

Original Research Article

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Effect of Biofertilizers in Combination with Inorganics on Quality Characters of Carrot

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ABSTRACT

The investigation was carried out at the Horticultural Research Station, Dr. Y. S. R. Horticultural University, Andhra Pradesh during Rabi 2017-18 to study the effect of bioinoculants and inorganics on quality characters of carrot. Two factors were taken, the first factor being the chemical fertilizers at three levels (100%, 75%, 50% of RDF) and the second factor was the different combinations of five biofertilizers (PSB, KSB, *Azospirillum*, *Azotobacter*, VAM). The experimental design adopted was the factorial RBD with 12 treatment combinations. The results revealed that the individual effect of chemical fertilizers at level 100% RDF (75:60:50 kg/ha) and biofertilizer's level PSB+ KSB+ *Azospirillum*+ *Azotobacter* + VAM showed a significant difference in quality characters compared to the other levels. The characters viz., total soluble solids (9.50 °Brix), β-carotene content (5.29 mg/100 g), total sugars (10.94 %), reducing sugars (6.23 %), non-reducing sugars (4.71 %) and total protein content (866.63 mg/100g) of carrot were recorded the highest with the application of 100% RDF+PSB+ KSB+ *Azospirillum*+ *Azotobacter*+ VAM. The lowest core diameter (2.11 cm), a favourable character was achieved with the application 50% RDF+ PSB+ KSB+*Azotobacter*. The end of shelf life was treated, at a stage where 50 per cent of the stored roots become unfit for consumption and the maximum shelf life (3 days) was obtained at lower levels of nutrient applications. Hence, varying rate of nutrients application effect the quality attributes significantly. The use of biofertilizers in combination with the chemical fertilizers would yield higher quality produce and also aid in adding steps towards sustainable crop production, by conserving the soil health.

Keywords

Carrot,
Biofertilizers,
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Introduction

The production and marketing of vegetable crops are undergoing continuous change globally, due to growing demands of consumers for safe and healthy vegetables. Vegetables make up a major portion of the

diet in many parts of the world and play a significant role in human nutrition, especially as sources of vitamins (C, A, B₁, B₆, B₉, E), minerals, dietary fibre and phytochemicals (Dias, 2012). Quality can be defined as a degree of excellence, a high standard or value in terms of appearance and nutritional value.

The general objectives for any growers is to obtain good yield, uniformity of crop and resistance to abiotic-biotic stress whereas, the objectives for consumers are quality, appearance, shelf life, taste and majorly the nutritional value.

Quality in vegetable crops is often more important than yield for consumers therefore, for the growers to survive, cultivars must be accepted by the market and hence forth meet the demands of the consumers (Silva, 2014). Human and environmental health risks are invited by inappropriate vegetable production practices that arise with the judicious application of nutrients to plants without due regard to the pollution on air, soil or water. The application of unsorted, excessive or insufficient dose of nutrients to plants negatively affects the quality attributes of the crop (Dias, 2011).

Consumers are prepared to pay a premium for such produce if their expectations are met and even the processing sector, other industries prefer vegetables with high TSS, sugars ascorbic acid etc for the varied purposes. A sustainable agriculture today makes a sustainable tomorrow. The different combinations of recommended dose of fertilizers along with the biofertilizers would furnish the immediate requirements and also supply the immobile and the fixed forms of the nutrients thereby improve the various quality traits of the crop. The experiment was conducted with the objective to find the effect of biofertilizers, NPK and the interaction effect of biofertilizers and different levels of NPK on quality characters of carrot.

Materials and Methods

Field experiment was conducted at Horticultural Research Station, Pandirimamidi that comes under high altitude tribal zone of Andhra Pradesh, India which is situated at an altitude of 250 m above mean sea level with

17°25' East latitude and 81°45' North longitudes. The experimental site received an annual rainfall of 1186 mm. The pH of irrigation water was recorded as 6.0 and EC was 1.66dSm⁻¹. The land used under the experiment was fairly uniform with pH of 6.5. The experiment consisted of twelve treatment combinations with three levels of inorganics (100% RDF (F₁)- 75:60:50 kg/ha; 75% RDF (F₂)- 56:45:37.5 kg/ha and 50% RDF (F₃)- 37.5:30:25 kg/ha) and four levels of biofertilizers (PSB+ KSB+ *Azospirillum* (B₁), PSB+ KSB+ *Azotobacter* (B₂), PSB+ KSB+ Vesicular Arbuscular Michorrhiza (B₃), PSB+ KSB+ *Azospirillum*+ *Azotobacter* + VAM (B₄)). The factorial randomized block design was adopted with three replications. The experimental field was thoroughly ploughed to a depth of 30 cm and harrowed twice. The field was laid at a gross plot size of 2.2 m X 1.8 m and net plot size of 2 m X 1.5 m. The biofertilizers (PSB, KSB, *Azospirillum*, *Azotobacter*, VAM) were applied to soil, by adding them to well decomposed FYM as per different treatments at the rate of 5 kg/ ha. The field was irrigated and let for the beneficial microorganisms to grow. Carrot seed cv. Pusa Rudhira was sown in ridge and furrow system at a depth of 1 cm. Standard cultural and management practices were adopted. Observations were recorded on various quality traits viz., total soluble solids, β-carotene content, total sugars, reducing sugars, non-reducing sugars and total protein content of carrot. The end of shelf life was treated, at a stage where 50 per cent of the stored roots become unfit for consumption. The data collected was subjected to analysis of variance (ANOVA). The test of significance (t-test) and critical difference was calculated at 0.05% probability.

Results and Discussion

The results obtained highlight the importance of the significant variation within the various levels of inorganics and biofertilizers, singly

and also in combinations. The TSS of carrot recorded highest (8.84 °B) in the plants applied with 100% RDF (F₁) followed by 75% RDF (F₂) and 50% RDF (F₃) with 8.50 °B and 7.99 °B respectively. Biofertilizers PSB+ KSB+ *Azospirillum*+ *Azotobacter*+ VAM (B₄) recorded the highest (8.94 °B) TSS, followed by PSB+ KSB+ *Azotobacter* (B₂) with 8.42 °B and PSB+ KSB+ VAM (B₃) with 8.32 °B were found to be on par with each other.

The crop applied with 100% RDF+ PSB+ KSB+ *Azospirillum*+ *Azotobacter* +VAM (F₁B₄) combination reported the maximum interaction effect and recorded highest TSS of 9.50 °B followed by 100% RDF+ PSB+ KSB+ *Azotobacter* (F₁B₂) with 8.80 °B.

The increasing K fertilizer played a key role in increasing the root TSS value. The higher dosage of nutrients provided to the crop hastens the metabolic activity in the shoot and the accumulation of photosynthates there by accumulation of various forms of carbohydrates *i.e.* sugars (predominantly sucrose). The findings are in agreement with Lyngdoh (2001) in carrot. It was suggested that, this could be due to the improvement of soil structure and improved nutrient and moisture status of the soil in favour of plant growth due to application of bio fertilizers.

Higher core diameter is considered as an unfavourable character. It was observed that the different levels of chemical fertilizers, biofertilizers and also the interaction of both the factors at various levels had no significant effect on core diameter of the roots. However, at lower levels of chemical fertilizers and biofertilizers, the lowest root diameter was recorded, which ultimately resulted in a lower core diameter.

The nutrition plays an important role for β-carotene content and protein accumulation in

the roots. The β-carotene and protein content increased with increasing levels of chemical fertilizers and recorded the highest of 5.06 mg/100g and 823.47 mg/100 g respectively with the treatment of 100% RDF (F₁), followed by 75% RDF (F₂) and 50% RDF (F₃) (Table 1). Similarly, biofertilizers PSB+ KSB+ *Azospirillum*+ *Azotobacter*+ VAM (B₄) recorded the highest β-carotene content of 5.05 mg/100 g and protein 828.40 mg/100 g followed by the application of PSB+ KSB+ *Azotobacter* (B₂) with 4.68 mg/100 g and 808.02 mg/100 g respectively. The lowest values in terms of β-carotene and protein content were recorded with PSB+ KSB+ *Azospirillum* (B₁) application (Table 1).

It was observed that within the interaction effects 100% RDF+ PSB+ KSB+ *Azospirillum*+ *Azotobacter*+ VAM (F₁B₄) recorded the highest β-carotene and protein contents 5.29 mg/100g and 866.68 mg/100 g respectively, followed by 100% RDF+ PSB+ KSB+ *Azotobacter* (F₁B₂) while the lowest values were recorded in the combination of 50% RDF+ PSB+ KSB+ *Azospirillum* (F₃B₁) in both the parameters (Table 2).

The higher photosynthates accumulation and metabolism in the plant coupled with rapid cell division might be the reason for the highest dose of chemical fertilizers showing relative effect on the biosynthesis of antioxidant compounds, pigments in the plant.

This would be due to specific soil nutrients which might have been more readily available for shoot absorption, as a result of mineral and biofertilizers integration, which activated specific enzymes for the synthesis of carotene in carrot. The results obtained were in accordance with Sanwal *et al.*, (2006) in broccoli and Vithwel and Kanaujia (2013) in carrot. Nitrogen is a fundamental component of amino acids, which are the molecular building blocks of protein.

Table.1 Quality characters as effected by the different chemical fertilizers and biofertilizers

| Treatments | Total soluble solids (°Brix) | Core diameter (cm) | β-Carotene (mg/100 g) | Total protein (mg/100 g) | Total sugars (%) | Reducing sugars (%) | Non-reducing sugars (%) | Shelf life (days) |
|---|------------------------------|--------------------|-----------------------|--------------------------|------------------|---------------------|-------------------------|-------------------|
| Chemical fertilizers | | | | | | | | |
| 100% RDF (F₁) | 8.84 | 2.57 | 5.06 | 823.47 | 18.16 | 13.50 | 11.13 | 2.66 |
| 75% RDF (F₂) | 8.50 | 2.50 | 4.49 | 803.55 | 17.09 | 13.23 | 10.44 | 2.58 |
| 50% RDF (F₃) | 7.99 | 2.36 | 4.21 | 701.71 | 16.32 | 12.18 | 10.20 | 2.58 |
| C.D. at 5% | 0.09 | N/S | 0.17 | 9.69 | 0.55 | 0.74 | 1.05 | N/S |
| SE(m) ± | 0.03 | - | 0.05 | 3.28 | 0.18 | 0.25 | 0.35 | - |
| Biofertilizers | | | | | | | | |
| PSB+ KSB+ <i>Azospirillum</i> (B₁) | 8.09 | 2.42 | 4.16 | 704.02 | 15.71 | 12.15 | 9.23 | 2.55 |
| PSB+ KSB+ <i>Azotobacter</i> (B₂) | 8.42 | 2.39 | 4.68 | 808.02 | 17.59 | 13.16 | 11.22 | 2.66 |
| PSB+ KSB+ VAM (B₃) | 8.32 | 2.54 | 4.45 | 764.53 | 16.96 | 12.66 | 9.87 | 2.77 |
| PSB+KSB+<i>Azospirillum</i>+<i>Azotobacter</i> + VAM (B₄) | 8.94 | 2.57 | 5.05 | 828.40 | 18.50 | 13.91 | 12.04 | 2.44 |
| C.D. at 5% | 0.11 | N/S | 0.19 | 11.19 | 0.63 | 0.85 | 1.21 | N/S |
| SE(m) ± | 0.03 | - | 0.06 | 3.79 | 0.21 | 0.29 | 0.41 | - |

NOTE: The values for the total, reducing and non-reducing sugars are transformed values, as for percentages angular transformation is followed.

Table.2 Quality characters as affected by different combinations of chemical fertilizers and biofertilizers

| Treatment combinations | Total soluble solids (°Brix) | Core diameter (cm) | β – Carotene (mg/100 g) | Total protein (mg/100 g) | Total sugars (%) | Reducing sugars (%) | Non-reducing sugars (%) | Shelf life (days) |
|---|------------------------------|--------------------|-------------------------|--------------------------|------------------|---------------------|-------------------------|-------------------|
| 100% RDF+ PSB+ KSB+ <i>Azospirillum</i> (F₁B₁) | 8.35 | 2.35 | 4.66 | 750.07 | 8.53 (16.97) | 4.8 (12.60) | 3.73 (9.91) | 3.0 |
| 100% RDF+ PSB+ KSB+ <i>Azotobacter</i> (F₁B₂) | 8.80 | 2.64 | 5.18 | 852.88 | 10.02 (18.43) | 5.81 (13.94) | 4.21 (11.46) | 2.66 |
| 100% RDF+ PSB+ KSB+ VAM (F₁B₃) | 8.72 | 2.62 | 5.12 | 824.23 | 9.51 (17.95) | 5.32 (13.03) | 4.39 (10.23) | 2.66 |
| 100%RDF+PSB+KSB+<i>Azospirillum</i>+ <i>Azotobacter</i> + VAM (F₁B₄) | 9.50 | 2.69 | 5.29 | 866.68 | 10.94 (19.29) | 6.23 (14.44) | 4.71 (12.91) | 2.33 |
| 75% RDF+ PSB+ KSB+ <i>Azospirillum</i> (F₂B₁) | 8.25 | 2.57 | 4.11 | 766.27 | 7.25 (15.61) | 4.86 (12.72) | 2.54 (9.04) | 2.33 |
| 75% RDF+ PSB+ KSB+ <i>Azotobacter</i> (F₂B₂) | 8.54 | 2.43 | 4.56 | 805.06 | 9.03 (17.46) | 5.32 (13.29) | 3.71 (10.81) | 3.00 |
| 75% RDF+ PSB+ KSB+ VAM (F₂B₃) | 8.46 | 2.33 | 4.11 | 795.87 | 8.61 (17.05) | 5.04 (12.96) | 3.56 (10.45) | 2.66 |
| 75%RDF+PSB+KSB+<i>Azospirillum</i>+ <i>Azotobacter</i> + VAM (F₂B₄) | 8.76 | 2.11 | 5.17 | 847.01 | 9.81 (18.24) | 5.81 (13.94) | 3.99 (11.47) | 2.33 |
| 50% RDF+ PSB+ KSB+ <i>Azospirillum</i> (F₃B₁) | 7.69 | 2.41 | 3.71 | 595.73 | 6.33 (14.56) | 3.78 (11.13) | 2.38 (8.75) | 2.33 |
| 50% RDF+ PSB+ KSB+ <i>Azotobacter</i> (F₃B₂) | 7.93 | 2.58 | 4.30 | 766.13 | 8.45 (16.87) | 4.51 (12.25) | 3.94 (11.38) | 2.33 |
| 50% RDF+ PSB+ KSB+ VAM (F₃B₃) | 7.80 | 2.41 | 4.13 | 673.48 | 7.51 (15.87) | 4.36 (11.99) | 3.15 (8.93) | 3.00 |
| 50%RDF+PSB+KSB+<i>Azospirillum</i>+ <i>Azotobacter</i> + VAM (F₃ B₄) | 8.56 | 2.58 | 4.70 | 771.50 | 9.53 (17.97) | 5.35 (13.36) | 4.18 (11.73) | 2.66 |
| C.D. at 5% | 0.19 | N/S | 0.34 | 19.38 | 0.92 | 1.31 | 1.91 | N/S |
| SE(m) ± | 0.06 | - | 0.11 | 6.56 | 0.37 | 0.50 | 0.71 | - |

NOTE: The values in the brackets are transformed values, as for percentages angular transformation is followed

Therefore, increase in nitrogen based inputs, through the increasing levels of inorganics and biofertilizers would have triggered the protein accumulation. The use of biofertilizers improved the nitrogen availability for the plants by binding the atmospheric nitrogen and thus, improving the bioactive molecules in the roots.

The results obtained were in line with Solanki *et al.*, (2010) in brinjal and with Singh *et al.*, (2014) in broccoli who reported that the combination of biofertilizers along with chemical fertilizers recorded a high protein and lipid profile along with phosphate and sulphate content of broccoli curds.

The sugar's content increased linearly with the increasing fertilizer levels. The highest total sugars (18.16%), reducing sugars (13.50%) and non-reducing sugars (11.13%) with 100% RDF (F₁) followed by 75% RDF (F₂) and 50% RDF (F₃) (Table 1).

Among the various biofertilizers the application of PSB+ KSB+ *Azospirillum* + *Azotobacter*+ VAM (B₄) recorded the highest total sugar (18.50%), reducing sugar (14.44%) and non-reducing sugars (12.04%) followed by PSB+ KSB+ *Azotobacter* (B₂) and PSB+ KSB+ VAM (B₃) (Table 1). Within the total sugars PSB+ KSB+ *Azotobacter* (B₂) recorded 17.59% and was on par with PSB+ KSB+ VAM (B₃) with 16.96%. The results with regard to non-reducing sugars showed, that the treatment of biofertilizers PSB+ KSB+ *Azospirillum*+ *Azotobacter*+ VAM (B₄) was on par with PSB+ KSB+ *Azotobacter* (B₂) with 11.22%. The lowest total sugars (15.71%), reducing sugar (11.13%) and non-reducing sugars (9.23%) were recorded with the treatment of PSB+ KSB+ *Azospirillum* (B₁). The treatment combinations at various levels of chemical fertilizers and biofertilizers recorded the highest values of total sugars (19.29%),

reducing sugar (14.44%), non-reducing sugars (12.91%) in the plants applied with 100% RDF+ PSB+ KSB+ *Azospirillum*+ *Azotobacter*+ VAM (F₁B₄) followed by 100% RDF+ PSB+ KSB+ *Azotobacter* (F₁B₂) while, the lowest values were recorded with combination of 50% RDF+ PSB+ KSB+ *Azospirillum* (F₃B₁) (Table 2).

Total sugars are the sum of reducing and non-reducing sugars, a similar trend of response was observed to be followed as in the case all the sugars. The nutrients applied increased the shoot growth and photosynthetic accumulation this might have increased the sugar content in the roots as a fact that fertilizers play a key role in effective development of the plants, as each mineral nutrient has a specific role in running a dynamic system in the plants which yield various quality and quantity related characters in the plants' internal processes. Solanki *et al.*, (2010) also obtained similar results with regard to sugars in brinjal crop.

The presence of PSB, KSB and VAM would have increased the availability of nutrients by forming symbiotic associations with the plants and increasing the surface of absorption along with mobilising the nutrients. Abdelaal and Sahar (2015) also obtained similar results with regard to the application of biofertilizers which improves the efficiency of the nutrient uptake and aids in the storage of sugars after photosynthesis in sugar beet.

The different levels of chemical fertilizers, biofertilizers and the interaction had no significant influence on the shelf life of the carrot roots. The roots were found to lose their edible quality when kept under room temperature within an average of 2-3 days.

The quality of vegetables deteriorates gradually during storage in response to endogenous factors and environmental

conditions. Processes such as transpiration, respiration, activation of growth and attack by pathogens lead not only to quantitative losses but quality losses, which can destroy the marketability of the product (Sable and Bhamare, 2007).

With the results from the present experiment it can be concluded that the best quality carrots can be obtained with the application of 100% RDF+ PSB+ KSB+ *Azospirillum*+ *Azotobacter*+ VAM. As, the complete dose of fertilizers would add in the crops the immediate source of nutrition for the metabolisms to show appropriate growth and the biofertilizers would supply the required nutrients throughout the season in a sustainable manner and available form by maintaining the soil health.

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