



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating: 5.20
www.agronomyjournals.com
2025; 8(5): 355-360
Received: 23-02-2025
Accepted: 29-03-2025

Kakali Das
Division of Vegetable Science,
ICAR-Indian Agricultural
Research Institute, New Delhi,
India

Sayani Das
Department of Horticulture and
Post-Harvest Technology, Palli
Siksha Bhavana, Visva-Bharati,
West Bengal, India

Chandrika Ghoshal
Division of Vegetable Science,
ICAR- Indian Agricultural
Research Institute, New Delhi,
India

Ranjit Chatterjee
Department of Vegetable and Spice
Crops, Uttar Banga Krishi
Viswavidyalaya, Pundibari, Cooch
Behar, West Bengal, India

Corresponding Author:
Ranjit Chatterjee
Department of Vegetable and Spice
Crops, Uttar Banga Krishi
Viswavidyalaya, Pundibari, Cooch
Behar, West Bengal, India

Potential of different enriched organic manures and bio-stimulants on growth, yield and quality of organic carrot

Kakali Das, Sayani Das, Chandrika Ghoshal and Ranjit Chatterjee

DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i5e.2917>

Abstract

Carrot is an important salad crop worldwide. Demand of organic carrot is increasing day by day in India and other countries. Generally, farmers are growing carrot organically by using farmyard manure to fulfil the nutrient requirement of the crop, which is not sufficient for yield optimization. To combat this, field experiments were conducted at UBKV, West Bengal during 2018-19 and 2019-20 to study the effect of different enriched organic manures and liquid bio-stimulants on growth, yield and quality attributes of carrot (*Daucus carota* L.). 18 different treatment combinations were laid in split plot design with 3 replications. The pooled result revealed that carrot growth, root yield, TSS and vitamin C contents were significantly influenced by the application of different organic nutrient sources and bio-stimulants. Significant change in physico-chemical properties of soil like organic carbon, available nitrogen and available potassium content after 2 years of harvest were observed in different treatments. Results of the experiment clearly suggested that nutrient schedule consists of *Azophos* biofertilizer enriched farmyard manure (20 t ha⁻¹) as basal application and foliar spray of jiwamrita (3%) at 45, 60 and 75 days after seed sowing emerged as best combination for organic carrot cultivation.

Keywords: Carrot growth and yield, organic production, enriched organic manures, bio-stimulants

Introduction

Carrot (*Daucus carota* L.) is a popular umbelliferous winter season root vegetable, largely consumed as salad, cooked into stews, parathas, pickles and roasted vegetable. The root is excellent source of essential vitamins, several minerals and dietary fibres. Carrot gets its characteristic bright orange colour from β -carotene pigment which partly metabolized into Vitamin A in the digestive system. It also possesses trace amounts of α -carotene, γ -carotene, lutein, and zeaxanthin. For early and higher production, farmers use traditional production practices. But vegetables and fruits grown on chemically overfertilized soils are more prone to attack by insects and diseases (Karungi *et al.*)^[4]. Moreover, it also reduces the protein and carbohydrate content of crops (Marzouk and Kassem,)^[5]. High potassium containing soil decreases carotene, vitamin C and antioxidant compounds in vegetables (Toor *et al.*)^[18]. Carrot is consumed as salad in raw form. Therefore, demand for contamination free carrot is increasing day by day both in international and domestic market. Traditional organic production consists of sole use of farmyard manure and occasional use of biofertilizer. Thus, the system suffers from adequate supply of essential plant nutrients which results marginal yield and economic return. Influence of *Azotobacter*-enriched organic manures increase nitrogen fixation and productivity of lettuce and turnip (Rodrigues *et al.*)^[11]. In the present experiment, apart from farmyard manure, vermicompost and poultry manure were also included as sources of organic manure. To increase the amount of nutrient availability, the organic manures were enriched by incorporating *Azotobacter* and phosphate solubilizing bacteria. Apart from basal use of enriched organic manures, foliar application of different bio stimulants namely panchagavya, jiwamrita, vermiwash, liquid mustard cake, seaweed extract and humic acid were incorporated in the standing crops to enhance further root yield.

Materials and Methods

The field experiment was conducted at the Instructional Farm of UBKV, Pundibari, Cooch

Behar, West Bengal, India during winter season of 2018-19 and 2019-20. The soil was sandy loam in texture and slight acidic in reaction. The initial available N, P and K and organic C contents were 85.45, 19.82, 123.99 kg/ha and 0.72% respectively. 3 different main plot factors [A₁ -Farmyard manure/ FYM (20 t ha⁻¹) enriched with *Azophos* Biofertilizer, A₂ -Vermicompost (5 t ha⁻¹) enriched with *Azophos* Biofertilizer, A₃ -Poultry manure (5 t ha⁻¹) enriched with *Azophos* Biofertilizer] and 6 different sub plot factors [B₁ - Panchagavya (3%), B₂- Jiwamrita (3%), B₃-Vermiwash (3%), B₄- Liquid mustard cake (3%), B₅- Sea weed extract (0.3%), B₆- Humic acid (0.3%)] thus, 18 different treatment combinations [A₁B₁= FYM + *Azophos* Biofertilizer + Panchagavya; A₁B₂= FYM + *Azophos* Biofertilizer + Jiwamrita; A₁B₃= FYM + *Azophos* Biofertilizer + Vermiwash; A₁B₄= FYM + *Azophos* Biofertilizer + Liquid mustard cake; A₁B₅= FYM + *Azophos* Biofertilizer + Seaweed extract; A₁B₆= FYM + *Azophos* Biofertilizer + Humic acid; A₂B₁= Vermicompost + *Azophos* Biofertilizer + Panchagavya; A₂B₂= Vermicompost + *Azophos* Biofertilizer + Jiwamrita; A₂B₃= Vermicompost + *Azophos* Biofertilizer + vermiwash; A₂B₄= Vermicompost + *Azophos* Biofertilizer + Liquid mustard cake; A₂B₅= Vermicompost + *Azophos* Biofertilizer + Seaweed extract; A₂B₆= Vermicompost + *Azophos* Biofertilizer + Humic acid; A₃B₁= Poultry manure + *Azophos* Biofertilizer + Panchagavya; A₃B₂= Poultry manure + *Azophos* Biofertilizer + Jiwamrita; A₃B₃= Poultry manure + *Azophos* Biofertilizer + Vermiwash; A₃B₄= Poultry manure + *Azophos* Biofertilizer + Liquid mustard cake; A₃B₅= Poultry manure+ *Azophos* Biofertilizer+ Seaweed extract; A₃B₆= Poultry manure+ *Azophos* Biofertilizer+ Humic acid] were laid in split plot design with 3 replications. 'Early Nantes' variety of carrot was sown during first fortnight on November for both the years in the plot size of 2 m × 1.5 m with a spacing of 20cm × 10 cm. The seeds for the experiment were collected from local market. Well decomposed organic manures (FYM, Vermicompost, Poultry manure) were mixed with the microbial inoculants *Azophos* containing *Azotobacter chroococcum* and Phosphate Solubilizing Bacteria (*Acinetobacter* sp.) with standard

microbial population (5x 10⁸) at the rate of 10 g biofertilizer per kg of organic manure. The treated organic manures were kept in shade for 20 days and then applied as basal dose as per the treatment combination. The different bio-stimulants were applied as foliar spray at 45, 60 and 75 DAS. A pre sowing irrigation was given for better germination of seeds. There after irrigation was given as and when required depending upon the soil moisture condition. Weeding, hoeing and other operations were conducted as and when required. Observation on different growth, yield and quality characters of carrot were recorded following standard procedure. Vitamin C (Ranganna) ^[10], total soluble solids (ERMA hand refractometer (0 to 32°Brix), total sugar content (Anthrone method (Dubois *et al.*) ^[12] of root were analysed. Total chlorophyll content of leaves was also estimated (Sadasivam and Manickam,) ^[12]. Among different soil parameters organic carbon of soil samples expressed in percentage (%), available N (kg ha⁻¹), available P (kg ha⁻¹) and potassium (kg ha⁻¹) content were determined using the standard protocols.

Results and Discussion

The result showed that enriched organic manures had significant effect on growth, yield, physiological attributes and root quality of carrot (Table 1). Among different organic manures used, enriched farmyard manure (20 t ha⁻¹) recorded the highest plant height (34.96 cm), numbers of leaves (13.57), total chlorophyll content of leaves (225.25 mg 100 g⁻¹), crop growth rate (3.77 g m⁻²days⁻¹ at 75-120 DAS), root length (15.02 cm), root diameter (3.27 cm), individual root weight (88.35 g), total root yield (22.97 t ha⁻¹) and harvest index (78.06%). Result also showed that enriched FYM showed 11.073% and 36.64% higher root yield over the enriched vermicompost and enriched poultry manure. The same treatment not only improved the growth and yield attributes but also enhanced the quality attributes and recorded the highest root TSS (5.74 °B), beta-carotene content in roots (10738 IU/100 g), root total sugar (6.46%) and root ascorbic acid content (7.25 g 100 g⁻¹).

Table 1: Individual effect of enriched organic manures on different parameters of carrot.

Treatment	A ₁	A ₂	A ₃	CD (0.05)
Height (cm)	34.96	33.05	28.66	0.43
Leaf number	13.48	12.48	11.61	0.12
Leaf total Chlorophyll content (mg 100 g ⁻¹)	225.25	217.16	191.12	0.17
Crop growth rate (g m ⁻² days ⁻¹)	3.77	3.14	2.72	0.40
Relative growth rate (g g ⁻¹ day ⁻¹)	0.009	0.007	0.005	0.0011
Root length (cm)	15.02	14.35	12.84	0.1
Root diameter (cm)	3.35	3.18	2.64	0.07
Root weight (g)	88.35	79.53	64.65	0.17
Root yield (t ha ⁻¹)	22.97	20.68	16.81	0.04
Harvest Index (%)	78.06	75.13	67.73	0.51
Beta-carotene (µg 100 g ⁻¹)	10738.09	10334.62	10135.59	12.07
Ascorbic acid content (g 100 g ⁻¹)	7.25	7.01	5.96	0.09
Root TSS (°B)	5.74	5.62	5.32	0.11
Root total sugar (%)	6.46	6.19	5.39	0.16
Root reducing sugar (%)	4.28	4.05	3.47	0.09

As carrot slowly developed their roots, it requires continuous supply of essential nutrients. Enrichment of organic manures may have promoted the mineralization of nutrients present in FYM which gave steady supply of nutrients, in turn better result in physiological parameters, root yield and quality of carrot. Among different bio-stimulants (Table 2), the maximum plant height (33.79 cm) was recorded with foliar application of

panchagavya (3%) at 45, 60 and 75 DAS. However, the highest number of leaves (13.28), crop growth rate (3.36 g m⁻²days⁻¹ at 75-100 DAS), root length 100 g⁻¹) were recorded with foliar use of 3% panchagavya. Bio-stimulants are the bioactive compounds that stimulate physiological activities of plant and biosynthesis of beneficial compounds. Application of bio-stimulants in standing crop have significant positive effect on

crop growth, yield and quality. Palekar reported that bio-stimulants contains growth promoting hormones and encourages growth of beneficial soil microorganisms, thus enhances the uptake of plant nutrients.

The result showed a significant interaction between combined application of enriched organic manure and bio-stimulants through foliar application for the different growth, root yield and quality attributes of carrot (Table 2). Application of enriched farmyard manure (20 t ha⁻¹) as basal along with vermiwash through foliar application (3%) at 45, 60 and 75 DAS (A₁B₃) recorded the maximum plant height (38.40 cm) and the highest crop growth rate of carrot (4.54 g m⁻²days⁻¹ at 75-100 DAS). This might be attributed to enhanced vegetative growth in presence of beneficial microorganisms and growth promoting substances released by vermiwash (Tomati and Galli, 1995; Edwards, 1998) [17, 3]. However, combined use of enriched farmyard manure (20 t ha⁻¹) as basal and jiwamrita bio-stimulant through foliar application (3%) at 45, 60 and 75 DAS recorded the highest root length (15.00 cm), root diameter (3.27 cm), root weight (87.33 g), root yield (22.70 t ha⁻¹) and harvest index (78.27%). Jiwamrita is a fermented microbial culture which acts as a catalytic agent and promotes the activity of soil microorganisms as well as increases the activity of earthworm in the soil that subsequently sustain the availability and uptake of applied as well as inherent soil nutrients. The combined

application of enriched FYM and jiwamrita might have enhanced the decomposition of organic substances and increased the slow and steady supply of essential nutrients which ultimately resulted in better root yield in carrot.

The quality attributes of carrot root were also influenced significantly in presence of enriched organic manure and bio-stimulants. The maximum root TSS (5.75 °B), ascorbic acid content (7.24 g 100 g⁻¹) and root total sugar (6.63%) were recorded for the plants received enriched farmyard manure (20 t ha⁻¹) as basal and panchagavya bio-stimulant as foliar application (3%) at 45, 60 and 75 DAS. However, the highest beta-carotene content in roots (10735 IU 100 g⁻¹) was registered for the treatment comprised of enriched farmyard manure (20 t ha⁻¹) as basal and sea weed extract bio-stimulant as foliar spray (3%) at 45, 60 and 75 DAS. The increase level of root TSS and ascorbic acid content in the enriched farmyard manure and panchagavya bio-stimulants may have attributed to increased availability of nutrients in the soil that might lead to biosynthesis of ascorbic acid. Seaweed extract contains auxins, cytokinins and or other hormone-like substances that enhances the photosynthetic activity and improve the quality of produce. Improvement in ascorbic acid content with the application of higher amount of organic manures was reported earlier by Bahadur in broccoli and Wang in chinese cabbage.

Table 2: Individual effect of bio-stimulants on different parameters of carrot

Treatment	B ₁	B ₂	B ₃	B ₄	B ₅	B ₆	C D (0.05)
Height (cm)	33.88	32.75	33.46	30.6	30.85	31.8	0.51
Leaf number	13.01	13.33	12.48	11.96	12.13	12.23	0.17
TCC (mg 100 g ⁻¹)	223.41	216.08	219.75	197.94	205.87	203.99	0.56
CGR (g m ⁻² days ⁻¹)	3.12	3.36	3.34	3.13	3.11	3.08	0.45
RGR (g g ⁻¹ day ⁻¹)	0.006	0.007	0.008	0.007	0.006	0.006	0.0019
Root length (cm)	14.43	15	14.05	13.44	13.62	13.87	0.2
Root diameter (cm)	3.21	3.27	3.09	2.88	2.9	3	0.11
Root weight (g)	81.7	87.33	78.2	69.82	72.5	75.51	0.22
Root yield (t ha ⁻¹)	21.24	22.7	20.33	18.15	18.85	19.63	0.06
Harvest Index (%)	74.57	78.27	73.49	71.59	72.26	71.65	1.24
BC (µg/100 g)	10408.93	10488.03	10735.21	10116	10523.2	10145.23	12.91
AA (g 100 g ⁻¹)	7.24	7.02	7.1	6.18	6.54	6.38	0.12
TSS (°B)	5.75	5.65	5.69	5.36	5.5	5.42	0.07
Total sugar (%)	6.63	6.12	6.19	6.2	5.89	5.77	0.06
Reducing sugar (%)	4.32	4.05	4.17	3.61	3.78	3.67	0.16

NB. TCC= Total Chlorophyll Content, CRR=Crop Growth Rate, RGR=Relative Growth Rate, BC= Beta-carotene, AA= Ascorbic acid

The status of soil nutrients at the end of two consecutive years of experiment revealed that among the different organic manures, application of enriched farmyard manure (20 t ha⁻¹) recorded the highest soil available nitrogen (124.47 kg ha⁻¹), whereas application of enriched vermicompost (5 t ha⁻¹) recorded the highest soil available phosphorous (28.10 kg ha⁻¹). Among the different bio-stimulants, the highest soil available nitrogen (122.27 kg ha⁻¹) as well as soil available phosphorous (26.76 kg ha⁻¹) were recorded in jiwamrita application (3%). The interaction effect showed that the combined application of enriched farmyard manure (20 t ha⁻¹) as basal and jiwamrita through foliar application (3%) recorded the highest soil available nitrogen (125.91 kg ha⁻¹), whereas combination of enriched vermicompost (5 t ha⁻¹) as basal and jiwamrita through foliar application (3%) showed the highest available phosphorous (28.97 kg ha⁻¹) in soil.

The economics of organic production of carrot (Table 4) revealed that the gross return and net return of carrot was influenced to a great extent by the combination of different nutrient sources. The combined use of enriched farmyard

manure (20 t ha⁻¹) as basal and jiwamrita bio-stimulant as topdressing (3%) recorded the maximum gross return (Rs.397878.00 ha⁻¹) and net return (Rs.292018.00 ha⁻¹). However, the treatment comprising of enriched farmyard manure (20 t ha⁻¹) and foliar spray of Panchagavya (3%) recorded the maximum benefit cost ratio (2.96) owing to reduction in variable cost of production.

The experimental findings established that depending on duration of crops, the organic manures should be selected. Organic carrot produces root around 110-120 days, enriched farmyard manure will be the best option over enriched vermicompost and poultry manure due to slow decomposition and steady mineralization of nutrients. Use of bio-stimulants impart positive impact on carrot growth, root yield and quality. The nutrient schedule comprised of basal application of Azophos containing Azotobacter and Phosphate Solubilizing Bacteria enriched farmyard manure (20 t ha⁻¹) along with foliar application of Jiwamrita (3%) at 45, 60 and 75 DAS may be adopted for large scale organic carrot production.

Table 3: Combined effect of enriched organic manures and bio-stimulants on growth and root yield of carrot.

Treatments*	Plant height (cm)	Leaf number	CRR (g m ⁻² days ⁻¹)	RGR (g ⁻¹ g ⁻¹ day ⁻¹)	Root length (cm)	Root diameter (cm)	Root weight (g)	Root yield (t ha ⁻¹)	Harvest Index (%)
A ₁ B ₁	37.81	14.23	3.26	0.009	15.29	3.48	90.65	23.57	77.19
A ₁ B ₂	32.49	14.33	4.07	0.011	16.26	3.50	103.39	26.88	87.43
A ₁ B ₃	38.40	14.03	4.54	0.010	15.12	3.41	88.44	22.99	75.57
A ₁ B ₄	33.43	12.30	2.36	0.009	14.33	3.19	79.76	20.73	75.16
A ₁ B ₅	33.20	12.86	2.39	0.009	14.46	3.21	82.82	21.53	75.92
A ₁ B ₆	34.43	13.16	2.78	0.009	14.67	3.30	85.04	22.11	77.06
A ₂ B ₁	34.58	13.36	2.27	0.007	14.74	3.33	86.43	22.47	77.08
A ₂ B ₂	35.75	13.70	3.49	0.008	15.02	3.43	87.42	22.73	75.23
A ₂ B ₃	32.37	11.83	2.95	0.006	14.21	3.16	79.06	20.55	76.32
A ₂ B ₄	31.28	12.10	3.27	0.009	14.07	3.04	74.69	19.42	73.82
A ₂ B ₅	32.05	11.96	3.82	0.006	13.86	3.01	72.69	18.90	73.12
A ₂ B ₆	32.28	11.43	2.27	0.007	14.18	3.13	76.89	19.99	75.17
A ₃ B ₁	29.24	11.96	4.52	0.004	13.27	2.81	68.03	17.68	69.44
A ₃ B ₂	30.03	11.60	1.76	0.005	13.72	2.88	71.19	18.51	72.14
A ₃ B ₃	29.60	11.10	3.70	0.009	12.82	2.70	67.09	17.44	68.57
A ₃ B ₄	27.10	11.50	3.55	0.003	12.43	2.54	59.52	14.30	65.78
A ₃ B ₅	27.28	11.60	3.32	0.004	12.54	2.58	62.00	16.12	67.68
A ₃ B ₆	28.68	11.56	3.55	0.004	12.76	2.57	64.59	16.79	62.78
CD (0.05)	0.89	0.30	0.44	0.0024	0.35	0.19	0.39	0.10	2.14

NB- CRR=Crop Growth Rate, RGR=Relative Growth Rate

Table 4: Combined effect of enriched organic manures and bio-stimulants on different bio-chemical parameters in carrot.

Treatments	TCC (mg 100 g ⁻¹)	BC (µg 100 g ⁻¹)	AA (g 100 g ⁻¹)	Root TSS (°B)	Total sugar (%)	Reducing sugar (%)
A ₁ B ₁	237.60	10920.01	7.58	5.98	7.00	4.77
A ₁ B ₂	233.36	11126.67	7.13	5.83	6.59	4.46
A ₁ B ₃	235.03	11136.45	7.28	5.90	6.62	4.47
A ₁ B ₄	212.54	10149.97	6.87	5.52	6.09	3.86
A ₁ B ₅	217.54	10952.01	6.96	5.63	6.27	4.07
A ₁ B ₆	215.40	10143.43	6.89	5.56	6.22	3.92
A ₂ B ₁	230.11	10944.54	7.39	5.80	6.54	4.41
A ₂ B ₂	221.39	10162.53	7.13	5.71	6.31	4.22
A ₂ B ₃	228.18	10188.91	7.23	5.76	6.38	4.36
A ₂ B ₄	205.22	10132.00	6.73	5.49	5.91	3.71
A ₂ B ₅	209.98	10166.51	6.83	5.01	6.01	3.82
A ₂ B ₆	208.09	10113.24	6.79	5.50	5.98	3.77
A ₃ B ₁	202.54	10124.63	6.54	5.48	5.71	3.70
A ₃ B ₂	193.48	10174.88	6.48	5.41	5.46	3.46
A ₃ B ₃	196.03	10117.86	6.50	5.41	5.57	3.63
A ₃ B ₄	176.07	10066.11	5.88	5.06	5.08	3.37
A ₃ B ₅	190.08	10151.07	6.04	5.36	5.40	3.44
A ₃ B ₆	188.49	10179.02	5.93	5.19	5.11	3.39
CD (0.05)	0.45	22.37	0.32	0.04	0.10	0.10

NB. TCC= Total Chlorophyll Content, BC= Beta-carotene, AA= Ascorbic acid

Table 5: Effect of interaction of enriched organic manures and bio-stimulants on post- harvest soil quality

Treatments	Organic C (%)	Available soil N (kg ha ⁻¹)	Available soil K (kg ha ⁻¹)
A ₁ B ₁	0.82	125.07	160.45
A ₁ B ₂	0.77	125.91	158.36
A ₁ B ₃	0.78	124.56	155.27
A ₁ B ₄	0.77	123.29	152.67
A ₁ B ₅	0.76	123.86	152.83
A ₁ B ₆	0.77	124.11	154.82
A ₂ B ₁	0.87	121.63	157.46
A ₂ B ₂	0.83	121.93	155.62
A ₂ B ₃	0.86	121.60	150.42
A ₂ B ₄	0.84	119.29	147.29
A ₂ B ₅	0.80	119.47	148.30
A ₂ B ₆	0.84	121.33	148.13
A ₃ B ₁	0.76	117.69	145.27
A ₃ B ₂	0.75	118.97	142.07
A ₃ B ₃	0.76	114.03	141.77
A ₃ B ₄	0.75	112.35	134.46
A ₃ B ₅	0.74	112.67	140.08
A ₃ B ₆	0.75	114.75	140.75
CD (0.05)	0.019	1.255	1.55

Table 6: Effect of interaction of enriched organic manures and bio-stimulants on benefit: cost ratio.

Particulars	Root yield (t/ha)	Gross return (Rs.)	Treatment cost (Rs.)			Net return (Rs.)	Benefit: cost ratio
			Fixed cost	Variable cost	Total cost		
A ₁ B ₁	23.80	357006	46750	48331	95081	261925	2.75
A ₁ B ₂	26.52	397878	46750	59110	105860	292018	2.75
A ₁ B ₃	23.45	351819	46750	47350	94100	257719	2.73
A ₁ B ₄	21.76	326469	46750	46561	93311	233158	2.49
A ₁ B ₅	21.89	328419	46750	47710	94460	233959	2.47
A ₁ B ₆	22.58	338793	46750	45658	92408	246385	2.66
A ₂ B ₁	23.30	349635	46750	41331	88081	261554	2.96
A ₂ B ₂	23.11	346710	46750	41110	87860	258850	2.94
A ₂ B ₃	22.01	330174	46750	37350	84100	246074	2.92
A ₂ B ₄	20.94	314106	46750	36561	83311	230795	2.77
A ₂ B ₅	20.74	311181	46750	37710	84460	226721	2.68
A ₂ B ₆	21.58	323778	46750	35658	82408	241370	2.92
A ₃ B ₁	19.43	291486	46750	38331	85081	206405	2.42
A ₃ B ₂	20.65	309894	46750	34110	80860	229034	2.83
A ₃ B ₃	18.86	282984	46750	37350	84100	198884	2.36
A ₃ B ₄	15.50	232557	46750	36561	83311	149246	1.79
A ₃ B ₅	16.89	253461	46750	37710	84460	169001	2.00
A ₃ B ₆	18.18	272688	46750	35658	82408	190280	2.30

Conclusion

The present investigation clearly demonstrated that the combined application of enriched farmyard manure (FYM) with Azotobacter and PSB, along with foliar application of Jiwamrita at 45, 60 and 75 days after sowing, significantly enhanced growth, yield, quality attributes, and nutrient uptake in organic carrot production. Among the various treatments, the integration of Enriched FYM + Azotobacter + PSB with Jiwamrita foliar spray proved most effective, recording the highest root yield (22.70 t/ha), superior quality (total soluble solids, sugars, carotene), and improved nutrient uptake and soil fertility. Therefore, the use of enriched organic manures in conjunction with bio-stimulants like Jiwamrita offers a promising, sustainable, and eco-friendly approach to boost productivity and quality in organic carrot cultivation.

Authors contribution: Conceptualization of research (R.C., K.D.); Designing of the experiments (R.C., K.D.); Contribution of experimental materials (R.C.); Execution of field/lab experiments and data collection (R.C., K.D.); Analysis of data and interpretation (R.C., K.D.); Preparation of the manuscript (K.D., R.C., S.D., C.G.).

Declaration

The authors declare that they do not have any conflict of interest.

Acknowledgements

Authors are highly thankful to Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalay, West Bengal, India for giving the opportunity to conduct the research work.

References

- Das SP, Mandal AR, Rambabu E, Aslam T. Studies on fruit yield of different varieties of tomato under new alluvial zone of West Bengal. *Res Crops*. 2016;17:784-7.
- DuBois M, Gilles KA, Hamilton JK, Rebers PT, Smith F. Colorimetric method for determination of sugars and related substances. *Anal Chem*. 1956;28:350-6.
- Edwards CA. The use of earthworms in the breakdown and management of organic wastes. In: Edwards CA, editor. *Earthworm ecology*. Boca Raton: CRC Press; 1998. p. 327-54.
- Karungi J, Ekbohm B, Kyamanywa S. Effects of organic versus conventional fertilizers on insect pests, natural enemies and yield of *Phaseolus vulgaris*. *Agric Ecosyst Environ*. 2006;115:51-5.
- Marzouk HA, Kassem HA. Improving fruit quality, nutritional value and yield of Zaghoul dates by the application of organic and/or mineral fertilizers. *Sci Hortic*. 2011;127:249-54.
- Mishra N, Sahu GS, Mishra PP, Ray M. Effect of panchagavya on growth and yield of capsicum. *Int J Trop Agric*. 2015;33:1-4.
- Nagendra Rao T. Phosphorus and Potassium nutrient management options for organic production systems. In: *Efficient use of on-Farm and Off-Farm Resources in Organic Farming*. Bhopal: IISS; 2009. p. 82-91.
- Nath G, Singh K, Singh DK. Chemical analysis of vermicomposts/vermiwash of different combinations of animal, agro and kitchen wastes. *Aust J Basic Appl Sci*. 2009;3:3671-6.
- Panda N, Sahoo BB, Mandal P, Nayak BR, Dash DK. Comparative efficacy of farm yard manure, poultry manure and vermicompost with and without *Azospirillum* on soil biological properties, growth and yield of tomato (*Lycopersicon esculentum* L.). *Environ Ecol*. 2015;33:2041-6.
- Ranganna S. *Handbook of Analysis and Quality Control of Fruit and Vegetable Products*. 2nd ed. New York: Tata McGraw-Hill Education; 1986.
- Rodrigues MA, Ladeira LC, Arrobas M. Azotobacter-enriched organic manures to increase nitrogen fixation and crop productivity. *Eur J Agron*. 2018;93:88-94.
- Sadasivam S, Manickam A. Peroxidase. In: *Methods in Biochemistry*. New Delhi: New Age International; 1996. p. 108-10.
- Sindhu PV, Kanakamany MT, Beena C. Effect of organic manures and biofertilisers on herbage yield, quality and soil nutrient balance in *Indigofera tinctoria* cultivation. *J Trop Agric*. 2016;54:16.
- Singh TB, Ali A, Prasad M, Yadav A, Shrivastav P, Goyal D, et al. Role of organic fertilizers in improving soil fertility. In: Larramendy ML, Soloneski S, editors. *Contaminants in Agriculture: Sources, Impacts and Management*. London: IntechOpen; 2020. p. 61-77.

15. Tiwari SC, Mishra RR. Fungal abundance and diversity in earthworm casts and in uningested soil. *Biol Fertil Soils*. 1993;16:131-4.
16. Tomati U, Grappelli A, Galli E. The hormone-like effect of earthworm casts on plant growth. *Biol Fertil Soils*. 1988;5:288-94.
17. Tomati U, Galli E. Earthworms, soil fertility and plant productivity. *Acta Zool Fenn*. 1995;196:11-4.
18. Toor RK, Savage GP, Heeb A. Influence of different types of fertilisers on the major antioxidant components of tomatoes. *J Food Compos Anal*. 2006;19:20-7.