of NPK (60:80:75Kg/ha)	20.183	280.14
GM		**20.870**	**289.68**
SEm±		**1.02**	**11.40**
CD at 5%		**2.41**	**33.44**

Table.7 Dry weight of root (g) and total soluble solids (^{0}brix) as affected by different treatments of organic and inorganic sources of nutrients

Symbol	Treatments	Dry weight of root (g)	Total soluble solids (^{0}brix)
T_1	FYM 20t/ha	4.93	9.66
T_2	Vermicompost 5t/ha	6.43	8.00
T_3	FYM 10t/ha + Vermicompost	5.20	9.13
T_4	FYM 10t/ha + 50% NPK + biofertilizer (2kg/ha)	7.16	8.83
T_5	Vermicompost 2.5t/ha + 50% NPK + biofertilizer (2kg/ha)	8.46	8.00
T_6	FYM 10t/ha + biofertilizer (2kg/ha)	5.30	8.33
T_7	Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	6.30	7.33
T_8	FYM10t/ha + Vermicompost 2.5t/ha + biofertilizer (2kg/ha)	7.56	8.66
T_9	FYM10t/ha + biofertilizer (5kg/ha) + 50% NPK	7.33	8.83
T_{10}	Vermicompost 2.5t/ha + biofertilizer (5kg/ha)+50% NPK	7.46	7.83
T_{11}	FYM 10t/ha + Vermicompost 2.5t/ha + biofertilizer (2.Kg/ha) + 50% NPK	9.60	9.00
T_{12}	Full dose of NPK (60:80:75Kg/ha)	6.83	7.83
GM		**6.88**	**8.40**
SEm±		**0.83**	**NS**
CD at 5%		**2.45**	**NS**

The minimum root forking (5.53 %) was observed in treatment T_{11} (FYM 10t/ha + vermicompost 2.5t/ha + biofertilizer 2kg/ha + 50% NPK) (table 4). The minimum root cracking (2.20 %) was observed in treatment T_4 (FYM 10t/ha + 50% NPK + biofertilizer 2kg/ha) (table 5). The above findings gave a clear indication that the application of organic manure along with inorganic fertilizers positively influences the growth and development. This might be due to its positive role in increasing the plant height in association with other essential elements. Organic fertigation also reduces the incidence of root cracking and root forking. This finding is also in agreement with the findings of Sharma (1997), Jadhao *et al.,* (1999), Thilakavathy and Ramaswamy (1999), Gupta and Sangar (2000), Singh and Singh (2000), Lyngdoh (2001), Netra Pal (2001), Sunandarani and Mallareddy (2007), Meena *et al.,* (2007), Silva *et al.,* (2010).

On the basis of present investigation, it was concluded that carrot variety Pusa Kesar responded well in terms of growth, yield and quality, by the application of combination of organic manures and inorganic fertilizers. Soil application of FYM 10 t/ha + vermicompost 2.5 t/ha + biofertilizer 2 kg/ha + 30:40:37.5 kg NPK/ha gave the highest root yield of 388.63q/ha when compared with other treatments. The quality of carrot was also superior in this treatment.

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