Effect of Integrated Nutrient Management on Growth and Yield of Beetroot (*Beta vulgaris* L.) *cv*. Ruby Queen

ABSTRACT

A field experiment was carried out to study the effect of integrated nutrient management on the growth and yield of beetroot (*Beta vulgaris* L.) *cv*. Ruby Queen. The experiment was laid out in a randomized block design using ten treatments and three replications at the college farm of the Department of Horticulture, Tilak Dhari PG College, Jaunpur, (U.P.) during the *rabi* season of 2021-22. Integration of nutrient sources was comprised in the form of treatments *viz*. T_1 - 100% NPK (70:110:70), T_2 -75% NPK + FYM (10 t/ha) + *Azotobacter* (10 kg/ha) + PSB (10 kg/ ha), T_3 - 75% NPK + VC (3 t/ha) + *Azotobacter* (10 kg/ha) + PSB (10 kg/ha), T_4 - 75% NPK + FYM (5 t/ha) + VC (1.5 t/ha) + *Azotobacter* (10 kg/ha) + PSB (10 kg/ha), T_5 - 50% NPK + FYM (10 t/ha) + *Azotobacter* (10 kg/ha) + PSB (10 kg/ha), T_6 - 50% NPK + VC (3 t/ha) + *Azotobacter* (10 kg/ha) + PSB (10 kg/ha), T_7 - 50% NPK + FYM (5 t/ha) +VC (1.5 t/ha) + *Azotobacter* (10 kg/ha) + PSB (10 kg/ha), T_8 - 75% NPK + FYM (10 t/ha), T_9 - 50% NPK + VC (3 t/ha) and T_{10} - Control. Among all treatments, T_4 (75% NPK + FYM + VC + *Azotobacter* + PSB) performed best for growth and yield parameters recorded significantly minimum number of days required for 80 percent germination of seedlings (2.68 days), highest plant height (50.24 cm), most leaves per plant (13.53), maximum leaf area (3227.50 cm^2), higher chlorophyll content index (21.76), maximum root length (16.23 cm), root diameter (7.73 cm), root yield per plant (220.14 g), root yield per plot (4.40 kg), root yield per hectare (22.014 t), and highest harvest index (0.91) was observed.

Keywords: Beetroot, Growth, Yield, INM, Azotobacter, PSB

INTRODUCTION

Beetroot (*Beta vulgaris* L.) is usually known as chukandar. It's one of the most valuable root vegetable crops and is consumed worldwide due to its high nutrient content. It has a diploid chromosome number of 2n=18. Beetroot is a biennial crop although it is commonly grown annually. It produces green tops and swollen roots during the first growing season. It is grown for vegetables, salad, Juice, and other food uses (pickles). Beetroot was first described in 1557 when it was referred to as Roman beet in Germany. The crop was introduced in the USA in 1800 and is known as garden beet (Bose and som, 1986). In India Beetroot is mainly cultivated in Haryana, Uttar Pradesh, Himachal Pradesh, West Bengal, Maharashtra, and Tamil Nadu. It is highly productive and usually free from pests and diseases (Ado, 1999).

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 (Aykroyd, 1963). Hence it is an ideal vegetable for health-conscious people (Deuter and Grundy, 2004). 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 (Pedreno and Escribano, 2000; Kugler *et al.*, 2007) drawing the attention of consumers to use it in cuisine (Kavitha *et al.*, 2014). It is also beneficial in many clinical conditions including coronary heart disease and cancer (Jurgen *et al.*, 2015). It is one of the natural foods which boosts the energy in athletes as it has one of the highest nitrates and sugar contents (Yadav *et al.*, 2016). It received increasing attention due to possible health benefits in humans, especially its antioxidant and anti-inflammatory activities (Georgie *et al.*, 2010 and Zielinska *et al.*, 2009).

In modern times, chemical fertilizers have become the main source for providing the required quantities of nutrients to plants, and application aids in achieving maximum production but it must be interpreted given its harmful effects on the environment as well as increasing production costs due to its expenses (Dadarwal *et al.*, 2009; Ranjan *et al.*, 2013). The continuous use of chemical fertilizers often in excess, over a long time in arable land has led to the contamination of food material, environmental pollution, and depletion of soil fertility (Singh, 1999). To reduce the cost of chemical fertilizers and their harmful effect on soil, environment, and quality, it is necessary to seek an alternative that will improve productivity, quality, and also be eco-friendly to the environment.

Integrated nutrient management (INM) is a possible way forward to achieve sustainable crop production rather than relying on only inorganic fertilizers. The use of combined organic manure, bio-fertilizers, and reduced-dose chemical fertilizers not only helps to improve crop growth, yield, and quality but also helps to maintain soil health, reduce pollution problems and increase production (Ahmad *et al.*, 2016) and ensure better food security. Keeping all the above points in view the current research work initiates to find out the ideal combination of integrated nutrient management on growth and yield of beetroot (*Beta vulgaris* L.) *cv*. Ruby Queen.

MATERIALS AND METHODS

The present experiment was laid out at the college farm of the Department of Horticulture, Tilak Dhari Post Graduate College, Jaunpur, Uttar Pradesh on 1st week of November during the *rabi* season of the year 2021-22. The experimental site is situated at an altitude of 79.75 m above mean sea level at 25°73' North latitude and 82°68' East longitude. The climate condition of Jaunpur is sub-tropical with three seasons *i.e.*, rainy, winter, and summer. During the summer season temperature reaches as high as 45°C, while in winter it falls to 5°C or even low. Most of the rainfall was received between the third week of June and the first week of October. The annual rainfall of Jaunpur is about 1097.9 mm with 46 normal rainy days. The experiment was carried out in a randomized block design using ten treatments having three replications. The treatments comprises of *i.e.*, T_1 - 100% NPK (70:110:70), T_2 -75% NPK + FYM (10 t ha^{-1}) + *Azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1}), T_3 - 75% NPK + VC (3 t ha^{-1}) + *Azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1}), T_4 - 75% NPK + FYM (5 t ha^{-1}) + VC (1.5 t ha^{-1}) + *Azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1}), T_5 - 50% NPK + FYM (10 t ha^{-1}) + *Azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1}), T_6 - 50% NPK + VC (3 t ha^{-1}) + *Azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1}), T_7 - 50% NPK + FYM (5 t ha^{-1}) +VC (1.5 t ha^{-1}) + *Azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1}), T_8 - 75% NPK + FYM (10 t ha^{-1}), T_9 - 50% NPK + VC (3 t ha^{-1}) and T_{10} - Control.

The variety under investigation was 'Ruby Queen' which is a high-yielding variety. Seeds of this variety were collected from a certified private seller. The soil of the experimental plot was deep, loamy sand. The site was divided into a 2 m x 1 m plot size of 30 plots. Seeds were sown in a ridge and furrow system at a depth of 1.5 cm and spacing of 45 cm × 15 cm to ensure proper spacing. To cultivate a good crop, all other recommended cultural practices were followed properly. N, P, and K were given through Urea, Single Super Phosphate, and Muriate of Potash respectively. The full dose of phosphorus and potassium and a half dose of nitrogen was applied as basal dose, as per treatment before sowing, and the remaining half dose of nitrogen was given after 30 days of sowing. Manures *viz*., FYM and vermicompost were integrated as per treatment to respective plots before sowing. Biofertilizers (*Azotobacter* and PSB) were inoculated to seeds before sowing as a seed treatment. The observations of Growth parameters and yield parameters were recorded on five randomly selected and tagged plants from each treatment in all replications.

Growth parameters were the number of days required for 80% germination of the seedlings, plant height (cm) which was measured from ground level to the tip of the longest leaf, number of leaves per plant, leaf area (cm^2) which was measured using non-destructive methods by recording the observations of length and width of the leaf at the middle portion of each leaf and chlorophyll content index measured using spad meter and recorded data on 25 DAS, 45 DAS, and 65 DAS. Yield parameters were the root length (cm), root diameter (cm), root yield per plant (g $plant^{-1}$), root yield per plot (kg $plot^{-1}$), root yield per hectare (t ha^{-1}), and harvest index. The statistical analysis of the variance of the data in respect of growth and yield components of beetroot was done according to the standard procedure for factorial randomized block design given by Panse & Sukhatme (1985).

RESULT AND DISCUSSION

Growth Parameters

The number of days required for 80 % germination: The days required for 80 % germination of beetroot seedlings were significantly influenced by integrated nutrient combinations as presented in table 1 and figure 1. Among all the treatments T_4 (75% NPK + FYM (5 t ha^{-1}) + VC (1.5 t ha^{-1}) + *Azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1})) resulted in early germination (2.68 days) and it was at par with T_7 (3.14 days). The results show early germination in the combined application of N., P., K., FYM, VC, *Azotobacter*, and PSB which was due to the combined effect of all these nutrients which enhanced the availability of all macro and micronutrients in the rhizosphere also of its high content of nitrogen, phosphorus, and potassium may help in early germination of seedlings (Warman, 1986). The findings agreed with those of Gyewali *et al*. (2020). Similar results were also obtained by Jagadeesh *et al*. (2018) and Mounika *et al*. (2021) in beetroot.

Table 1: Effect of integrated nutrient management on number of days required for 80 % germination of beetroot seedlings *cv* Ruby Queen

Treatments (T)	Number of days required for 80 % germination (days)
T_1-100% NPK	3.98
T_2-75% NPK + FYM + *Azotobacter* + PSB	3.28
T_3-75% NPK + VC + *Azotobacter* + PSB	3.21
T_4-75% NPK + FYM + VC + *Azotobacter* + PSB	2.68
T_5-50% NPK + FYM + *Azotobacter* + PSB	3.67
T_6-50% NPK + VC + *Azotobacter* + PSB	3.51
T_7-50% NPK + FYM +VC + *Azotobacter* + PSB	3.14
T_8-75% NPK + FYM	4.05
T_9-50% NPK + VC	4.08
T_{10}-Control	4.81
CD at 5 %	**0.49**
SE (m) ±	**0.16**

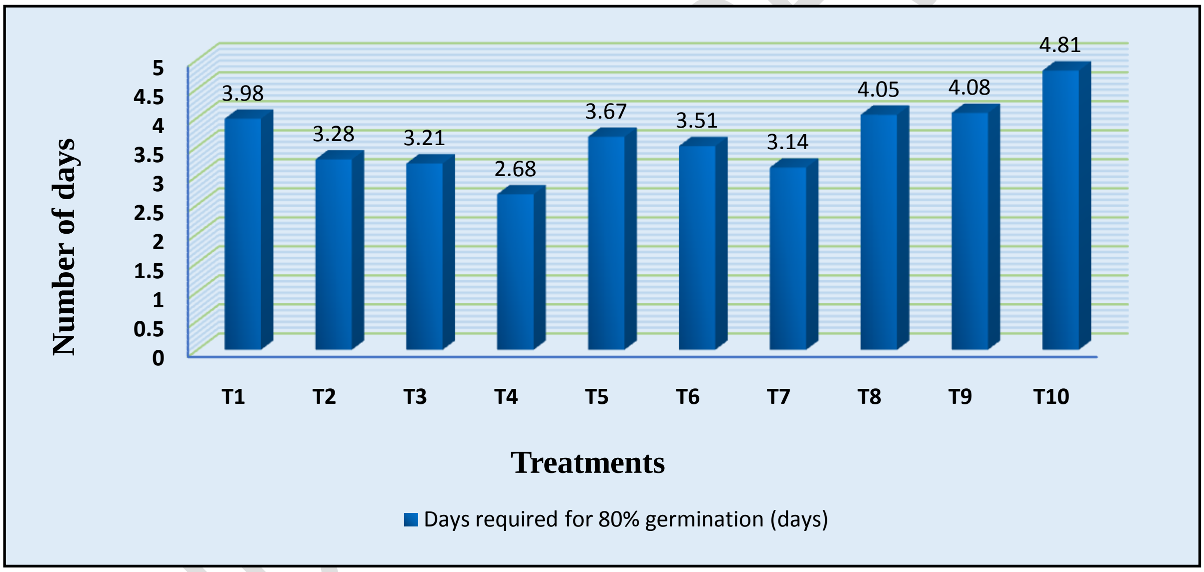

Fig. 1: Effect of integrated nutrient management on number of days required for 80 % germination of beetroot seedlings *cv* Ruby Queen

Plant height: The data on plant height at 25, 45, and 65 days after sowing was significantly increased by the treatment as shown in table 2 and figure 2. At 25 DAS the highest plant height was recorded in T_4 (15.77 cm) and it was at par with T_7 (15.42 cm) and T_3 (15.19 cm) but significantly superior to all other treatments. At 45 DAS and 65 DAS T_4 treatments were significantly superior to all other treatments with heights of 36.74 cm and 50.24 cm respectively. The treatment T_4 (75% NPK + FYM + VC + *Azotobacter* + PSB) was recorded at the highest plant height in every stage. The positive effect of treatment (T_4) on plant height could be due to the readily available required nitrogen, which is a component of amino acids, nucleotides, nucleic acids, a number of co-enzymes, auxins, cytokinin and alkaloids that resulted in increased cell elongation, cell enlargement, and cell division, Also, higher plant height could be due to certain growth promoting substances secreted by the *Azotobacter* and PSB, which improved better transportation of water, uptake and deposition of nutrients which positively affect the better root development. The results are in conformity with the findings of Singh *et al*. (2017) and Shanu *et al.* (2019) in carrot, Dlamini *et al.* (2020), and Mounika *et al*. (2021) in beetroot.

Number of leaves per plant: The data recorded on the number of leaves per plant was significantly influenced by the various integrated nutrient management treatments at different stages of plant growth. The results are presented in table 2 and figure 3. At 25 DAS, the maximum number of leaves per plant was observed in T_4 (6.40) which was at par with T_7 (6.20). At 45 DAS T_4 (10.47) recorded the highest value which was at par with T_7 (10.07) and 65 DAS, the Maximum value was recorded in T_4 (13.53) which was significantly superior to all other treatments. T_7 (12.53) was comparable with T_2 (12.07) and T_3 (12.20). The maximum number of leaves per plant at all growth stages was recorded in T_4 treatment with 75% NPK + FYM + VC + *Azotobacter* + PSB which was due to the timely supply of all nutrients in the rhizosphere, resulted in a greater number of leaves per plant. Besides, it might be due to the same reasons that registered the highest plant height over other treatments. These results are in accordance with that of Shanu *et al*. (2019) in carrot, Dlamini *et al.* (2020), and Mounika *et al*. (2021) in beetroot.

Table 2: Effect of integrated nutrient management on plant height (cm) and Number of leaves per plant at different growth stages of beetroot *cv*. Ruby Queen

Treatments (T)	Plant height (cm)			Number of leaves per plant		
	25 DAS	45 DAS	65 DAS	25 DAS	45 DAS	65 DAS
T_1	13.62	30.56	39.61	5.20	8.80	11.13
T_2	14.75	33.23	44.95	5.73	9.87	12.07
T_3	15.19	33.97	44.71	5.80	9.80	12.20
T_4	15.77	36.74	50.24	6.40	10.47	13.53
T_5	14.20	31.33	43.28	5.60	9.27	11.40
T_6	14.07	31.03	42.63	5.73	9.13	11.47
T_7	15.42	34.63	46.79	6.20	10.07	12.53
T_8	13.52	31.02	40.74	5.53	9.00	11.40
T_9	12.90	29.67	39.29	5.40	8.93	11.00
T_{10}	10.55	26.43	34.89	5.07	8.20	10.13
CD at 5 %	**0.73**	**1.59**	**2.27**	**0.33**	**0.58**	**0.63**
SE (m) ±	**0.24**	**0.53**	**0.76**	**0.11**	**0.19**	**0.21**

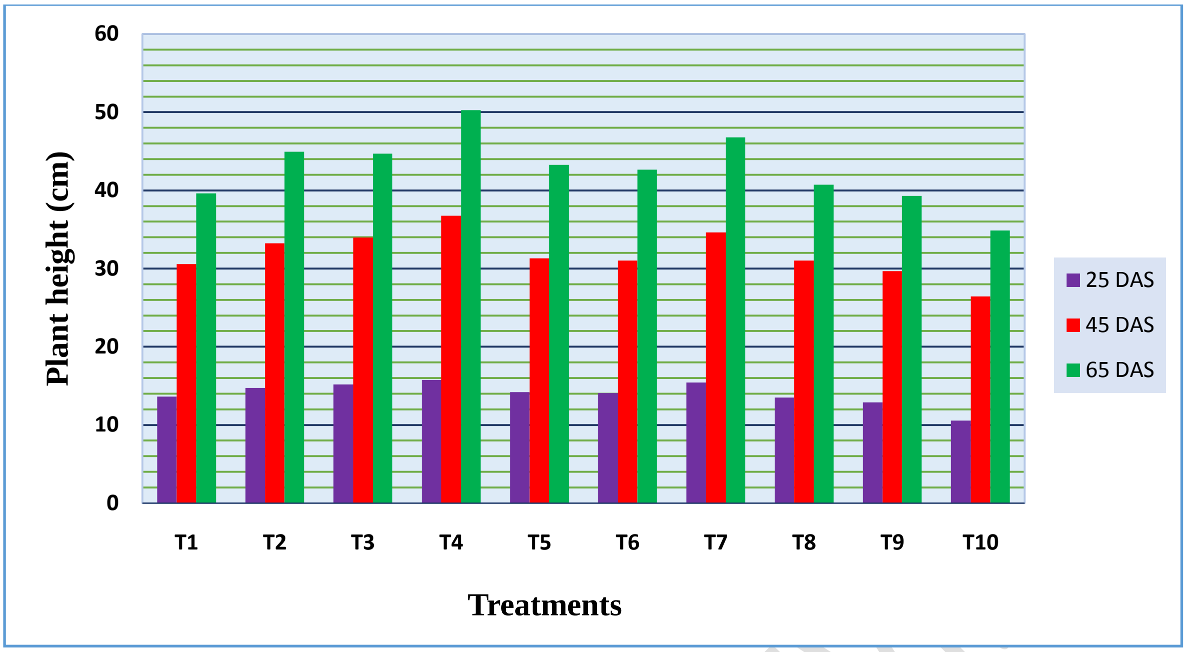

Fig. 2: Effect of integrated nutrient management on plant height (cm) at different growth stages of beetroot *cv*. Ruby Queen

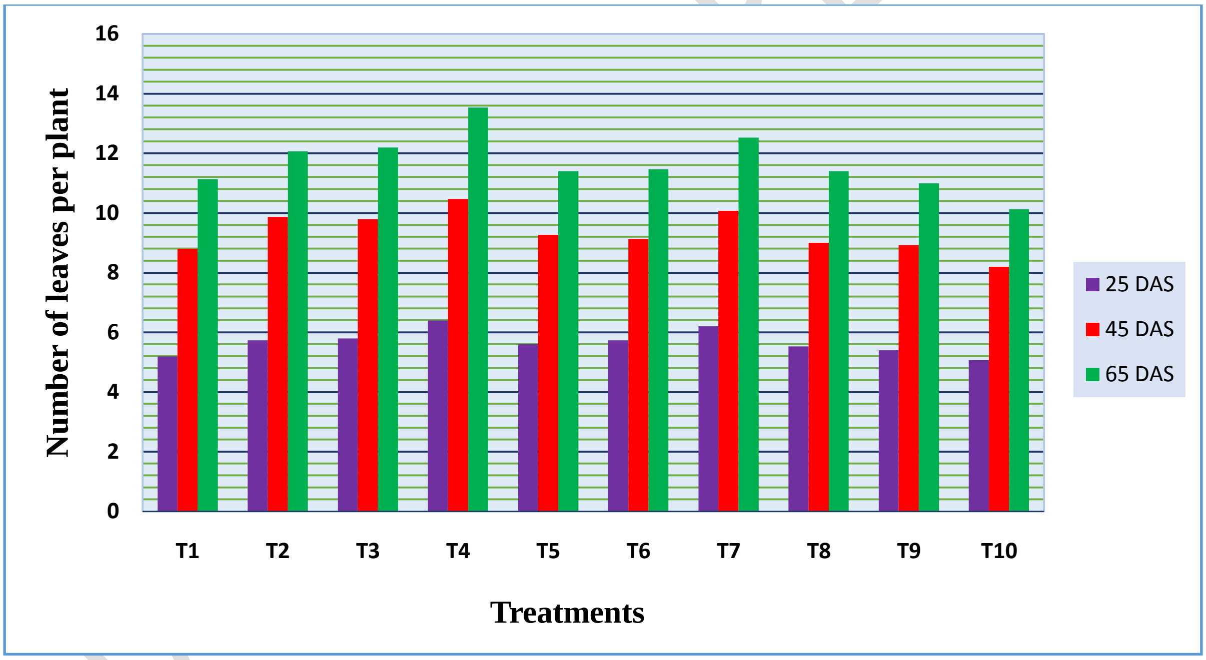

Fig. 3: Effect of integrated nutrient management on number of leaves per plant at different growth stages of beetroot *cv*. Ruby Queen

Leaf area: Leaf area was found significant influence by the integrated nutrient management treatments. The results are presented in table 3 and figure 4. At 25 DAS T_4 recorded a maximum leaf area (270.11 cm^2) which was at par with T_7 (253.59 cm^2). At 45 DAS highest leaf area was recorded in T_4 (1649.52 cm^2) and it was comparable with T_7 (1609 cm^2). At 65 DAS maximum leaf area was recorded in T_4 (3227.50 cm^2) and it was at per with T_7 (3136.76

cm^2), followed by T_3 treatment (3069.09 cm^2), and T_2 (3052.43 cm^2). The data revealed that maximum leaf area at 25, 45, and 65 days after sowing was recorded in T_4 treatment with 75% NPK + FYM + VC + *Azotobacter* + PSB may be due to the same treatment registered the highest plant height and a greater number of leaves per plant, resulted in maximum leaf length and width of the leaf led to higher leaf area at all growth stages. Similar results were also reported by Jaisankar (2018) in radish.

Chlorophyll content index: The chlorophyll content index was found to be significant to the integrated nutrient management treatment combinations as shown in table 3 and figure 5. At 25 DAS the highest value was recorded in T_4 (13.88) and it was at par with T_7 treatment (13.35), T_3 (13.19), and T_2 (13.06). It was the minimum in the T_{10} treatment (8.99). At 45 DAS Maximum value was recorded in the T_4 treatment (17.44). At 65 DAS maximum value was recorded in T_4 (21.76) treatment and was at par with T_7 (20.84) and T_3 (20.62). T_4 treatment with 75 % NPK + FYM + Vermicompost + *Azotobacter* + PSB recorded the highest value in every stage. It might be due to readily available macro and micronutrients, particularly nitrogen supplied by FYM, vermicompost, and biofertilizers, and an important constituent of chlorophyll. These results are in accordance with that of Gairola *et al.* (2009) in spinach beet.

Table 3: Effect of integrated nutrient management on leaf area (cm^2) and Chlorophyll content index at different growth stages of beetroot *cv*. Ruby Queen

Treatments (T)	leaf area (cm^2)			Chlorophyll content index		
	25 DAS	45 DAS	65 DAS	25 DAS	45 DAS	65 DAS
T_1	200.33	1404.78	2809.85	12.01	15.10	18.41
T_2	236.77	1555.37	3052.43	13.06	16.12	20.39
T_3	239.09	1528.47	3069.09	13.19	16.26	20.62
T_4	270.11	1649.52	3227.50	13.88	17.44	21.76
T_5	222.00	1465.76	2961.73	12.40	15.58	18.86
T_6	230.34	1456.78	2996.93	12.31	15.81	19.61
T_7	253.59	1608.22	3136.73	13.35	16.50	20.84
T_8	209.72	1425.11	2871.15	12.31	15.33	19.37
T_9	201.35	1409.26	2797.64	10.21	14.21	17.37
T_{10}	162.48	1201.81	2348.32	8.99	12.09	15.58
CD at 5 %	**24.97**	**64.46**	**121.11**	**1.01**	**1.22**	**1.26**
SE (m) ±	**8.34**	**21.53**	**40.45**	**0.34**	**0.41**	**0.42**

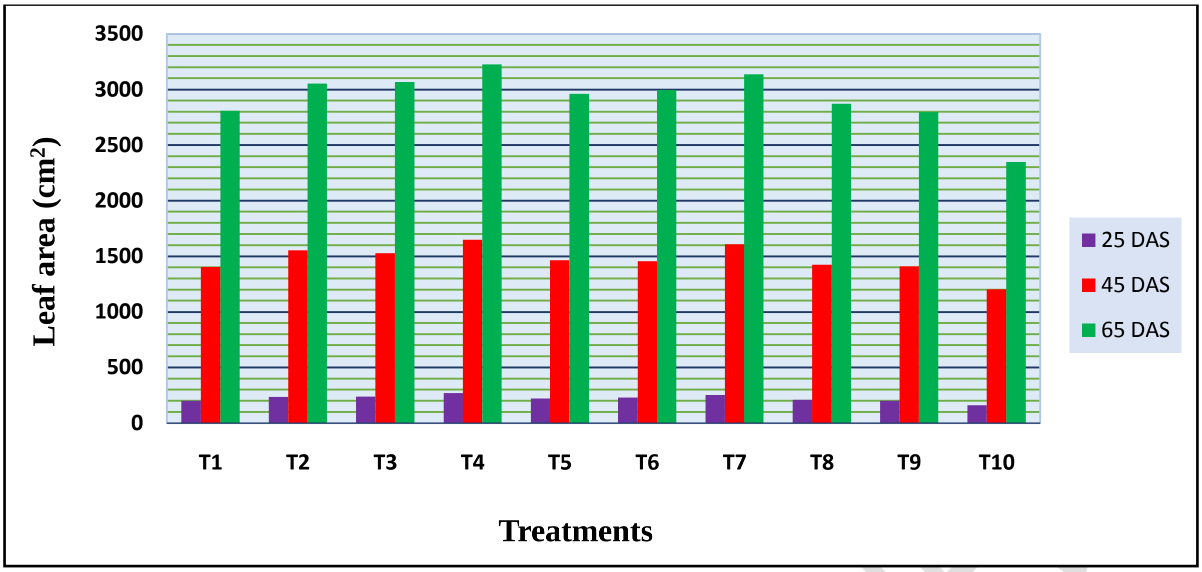

Fig. 4: Effect of integrated nutrient management on leaf area (cm^2) at different growth stages of beetroot *cv.* Ruby Queen

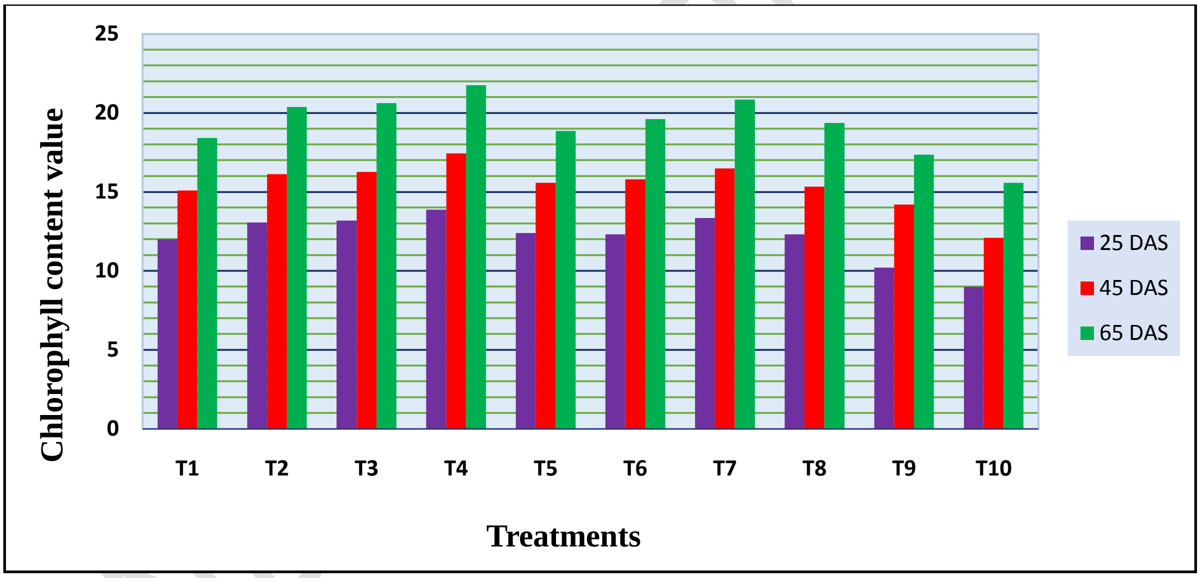

Fig. 5: Effect of integrated nutrient management on chlorophyll content index at different growth stages of beetroot *cv.* Ruby Queen

Yield Parameters

Root length and Root diameter: Root length and root diameter were significantly influenced by the integrated nutrient management treatments. The results are presented in table 4.

The highest root length (16.23 cm) was recorded in the T_4 treatment and it was on par with the T_7 treatment (15.67 cm), T_3 (15.20 cm), and T_2 (15.067 cm), whereas the lowest value was recorded in T_{10} treatment (9.27 cm) with control and the highest root diameter (7.73 cm) was recorded in T_4 treatment which was at par T_7 (7.49 cm), T_2 (7.27 cm) and T_3 (7.17 cm).

T_1 with 100% NPK recorded a root diameter of 6.13 cm which is comparable with T_9 (5.99 cm) while the lowest was recorded in T_{10} (4.74) with control (fig. 6). It might be due to enhanced cell division and quick cell multiplication resulted in better plant growth in all aspects and more translocation of photosynthates from leaves (source) to root (sink) led to increased root length and diameter. Similar results were also reported by Mali *et al.* (2018) in radish, Ingole *et al.* (2018), and Dlamini *et al* (2020) in beetroot.

The results pertaining to root yield per plant (g $plant^{-1}$), root yield per plot (kg $plot^{-1}$), root yield per hectare (t ha^{-1}), and harvest index were significantly influenced by the integrated nutrient management treatments combinations as results are presented in table 4.

Root yield: The highest value of root yield per plant was recorded in T_4 (220.14 g $plant^{-1}$) treatment which is significantly superior to all, followed by the T_7 treatment (191.98 g $plant^{-1}$). It was significantly minimum (96.77 g $plant^{-1}$) in T_{10} treatment with control.

Root yield per plot is significantly superior to treatments with T_4 recorded as the highest value (4.40 kg $plot^{-1}$) and superior among others, followed by T_7 treatment (3.84 kg $plot^{-1}$), whereas it was minimum in T_{10} (1.94 kg $plot^{-1}$) treatment with control. T_1 (100% NPK) recorded a lower value (2.97 kg $plot^{-1}$) among treatments combination and was only better than T_9 (2.74 kg $plot^{-1}$).

Maximum root yield per hectare was recorded (22.014 t ha^{-1}) in the T_4 treatment which was significantly superior to anyone followed by the T_7 treatment (19.20 t ha^{-1}) and was statistically significant with each other, while it was minimum in T_{10} (9.68 t ha^{-1}) with control. T_1 (100% NPK) recorded 14.87 t ha^{-1} which is a lower value than all treatments and only better than T_9 (13.72 t ha^{-1}) (fig. 7).

Harvest index: The highest harvest index (0.91) was recorded in T_4 which was significantly superior to all other treatments, followed by T_7 (0.84). T_1 with 100% NPK recorded a harvest index of 0.73 and T_{10} with control resulted lowest (0.64).

The data shows that T_4 treatment with 75% NPK + FYM + VC + *Azotobacter* + PSB recorded the highest value in root yield per plant (g $plant^{-1}$), root yield per plot (kg $plot^{-1}$), root yield per hectare (t ha^{-1}), and harvest index parameters which might be due to the maximum root length and root diameter recorded over other treatments. The present investigation was consistent with other reports by Pathak *et al.* (2018), and Monika *et al.* (2018) in radish. The present findings are comparable with that of Jagadeesh *et al*. (2018) and Mounika *et al*. (2021) in beetroot.

Table 4: Effect of integrated nutrient management on root length (cm), root diameter (cm), root yield per plant (g plant^{-1}), root yield per plot (kg plot^{-1}), root yield per hectare (t ha^{-1}), and harvest index of beetroot *cv.* Ruby Queen

Treatments (T)	Root length (cm)	Root diameter (cm)	Root yield (g plant^{-1})	Root yield (kg plot^{-1})	Root yield (t ha^{-1})	Harvest index
T_1	13.633	6.127	148.663	2.973	14.866	0.727
T_2	15.067	7.267	171.727	3.435	17.173	0.813
T_3	15.200	7.173	184.170	3.683	18.417	0.833
T_4	16.233	7.727	220.143	4.403	22.014	0.907
T_5	14.933	6.747	152.293	3.046	15.229	0.787
T_6	14.767	6.810	159.287	3.186	15.929	0.800
T_7	15.667	7.487	191.977	3.840	19.198	0.840
T_8	14.300	6.630	153.907	3.078	15.391	0.747
T_9	13.133	5.993	137.150	2.743	13.715	0.720
T_{10}	9.267	4.743	96.767	1.935	9.677	0.637
CD at 5 %	**1.225**	**0.597**	**23.727**	**0.475**	**2.373**	**0.046**
SE (m) ±	**0.409**	**0.199**	**7.924**	**0.158**	**0.792**	**0.015**

Fig. 6: Effect of integrated nutrient management on root length (cm) and root diameter (cm) of beetroot *cv.* Ruby Queen

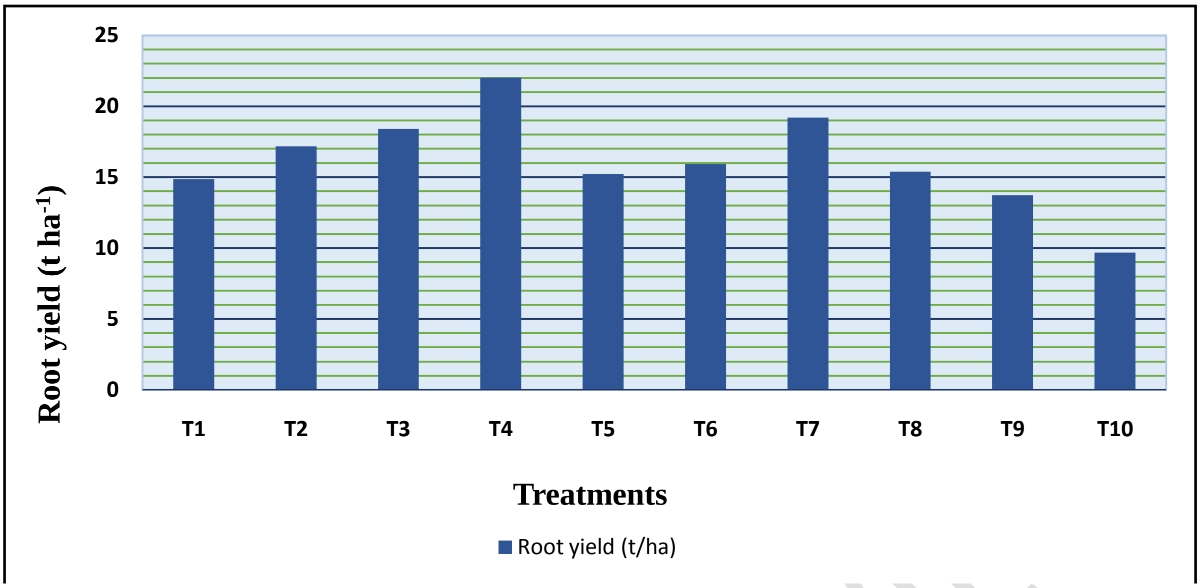

Fig. 7: Effect of integrated nutrient management on root yield (t ha^{-1}) of beetroot *cv.* Ruby Queen

CONCLUSION

Among all the different integrated nutrient treatment combinations, T_4 treatment with 75% NPK + FYM (5 t ha^{-1}) + VC (1.5 t ha^{-1}) + *Azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) proven to the best treatment followed by T_7 treatment (50% NPK + FYM (5 t ha^{-1}) +VC (1. 5 t ha^{-1}) + *Azotobacter* (10 kg ha^{-1}) + PSB (10 kg ha^{-1}) to give maximum results on growth parameters and yield parameters of beetroot (*Beta vulgaris* L.) *cv* Ruby Queen.

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