Original Research Article

**Impact of various levels of mineral nutrients on the yield and quality attributes of beetroot (Beta vulgaris L.)**

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ABSTRACT

Beetroot (*Beta vulgaris* L.), also known as garden beet or table beet, is one of the most widely cultivated root crops. Although it is produced on a limited scale, it is grown in almost all states across India. The plant produces edible leafy tops and an enlarged root, which is often consumed raw in salads. A field investigation was conducted during the Rabi season of 2023 at Woodhouse, Horticultural Research Station, in the Ooty district, to assess the impact of different levels of mineral fertilizers on the root production, and quality of beetroot cultivated in acidic soils. The experiment followed a Randomized Block Design (RBD) with eight fertilizer treatments, each replicated three times:T1: N₀P₀K₀, T2: N₁P₁K₂, T3: N₁P₂K₂, T4: N₂P₂K₀, T5: N₂P₁K₁, T6: N₃P₁K₁, T7: N₂P₃K₂, T8: N₃P₃K₂. Among all treatments, T8 (N₃P₃K₂) exhibited the superior performance in terms of yield parameters, including:Fresh root weight per plant (135.5 g), Dry root weight per plant (10 g), Root diameter (21.91 cm), Root yield per plot (42.1 kg), Estimated root yield per hectare (421.13 quintals), Root-to-shoot ratio (3.98),In addition, T8 recorded the highest quality traits, such as: Total soluble solids (TSS) (19.96 °Brix), Total sugar content (8.10%).

*Keywords: Beetroot, yield, quality parameter, Beta vulgaris*

1. INTRODUCTION

Beetroot (*Beta vulgaris* L.), belonging to the Chenopodiaceae family, is known for its vibrant deep red or crimson pigmentation. Commonly referred to as beet, chard, spinach beet, sea beet, or garden beet, it is highly beneficial to human health. Beets can be consumed raw, boiled, steamed, or roasted. Red beetroot is a rich source of essential minerals such as magnesium, manganese, sodium, potassium, iron, and copper. Beetroot possesses a wide range of therapeutic properties, which contribute to the prevention of cardiovascular diseases and certain types of cancer. It contains numerous bioactive compounds, including glycine, betaine, saponins, betacyanins, carotenoids, folates, betanins, polyphenols, and flavonoids, all of which offer significant health-promoting benefits.

Across the country, beetroot is an important root vegetable crop, cultivated on approximately 645 hectares in Tamil Nadu, yielding around 15,480 metric tonnes annually, with an average productivity of 24 tonnes per hectare. Since the current yield levels are below the global average, it is essential to enhance production through the adoption of advanced cultivation techniques. The key beetroot-growing states in India include Haryana, Himachal Pradesh, West Bengal, Uttar Pradesh, Maharashtra, and Tamil Nadu. Nationwide, beetroot is grown on about 7,900 hectares, with Telangana accounting for 425 hectares and producing approximately 11,132 metric tonnes. In total, India has around 2,164 hectares under beetroot cultivation, producing nearly 36,260 tonnes, with an average yield of 16.75 tonnes per hectare. (Arulmani et al., 2024)

The beetroot refers to the taproot portion of the plant and is considered a nutritious food vital for human growth and overall development. It is rich in essential nutrients and antioxidant compounds. Beetroot serves the dual role of being consumed as both a vegetable and a fruit substitute. In its fresh state, it is commonly used in salads. It contains betalains, which play an important role in supporting cardiovascular health. Additionally, beetroot is known for its medicinal properties, being used in the treatment of various health conditions, and it also functions as a natural dye in the textile industry.This plant has several uses, including diuretic, carminative, antibacterial, antifungal, anti-inflammatory, antioxidant, and antidepressant. A food that has an alkaline pH of 7.5-8, beetroot is rich in vitamin C, B1, B2, niacin, B6, B12, and its leaves are a great source of vitamin A.

Fertilizer is one of the **costliest inputs** in agriculture, and applying the **appropriate dosage** is crucial for both **environmental sustainability** and **maximizing farm income.** The **excessive application** of **synthetic fertilizers** across different soil types has aggravated the **deficiency of secondary and micronutrients.** Furthermore, **inadequate plant nutrition** further intensifies the issue of **deteriorating soil health and fertility.** The present study focused on determining the influence of different rates of mineral nutrient application on the root development and quality traits of beetroot under acidic soil conditions.

2. material and METHODS

A field study was conducted using the Improved Crystal Hybrid variety from September to December 2023 to investigate the influence of varying levels of mineral fertilizers on the growth, root yield, and quality of beetroot. The trial was carried out at the Horticultural Research Station in Ooty. The experiment followed a Randomized Block Design (RBD) with eight treatments, each replicated three times.

**Table 1: Details of treatment structure**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No** | **Treatment** | **N (Kg ha-1)** | **P2O5 (Kg ha-1)** | **K2O (Kg ha-1)** |
| 1 | T1 - N0P0K0 | 0 | 0 | 0 |
| 2 | T2 - N1P1K2 | 60 | 80 | 100 |
| 3 | T3 - N1P2K2 | 60 | 160 | 100 |
| 4 | T4 - N2P2K0 | 120 | 160 | 0 |
| 5 | T5 - N2P1K1 | 120 | 80 | 50 |
| 6 | T6 - N3P1K1 | 180 | 80 | 50 |
| 7 | T7 - N2P3K2 | 120 | 240 | 100 |
| 8 | T8 - N3P3K2 | 180 | 240 | 100 |

The initial soil nutrient status was: alkaline KMnO₄-extractable nitrogen (N) at 385 kg ha-1, Bray's extractable phosphorus (P) at 192 kg ha-1, and NH₄OAc-extractable potassium (K) at 578 kg ha-1. Fertilizers P₂O₅ and K₂O were applied as a basal dose, while nitrogen (N) was split into two equal applications-one at sowing and the other 30 days after planting.

The data were recorded on root length (cm), root diameter (cm), root to shoot ratio, root yield per plot (kg plot-1), root yield per ha (t ha-1), total soluble solids, total sugar, Beetroot fresh weight, and beetroot dry weight expressed in gram.

The root to shoot ratio was computed using the following formula on a weight basis

Root:shoot ratio= Root weight / Foliage weight

**2.1 Total soluble solids (0B)**

Erma Hand Refractometer used to test total soluble solids. The outcome was given as a degree Brix (0B).

**2.2 Total Sugars (%)**

Below is the formula used for calculation of total sugar (%)

Total sugars (%)=0.05/titre value\* 250/25\*250/25\*100

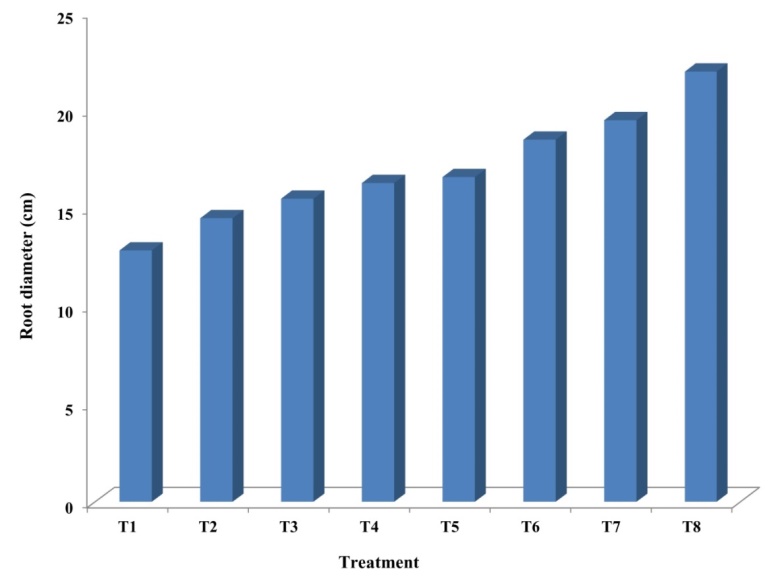
Vernier calipers were used to measure the root diameter, and the average was given in centimeters. Five plants were chosen at random from each plot, and the root and shoot ratio was determined by weighing the roots and shoots separately using an electronic scale. Every treatment plot's roots were extracted individually, weighed using a machine, and expressed in kilograms for each plot. When the roots reached their complete development and reached their maximum size and color, they were manually harvested. The yield was expressed in kilograms per plot after mature roots were removed from the net plot and weighed. To get the estimated yield per hectare and express it in tonnes per hectare, it was multiplied by a factor.

3. results and discussion

**3.1 Fresh weight, Root diameter**

Table 3 indicated the impact of various nutrient doses on root fresh weight per plant, root dry weight per plant, root diameter, and root to shoot ratio. The addition of nutrients had a major impact on the root diameter. T8 (N3P3K2) had the largest root diameter (21.97) compared to T7 (19.50 cm) and T6 (18.50 cm), which was significantly better than any other treatment. T1 had the lowest root diameter measured (12.87). The largest fresh weight of root per plant (135.5 g) among the various fertilizer treatments was attained under treatment T8 (N3P3K2), which was noticeably better than the other treatments. In the treatment T1 (N0P0K0), a significantly lower minimum fresh weight of root per plant (22.9 g) was achieved.

When compared to the control, the nitrogen treatment greatly boosted the fresh weight and diameter of the roots. This outcome was consistent with the findings of El-Harriri and Mirvat (2001) as well as Nawar and Saleh (2003). He discovered that adding more nitrogen to the soil as fertilizer greatly increased the weight and diameter of the roots. Additionally, Nemeat Alla (2002) found that applying more nitrogen fertilizer to the soil resulted in a considerable increase in root diameter, fresh weight, and sugar yield.

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**Fig 1: Effect of Various nutrient level on root diameter (cm) of Beetroot at harvest of crop growth**

**3.2 Dry weight, Root to shoot ratio**

The treatment T8 produced the highest dry weight of root per plant (10.0g), which was statistically considerably better than the other treatments. In treatment T1, the lowest dry weight of root per plant (2.5 g) was attained. T8 (N3P3K2) had the maximum root to shoot ratio (3.98), which was significantly higher than the other treatments; T1 (N0P0K0) had the lowest root to shoot ratio (2.72).

**Table 2: Effect of different nutrient level on Root fresh weight per plant, Root dry weight per plant, Root diameter, Root to shoot ratio Root yield (kg ha-1) and Root yield (q ha-1) of beetroot**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **S.No** | **Treatment** | **Root fresh weight per plant (g)** | **Root dry weight per plant (g)** | **Root diameter**  **(cm)** | **Root to shoot ratio** | **Root yield (10 m2)**  **(kg plot-1)** | **Root yield**  **(q ha-1)** |
| 1 | T1 - N0P0K0 | 22.9 | 2.5 | 12.87 | 2.72 | 28.1 | 281.13 |
| 2 | T2 - N1P1K2 | 38.6 | 4.0 | 14.51 | 3.12 | 28.8 | 287.57 |
| 3 | T3 - N1P2K2 | 50.5 | 4.8 | 15.50 | 3.24 | 30.6 | 306.33 |
| 4 | T4 - N2P2K0 | 77.1 | 6.8 | 16.30 | 3.51 | 31.8 | 317.67 |
| 5 | T5 - N2P1K1 | 90.5 | 7.7 | 16.60 | 3.55 | 33.4 | 333.75 |
| 6 | T6 - N3P1K1 | 100.3 | 8.2 | 18.50 | 3.68 | 34.9 | 349.30 |
| 7 | T7 - N2P3K2 | 107.6 | 8.4 | 19.50 | 3.75 | 36.2 | 361.97 |
| 8 | T8 - N3P3K2 | 135.5 | 10.0 | 21.97 | 3.98 | 42.1 | 421.13 |
| **SEd** | | 4.14 | 0.03 | 2.19 | 0.03 | 2.51 | 19.42 |
| **CD (*P=*0.05%)** | | 8.89 | 0.08 | 4.71 | 0.06 | 5.40 | 41.65 |

The treatment T8 produced the highest dry weight of root per plant (10.0g), which was statistically considerably better than the other treatments. In treatment T1, the lowest dry weight of root per plant (2.5 g) was attained. T8 (N3P3K2) had the maximum root to shoot ratio (3.98), which was significantly higher than the other treatments; T1 (N0P0K0) had the lowest root to shoot ratio (2.72). Sarhan and Ismail (2003) reported that root dry matter yield of fodder beet was significantly increased by increasing nitrogen fertilizer level. These results are consistent with the present results.

**3.3 Root yield (kg plot-1), Root yield (q ha-1)**

T8 had the maximum root yield (42.1 kg plot-1) compared to all other treatments, which indicated a considerable improvement. The lowest yield was recorded in control plot T1 (28.1 kg plot-1).

T8 had the greatest root production (421.13), which was much higher than any other treatment. T7 ranked in second (361.97). Plot T1, the control, had the lowest yield (281.13). The lowest yield was recorded in control plot T1 (281.13).

It's possible that greater cell division and rapid cell multiplication resulted in better plant growth in all aspects, while increased photosynthate translocation from leaves (source) to roots (sink) resulted in longer and wider roots. Similar results were found by Mali et al. (2018) in radish, Ingole et al. (2018), and Dlamini et al. (2020) in beetroot.

**3.4 Total soluble solids, Total sugar**

T.S.S. levels varied between treatments. The highest T.S.S concentration (19.96 0B) was reported in T8, which is comparable to T7 and T6, and the lowest in T1 (12.59 0B). There was variation among the treatments in terms of total sugar. The highest total sugar level was reported (8.10%) in T8, which is comparable to T7 and T6, and the lowest in T1 (3.33%). T.S.S. is a key quality characteristic that quantifies the concentration of reducing sugars (fructose and glucose) and non-reducing sugars (sucrose), which are related to the root's sweet flavour. The T.S.S content of beetroot is advantageous because it can be used as a salad vegetable.

The nitrogen level has a substantial impact on the total soluble solids and sugar content of beets. Nitrogen application at 50 kg N ha-1 resulted in significantly higher total soluble solids and total sugar levels than the control (0 kg N ha-1). Increasing the nitrogen level of the fertilizers up to 150 kg N ha-1 enhanced the total soluble solids and total sugar of beetroot, but the tendency reversed at the highest level (200 kg N ha-1).(Rantao, 2013). The decline in TSS% caused by excessive nitrogen application can be attributed to its involvement in increasing root weight and diameter, tissue water content, and partitioning of more photosynthates to the tops rather than the roots of sugar beet plants, which may result in a lower TSS%. Abdelaal, and Tawfik (2015) and Ramadan et al., (2003) support this finding.

**Table 3. Effect of various inorganic nutrient dose on TSS, Total sugars of beetroot**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Treatment** | **T.S.S (0B)** | **Total sugar (%)** |
| 1 | T1 - N0P0K0 | 12.59 | 3.33 |
| 2 | T2 - N1P1K2 | 14.16 | 4.14 |
| 3 | T3 - N1P2K2 | 15.04 | 5.09 |
| 4 | T4 - N2P2K0 | 15.51 | 5.26 |
| 5 | T5 - N2P1K1 | 16.38 | 5.46 |
| 6 | T6 - N3P1K1 | 17.43 | 6.17 |
| 7 | T7 - N2P3K2 | 18.60 | 7.13 |
| 8 | T8 - N3P3K2 | 19.96 | 8.10 |
| **SEd** | | 1.64 | 1.16 |
| **CD (P=0.05%)** | | 3.52 | 2.50 |

**CONCLUSION**

Based on these experiments, beet root treated with T8 (N-180 kg ha-1, P2O5 240 kg ha-1, K2O 100 kg ha-1) and then treated with T7 (N-120 kg ha-1, P2O5 240 kg ha-1, K2O 100 kg ha-1) seems to be a good combination for increasing the yield characteristics, and quality parameter of beetroot (improved crystal hybrid).

**DISCLAIMER (ARTIFIICIAL INTELLIGENCE)**

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1. ChatGPT

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Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

References

Arulmani, R., Sellamuthu, K.M., Maragatham, S., Senthil, A., Thamaraiselvi, S.P., Anandham, R., Malathi, P., & Sridevi, G. (2024). Yield and quality of beetroot to soil test crop response (STCR) - integrated plant nutrient system (IPNS) based fertilizer prescription in Ultisols of Western Ghats of Tamil Nadu, India. Plant science today,11 (4):91-97. <https://doi.org/10.14719/pst.4623>

El-Harriri, D. M., & Gobarah Mirvat, E. (2001). Response of growth, yield and quality of sugar beet to nitrogen and potassium fertilizers under newly reclaimed sandy soil. J. Agric. Sci. Mansoura Univ., 26(10), 5895-5907.

Nawar, F. R. R., & Saleh, S. A. (2003). Effect of plant spacing and nitrogen fertilizer levels on yield and yield components of sugar beet under calcareous soil condition. J. Adv. Agric. Res., 8(1), 47–57.

Nemeat Alla, E. A. E., Mohamed, A. A. E., & Zalat, S. S.(2002). Effect of soil and foliar application of nitrogen fertilization on sugar beet. J. Agric. Sci. Mansoura Univ., 27(3), 1343-1351.

Sarhan, G.M.A., & Smail, S.A. (2003). Response of fodder beet (Beta vulgaris L.) to different sources and levels of nitrogen under two levels of potassium fertilization. Annals of Agric. Sci, Moshtohor, 41(1), 461-473.

Mali, D.L., Virendra, S., Sarolia, D.K., Suresh, K.T, Akshay, C. & Dhakar. R. (2018). Effect of organic manures and biofertilizers on growth and yield of radish (Raphanus sativus L.) cv. Japanese white. International Journal of Chemical Studies, 6(2),1095-1098.

Ingole, V.S., Wagh, P.K., Nagre, P.K. & Bharad, S.G. (2018). Effect of biofertilizer and organic manure on yield and yield contributing characters of beetroot (Beta vulgaris L.). International Journal of Chemical Studies, 6(5),1226-1228.

Dlamini, V.C., Kwanele, A.N., Michael, T. M., Paul, K. W., Tajudeen, O. O., & Mathole, G. Z. (2020). Effects of Cattle Manure on the Growth, Yield, Quality and Shelf Life of Beetroot (Beta vulgaris L. cv. Detroit Dark Red). Journal of Experimental Agriculture International, 42(1), 93-104,

G. Rantao. (2013). Growth, Yield and Quality Response of Beet (Beta Vulgaris L.) to Nitrogen. M.Sc Thesis, University of The Free State, Bloemfontein.

Abdelaal, K.A.A., & Tawfik, S.F. (2015). Response of Sugar Beet Plant (Beta vulgaris L.) to Mineral Nitrogen Fertilization and Bio-Fertilizers, Int.J.Curr.Microbiol.App.Sci, 4(9), 677-688.

Ramadan, B.S.H., Hassan, H.R., & Fatma, A.A. (2003). Effect of mineral and biofertilizers on photosynthetic pigments, root quality, yield components and anatomical structure of sugar beet (Beta vulgaris L.) plants grown under reclaimed soils. J. Agric. Sci. Mansoura Univ., 28(7), 5139-5160