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**Fouzea Nisar**
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu and Kashmir, India

**Shahnaz Mufti**
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu and Kashmir, India

**Baseerat Afroza**
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu and Kashmir, India

**Faheema Mushtaq**
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu and Kashmir, India

**Rakshanda Bhat**
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu and Kashmir, India

**Najmah Andrabi**
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu and Kashmir, India

**Insha Majid**
Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu and Kashmir, India

**Shaila Din**
Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu and Kashmir, India

**Corresponding Author:**
**Fouzea Nisar**
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu and Kashmir, India

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

**Fouzea Nisar, Shahnaz Mufti, Baseerat Afroza, Faheema Mushtaq, Rakshanda Bhat, Najmah Andrabi, Insha Majid and Shaila Din**

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## Abstract
A field experiment was conducted during *Rabi* of 2017-2018 to assess the effect of integrated nutrient management on quality 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 dry matter content (14.40%), soluble solid concentration (12.91°Brix), total sugars (8.19%), total carotenoids(3.90 mg100 $g^{-1}$), total phenolic content (251.83 mg 100$g^{-1}$), anthocyanin content (49.66 mg 100$g^{-1}$). The colour values of black carrot was maximam in treatment $T_9$ having L* value of 16.04, a* value (5.07), b value (-40.84).

**Keywords:** Black carrot, organic manures, inorganic fertilizers, biofertilizers, quality

## Introduction
Carrot is one of the major vegetable crops grown throughout the world (Vilel, 2004) [20] and it is considered as an important economical vegetable due to its high yield per unit area (Hassan *et al*., 2005) [11]. 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 which adversely affected the quality of vegetables (Agarwal, 2003) [3]. 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) [2] and help to improve the quality of vegetables (Chatoo *et al*., 2003) [5] 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 quality attributes of crop. Data on dry matter, soluble solid concentration, total sugars, total carotenoids, total phenols, anthocyanin content, colour values were recorded following standard procedures. The experimental data was then subjected to statistical analysis as per the standard statistical procedure given by (Gomez and Gomez, 1984) [8].

## Results and Discussions

The experimental findings presented in Table 1, Table 2 and Table 3 provided a detailed account of response of black carrot to the integrated nutrient management on quality parameters. The study revealed that integrated nutrient management exhibited a significant influence on quality parameters under study over the sole application of chemical fertilizers. The highest mean values for quality attributes were obtained under 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).

Improvement in quality attributes of black carrot due to conjugation of organic manures with inorganics and biofertilizers (PSB&KSB) could be attributed to better and balanced nutrition and production of growth promoting substances, secondary metabolites by organics in presence of biofertilizers which might have led to improvement in quality. Improvement in quality can also be attributed to improvement in soil physical, chemical and biological properties which might have led to better root proliferation, improved nutrient uptake and better accumulation of photosynthates. While in chemical fertilizers (control) reduction in quality in comparison to integrated treatments could be attributed to the fact that these either provide single or sometimes two essential nutrients but not other nutrients. The present investigation also reveal that microbial inoculation in presence of organic manures increases the quality parameters as compared to control. The enhancing effect of biofertilizers on the quality of the roots can be related to the hormonal exudates secreted by them which modify root growth, morphology and physiology resulting in more acquisition of nutrients for growing plants. Similar findings were reported by (Gundala *et al*., 2013) [9].

The data presented in Table 1 revealed significant variation in dry matter due to various treatments. Dry matter content is one of the most important attribute that gives an idea about the photosynthetic ability and food accumulation in edible parts. The present investigation revealed that treatment $T_9$ (50%N+25%P&K+PSB+KSB+50%VC) resulted in significant improvement in dry matter content followed by treatment $T_8$ (50%N+25%P&K+PSB+KSB+50%FYM) over all other treatments. The increase in dry matter content might be due to the beneficial effect of organics (VC) as well as the concomitant application of bioferilizers (PSB & KSB) on soil physical and biological properties and its ability in solubilizing the available plant nutrients. It could also be attributed to better accumulation of photosynthates due to the availability of micronutrients (Kavitha *et al*., 2013) [13], Sheikh *et al*., 2017) [17]. Dry matter has direct influence on soluble solid concentration (SSC). The results of our experiment also support the findings in a way that treatment $T_9$ (50%N+25%P&K+PSB+KSB+50%VC) which recorded the highest dry matter content of roots also recorded the highest SSC of roots (Table 1). This could be due to better production of photosynthates and their translocation thereof (Narayan *et al.,* 2013) [16].Vermicompost in combination with biofertilizers and inorganic fertilizers have shown positive effect on total carotenoid content in carrot root (Table 1). Biofertilizers increased the availability and uptake of nutrients which physiologically influence the activity of number of enzymes that leads to increased cell metabolism which in turn change the biochemical composition of root. These results are in line with the similar findings of (Kavitha *et al*., 2013) [13] and (Singh *et al*., 2014) [18].

Phenolic content is one of the most important biochemical attribute of black carrot which occurs as secondary metabolites in all plant species. The phenolics are divided into several main groups one of which include the anthocyanins. The value of these compounds relies on the conditions under which the plants are grown. In the present investigation a consistently higher levels of total phenolics was also observed 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) (Table 1). This was attributed to a slow, gradual and balanced release of plant-available nutrients (Asami *et al*., 2003) [4] and (Pant *et al*., 2009) [14]. Furthermore, the concomitant application of biofertilizers (PSB&KSB) were responsible for production of secondary metabolites which favours the phenolic content of roots. (Glick, 2012) [7] and (Wani *et al*., 2007) [21].

The maximum anthocyanin content was also observed in the 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) due to combined application of organics with biofertilizers along with chemical fertilizers (Abbas andAli,2011)[1] and (Hassan, 2009) [10]. Since anthocyanin is the component of phenols, the increase in phenolic content has resulted in increase in anthocyanin content of roots as revealed from data in table 1.

The results pertaining to table 2 shows an increase in total sugars under treatment $T_9$ (50%N+25%P&K+ PSB+KSB+50%VC) which might be due to gradual supply of nutrients from vermicompost throughout the growth period of crop. It was observed that vermicompost application enhanced the activity of beneficial microbes which play an important role in mobilization of nutrients thus, leading to better availability of nutrients and uptake by plants and resulting in better quality. Similar results have been reported by (Indumathi, 2000) [12] and (Peyast *et al*., 2008) [15]. Further, the concomitant application of biofertilizers (PSB & KSB) activates the various soil enzymes and mobilizes the bound P &K which have a positive effect on sugar content of roots (Dinesh *et al.*, 2013) [6].

Amount of anthocyanins is the main determinant of the visual colour of black carrot (Wrolstad. 2004) [22]. Since the amount of anthocyanin was increased by the combined application of fertilizers, organic manures as well as biofertilizers, so the treatment which resulted in improvement of anthocyanin has more intense purple colour than all other treatments which is also supported by the fact that treatment $T_9$ (50%N+25%P&K+PSB+KSB+50%VC) showed the maximum colour difference over control (ΔE) which indicated that carrots grown under treatment $T_9$ developed more intense purple colour than the treatment which received nutrients solely through inorganic form (Table 3). Similar results were observed in orange carrots where the accumulation of total carotenoids is the main determinant of the visual colour of roots and the carrots which were grown with different combination of manures accumulated more carotenoids and showed more intense colour (Umiel and Gablelman, 1971) [19]

**Table 1:** Effect of Integrated Nutrient Management on dry matter content (%), soluble solid concentration ($^0$Brix), total carotenoids(mg100g$^{-1}$), total phenols (mg100g$^{-1}$), anthocyanin content (mg100g$^{-1}$) of black carrot

| Treatment combinations | | Dry matter (%) | Soluble Solid Concentration ($^0$Brix) | Total carotenoids (mg 100g$^{-1}$) | Total phenols (mg100g$^{-1}$) | Anthocyanin content (mg100g $^{-1}$) |
|---|---|---|---|---|---|---|
| $T_1$ | RFD | 9.26$^i$ | 8.31$^f$ | 2.19$^f$ | 243.00$^i$ | 40.84$^i$ |
| $T_2$ | 50% RFD+50%FYM | 9.77$^h$ | 9.15$^e$ | 2.42$^e$ | 244.00$^h$ | 41.89$^h$ |
| $T_3$ | 50% RFD+50% VC | 10.30$^g$ | 9.76$^d$ | 2.65$^d$ | 245.04$^g$ | 42.89$^g$ |
| $T_4$ | 50%N&K+25%P+PSB+50%FYM | 12.00$^d$ | 11.50$^b$ | 3.32$^b$ | 248.90$^d$ | 46.09$^d$ |
| $T_5$ | 50%N&K +25%P+PSB+50%VC | 12.67$^c$ | 11.77$^b$ | 3.51$^b$ | 249.93$^c$ | 47.03$^c$ |
| $T_6$ | 50%N&P+25%K+KSB+50%FYM | 10.83$^f$ | 10.44$^c$ | 291$^c$ | 247.22$^e$ | 44.43$^e$ |
| $T_7$ | 50%N&P+25%K+KSB+50%VC | 11.31$^e$ | 10.91$^c$ | 3.07$^c$ | 247.85$^e$ | 45.04$^e$ |
| $T_8$ | 50%N+25%P&K+PSB+KSB+50%FYM | 13.17$^b$ | 12.44$^a$ | 3.76$^a$ | 250.92$^b$ | 48.90$^b$ |
| $T_9$ | 50%N+25%P&K+PSB+KSB+50%VC | 14.40$^a$ | 12.91$^a$ | 3.90$^a$ | 251.83$^a$ | 49.66$^a$ |
| C.D ($p$≤0.05) | | 0.46 | 0.56 | 0.21 | 0.78 | 0.75 |
| S.E (d) | | 0.219 | 0.263 | 0.099 | 0.368 | 0.354 |

Mean values with same letters don't differ significantly

**Table 2:** Effect of Integrated Nutrient Management on total sugar (%), reducing, non-reducing sugar (%) of black carrot

| Treatment combinations | | Total Sugar (%) | Reducing Sugar (%) | Non Reducing sugar (%) |
|---|---|---|---|---|
| $T_1$ | RFD | 6.19$^i$ | 3.71$^i$ | 2.48$^i$ |
| $T_2$ | 50% RFD+50%FYM | 6.53$^h$ | 3.93$^h$ | 2.60$^h$ |
| $T_3$ | 50% RFD+50% VC | 6.76$^g$ | 4.04$^g$ | 2.72$^g$ |
| $T_4$ | 50%N&K+25%P+PSB+50%FYM | 7.46$^d$ | 4.40$^d$ | 3.06$^d$ |
| $T_5$ | 50% N&K +25%P+PSB+50%VC | 7.69$^c$ | 4.51$^c$ | 3.18$^c$ |
| $T_6$ | 50%N&P+25%K+KSB+50%FYM | 7.02$^f$ | 4.18$^f$ | 2.84$^f$ |
| $T_7$ | 50% N&P +25%K+KSB+50%VC | 7.25$^e$ | 4.30$^e$ | 2.95$^e$ |
| $T_8$ | 50%N+25%P&K+PSB+KSB+50%FYM | 7.89$^b$ | 4.61$^b$ | 3.28$^b$ |
| $T_9$ | 50%N+25%P&K+PSB+KSB+50%VC | 8.19$^a$ | 4.80$^a$ | 3.39$^a$ |
| C.D ($p$≤0.05) | | 0.022 | 0.050 | 0.038 |
| S.E (d) | | 0.010 | 0.023 | 0.018 |

Mean values with same letters don't differ significantly

**Table 3:** Effect of Integrated Nutrient Management on colour values (L, a*,b) of black carrot

| Treatment combinations | | Colour value "L" | Colour value a* | Colour Value b | Colour difference over control (ΔE) |
|---|---|---|---|---|---|
| $T_1$ | RFD | 28.03$^a$ | 9.85$^a$ | -30.44$^h$ | - |
| $T_2$ | 50% RFD+50%FYM | 26.48$^b$ | 9.12$^b$ | -31.47g | 1.99 |
| $T_3$ | 50% RFD+50% VC | 24.93$^c$ | 8.52$^c$ | -32.49$^f$ | 3.47 |
| $T_4$ | 50% N&K+25%P+PSB+50%FYM | 20.25$^e$ | 6.43$^e$ | -35.58$^d$ | 9.93 |
| $T_5$ | 50% N&K +25%P+PSB+50%VC | 18.71$^f$ | 6.22$^e$ | -36.59$^c$ | 11.74 |
| $T_6$ | 50%N&P+25%K+KSB+50%FYM | 23.39$^d$ | 7.71$^d$ | -33.55$^e$ | 5.95 |
| $T_7$ | 50% N&P +25%K+KSB+50%VC | 22.37$^d$ | 7.23$^d$ | -34.54$^e$ | 7.88 |
| $T_8$ | 50%N+25%P&K+PSB+KSB+50%FYM | 17.14$^g$ | 5.51$^f$ | -39.04$^b$ | 15.30 |
| $T_9$ | 50%N+25%P&K+PSB+KSB+50%VC | 16.04$^h$ | 5.07$^f$ | -40.84$^a$ | 16.44 |
| | C.D ($p$≤0.05) | 1.07 | 0.51 | 0.99 | |
| | S.E (d) | 0.50 | 0.24 | 0.46 | |

Mean values with same letters don't differ significantly

## Conclusion

From this study, it is concluded that integrated nutrient management exhibited a significant influence on all treatments under study over sole application of chemical fertilizers (treatment $T_1$). Among various treatment combinations, quality attributes 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).

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