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# Growth, yield and quality improvement in beetroot (*Beta vulgaris* L.) through integrated nutrient management practices

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**Abstract**
A field experiment entitled "Growth, Yield and Quality Improvement in Beetroot (*Beta vulgaris L.*) through Integrated Nutrient Management Practices" was conducted during *rabi*, 2024-25 at Instructional Farm, School of Agricultural Sciences, Dabok, Udaipur. The experiment comprised of twelve treatments using vermicompost and recommended dose of fertilizerse it her alone in combinations which were replicated thrice in randomized block design. Beetroot variety USM - Janifer was used as a test crop.
The results reveled that among all treatments $T_{12}$ (5 t $ha^{-1}$ Vermicompost + 100% RDF) was found to significantly increase growth, yield attributes, yield, quality parameters, soil properties as well as economics of beetroot. It was found that maximum value of growth parameters *viz*., germination percentage (92.33%), plant height(18.27,29.83 and 41.17 cm) and number of leaves (8.67,13.00 and 17.33) at 30,60 and 90DAS) was found with treatment $T_{12}$ (5 t $ha^{-1}$ Vermicompost + 100% RDF), yield attributes and yield *viz*., diameter of bulb (8.83 cm), average weight of bulb (198.33 g), harvest index (70.67%), yield $plot^{-1}$ (29.33 kg), yield $ha^{-1}$ (52.38t $ha^{-1}$) were observed witht he application of $T_{12}$ (5 t $ha^{-1}$ Vermicompost + 100% RDF). Further it was noted that maximum values of quality parameters *viz*., TSS (11.77 °Brix) and chlorophyll content in leaf (1.46 mg $g^{-1}$), was found with treatment $T_{12}$ (5 t $ha^{-1}$ Vermicompost + 100% RDF). Maximum net return (₹456,850 $ha^{-1}$) and B-C ratio (4.29) were obtained with $T_{12}$ (5 t $ha^{-1}$ Vermicompost + 100% RDF).

**Keywords:** Beetroot, integrated nutrient management on growth, yield and quality

## Introduction

Beetroot (*Beta vulgaris* L.), also known as garden beet or table beet, belongs to the family Chenopodiaceae in company with palak, spinach, swiss chard, parsley, celery. The chromosome number of cultivated beetroot is 2n=18. Western Europe and North Africa is the origin of beetroot where they were grown to feed both humans and livestock. It is a biennial crop and also grown as a cool season annual. In India it is grown in northern and southern parts. It is grown in almost all states of India but in small scale only. It produces green tops and a swollen, fleshy and thick root used both as vegetable and salad. The upper and lower portion of the root develops from the hypocotyl and taproot respectively. During the development of root, concentric rings in a median cross section of mature beetroot is visible due to the alternately form of the vascular and parenchymatissues.

Beetroot is a rich source of protein, carbohydrates, calcium, phosphorus, and vitamin C and has 87.7% of water per 100 g of fresh weight. Hence it is an ideal vegetable for health-conscious people, Deuter and Grundy (2004) [3]. The colour of beetroot is due to the presence of red violet pigments of β cyanine and a yellow pigment β xanthine. It has many nutritive properties such as antiradical properties which improve the quality of human blood and revive stress-based disorders drawing the attention of consumers to use it in cuisine. It is also beneficial in many clinical conditions including coronary heart disease and cancer, Kavitha *et al*. (2014) [5]. It is one of the natural foods which boost the energy in athletes as it has one of the highest nitrates and sugar contents. It received increasing attention due to possible health benefits in humans, especially its antioxidant and anti-inflammatory activities.

Beetroot productivity in India varies, with average yields ranging from 15 to 25t $ha^{-1}$, depending on the region and agricultural practices. High-input farms that utilize improved beetroot varieties, effective irrigation systems, and pest control can reach yields of up to 30 tons per hectare. This increase in yield reflects the impact of modern agricultural techniques on beetroot production in India.

Research shows that a combination of integrated organic nutrient management practices can produce better results than using either alone. Organic manure improves the physical and chemical properties of soil, while biofertilizer enhance biological activity, which can lead to improved growth and yield. Combining organic manure and biofertilizer results in higher beetroot yield due to a more balanced nutrient supply and improved soil health.

Both organic manure and biofertilizers have demonstrated positive effects on beetroot growth, yield, and quality. Their combined use tends to produce synergistic results. More long-term, field-based studies across different regions and beetroot varieties, as wellas the need for cost-benefit analysis for farmers.

## Materials and Methods

The field experiment was conducted during December, 2024to March, 2025 Horticulture farm, Department of Horticulture, School of Agricultural Sciences, Dabok, Udaipur. Geographically, Udaipur is located at 24° 34' N latitude and 73° 42' E longitude at an elevation of 582.17 meters above mean sea level (MSL). This particular part of India falls under agro climatic zone IV a *i.e.* "Sub-Humid Southern Plain and Aravalli Hills" of Rajasthan state. The geography of the experimental site was fairly levelled with an ample surface drainage and the field soil was having clay loam texture. In experiment conducted ten treatments in RBD Design with trice replications. In study, cultivar USM -Janifer was used. Seeds of beetroot variety USM - Janifer were sown directly in the prepared beds at a spacing of 45 cm between rows and 20 cm between plants. Light irrigation was provided immediately after sowing to ensure proper germination.

## Results and Discussion

### Effect of Integrated nutrient management on Growth attributes

Data examine in Table 1 to 2 indicate that application of integrated nutrient management brought about a significant variation in growth parameters as *viz*., Germination percentage, Plant height and Number of leaves plant-$^{1}$. The maximum germination percentage (92.33%), maximum plant height (18.27, 29.83 and 41.17 cm), maximum number of leaves (8.67, 13.00 and 17.33) was observed at 30, 60 and 90 DAS under $T_{12}$ (5 t ha$^{-1}$ Vermicompost + 100% RDF), followed by treatments $T_{11}$ (5 t ha$^{-1}$ Vermicompost + 75% RDF) and $T_9$ (2.5 t ha$_{-1}$ Vermicompost + 100% RDF), respectively. The result obtained by the use of integrated nutrient management are due to rapid cell division, multiplication and cell elongation in meristematic region of plant which promoted vegetative growth of plant in the form of plant height. Maximum value of growth parameters might be due to improved physio-chemical and biological properties of soil like water holding capacity, hydraulic conductivity, high rate of microbial transformation due to availability of organic carbon for heterotrophic organism, buffering effect, improved soil aggregation, aeration, release of organic acids etc. which act as stimulant for supply of crop nutrients during the course of microbial decomposition and enable the crop to utilize nutrient and water more efficiently Shanu *et al*. (2019) [11] and Kushwah *et al*. (2019) [6].

The organic manures are useful to maintain and sustain higher status of soil fertility and availability of nutrient to crop. Nutrient management by use of vermicompost improved chemical physical and biological properties of soil which lead to higher growth of rootswhich might have resulted in increased absorption and efficient translocation of nutrients towards plant system during vegetative growth. Thus, balanced nutrition under appropriate nutrient environment might have resulted in better root development and plant growth. Moreover increasing value ofgrowthparameters under $T_{12}$ (5t ha$^{-1}$ Vermicompost +100% RDF) might be due to increased availability of nitrogen, phosphorous and potassium to the plant initiallythrough vermicompost and then by inorganic fertilizers matching the needs of plants throughout the cropping season. The findings of the present study are in the similar consent with the findings of Mahmoud and Mohamed (2018) [7] and Baria *et al.* (2023) [1] in beetroot.

### Yield attributes and yield

A glance of the data represented in Table 3 to 4 clearly revealed that there was significant increase in bulb diameter with the application of integrated nutrient management. A perusal of data revealed that diameter of bulb was significantly affected by the application of integrated nutrient management. The maximum diameter of bulb (8.83 cm) maximum average weight of bulb (198.33 g) The maximum harvest index (70.67%) highest yield plot$^{-1}$ (29.33 kg) maximum yield hectare$^{-1}$ (52.38 t ha$^{-1}$) were recorded under $T_{12}$ (5 t ha$^{-1}$ Vermicompost + 100% RDF).

The important reasons responsible for better production of yield attributes and bulb yield might be due to supply of nutrients in balanced amount and adequate availability. The higher bulb yield of beetroot seemed to be the cumulative effect of increased plant growth parameters like plant height, number of leaves and yield attributes due to application of integrated organic nutrient management. The better plant growth provided greater sites for photosynthesis and translocation of photosynthates from source to sink (bulbs) Das *et al.* (2018) [2]. The use of integrated nutrient management significantly improve the growth of beetroot crop. The increased values for yield parameters in the study might be due tohigher number of bacteria, fungiand actinomycetes found in vermicompost and due to which higher mineralization and solubilization of nutrients occurs that provide nutrients to plants resulting to increased yield attributes and yield. These results are in close conform.

### Quality parameters

The data Table 5 regards to effect of integrated nutrient management on total soluble solids of beetroot have been presented in Table 7. Application of integrated nutrient management had significant effect on total soluble solids of beetroot. The maximum total soluble solids (11.77 °Brix) maximum chlorophyll content in leaf (1.46 mg g$^{-1}$) $T_{12}$ (5 t ha$^{-1}$ Vermicompost + 100% RDF) Application of organic manures provides all essential 17 elements in sufficient amount which improves the overall metabolism of plant. Availability of micro-nutrients, which are required for the synthesis of various nutrient components, improves the nutritional quality of the end product. Further the accumulation of more mineral nutrient improves the dry matter and overall quality of the product. This might be due to easy availability of nutrient and organic carbon lead to balanced C-N ratio which improved the quality of produce. Vermicompost increases the availability of nutrients by enhancing microbial population resulting in increased mineralization and oxidation process. Similar findings were also noticed by Reddy *et al.* (2020) [10], Patel *et al.* (2018) [9] and Naeem *et al.* (2013) [8] in beetroot.

## Economics

A keen observation of data Table 6 revealed that the application of integrated organic nutrient management influences the net return. The maximum net return of ₹456,850 ha$^{-1}$ and maximum B-C of 4.29 was found with the application of with $T_{12}$ (5 t ha$^{-1}$ Vermicompost + 100% RDF) This increased net return and B:C ratio might be due to the fact that under $T_{12}$ treatment the output was significantly higher due to increased yield, therefore, higher bulb yields resulted in higher net returns and B-C ratio. Similar finding was recorded through use of integrated organic nutrient management by Jawadagi *et al.* (2020) [4] who emphasized that INM reduces the reliance on synthetic fertilizers, leading to lower production costs and reduced environmental impact. Economic analyses indicate higher benefit-cost ratios with INM due to sustained yields and improved product quality.

**Table 1:** Effect of integrated nutrient management on germination percentage and plant height of beetroot

| Treatments | Treatments | Germination percentage (%) | 30DAS | 60DAS | 90DAS |
|---|---|---|---|---|---|
| $T_1$ | Control | 76.33 | 12.13 | 19.77 | 27.10 |
| $T_2$ | Vermicompost @ 2.5tha$^{-1}$ | 79.67 | 13.50 | 22.03 | 30.17 |
| $T_3$ | Vermicompost @ 5.0tha$^{-1}$ | 85.00 | 15.80 | 25.67 | 35.33 |
| $T_4$ | 50%RDF | 80.33 | 13.83 | 22.60 | 30.93 |
| $T_5$ | 75%RDF | 82.33 | 14.57 | 23.73 | 32.50 |
| $T_6$ | 100% RDF | 84.67 | 15.53 | 25.33 | 34.70 |
| $T_7$ | 50%RDF + Vermicompost2.5t ha$^{-1}$ | 85.33 | 15.97 | 26.03 | 35.67 |
| $T_8$ | 75%RDF +Vermicompost2.5t ha$^{-1}$ | 87.67 | 16.60 | 27.07 | 37.07 |
| $T_9$ | 100%RDF +Vermicompost2.5t ha$^{-1}$ | 89.33 | 17.07 | 27.93 | 38.77 |
| $T_{10}$ | 50% RDF + Vermicompost5tha-$^{1}$ | 88.33 | 16.90 | 27.60 | 37.83 |
| $T_{11}$ | 75% RDF +Vermicompost5tha$^{-1}$ | 90.67 | 17.63 | 28.97 | 40.03 |
| $T_{12}$ | 100% RDF +Vermicompost5tha$^{-1}$ | 92.33 | 18.27 | 29.83 | 41.17 |
| | S.Em.± | 1.32 | 0.43 | 0.62 | 0.87 |
| | C.D. (P=0.05) | 3.87 | 1.26 | 1.82 | 2.54 |

**Table 2:** Effect of integrated nutrient management on number of leaves plant $^{-1}$of beetroot

| Treatments | Treatments | 30 DAS | 60 DAS | 90 DAS |
|---|---|---|---|---|
| $T_1$ | Control | 5.33 | 7.67 | 10.33 |
| $T_2$ | Vermicompost @ 2.5 t ha$^{-1}$ | 6.00 | 8.67 | 11.67 |
| $T_3$ | Vermicompost @ 5.0 t ha$^{-1}$ | 7.00 | 10.33 | 14.00 |
| $T_4$ | 50% RDF | 6.33 | 9.00 | 12.33 |
| $T_5$ | 75% RDF | 6.67 | 9.67 | 13.00 |
| $T_6$ | 100% RDF | 7.33 | 10.67 | 14.33 |
| $T_7$ | 50% RDF + Vermicompost 2.5 t ha$^{-1}$ | 7.33 | 10.67 | 14.67 |
| $T_8$ | 75% RDF + Vermicompost 2.5 t ha$^{-1}$ | 7.67 | 11.00 | 15.33 |
| $T_9$ | 100% RDF + Vermicompost 2.5 t ha$^{-1}$ | 8.00 | 11.67 | 16.00 |
| $T_{10}$ | 50% RDF + Vermicompost 5 t ha-$^{1}$ | 7.67 | 11.33 | 15.33 |
| $T_{11}$ | 75% RDF + Vermicompost 5 t ha$^{-1}$ | 8.33 | 12.33 | 16.67 |
| $T_{12}$ | 100% RDF + Vermicompost 5 t ha$^{-1}$ | 8.67 | 13.00 | 17.33 |
| | S.Em. ± | 0.29 | 0.44 | 0.55 |
| | C.D. (P=0.05) | 0.84 | 1.28 | 1.61 |

**Table 3:** Effect of integrated nutrient management on diameter of bulb, average weight of bulb and harvest index of beetroot

| Treatments | Treatments combination | Diameter of bulb (cm) | Average weight of (bulb(g) | Harvest index (%) |
|---|---|---|---|---|
| $T_1$ | Control | 5.40 | 112.67 | 52.33 |
| $T_2$ | Vermicompost @ 2.5 t ha$^{-1}$ | 6.03 | 127.33 | 55.67 |
| $T_3$ | Vermicompost @ 5.0 t ha$^{-1}$ | 7.00 | 154.33 | 62.33 |
| $T_4$ | 50% RDF | 6.27 | 134.00 | 57.00 |
| $T_5$ | 75% RDF | 6.60 | 143.67 | 59.33 |
| $T_6$ | 100% RDF | 6.93 | 152.00 | 61.67 |
| $T_7$ | 50% RDF + Vermicompost 2.5 t ha$^{-1}$ | 7.17 | 158.67 | 63.67 |
| $T_8$ | 75% RDF + Vermicompost 2.5 t ha$^{-1}$ | 7.57 | 170.00 | 65.33 |
| $T_9$ | 100% RDF + Vermicompost 2.5 t ha$^{-1}$ | 8.13 | 182.33 | 66.67 |
| $T_{10}$ | 50% RDF + Vermicompost 5 t ha-$^{1}$ | 7.83 | 176.67 | 64.33 |
| $T_{11}$ | 75% RDF + Vermicompost 5 t ha$^{-1}$ | 8.47 | 189.67 | 68.33 |
| $T_{12}$ | 100% RDF + Vermicompost 5 t ha$^{-1}$ | 8.83 | 198.33 | 70.67 |
| | S.Em. ± | 0.19 | 4.58 | 1.31 |
| | C.D. (P=0.05) | 0.57 | 13.44 | 3.83 |

**Table 4:** Effect of integrated nutrient management on yield plot$^{-1}$ and yield ha$^{-1}$ of beetroot

| Treatments | Treatments combination | Yield plot$^{-1}$ (kg) | Yield (t ha$^{-1}$) |
|---|---|---|---|
| $T_1$ | Control | 15.93 | 41.07 |
| $T_2$ | Vermicompost @ 2.5 t ha$^{-1}$ | 17.70 | 33.70 |
| $T_3$ | Vermicompost @ 5.0 t ha$^{-1}$ | 23.00 | 37.02 |
| $T_4$ | 50% RDF | 18.87 | 40.66 |
| $T_5$ | 75% RDF | 20.73 | 42.73 |
| $T_6$ | 100% RDF | 22.77 | 45.77 |
| $T_7$ | 50% RDF + Vermicompost 2.5 t ha$^{-1}$ | 23.93 | 48.09 |
| $T_8$ | 75% RDF + Vermicompost 2.5 t ha$^{-1}$ | 25.63 | 46.25 |
| $T_9$ | 100% RDF + Vermicompost 2.5 t ha$^{-1}$ | 26.93 | 50.12 |
| $T_{10}$ | 50% RDF + Vermicompost 5 t ha-$^{1}$ | 25.90 | 52.38 |
| $T_{11}$ | 75% RDF + Vermicompost 5 t ha$^{-1}$ | 28.07 | 1.54 |
| $T_{12}$ | 100% RDF + Vermicompost 5 t ha$^{-1}$ | 29.33 | 4.52 |
| | S.Em. ± | 0.86 | 41.07 |
| | C.D. (P=0.05) | 2.53 | 33.70 |

**Table 5:** Effect of integrated nutrient management on total soluble solids and chlorophyll content of beetroot

| Treatments | Treatments combination | TSS (°Brix) | Chlorophyll content (mg g-1) |
|---|---|---|---|
| $T_1$ | Control | 5.40 | 0.89 |
| $T_2$ | Vermicompost @ 2.5 t ha$^{-1}$ | 6.03 | 0.97 |
| $T_3$ | Vermicompost @ 5.0 t ha$^{-1}$ | 7.00 | 1.16 |
| $T_4$ | 50% RDF | 6.27 | 1.02 |
| $T_5$ | 75% RDF | 6.60 | 1.09 |
| $T_6$ | 100% RDF | 6.93 | 1.14 |
| $T_7$ | 50% RDF + Vermicompost 2.5 t ha$^{-1}$ | 7.17 | 1.20 |
| $T_8$ | 75% RDF + Vermicompost 2.5 t ha$^{-1}$ | 7.57 | 1.26 |
| $T_9$ | 100% RDF + Vermicompost 2.5 t ha$^{-1}$ | 8.13 | 1.35 |
| $T_{10}$ | 50% RDF + Vermicompost 5 t ha-$^{1}$ | 7.83 | 1.28 |
| $T_{11}$ | 75% RDF + Vermicompost 5 t ha$^{-1}$ | 8.47 | 1.41 |
| $T_{12}$ | 100% RDF + Vermicompost 5 t ha$^{-1}$ | 8.83 | 1.46 |
| | **S.Em. ±** | 0.19 | 0.04 |
| | **C.D. (P=0.05)** | 0.57 | 0.11 |

**Table 6:** Effect of integrated nutrient management on net return and B-C ratio of beetroot

| Treatments | Treatments combination | Net return (₹ha$^{-1}$) | B:Cratio |
|---|---|---|---|
| $T_1$ | Control | 224,500 | 2.80 |
| $T_2$ | Vermicompost @ 2.5 t ha$^{-1}$ | 251,100 | 2.95 |
| $T_3$ | Vermicompost @ 5.0 t ha$^{-1}$ | 330,700 | 3.31 |
| $T_4$ | 50% RDF | 271,000 | 3.09 |
| $T_5$ | 75% RDF | 305,200 | 3.21 |
| $T_6$ | 100% RDF | 336,600 | 3.35 |
| $T_7$ | 50% RDF + Vermicompost 2.5 t ha$^{-1}$ | 357,300 | 3.51 |
| $T_8$ | 75% RDF + Vermicompost 2.5 t ha$^{-1}$ | 387,700 | 3.67 |
| $T_9$ | 100% RDF + Vermicompost 2.5 t ha$^{-1}$ | 410,900 | 3.81 |
| $T_{10}$ | 50% RDF + Vermicompost 5 t ha-$^{1}$ | 392,500 | 3.69 |
| $T_{11}$ | 75% RDF + Vermicompost 5 t ha$^{-1}$ | 436,200 | 4.17 |
| $T_{12}$ | 100% RDF + Vermicompost 5 t ha$^{-1}$ | 456,850 | 4.29 |
| | S.Em. ± | 17,850 | 0.18 |
| | C.D. (P=0.05) | 52,3600 | 0.36 |

## Conclusion

On the basis of present investigation entitled "Growth, Yield and Quality Improvement in Beetroot (*Beta vulgaris* L.) through Integrated Nutrient Management Practices" it may be concluded that treatment $T_{12}$ (5 t ha$^{-1}$ Vermicompost + 100% RDF) and $T_{11}$ (5t ha$^{-1}$ Vermicompost + 75% RDF) were found significantly superior in terms of growth, yield attributing characters, yield and quality parameters of beetroot crop. The significant increase in economic characters *viz*., net return and B-C ratio was found with the application of $T_{12}$ (5 t ha$^{-1}$ Vermicompost + 100% RDF). Therefore, treatment $T_{12}$ (5 t ha$^{-1}$ Vermicompost + 100% RDF) may be recommended for beetroot crop to obtain superior values of growth, yield, quality parameters and increased net return of the treatments. This treatment also enhanced the physical properties of the soil. However, this conclusion is on the basis of one year investigation further evaluation is required.

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