*Original Research Article*

**Effect of different mixed fertilizer on some physiological traits, growth and nutrient uptake in beetroot (*Beta vulgaris* L.)**

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ABSTRACT

Beetroot is a widely grown crop in Tamil Nadu and other states in India. In Tamil Nadu, beetroot yield is lower than in other states due to inadequate fertilization. A field experiment was carried out during rabi, 2023 to study the effect different mixed fertilizer on some physiological traits, growth and nutrient uptake in beetroot (Beta vulgaris L.) in acid soils, at woodhouse, Horticulture Research Station, Ooty district. Three replicated eight treatments (T1: N0P0K0, T2: N1P1K2, T3: N1P2K2,T4: N2P2K0, T5: N2P1K1, T6: N3P1K1, T7: N2P3K2, and T8:N3P3K2) were used in the randomized block design experiment. Among the treatments T8 (N3P3K2) is best for growth recorded as minimum number of days required for 80 per cent germination of seedlings (6.00 days), longer plant height (56.2 cm), more number of leaves per plant (21), Leaves breadth (14.5) and higher chlorophyll content index (46.38), with maximum availability of Nitrogen (169.76 kg ha-1), Phosphorous (94.24 kg ha-1), Potassium (110.16 kg ha-1).

*Keywords: Beetroot, growth parameter, nutrient uptake, STCR*

1.INTRODUCTION

Beetroot (Beta vulgaris L.) is in the Chenopodiaceae family. It has a wonderful crimson color. Beetroot is also known as beet, chard, spinach beet, sea beet, garden beet, have a good effect on the human body. Beets can be eaten raw, cooked, steamed, or roasted. Red beetroot is high in minerals such as magnesium, manganese, sodium, potassium, iron, and copper. Beetroot has a various therapeutic characteristics that can help prevent heart disease and certain malignancies. Beetroot has many beneficial compounds, including glycine, betaine, saponins, betacyanin, carotenoids, folates, betanins, polyphenols, and flavonoids.

Beetroot is a significant root vegetable crop farmed on 645 hectares in Tamil Nadu. It produces 15,480 MT annually, with an average yield of 24 t ha-1. .Given that beetroot productivity is below the global average, it is imperative to boost productivity through improved technologies. The states of Haryana, Himachal Pradesh, West Bengal, Uttar Pradesh, Maharashtra, and Tamil Nadu are the main producers of beetroot in India. Every year, beetroot is produced throughout 0.079 lakh hectares in the country, with Telangana contributing 425 hectares and 11,132 million tons of production. In India, there are roughly 2164 hectares of beetroot farming, with 36260 t produced and 16.75 t ha-1 of productivity ( Arulmani et al., 2024).

The taproot part of the plant is called the beetroot. It is a wonderful food essential to the human body’s growth and development. It has a lot of nutrients and antioxidants. It functions as both fruits and veggies. Beetroot in its fresh form is typically eaten in salads. It has betalain, which is vital for heart health. It also serves as a medicinal herb to treat a variety of ailments and as a natural color 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.

One of the most expensive agricultural inputs is fertilizer, and using the proper amount of fertilizer is essential to both environmental preservation and farm profitability. The overuse of chemical fertilizers in various soils has made the shortages in secondary and micronutrients worse. Moreover, poor crop nutrition exacerbates the problem of declining soil fertility. Important part of that challenge is knowing what potential crop yields may be and how appropriate current growing practices (e.g. plant spacing, sowing dates, fertilizer rates) are for growers aiming for economically viable yields with minimal environmental impact (Reid et al., 2020). The insufficient, imbalanced, or improper use of fertilizers by farmers at ooty. Hence, the proper amount of fertilizer application is necessary to increase beetroot production and maintain soil health.

2. material and methods

A field experiment was conducted (Improved crystal hybrid) from September to December, 2023 to study the “Effect of different level mineral fertilizer on growth, root yield and quality of Beetroot ”. Field experiment is carried out at Horticulture Research Station in Ooty. Three replicated eight treatments were included in the randomized block design of the trial. The initial soil-available alkaline potassium permanganate (KMnO4) nitrogen (N), Brey phosphorus (P), and ammonium acetate (NH4OAc) K were 385 kg ha-1, 192 kg ha-1, and 578 kg ha-1, respectively. Fertilizer P2O5 and K2O were applied basally while fertilizer N was applied in two equal splits (i.e., basal and 30 days after sowing).

**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 data were recorded on days required for germination of seedlings, plant height (cm), number of leaves per plant, leaf width (cm), crop growth rate (g m-2 d-1), relative growth rate (g g-1 d-1), net assimilation rate (g cm-2 d-1), SPAD value, primary nutrient uptake.

Five tagged plants were used to measure the height of the plants at 80 and 110 days following sowing, from ground level to the tip of the tallest leaf, and their mean was calculated. Five randomly chosen plants had their total number of leaves counted at 80 and 110 days following seeding, and their mean was calculated.

Using the formula, the crop growth rate for each sampling day was determined.

**CRG= 1/p\*W2-W1/T2-T1**

where W1 and W2 represent the plant's total dry weight at periods T1 and T2, respectively.

The formula was used to calculate the relative growth rate

**RGR= loge W2- loge W1 / T2-T1**

where W1 and W2, respectively, stand for the plant dry weights at periods T1 and T2

Using the formula, the net assimilation rate was determined

**NAR=W2-W1/ T2-T1 ˟ loge A2- loge A1 / A2-A1**

where A1 and A2 represent the leaf area at times T1 and T2, respectively, and W1 and W2 represent the total plant dry weights.

**2.1 Uptake of nutrients** **(kg ha-1)**

Nitrogen content was determined using the micro-Kjeldahl method following diacid digestion. Phosphorus was estimated through the vanado-molybdophosphoric yellow colorimetric technique using triacid digestion, while potassium levels were assessed via flame photometry, also employing triacid extraction, as described by Piper (1966). Nutrient uptake was computed by multiplying the respective nutrient concentrations by the dry matter yield of beetroot.

The five tagged plants in each replication of all treatments had their chlorophyll content index measured using a SPAD meter at various intervals, and the average was calculated.

3. results and discussion

**3.1 Crop growth rate (CGR)**

Table 2 indicate the results of a statistical analysis and analysis of the crop growth rate recorded, relative growth rate and net assimilation rate (mg cm-2 d-1) during the growing phases of 50–80 DAS, and 80-110 DAS. The crop growth rate was lower in the early stages of the plant's life (50–80 DAS), but it progressively raised as the plant became older. The treatment (T8) with the greatest crop growth rate during 50–80 DAS was noted (0.77), closely followed by T7 (0.72), which was statistically equivalent. The crop growth rate in 80-110 days showed the same patterns, i.e., T8 is on par with T7. The pace of crop development increased in both stages as the amount of various nutrients increased. This could be because the necessary amount of nutrients is present. Increased crop growth rate throughout a plant's growth phase is a common occurrence for the successful transformation required for optimal yield, as well as for sufficient vegetative growth. These results are also consistent with the study conducted by Sharu (2002) on chilli.). Increase crop growth rate suggests that a tuber crop is efficiently using the available nutrients in the soil. Key macronutrients, like nitrogen, phosphorus, and potassium, foster accelerated growth and development (Rekha *et al.*, 2018).

**3.2 Relative growth rate (RGR)**

The relative growth rate was quite high in the early stages of plant growth (50-80 DAS), but it gradually dropped as the plant became older. The treatment (T8) showed the highest relative growth rate (95.86) from 50 to 80 DAS.T8 had the highest relative growth rate (55.92) at the advanced stage of crop growth, which occurred between 80 and 110 DAS. The minimum relative growth rate (63.42 and 31.54) was obtained in control at the crop growth phases of 50-80 DAS and 80-110 DAS-harvest, respectively. In general, RGR always drops as a plant's biomass rises. The results showed the lower RGR in control treatment due to insufficient nutrients in soil for plant growth. Overall, biomass increases more slowly as total biomass rises because respiration scales with total biomass but photosynthesis only scales with photosynthetic biomass (Jagadeesh et al., 2018). As highlighted by Arulmozhiyan et al. (2002), increases in relative growth rate (RGR) are strongly tied to the balance between resource acquisition and utilization. When nutrient availability or environmental conditions are optimal, the expansion of the leaf area index accelerates biomass accumulation, thereby enhancing RGR during key growth stages.

**3.3 Net assimilation rate (NAR)**

Table 2 indicate the statistically assessed net assimilation rate that was observed during the growth periods of 50-80 DAS and 80-110 DAS harvest. The Treatment (T8) had the highest net assimilation rate (9.24) during 50 - 80 DAS, which is comparable to T7 and T8. During maximum net assimilation rate of 8.81 in T8 shows the increasing of photosynthetic efficiency of plant leaves due to sufficient nutrient in soil. It was caused by a rise in the plant's nitrogen concentration, which raises the leaf's chlorophyll content and, in turn, raises the NAR (Jagadeesh et al. 2018). The combination of the highest levels of nitrogen (N) and potassium (K) showed the greatest net assimilation rate (NAR). This is likely attributed to the beneficial effect of nitrogen on the plant's photosynthetic activity, along with potassium's role in enhancing tuber yield by increasing the amount of dry matter diverted to the tubers (Congera et al., 2021). Nitrogen availability enhances the absorption of other key nutrients, leading to better plant health and more efficient resource use. This combined effect can stimulate metabolic activity and result in a higher net assimilation rate.

**Table 2: Effect of different nutrient dose on crop growth rate (gm-2  d-1), relative growth rate (mg g-1d-1) and net assimilation rate (mg cm-2 d -1) of Beet root at different stages of crop growth.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No** | **Treatment** | **CGR****(gm-2 d-1)** | **RGR****(mg g-1d-1)** | **NAR****(mg cm-2 d-1)** |
| **50-80 days** | **80-110 days** | **50-80 days** | **80-110 days** | **50-80 days** | **80-110 days** |
| 1 | T1 - N0P0K0 | 0.44 | 0.67 | 63.42 | 31.54 | 5.25 | 4.61 |
| 2 | T2 - N1P1K2 | 0.45 | 0.72 | 67.49 | 35.29 | 6.28 | 5.12 |
| 3 | T3 - N1P2K2 | 0.49 | 0.75 | 82.16 | 38.59 | 6.28 | 5.62 |
| 4 | T4 - N2P2K0 | 0.55 | 0.78 | 71.28 | 40.75 | 7.15 | 6.29 |
| 5 | T5 - N2P1K1 | 0.62 | 0.81 | 76.49 | 43.18 | 7.22 | 6.44 |
| 6 | T6 - N3P1K1 | 0.66 | 0.86 | 89.47 | 47.19 | 8.14 | 7.37 |
| 7 | T7 - N2P3K2 | 0.72 | 0.91 | 78.42 | 50.75 | 9.05 | 8.34 |
| 8 | T8 - N3P3K2 | 0.77 | 0.99 | 95.86 | 55.92 | 9.24 | 8.81 |
|  **SEd** | 0.03 | 0.05 | 0.87 | 0.43 | 0.68 | 0.74 |
|  **CD (P=0.05%)** | 0.08 | 0.11 | 1.87 | 0.93 | 1.47 | 1.58 |

**3.4 Plant height, Number of leaves per plant, Leaves Width and Chlorophyll content index**

Different mixed nutrients had a substantial impact on improvement of plant growth as Tables 3 and 4 showed. Out of all the treatments, T8(N3P3K2) had the highest plant height at 80 and 110 days after sowing (48.3 and 56.2 cm, respectively), the most leaves per plant, and the widest leaves at 80 and 110 days (14,21, and 11,14.5, respectively), along with the highest index of chlorophyll content (48.87, 46.38, respectively).

The increased plant height, leaf width observed due to higher nitrogen levels primarily due to increased availability and utilization of nitrogen by crop, resulting in increased vegetative growth and accelerated cell division, expansion, and differentiation, thus leading to luxuriant growth (Varshini and Babu 2022).

Reasons for the increased number of leaves may be attributed to the beneficial effects of macro nutrients on vegetative growth, which ultimately boost photosynthetic activity. These results are consistent with the findings of (Mounikaet al*., 2020*); (Jabeenet al*.*, 2018) and (Kiranet al*.*, 2016).

The increase in chlorophyll may be attributed to the sustained and controlled release of essential macronutrients, especially nitrogen. As a fundamental element of chlorophyll, proteins, and amino acids, nitrogen synthesis is promoted by its enhanced presence in the soil (Verma et al., 1974).

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**Fig 1.** **Measurement of chlorophyll content using SPAD (Soil Plant Analysis Development meter) meter**

**Table 3: Influence of various nutrient dose on plant height (cm) and No. of leaves per plant at different growth stages of beet root**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Treatment** | **Plant height (cm)** | **Number of leaves per plant** |
| **80 th days** | **110 th days** | **80 th days** | **110 th days** |
| 1 | T1 - N0P0K0 | 28.5 | 34.6 | 8 | 14 |
| 2 | T2 - N1P1K2 | 30.4 | 42.7 | 9 | 15 |
| 3 | T3 - N1P2K2 | 31.7 | 38.9 | 11 | 15 |
| 4 | T4 - N2P2K0 | 32.9 | 45.4 | 11 | 16 |
| 5 | T5 - N2P1K1 | 35.4 | 45.6 | 12 | 16 |
| 6 | T6 - N3P1K1 | 35.8 | 45.4 | 13 | 18 |
| 7 | T7 - N2P3K2 | 37.2 | 46.7 | 13 | 19 |
| 8 | T8 - N3P3K2 | 48.3 | 56.2 | 14 | 21 |
|  **SEd** | 2.16 | 2.18 | 1.09 | 1.22 |
|  **CD (P=0.05%)** | 5.61 | 4.68 | 2.34 | 2.61 |

**Table 4: Influence of various nutrient dose on Leaves width (cm), Chlorophyll content index growth stages of beet root**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Treatment** | **Leaves width (cm)** | **Chlorophyll content index** |
| **80 th days** | **110 th days** | **80 th days** | **110 th days** |
| 1 | T1 - N0P0K0 | 6.0 | 9.1 | 38.17 | 29.60 |
| 2 | T2 - N1P1K2 | 6.2 | 10.4 | 41.07 | 32.30 |
| 3 | T3 - N1P2K2 | 6.7 | 11.2 | 41.17 | 37.11 |
| 4 | T4 - N2P2K0 | 7.5 | 12.4 | 41.67 | 38.25 |
| 5 | T5 - N2P1K1 | 7.5 | 13 | 44.27 | 40.50 |
| 6 | T6 - N3P1K1 | 7.7 | 13.6 | 45.77 | 43.74 |
| 7 | T7 - N2P3K2 | 8.9 | 14.1 | 48.27 | 45.70 |
| 8 | T8 - N3P3K2 | 11.0 | 14.5 | 48.87 | 46.38 |
|  **SEd** | 0.75 | 0.13 | 2.83 | 1.39 |
|  **CD (P=0.05%)** | 1.62 | 0.28 | 6.08 | 2.99 |

**3.5 Plant uptake nutrient**

The results obtained on plant uptake nutrient status after the trial disclosed in Table 5 showed that, among the treatments, T8 treatment reported highest uptake of nitrogen (169.76 kg ha-1), phosphorus (94.24 kg ha-1), and potassium (110.16 kg ha-1).

The higher N uptake could be attributed to increased and sustained N availability to the plants under these treatments, as well as increased dry matter yields. Ramakal et al. (1998) found that nutrient intake is positively related to dry matter yield. This is consistent with the findings of Chalapathi et al. (1997) and Mallangouda et al. (1995) for onions and garlic. The enhanced nitrogen assimilation by beetroot tubers may stem from increased mineral nitrogen levels in the soil (Chawla, 1969). Nitrogen may have altered potassium uptake due to its complimentary action with potassium. The increase in K intake was caused by the increased availability of nutrients from the native, which may have increased the concentration of K in the soil solution, making it readily available for absorption. Jagadeesh et al. 2018

**Table 5: Effect of different Nutrient level on Nitrogen (N), Phosphorus (P) and Potassium (K) uptake (kg ha-1 ) of Beetroot at harvest**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No** | **Treatment** | **N Uptake (Kg/ha)** | **P Uptake****(Kg/ha)** | **K Uptake (Kg/ha)** |
| 1 | T1 - N0P0K0 | 97.27 | 53.06 | 79.82 |
| 2 | T2 - N1P1K2 | 128.72 | 68.54 | 99.94 |
| 3 | T3 - N1P2K2 | 134.92 | 71.25 | 105.42 |
| 4 | T4 - N2P2K0 | 151.98 | 71.21 | 106.05 |
| 5 | T5 - N2P1K1 | 152.12 | 81.52 | 108.14 |
| 6 | T6 - N3P1K1 | 152.31 | 82.52 | 108.86 |
| 7 | T7 - N2P3K2 | 169.29 | 92.59 | 110.23 |
| 8 | T8 - N3P3K2 | 169.76 | 94.24 | 110.16 |
|  **SEd** | 5.61 | 3.70 | 4.55 |
|  **CD (P=0.05%)** | 12.16 | 7.95 | 9.77 |

**Fig 2: Effect of different Nutrient level on Nitrogen (N), Phosphorus (P) and Potassium (K) uptake (kg ha-1 ) of Beetroot at harvest**



4. 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 growth, nutrient uptake of beetroot (improved crystal hybrid).

**DISCLAIMER (ARTIFIICIAL INTELLIGENCE)**

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Details of the AI usage are given below:

1. ChatGPT

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