

Studies On Integrated Nutrient Management On Growth, Yield And Quality Of Carrot (*Daucus Carota L.*) Cv. Pusa Vasuda Under Valley Condition Of Garhwal Hills

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DOI: 10.47750/pnr.2022.13.S02.77

Abstract

Integrated nutrient management has significant potential for addressing the increased nutritional demands of carrot cultivation and sustaining higher levels of yield with an overall improvement in the quality of the resource base. A well-balanced application of organic, inorganic, and biofertilizers is necessary to maintain a healthy soil (biological and chemical) environment and provide energy for the soil's microbial biomass. It contributes to enhancing and maintaining soil fertility and provides a solid foundation for horticultural production systems that can adapt to changing conditions. This study aimed to investigate the interaction effects of organic (FYM & Chicken Manure), inorganic (RDF 100%) & Biofertilizer (*Azotobacter* & *Azospirillum*) on growth, yield, and quality of carrot (*Daucus carota L.*) Cv. Pusa Vasuda under valley condition of Garhwal hills during the *rabi* season, 2016-2017 at Horticultural Research Centre, Department of Horticulture, H.N.B. Garhwal University, Srinagar Garhwal, (Uttarakhand), India. A randomized block design was used for the experiment, which was replicated thrice comprising 20 treatments [Control (non-amended soil) + 19 (treatments and their combination)]. The experiment was conducted with two main objectives, *i.e.*, to find out the effect of different inorganic, organic, and bio-fertilizers and their combination and to assess the best nutrients for growth, yield, and quality of carrot. The results indicated that the treatment T₁₄ [RDF (100%) + *Azospirillum*] was rated as best for the growth parameter like minimum days to first seed germination (13.33 days), plant height at 60 DAS (31.44cm), number of leaves after 60 DAS (7.44) and leaves weight (62.38 g) in carrot. However, yield parameters like maximum core diameter (1.20 cm), cortex diameter (1.47 cm), and root diameter (2.67 cm) were observed in treatment T₁₆ [FYM + RDF (100%) + *Azotobacter*], while root weight (175.03 g) was observed in treatment T₁ (FYM). On the other hand, quality parameter like vitamin-A (8222.67 I.U./100g) was recorded in treatment T₁₂ (Chicken manure + *Azospirillum*), total soluble solid (9.00 ° Brix) in treatment T₁₆ (FYM + 100% RDF + *Azotobacter*) and vitamin C (7.26 mg/100g) in treatment T₅ (*Azospirillum*). Based on the results of the above investigation, Pusa Vasuda responded well to the treatment T₁₄ [RDF (100%) + *Azospirillum*] and T₁₆ [FYM + RDF (100%) + *Azotobacter*] for various growth and yield parameters. Hence, these treatments could be recommended to enhance carrot production under Garhwal hills.

Keywords: Biofertilizer Carrot, Integrated, Manure, Nutrient and Organic

1. INTRODUCTION

Carrot (*Daucus carota* subsp. *sativus*), an important root vegetable crop that belongs to the Apiaceae family, with a chromosome number $2n = 2x = 18$ that is cultivated during the cool season - in spring, summer, and autumn in temperate regions, and in winter in tropical and subtropical regions - and is renowned for its high vitamin A and carotenes content. Afghanistan represents the center of diversity of the anthocyanin carrot and is believed to be its primary center of origin before the ninth century (Manisha *et al.*, 2022). It possesses a fleshy, edible taproot botanically referred to as a conical

root. Carrots are classified into two major groups: Asiatic (tropical) and European (temperate) types. Asiatic carrots are generally red due to anthocyanin pigments, while European carrots are orange due to carotene (a precursor of Vitamin A).

Carrot is used as a vegetable soup, sweets, curries, and pies; Grated roots are used in puddings (halwa) and sweets (gajrela). Carrot jam is also popular, and the roots in the form of disc and slices can be dehydrated. Purple carrots are used to prepare a sort of beverage called kanji, considered an excellent appetizer.

Carrot is valued as food mainly because it is an excellent source of β -carotene (1890 μ g/100 g fresh weight) besides a precursor of vitamin A. Per 100 g; carrot root has 1890 μ g β -carotene, 0.2 g fat, 86 g moisture, 0.02 mg riboflavin, 0.9 g protein, 0.04 mg thiamine, 10.6 g carbohydrates, 3.0 mg vitamin C, 2.2 mg iron and 80 mg calcium.

Carrots also have antioxidant properties, neutralize harmful free radicals, protect against cardiovascular disease, and also help to eliminate uric acid & improve the quantity of urine. **Chopra et al. (1933)** reported carrot use as curing diseases of the kidney and dropsy. It has been discovered that a mixture of carrot and orange juices as a dietary supplement reduces the oxidation of low-density lipoprotein in cigarette smokers.

2. MATERIAL AND METHODS

2.1 Field survey

The present study was conducted at Horticultural Research Centre, Chauras Campus, Department of Horticulture, H.N.B. Garhwal University, Srinagar Garhwal, Uttarakhand (India), situated in Alakananda valley (78°47'30" E longitude and 30°13'0" N latitude at an altitude of 540 meters above mean sea level) during Rabi, 2016-2017. The experiment used a randomized block design with three replicates comprising 20 treatments [Control (non-amended soil) + 19 (treatments and their combination) given in **Table 1**].

The experimental material (variety) used in this experiment was "Pusa Vasuda," collected from IARI, New Delhi. It is the first public sector tropical carrot hybrid developed using the Cytoplasmic Male Sterility (CMS) system and released by Delhi State Seed Sub-Committee in 2013. Roots are smooth, attractive, vigorous, self-colored, red, juicy, and rich in total carotenoids, lycopene, TSS, and minerals. It is suitable for salad, juice extraction, cooking, and industry for carotenoid extraction. Maturity 80-90 days. Average yield 40.0 t/ha.

2.2 Physio-chemical data

The observations were recorded on a ten-plant basis from each plot per replication for the following characters viz., growth parameters such as first seed germination, plant height (cm) (30 DAS & 60 DAS), number of leaves/plant (30 DAS & 60 DAS) & yield parameters such as weight of plant (g), root weight (g), leaf weight (g), root length (cm), root diameter (cm), core diameter (cm), cortex diameter (cm), yield per plot (kg) and quality parameters such as TSS ($^{\circ}$ Brix), vitamin C (mg/100g), vitamin A (I.U/100g).

The estimation of Vitamin-A (I.U/100g) content was done by dissolving one gram sample in solvent (acetone) and ground till whole color is extracted. The reading was compared with the standard curve and quantity of carotenoid was calculated as per method described by (**Ranganna, 2004**).

$$\mu\text{g of carotenoids} = \frac{\text{Concentration} \times \text{Final Volume} \times \text{Dilution}}{\text{Weight of Sample}} \times 100$$

2.3 Statistical analysis

Sixteen traits from carrot were measured during the growing season. Analysis of variance (ANOVA) was performed as treatment with three replications. The data were subjected to analysis of variance (ANOVA) using a randomized block design (RBD) (**Panase and Sukhatme, 1961**). Pearson's correlation coefficients were obtained using SPSS ver. 16.

Table 1: Treatments and their combination.

Treatments	Description
T ₁	Farmyard manure (FYM)
T ₂	Chicken manure (CM)
T ₃	RDF (100%)
T ₄	<i>Azotobacter</i>
T ₅	<i>Azospirillum</i>
T ₆	FYM + CM
T ₇	FYM + RDF (100%)
T ₈	FYM + <i>Azotobacter</i>
T ₉	FYM + <i>Azospirillum</i>
T ₁₀	CM + RDF (100%)
T ₁₁	CM + <i>Azotobacter</i>
T ₁₂	CM + <i>Azospirillum</i>
T ₁₃	RDF (100%) + <i>Azotobacter</i>
T ₁₄	RDF (100%) + <i>Azospirillum</i>
T ₁₅	<i>Azotobacter</i> + <i>Azospirillum</i>

T ₁₆	FYM + RDF (100%) + <i>Azotobacter</i>
T ₁₇	FYM + RDF (100%) + <i>Azospirillum</i>
T ₁₈	CM + RDF (100%) + <i>Azotobacter</i>
T ₁₉	CM + RDF (100%) + <i>Azospirillum</i>
T ₂₀	Control

RESULT AND DISCUSSION

The obtained result from the study shows that the minimum days to first seed germination (13.33) was noticed in T₉ (FYM + *Azospirillum*), which was significantly superior over the rest of the treatments. In contrast, the maximum days to first seed germination was found in treatment T₈ (16.67) in (FYM + *Azotobacter*) (**fig. 1**). This may be due to the jaggery coating and *Azospirillum*, which stimulate moisture retention, strong microbial activity, and the release of amino acids and hormones into the seed, resulting in rapid germination. These findings are consistent with those of **Bruno et al. (2007)** in carrot research. The maximum plant height at 30 DAS (22.17 cm) and 60 DAS (33.64 cm) were recorded in T₇ (FYM + 100% RDF), which was significantly superior over the rest of the treatments, whereas the minimum plant height at 30 DAS (12.85 cm) and 60 DAS (29.22 cm) was found in treatment T₁₅ (*Azotobacter* + *Azospirillum*) (**fig. 1**). The integration of organic and inorganic manure, improves the soil condition, soil bulk density, aeration and increase the availability of macro, micro with other beneficial nutrients and also enhance the availability of beneficial growth promoting substances like, IAA, GA, kinetin, riboflavin and thiamine, an integral part of amino acids, auxins, cytokinins, nucleotides, nucleic acids, some co-enzymes and alkaloids, these hormones induces cell elongation, cell enlargement, and cell division. These enzymes and hormones produce the beneficial effects of plant growth, directly correlated with the yield attributed traits. These findings are in agreement with the findings of **Jeptoo et al. (2013)** and **Ali et al. (2014)**. The number of leaves per plant at 30 DAS and 60 DAS in carrot Cv. Pusa Vasuda, the maximum recorded in T₁₄ (100% RDF + *Azospirillum*), was significantly superior over the other treatments. On the other hand, the minimum number of leaves at 30 DAS was found in treatment in T₂₀ (Control), and 60 DAS was found in treatment in T₁₈ (chicken manure +100% RDF + *Azotobacter*) (**fig. 1**). The increment in the number of leaves is due to the ability of *azospirillum*, the *azospirillum* lead in mobilizing the mineral nutrient from non- soluble to a soluble form, the micronutrients especially nitrogen is an essential part of the amino acid, cytoplasm, chloroplast, and phosphorus plays a crucial role in development. Similar observations have been reported by **Kirad et al. (2010)** in carrots and **Kumar et al. (2014)** in radish.

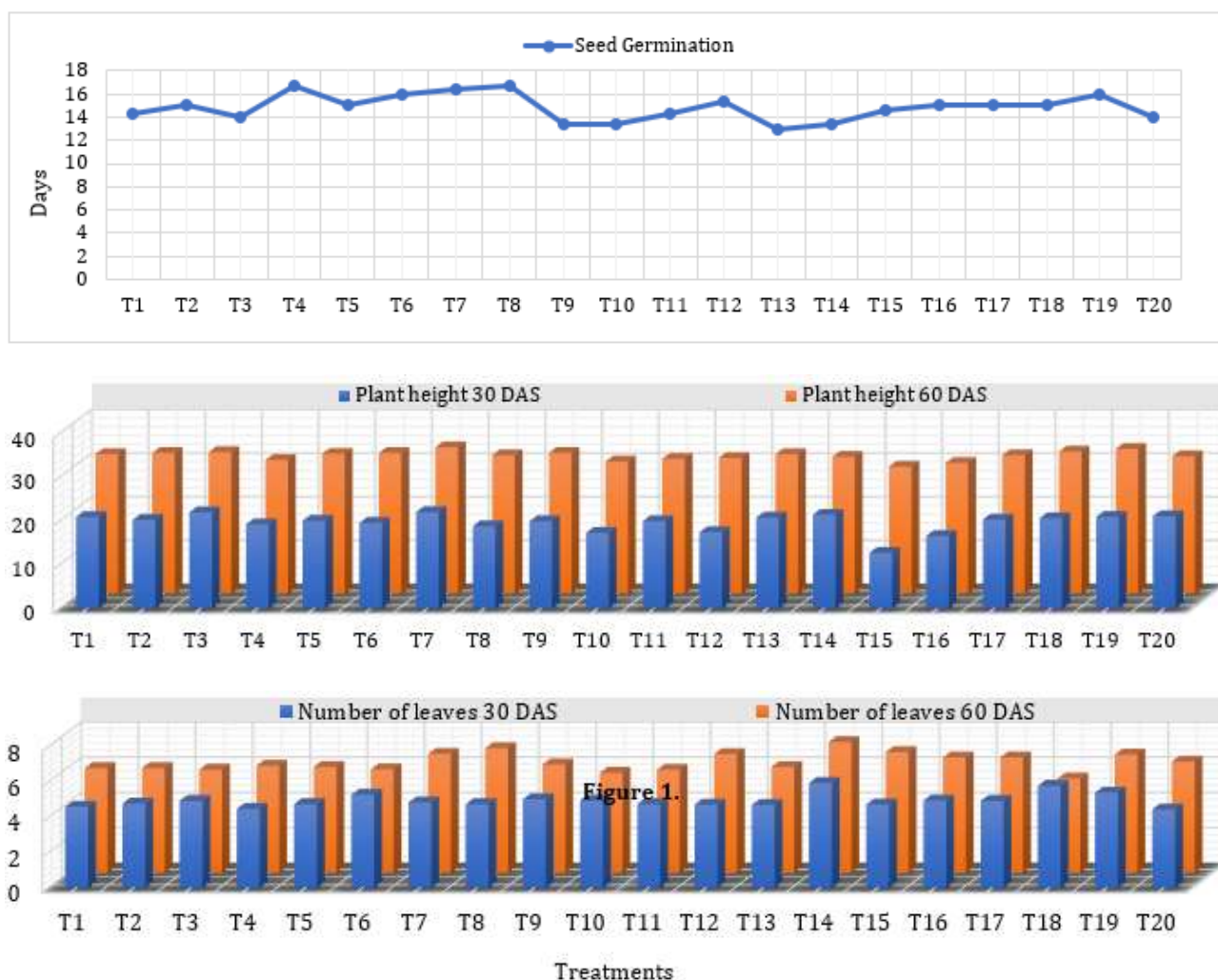


Figure 1.

Interaction of organic manure & inorganic fertilizer, and biofertilizers increased the root, leaf, and dry weight. The maximum (175.03 g) root weight of the plant was recorded in treatment T₁ (FYM). On the other hand, a minimum (111.50 g) root weight was found in treatment T₁₅ (*Azotobacter* + *Azospirillum*) shown in (fig. 2). The probable reason may be for the increased weight of root is due to optimum organic matter and humus content in the soil, which provides the reserve food materials to the sink, through increased activity of hydrolyzing and oxidizing enzymes. These findings are in agreement with the findings of Sunandarani and Mallareddy (2007). Significant differences in Pusa Vasuda were observed. The maximum (67.50 g) leaf weight was recorded in treatment T₂₀ (Control). On the other hand, a minimum (19.52 g) leaf weight was found in treatment T₃ (100% RDF) (fig. 2). The control showed that the high total leaf weight might be due to the high availability of nutrients in the plot. The maximum (223.65 g) total weight of the whole plant was recorded in treatment T₆ (FYM + chicken manure). While the minimum (148.17 g) total weight of the whole plant was found in treatment T₅ (*Azospirillum*) (fig. 2). The organic manures are the critical substances in the improvement of physical, chemical, and biological properties of soil. Organic manures are a rich source of various essential and beneficial nutrients necessary for the optimum growth and development of the crop. Similar findings have been reported by Ahmad et al. (2005) in carrot.

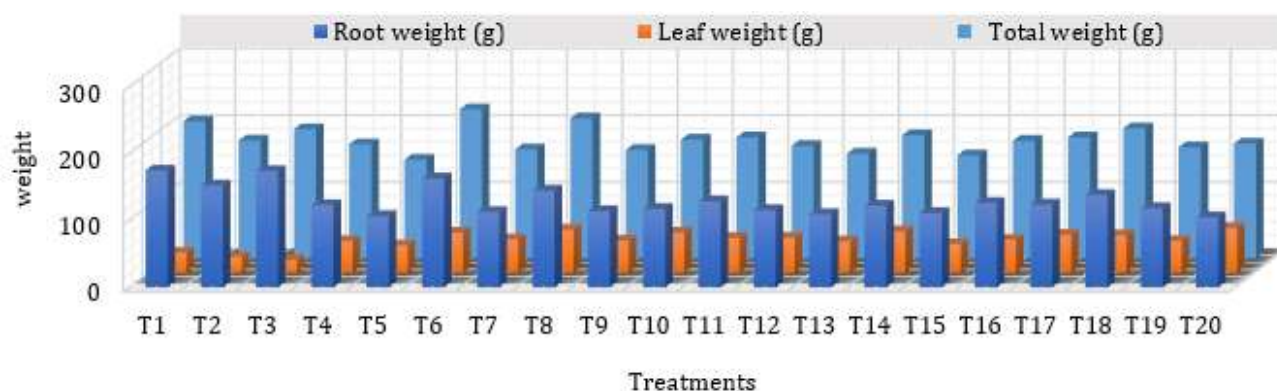


Figure 2.

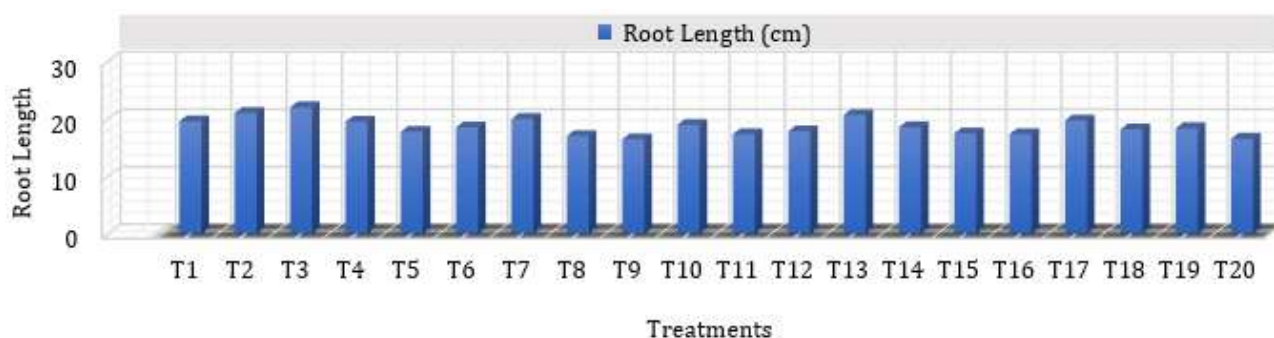


Figure 3.

The maximum (22.10 cm) root length was recorded in treatment T₃ (100% RDF); on the other hand, the minimum (16.52 cm) root length was found in treatment T₉ (FYM + *Azospirillum*) (fig. 3). The NPK play the crucial role of any crop development because these three elements are showed the influential role in chlorophyll content, cytoplasm and root growth of plants. All these parts of plants are essential for the rapid development of roots. These results are in accordance with the findings of Kamalakannan and Manivannan (2002) in radish, Sunandarani and Mallareddy (2007) in carrot.

The maximum core diameter (1.20 cm) of the root was recorded in treatment T₁₆ [FYM + RDF (100%) + *Azotobacter*]. On the other hand, a minimum (0.46 cm) core diameter of the root was found in treatment T₁₈ [Chicken manure+ RDF (100%) + *Azotobacter*] as shown in (fig. 4). Basically, FYM act to improve organic matter water holding capacity, availability of nutrients and decrease bulk density. In contrast, the inorganic manure and *Azotobacter* provide nitrogen which is a significant constitute of chlorophyll and enhances the mobilization & availability of insoluble to soluble nutrients, respectively, and finally leads to carbohydrate utilization, root growth, and development and stimulation of uptake and utilization of other nutrient elements. Which ultimately enhances cortex diameter. The maximum cortex diameter (1.47 cm) of the root was recorded in treatment T₁₆ [FYM + RDF (100%) + *Azotobacter*]. On the other hand, a minimum (0.80 cm) cortex diameter of the root was found in treatment T₂ (Chicken manure) (fig. 4). This may be due to the interactive effect of biofertilizer with the organic and inorganic manure, which converted the various nutrients to insoluble to soluble forms that are readily available to the plant. The organic and inorganic amendments maintain the continuous supply of essential nutrients, which increase the photosynthetic efficiency and root biomass and lead to more

cortex diameter. The maximum diameter of the root (2.67 cm) was recorded in treatment T₁₆ [FYM + RDF (100%) + *Azotobacter*]. On the other hand, a minimum (1.42 cm) root diameter was found in treatment T₂ (Chicken manure), as shown in (fig. 4). The root diameter is the result of the combination of core and cortex that ultimately showed in the form of root diameter.

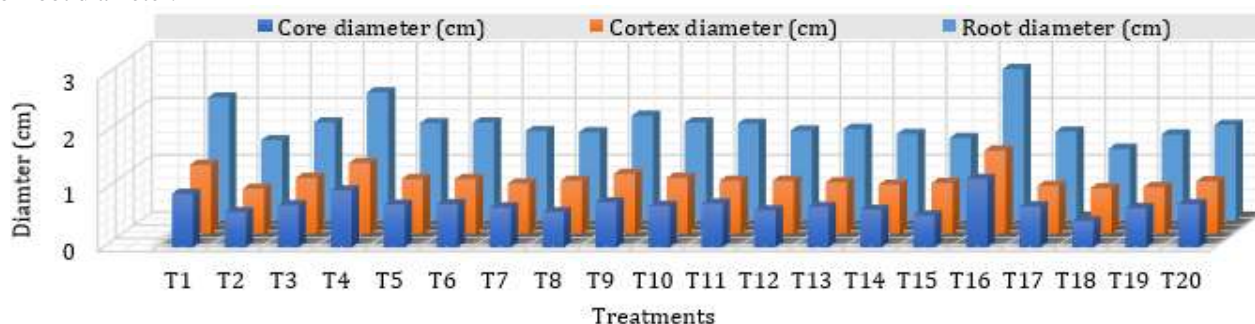


Figure 4.

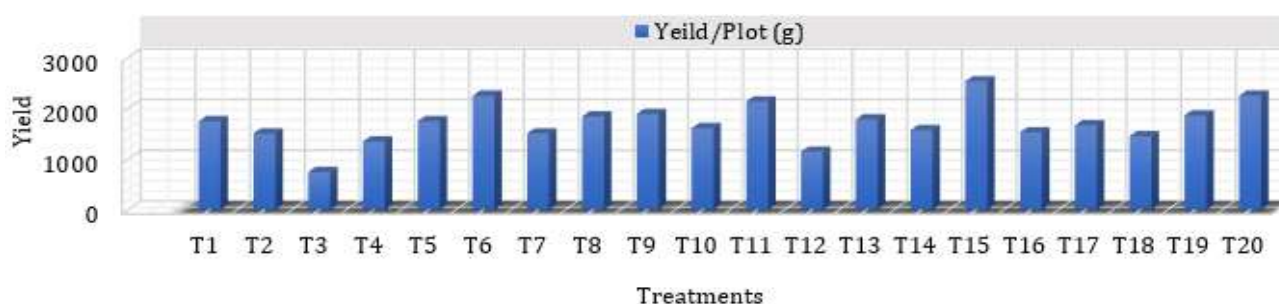


Figure 5.

There was significant variation regarding the yield per plot (kg). The maximum yield per plot (2.541 kg) was recorded in treatment T₁₅ (*Azotobacter* + *Azospirillum*). On the other hand, a minimum (0.751 kg) yield per plot was found in treatment T₃ (100% RDF) (fig. 5). This may be due to the additive effects of the entire growth and yield components; mutualistic relationship exists between *Azotobacter* and *Azospirillum* where both interact and attributed to improvements in root development. It stimulates development of foliage, and roots, triggered by fixed nitrogen and plant growth regulator substance produced, and ultimately increases the rate of leaf area, which determines the photosynthetic capacity of the plant, which leads to better assimilation of produce and towards yield. These findings agree with Kamalakannan and Manivannan (2003) in radish and Sarma et al. (2015) in carrot.

The maximum vitamin A (8222.67 mg/100g) was recorded in treatment T₁₂ (Chicken manure + *Azospirillum*). On the other hand, minimum (4862.33 mg/100g) vitamin A was found in treatment T₅ (*Azospirillum*) as shown in (fig. 6). The total carotenoids and β - carotene accumulation in carrot root were related to carrot genotype. Increasing light also caused an increase in carotenes. Light influences growth and differentiation, but with the time effect, we tend to classify carotenes as a differentiation-related characteristic, as carotenes are carrot-specific. Similar observations have been reported by Anjaiah and Padmaja (2006).

The maximum vitamin C (7.26 mg/100g) was recorded in treatment T₅ (*Azospirillum*). On the other hand, minimum vitamin C (4.94 mg/100g) was found in treatment T₃ (100% RDF). The biofertilizer is attributed to the increase in nutrient availability in the soil due to the mineralization of nutrients to increase uptake by the carrot plants. These factors enhance the vitamin C content in the root. The maximum total soluble solid (9.00 °Brix) was recorded in treatment T₁₆ (FYM + 100% RDF + *Azotobacter*). On the other hand, a minimum (6.33 °Brix) was found in treatment T₆ (FYM+ Chicken manure) (fig. 7). This may be because the N content is less in FYM, resulting in lower C: N ratio in soil, which has a positive correlation with ethylene production and it induces water core incidence along with loss of cell-to-cell adhesion, hence increased the sweetness. Similar observations have been reported by Ahmad et al. (2005) and Bruno et al. (2007) in carrot.

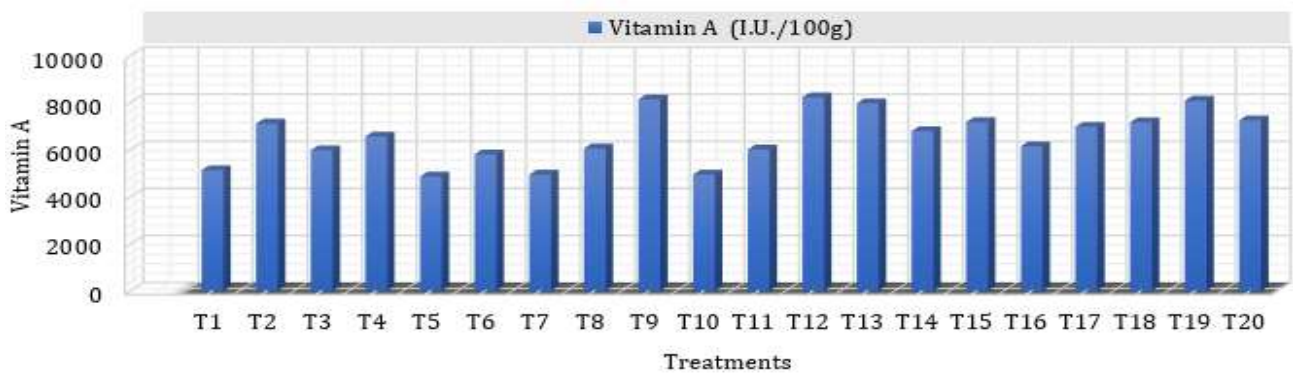


Figure 6.

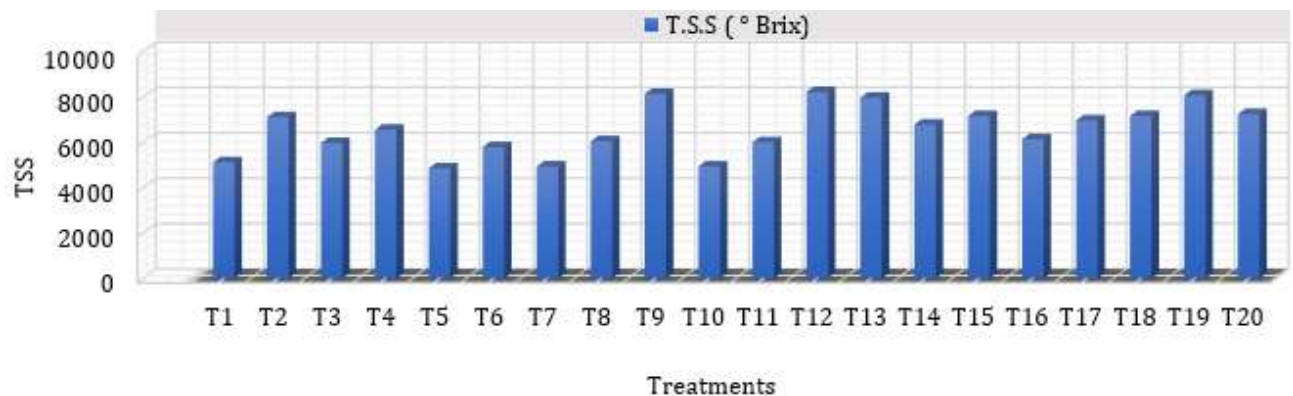


Figure 7.

CONCLUSION:

Based on results obtained from the present investigation, Pusa Vasuda responded well to the treatment T₁₄ [RDF (100%) + *Azospirillum*] for various growth and yield parameters. The treatments T₁₆ [FYM + RDF (100%) + *Azotobacter*] and T₃ [RDF (100%)] also performed well regarding different parameters as they showed significant parallel to the treatment T₁₄ [RDF (100%) + *Azospirillum*]. The treatment T₁₉ [Chicken manure+ RDF (100%) + *Azospirillum*] showed the overall best response among the 20 treatments in quality parameters like vitamin-A and total soluble solid (TSS). Hence, these treatments could be recommended to enhance carrot production under Garhwal hills.

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