Influence of integrated nitrogen management on growth and yield of beet root (*Beta vulgaris* L.) var. Crimson Globe

Abstract

A field experiment was conducted at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand with a view to study the Influence of integrated nitrogen management on growth and yield of beet root (*Beta vulgaris* L.) var. Crimson Globeduring *rabi*, year 2020-21.The experiment was arranged in Randomized Block Design (RBD) with three replications which includes10 treatments.The results revealed thatsignificantlymaximum plant height of 16.71, 35.20 and 35.25 cm at 25,50 DAS and at harvest, respectively observed in T_3 (60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake).Similarly, the same treatment T_3 was registered maximum number of leaves per plant at25 (6.50), 50 (10.68) DAS and at harvest14.30. The maximum fresh weight of leaves (224.45 g), dry weight of leaves (13.35 g), as well as leaf area **(**260.42 cm^2) was also recorded with an application of60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake. The yield attributing parameters viz.root length (16.23 cm),root diameter (7.85 cm), fresh weight of root (198.05g), dry weight of root (18.75g), root to shoot ratio (1.42), yield (21.91kg/plot and 28.08t/ha) and harvest index (55.68%) was recorded in treatment T_4[60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)].

Introduction

Beetroot (*Beta vulgaris* L.), commonly known as garden beet or table beet, stands out as a prominent root vegetable within the Chenopodiaceae family, sharing its botanical affiliation with spinach, palak, swiss chard, parsley, and celery. This versatile vegetable, characterized by its chromosome number of 2n=18. Its culinary appeal extends beyond the roots, encompassing nutrient-rich leaves suitable for consumption as a leafy green (Szopinska *et al.*, 2013) Widely cultivated across diverse climates, beetroot has earned popularity for its sweet and earthy flavor, making it a sought-after ingredient in salads, soups, and juices. Beyond the kitchen, beetroot's historical significance includes traditional uses for medicinal purposes, such as supporting liver health and enhancing endurance(Kumar *et al.*, 2015). Additionally, its adaptability to various soil

conditions underscores its resilience as a globally cultivated vegetable. The captivating red hue of beetroot has transcended its culinary role, finding application in natural dyes for fabrics, adding a sustainable dimension to its versatile profile.Beetroot is a genuine energy booster for athletes due to its high levels of nitrates and sugar, making it one of the most effective real foods for enhancing performance, (Yadav *et al.,* 2016).Beet root originated in Western Europe and North Africa where they were grown to feed both by humans and livestock (Patel *et al*.,2019). This crop is categorized as a biennial but is typically cultivated as a cool-season annual. It is mostly grown in northern and southern parts of India and all states of India but in small scale only. This versatile crop yields green tops and a swollen root, serving dual purposes as both a nutritious vegetable and a salad ingredient. Notably high in productivity, it generally thrives without succumbing to common pests and diseases (Ado, 1999). Beetroot is a cool-weather crop that thrives in India's winter with temperatures between 18.3 to 21.1°C, producing high-quality, red roots rich in sugar. Below 10°C, plants may wilt prematurely. In warmer conditions, beetroot can exhibit a zoning pattern with alternating white and colored circles when sliced.

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Adequate nitrogen fertilizer promotes beetroot growth, yield, and quality (Das *et al.*, 2015). Nitrogen is essential for plant growth and forms proteins, enzymes, and vitamins. However, excessive fertilizer use can lead to nitrogen overload in crops, particularly in vegetables, a primary source of dietary nitrates. Nitrate accumulation in beetroot poses health risks, as it can convert to nitrite when consumed, potentially causing methemoglobinemia (Hemmat *et al.*, 2010).

The integrated nutrient management (INM) system combines inorganic and organic fertilizers to improve soil fertility and enhance crop production. This balanced approach enriches sandy loam soil with carbon and essential nutrients, increasing crop yields while maintaining soil fertility. Using organic fertilizers reduces reliance on chemical ones, benefiting both the environment and crop production. INM aims to optimize natural and man-made nutrient sources for efficient and eco-friendly agriculture, ensuring soil health for future generations.

Materials and methods

Present investigation on “Influence of integrated nitrogen management on growth and yield of beet root (*Beta vulgaris* L.) var. Crimson Globe" was carried out during *rabi* season of the year 2020-21 at Horticultural Research Farm, Department of Horticulture. B. A. College of

Agriculture, A. A. U., Anand. The experiment was conducted in Randomized Block Design (RBD) with three replications, including following 10 treatments. The treatment were T_1:60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost,T_2: 60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake;T_3:60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake;T_4:60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed);T_5:60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed);T_6:60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed);T_7:30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed);T_8:30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed);T_9:30 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed);T_{10}:60 kg N/ha + 25 t/ha FYM (control).

The variety under study is Crimson Globe.Seeds were sown at a spacing of 30 cm × 10 cm, and thinning was carried out ten days after sowing to ensure proper spacing.Five plants per treatment plot were observed and recorded for growth and yield characteristics.The collected data for all studied characteristics were statistically analyzed using the Randomized Block Design (RBD) method as per Panse and Sukhatma's(1967) guidelines.

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Result and discussion

Growth and yield parameters

Growthparameter*viz.*, plant height and number of leaves at 25, 50 DAS and at harvest were found significant differences in the present investigation.

The maximum plant height (16.71, 35.20 and 35.25 cm) and no. of leaves (6.50, 10.68 and 14.30) at 25, 50 DAS and at harvest, respectively recorded in T_3 [(60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake)] and it was at par with T_4 (60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5 ml/kg seed) and T_2 (60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake) . The lowest plant height and no.of leaves was recorded in T_{10} (60 kg N/ha + 25 t/ha FYM) under control.

The significantlymaximum fresh weight of leaves (224.45g), dry weight of leaves (13.35g) and leaf area (144.98 cm²)was observedintreatmentT_3 (60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake) while lower were observed in T_{10} (60 kg N/ha + 25 t/ha FYM)*i. e.* control.

The notable increase in plant height can be attributed to the supplementation of major and minor nutrients via various levels of organic manures. This enhancement boosted photosynthetic activity, chlorophyll formation, nitrogen metabolism, and auxin content in the plants, leading to improved plant height, increased leaf count, and overall robust vegetative growth. These findings align with similar results reported by Mbithi *et al.* (2015) in beetroot, Jagadeesh(2018) in beetroot, and Jabeen*et al.* (2017) in spinach beet.

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The maximum fresh weight of leaves at harvesting stage it might be due to the more luxurious vegetative growth of this treatment as compared to the rest of treatments(Ajay*et. al.,* 2014).It was due to application of FYM and Vermicompost may enhance the nitrogen content in the plant which leads to the increase in the chlorophyll content of leaf and ultimately increases the fresh weight of leaves.The obtained results align closely with findings reported by Singh *et al.* (2017) and Kirad*et al.* (2010) in their studies on carrots.

Increasing the rate of nitrogen fertilizer affected leaf dry mass because nitrogen stimulates plant vegetative growth and increases leaf area. As a result increased in leaf area enhance the rate of plant photosynthesis and thus increases dry matter production.

Table 1.Influence of integrated nitrogen management on plant height and number of leavesof beetroot var.Crimson Globe

Treatment		Plant height (cm)			Number of leaves per plant		
		At 25 DAS	At 50 DAS	At harvest	At 25 DAS	At 50 DAS	At harvest
T_1	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost	14.48	29.45	30.90	5.31	7.82	10.79
T_2	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake	16.02	33.89	34.10	6.19	10.35	13.84
T_3	60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake	16.71	35.20	35.25	6.50	10.68	14.30
T_4	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	16.68	34.20	34.64	6.24	10.44	14.15
T_5	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	15.40	32.55	32.98	5.77	8.62	11.81
T_6	60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	14.67	29.48	31.19	5.59	7.95	10.95
T_7	30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	15.24	32.32	32.88	5.76	8.38	11.38
T_8	30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	14.80	31.68	31.89	5.67	8.29	11.29
T_9	30 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	15.45	32.51	33.10	5.82	8.90	12.22
T_{10}	60 kg N/ha + 25 t/ha FYM (control)	13.91	28.27	29.79	5.27	7.49	10.65
	S. Em. $\pm$	0.44	0.85	0.75	0.22	0.61	0.72
	C.D. (P=0.05)	1.25	2.42	2.14	0.65	1.75	2.06
	C.V. (%)	4.97	4.61	3.98	6.80	11.97	10.32

Table 2. Influence of integrated nitrogen management on fresh weight of leaves,dry weight of leaves and leaf area of beet root var. Crimson Globe

Treatment		Fresh weight of leaves (with petiole) (g)	Dry weight of leaves (g)	Leaf area per plant (cm^2)
T_1	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost	117.20	9.85	155.35
T_2	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake	148.44	12.44	239.22
T_3	60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake	224.45	13.35	260.42
T_4	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	198.88	12.49	247.48
T_5	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	147.84	11.63	210.59
T_6	60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	125.16	10.59	156.38
T_7	30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	135.67	11.41	181.43
T_8	30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	131.81	10.86	170.92
T_9	30 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	147.94	11.67	219.95
T_{10}	60 kg N/ha + 25 t/ha FYM (control)	103.39	9.78	144.98
S. Em. $\pm$		6.33	0.51	3.59
C.D. (P=0.05)		18.02	1.46	10.22
C.V. (%)		7.40	7.80	3.12

Yield parameters

Root length (cm),root diameter (cm), fresh weight of root (g), dry weight of root (g), root to shoot ratio, yield (kg/plot), yield (t/ha) and harvest index (%) were significantly influenced by various treatments in the present experiment.

The maximum root length (16.23 cm), root diameter (7.85 cm), root to shoot ratio (1.42) , harvest index (55.68 %) was observed in T_4 (60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5 ml/kg seed)) and it was at par with T_7 (30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5 ml/kg seed) and T_1 (60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost) at harvest. The lowest was recorded in control (13.47 cm).

Significantly maximum fresh root weight (198.05 g) and dry weight of root (18.75 g) was recorded in treatment T_4*i.e*. 60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5 ml/kg seed). The minimum fresh root weight (114.49 g) and dry root weight (10.42 g) was recorded with T_{10}*i.e.* 60 kg N/ha + 25 t/ha FYM (control).

The maximum root yield per plot (21.91 kg) and per hectare (28.08 t/ha)as influenced by various treatments was significantly recorded in T_4 with the application of 60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5 ml/kg seed) The lowest root yield was recorded in T_{10} *i.e.*60 kg N/ha + 25 t/ha FYM.

Enhanced plant growth and improved yield parameters may be due to increased photosynthate translocation from leaves to roots, resulting in longer roots. Organic nutrient sources likely reduced soil bulk density and increased soil porosity and water-holding capacity, promoting larger root diameter. These findings align with (Vithwel and Kanaujia's2013).There was a positive correlation between plant height, leaf dry mass and total yield of beet root. Therefore the maximum root to shoot ratio was observed in treatment with combination of FYM and Vermicompost. Similar findings have also been reported by Indikumari *et al.* (2016).The higher marketable root yield may be due to increased humus accumulation, which mobilized reserve food materials to the sink through enzyme activity. This was supported by a high C:N ratio and improved nutrient availability in a readily usable form.Nitrogen, a crucial component in

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chlorophyll, proteins, and amino acids, sees increased synthesis with higher soil nitrogen supply. This leads to improved nutrient availability and a balanced C:N ratio, promoting greater carbohydrate production and ultimately higher yields, as observed by (Jose *et al*. in 1988). Better carbon assimilation and increased carbohydrate accumulation in the plants also played a role in this process.

Combining chemical fertilizers with organic manures improves overall crop growth by synchronizing nutrient delivery. This synchronized supply enhances the availability of essential resources for both vegetative and reproductive structures, ultimately leading to an increased harvest index. (Shah *et al*. 2009) also reported the highest harvest index when Urea and farmyard manure (FYM) were used together.Applying organic manures to soil enhances its physical condition by improving particle aggregation, (Samandasingh*et al.*1988). These aggregates impact soil fertility, water retention, gas diffusion, and root growth, benefiting overall plant development

Table 3. Influence of integrated nitrogen management on root length, root diameter, fresh and dry weight of beet root var. Crimson Globe

Treatment		Root length (cm)	Root diameter (cm)	Fresh weight of root (g)	Dry weight of root (g)
T_1	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost	15.74	7.42	169.06	16.93
T_2	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake	14.52	6.95	146.05	12.19
T_3	60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake	14.38	6.93	135.58	11.14
T_4	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	16.23	7.85	198.05	18.75
T_5	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	14.74	7.06	158.63	14.59
T_6	60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	14.56	7.02	146.11	12.74
T_7	30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	15.78	7.55	180.99	17.00
T_8	30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	15.06	7.31	163.17	16.69
T_9	30 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	13.93	6.50	127.65	10.95
T_{10}	60 kg N/ha + 25 t/ha FYM (control)	13.49	6.04	114.49	10.42
S. Em. ±		0.39	0.17	4.19	0.35
C.D. (P=0.05)		1.12	0.49	11.94	1.02
C.V. (%)		4.59	4.22	4.71	4.38

Table 4. Influence of integrated nitrogen management on Root to Shoot ratio,Yield (kg/plot), Yield (t/ha) and harvest index of beet root var. Crimson Globe

Treatment		Root to Shoot ratio	Yield (kg/plot)	Yield (t/ha)	Harvest index (%)
T_1	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost	1.34	19.75	25.32	54.18
T_2	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake	1.14	18.26	23.41	50.89
T_3	60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake	1.09	17.64	22.61	49.72
T_4	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	1.42	21.91	28.08	55.68
T_5	60 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	1.18	18.40	23.58	52.02
T_6	60 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	1.16	18.31	23.47	51.12
T_7	30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Vermicompost + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	1.35	19.81	25.39	54.49
T_8	30 kg N/ha + 12.5 t/ha FYM + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	1.27	18.66	23.92	52.59
T_9	30 kg N/ha + 5 t/ha Vermicompost + 5 t/ha Castor cake + Seed treatment of Anubhav Bio NPK consortium (5ml/kg seed)	0.97	16.90	21.66	44.74
T_{10}	60 kg N/ha + 25 t/ha FYM (control)	0.86	15.06	19.30	38.93
S. Em. ±		0.03	0.71	0.91	0.97
C.D. (P=0.05)		0.09	2.02	2.58	2.76
C.V. (%)		4.64	6.66	6.64	3.33

Conclusions

The current study concludes that the most effective treatment for maximizing beetroot growth and root yield is the combined application of 60 kg of nitrogen, 12.5 tons of farmyard manure (FYM), and 5 tons of vermicompost per hectare, along with seed treatment using Anubhav Bio NPK consortium at a rate of 5 ml/kg of seed. This combination resulted in the highest beetroot growth and root yield.

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