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Effect of integrated nutrient management on growth and yield attributes of black carrot (*Daucus carota* subsp. *sativus* var. *atrorubens* Alef.)

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Abstract
A field experiment was conducted during *Rabi* of 2017-2018 to assess the effect of integrated nutrient management on growth and yield attributes of black carrot at Experimental Farm of Division of Vegetable Science SKUAST-K Shalimar. The experiment was laid out in randomized complete block design in which different combinations of inorganic fertilizers, organic manures and biofertilizers were applied constituting nine treatments and were replicated thrice. Results revealed that among the different treatment combinations, treatment T_9 (50%N+25%P&K+PSB+KSB+ 50%VC) recorded the higher values for shoot length at different intervals i.e., from 30 DAS (11.70 cm) till 90 DAS (46.86 cm), absolute growth rate from 30-45 DAS (0.46 g day^{-1}) till 75-90 DAS (0.87g day^{-1}), root length from 30 DAS (10.98 cm) till 90 DAS (30.99 cm), average root diameter (4.92 cm), average root weight (148.85 g), average shoot weight (75.27 g), root to shoot ratio (1.97), root yield per plot (23.81 kg) and root yield per hectare (285.79 q).

Keywords: Black carrot, organic manures, inorganic fertilizers, bio fertilizers, growth, yield

Introduction
Carrot is one of the major vegetable crops grown throughout the world (Vilela, 2004) [25] and it is considered as an important economical vegetable due to its high yield per unit area (Hassan *et al*., 2005) [13]. Although orange carrot varieties are more common but consumption of black carrots is increasing as well. The black carrot is rich in phenolic content, flavinols, calcium, iron zinc, vitamin A, B, C, E and selenium. It also contains calcium pectate which is a very good source of fibre. As the crop is heavy feeder of nutrients, judicious and proper nutrient management is essential for increased growth and yield of the crop. In India, during the past three decades, intensive agriculture involving exhaustive high yielding varieties has led to heavy withdrawal of nutrients from the soil which resulted in decreased nutrient uptake, deterioration of soil structure and decrease in the microbial population in the soil (Ganeshe *et al*., 1998) [7] which adversely affected the quality of vegetables (Agarwal, 2003) [2]. Moreover, in India, most of the farmers are small and marginal. Therefore, it becomes very difficult for them to purchase the chemical fertilizers at the higher cost. On the other hand organic manures like farmyard manure, vermicompost are eco-friendly, cheap source of nutrients and key factor in restoring the productivity of degraded soils as they supply the multiple nutrients and improve the organic matter content in the soil which in turn improves the physical properties, enhances the biological diversity and soil microflora, leading to sustainable vegetable production, devoid of harmful residues (Acharya and Mandal, 2002) [1] and help to improve the quality of vegetables (Singh *et al*., 2000) [20] Chatoo *et al*., 2003) [6] however, it has been observed that the crop response to organic manures is not as spectacular as with the chemical fertilizers owing to the slow release of nutrients during the initial years. Biofertilizers also play an important role in maintaining the sustainability of soil as biofertilizers are ready to use live formulations of such beneficial microrganisims which on application to seed, root or soil mobilizes the availability of nutrients by their biological activity in particular and help to build up the soil micro-flora and thereby the soil health. Therefore, to maintain the soil fertility and to supply the plant nutrients in balanced proportion without compromising the yield and

quality of the crop an integrated approach is to be practiced under specific agro-ecological situation through the combined use of inorganic and organic sources along with the application of biofertilizers.

Materials and Methods

The experiment was carried out at Experimental Farm, Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar. The experimental field is situated at 34.1° North latitude and 74.89° East longitude with an altitude of 1587 meters above mean sea – level. The experiment was laid out in randomized block design with nine treatments and three replications. The treatment combinations were T_1 RFD-(control), T_2(50%RFD+50%FYM), T_3(50%RFD+50%VC), T_4(50%N&K+25%P+PSB+50%FYM),T_5(50%N&K+25%P+ PSB+50%VC),T_6(50%N&P+25%K+KSB+50%FYM),T_7(50 %N&P+25%K+KSB+50%VC), T_8(50%N+ 25%P&K+PSB + KSB+ 50% FYM), T_9 (50%N+ 25%P&K+ PSB+ KSB+ 50%VC) Twenty seven plots of 3.0 m × 2.5 m size each were prepared as per layout specifications. The seeds of Black carrot variety Local Black were sown at spacing of 30 cm × 15 cm. Recommended dose of Nitrogen, Phosphorus and Potassium (90:60:60 kg ha^{-1}) was provided through urea, diammonium phosphate and muriate of potash according to the treatment. Organic manures viz., well decomposed farmyard manure (FYM), vermicompost were incorporated as per treatment to respective plots 15 days prior to sowing on the basis of nitrogen percentage. Biofertilizers (PSB&KSB) @ 5 l ha^{-1} were applied into the respective treatments before sowing of seed. Observations were recorded on various aspects like growth and yield attributes of crop. Data on shoot length, absolute growth rate, length of root, diameter of root and yield contributing characters were recorded from ten randomly selected plants. The experimental data was then subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (1984) [10].

Results and Discussions

Growth parameters

The experimental findings presented in Table 1 and Table 2 provided a detailed account of response of carrot to the integrated nutrient management on growth parameters. The study revealed that integrated nutrient management exhibited a significant influence on growth parameters under study over the sole application of chemical fertilizers. The highest mean values were obtained under treatment T_9 (50%N+25%P&K+PSB+KSB+ 50%VC) for growth parameters at different intervals of crop growth viz., shoot length from 30DAS (11.70 cm) till 90 DAS (46.86 cm), and absolute growth rate from 30-45DAS (0.46 g day^{-1}), 45-60DAS (0.56 g day^{-1}), 60-75 DAS (0.69 g day^{-1}) and 75-90DAS (0.87g day^{-1}) compared to other treatments.

Table 1: Effect of Integrated Nutrient Management on shoot length (cm) of black carrot

Treatment combinations		Shoot length (cm)				
		30DAS	45DAS	60DAS	75DAS	90 DAS
T_1	RFD	8.02^e	13.02^e	24.61^e	28.06^e	30.12^f
T_2	50% RFD+50%FYM	8.65^d	14.26^d	26.09^d	30.18^d	32.43^e
T_3	50% RFD+50% VC	8.87^d	14.48^d	27.03^d	30.29^d	32.73^e
T_4	50% N&K+25%P+PSB+50%FYM	10.65^b	17.22^b	30.30^b	35.11^b	40.13^c
T_5	50% N&K +25%P+PSB+50%VC	10.85^b	17.51^b	30.72^b	36.02^b	41.81^c
T_6	50%N&P+25%K+KSB+50%FYM	9.62^c	15.64^c	28.51^c	32.30^c	37.01^d
T_7	50% N&P +25%K+KSB+50%VC	9.96^c	16.05^c	28.82^c	33.10^c	37.65^d
T_8	50%N+25%P&K+PSB+KSB+50%FYM	11.56^a	18.74^a	32.48^a	38.03^a	44.35^b
T_9	50%N+25%P&K+PSB+KSB+50%VC	11.70^a	18.87^a	32.92^a	38.89^a	46.86^a
	C.D ($p \leq 0.05$)	0.61	1.15	1.40	2.00	**2.20**
	S.E (d)	0.317	0.538	0.658	0.936	**1.029**

Mean values with same letters don't differ significantly

Table 2: Effect of Integrated Nutrient Management on Absolute Growth Rate (g day^{-1}) of Black carrot

Treatment combinations		Absolute Growth Rate (g day^{-1})			
		30-45 DAS	45-60 DAS	60-75DAS	75-90 DAS
T_1	RFD	0.30^e	0.40^e	0.51^e	0.58^g
T_2	50% RFD+50%FYM	0.33^d	0.43^d	0.55^d	0.62^f
T_3	50% RFD+50% VC	0.34^d	0.44^d	0.56^d	0.66^e
T_4	50% N&K+25%P+PSB+50%FYM	0.41^b	0.51^b	0.64^b	0.77^c
T_5	50% N&K +25%P+PSB+50%VC	0.42^b	0.52^b	0.65^b	0.79^c
T_6	50%N&P+25%K+KSB+50%FYM	0.37^c	0.47^c	0.59^c	0.70^d
T_7	50% N&P +25%K+KSB+50%VC	0.38^c	0.48^c	0.61^c	0.73^d
T_8	50%N+25%P&K+PSB+KSB+50%FYM	0.45^a	0.55^a	0.68^a	0.83^b
T_9	50%N+25%P&K+PSB+KSB+50%VC	0.46^a	0.56^a	0.69^a	0.87^a
	C.D ($p \leq 0.05$)	0.021	0.026	0.028	0.035
	S.E (d)	0.010	0.012	0.014	0.016

Mean values with same letters don't differ significantly

The increase in shoot length due to the application of vermicompost may be due to its rich content of macro and micro nutrients, vitamins, growth hormones and micro flora as reported by Bhawalkar (1991) [5]. Apart from macro and micro nutrients in vermicompost and their secretions in considerable quantities, there are reports that certain metabolites produced from earthworms may be responsible for stimulating plant growth. Biofertilizers like PSB and KSB can exert positive effect on plant growth by two mechanisms: direct and indirect as reported by Glick (1995) [7]. Indirect growth promotion is due to decrease or prevention of deleterious effects of pathogenic microorganisms, mostly due to synthesis of antibiotics, secondary metabolites as reported by Lipping *et al*. (2008) [18], Taurian *et al*. (2010) [24]. Direct

growth promotion can be due to synthesis of phytohormones like indole acetic acid and gibberllins, synthesis of some enzymes that modulate the level of plant hormones as reported by Glick *et al*. (2007) [9], Souchie *et al*. (2007) [27]. Furthermore, the better efficiency of inorganic fertilizers in combination with vermicompost and biofertilizers is due to reduction in soil compaction and improvement in aeration and supply of macro and micronutrients, organic matter and increased availability of nutrients as reported by Suge *et al*. (2011) [23], Kavitha *et al*. (2013) [37].

The increase in absolute growth rate at different stages of growth could be attributed to increased nutrient availability and uptake because of the proliferous root system developed under balanced nutrient application. It may also be attributed to increased rate of photosynthesis and accelerated mobility of photosynthates from source to sink which increases the dry matter accumulation thus increasing the absolute growth rate in carrot root. These results are in acordance with the findings of Rabindra Kumar and Srivastava (2006) [19], and Islam *et al*. (2013) [16].

Yield parameteres

Perusal of table 3 and table 4 revealed significant variation in yield and yield attributing parameters. Among the integrated treatments, treatment T_9 (50%N+25%P&K +PSB+KSB+50%VC) recorded maximum values for root length at different intervals of crop growth i.e., from 30DAS (10.98cm) till 90DAS (30.99 cm). The maximum values for root diameter (4.92 cm), average root weight (148.85g), average shoot weight (75.27 g), root to shoot ratio (1.97), root yield per plot (23.81 kg plot^{-1}) and root yield per hectare (285.79 kg ha^{-1}) was also observed in the same treatment. Chemical fertilizers contain higher amounts of nutrients and are sources of readily available form of nutrients, but the fertilizer use efficiency is often low due to the inherent soil characteristics, losses and low uptake. On the other hand, the integration improves nutrient availability and uptake, influences the soil physical and biological properties favourably, which reflects positively on the yield of crop (Isaac and Verghese, 2016) [15]. The size of root was directly influenced by the enhanced vegetative growth of the plants. This results in the accumulation of more carbohydrates, resulting in increased diameter of the root, which is food storage organ as reported by Bhandari *et al*., (2012) [4]. The combined application of vermicompost and biofertilizers favoured the auxin activities in plant and ultimately resulted in increased root diameter, root weight and finally the total yield. As far as root length is concerned, it has increased due to the combined application of vermicompost and bio-fertilizers. The use of biofertilizers like PSB &KSB increased the availability of phosphorus and potassium in the soil as reported by Han and Lee (2005) [12], Zaffer *et al*. (2017) [26]. Phosphorus stimulates root growth, cell division, cell enlargement. It is also a part of various enzymes, co-enzymes and energy rich ATP resulting in increased root growth Gyaneshwar *et al*. (2002) [11]. Potassium is the most important plant nutrient that has a key role in growth, metabolism and development of plants as is required to activate over 80 different enzymes responsible for plant processes such as energy metabolism, starch synthesis, nitrate reduction, photosynthesis and sugar degradation thus promoting growth as reported by Almeida *et al*. (2015) [3], and Hussain *et al*. (2016) [14]. The increase in weight may be attributed to accelerated mobility of photosynthates from source to sink as influenced by growth hormones, released or synthesized due to organic sources as well as biofertilizers which contributed to increased root yield as reported by Rabindra Kumar and Srivastava (2006) [19]. The increase in root yield might be due to the cumulative effect of all yield attributing components viz., root diameter, fresh and dry weight of root. The results are in conformity with the findings of Kamla Singh (2000) [21].

Table 3: Effect of Integrated Nutrient Management on root length (cm) of black carrot

Treatment combinations		Root length (cm)				
		30DAS	45DAS	60DAS	75DAS	90 DAS
T_1	RFD	7.43^{e}	12.17^{f}	15.62^{e}	20.47^{e}	22.00^{f}
T_2	50% RFD+50%FYM	8.01^{d}	13.34^{d}	17.00^{d}	21.42^{d}	23.38^{e}
T_3	50% RFD+50% VC	8.41^{d}	13.56^{d}	17.12^{d}	21.70^{d}	24.75^{d}
T_4	50%N&K+25%P+PSB+50%FYM	9.80^{b}	16.26^{b}	20.16^{b}	25.00^{b}	27.80^{c}
T_5	50% N&K +25%P+PSB+50%VC	10.13^{b}	16.56^{b}	20.38^{b}	25.17^{b}	28.13^{c}
T_6	50%N&P+25%K+KSB+50%FYM	8.97^{c}	14.74^{c}	18.51^{c}	23.08^{c}	26.13^{d}
T_7	50% N&P +25%K+KSB+50%VC	9.22^{c}	15.07^{c}	18.78^{c}	23.60^{c}	26.43^{d}
T_8	50%N+25%P&K+PSB+KSB+50%FYM	10.74^{a}	17.77^{a}	21.76^{a}	26.58^{a}	29.49^{b}
T_9	50%N+25%P&K+PSB+KSB+50%VC	10.98^{a}	17.99^{a}	21.98^{a}	26.89^{a}	30.99^{a}
	C.D ($p \leq 0.05$)	0.53	1.05	1.34	1.33	1.34
	S.E (d)	0.251	0.493	0.627	0.622	0.627

Mean values with same letters don't differ significantly

Table 4 : Effect of Integrated Nutrient Management on root diameter (cm), average root weight (g), average shoot weight (g), root to shoot ratio, root yield per plot (kg), root yield per hectare (q) of black carrot

Treatment combinations		Root diameter (cm)	Average Root Weight (g)	Average Shoot Weight (g)	Root To Shoot Ratio	Root yield per plot (kg)	Root yield per hectare (q)
T_1	RFD	3.01^{h}	104.19^{i}	64.24^{h}	1.62^{i}	16.67^{i}	200.05^{i}
T_2	50% RFD+50%FYM	3.22^{g}	111.64^{h}	66.05^{g}	1.69^{h}	17.86^{h}	214.32^{h}
T_3	50% RFD+50% VC	3.51^{f}	115.67^{g}	67.09^{fg}	1.72^{g}	18.50^{g}	222.08^{g}
T_4	50%N&K+25%P+PSB+50%FYM	4.23^{d}	132.29^{d}	71.33^{cd}	1.85^{d}	21.16^{d}	253.99^{d}
T_5	50% N&K +25%P+PSB+50%VC	4.44^{c}	137.37^{c}	72.44^{bc}	1.89^{c}	21.97^{c}	263.75^{c}
T_6	50%N&P+25%K+KSB+50%FYM	3.75^{e}	121.24^{f}	68.27^{ef}	1.77^{f}	19.39^{f}	232.77^{f}
T_7	50% N&P +25%K+KSB+50%VC	3.95^{e}	126.24^{e}	69.42^{de}	1.81^{e}	20.19^{e}	242.38^{e}
T_8	50%N+25%P&K+PSB+KSB+50%FYM	4.68^{b}	144.18^{b}	74.01^{ab}	1.94^{b}	23.06^{b}	276.83^{b}
T_9	50%N+25%P&K+PSB+KSB+50%VC	4.92^{a}	148.85^{a}	75.27^{a}	1.97^{a}	23.81^{a}	285.79^{a}
	C.D ($p \leq 0.05$)	0.20	3.65	1.67	0.028	0.60	6.64
	S.E (d)	0.094	1.711	0.785	0.013	0.285	3.109

Mean values with same letters don't differ significantly

Conclusion

Growth and yield parameters were found significantly better in treatment T_9 (50%N+25%P&K+PSB+KSB+50%VC) followed by treatment T_8 (50%N+ 25%P&K+ PSB+KSB+ 50% FYM). While the lowest was recorded in treatment T_1 (RFD The integrated nutrient management exhibited a significant influence on all treatments under study over sole application of chemical fertilizers (treatment T_1).

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