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Studies on the effect of foliar application of micronutrients and their schedule of spray on quality of beet root (*Beta vulgaris* L.) cv. crimson globe under Telangana conditions

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Abstract
The present investigation entitled "Studies on the effect of foliar application of micronutrients and their schedule of spray on quality of beetroot (*Beta vulgaris* L.) cv. Crimson Globe under Telangana conditions'' was carried out during the rabi season of the year 2021-22 at the College of Horticulture, Rajendranagar, Hyderabad.

The field experiment was laid out in factorial randomized block design with three (3) replications and fourteen (14) treatment combinations. Seven (7) micronutrient concentrations are M_1: Zinc, Iron, Manganese each at 150 ppm, M_2: Zinc, Iron, Manganese each at 250 ppm, M_3: Zinc, Iron, Manganese each at 150 ppm + Copper at 100 ppm, M_4: Zinc, Iron, Manganese each at 250 ppm + Copper at 200 ppm, M_5: Zinc, Iron, Manganese each at 150 ppm + Copper at 100 ppm + Boron at 200 ppm, M_6: Zinc, Iron, Manganese each at 250 ppm + Copper at 200 ppm + Boron at 400 ppm, M_7: Control (No micronutrients spray) and two (2) schedule of sprays at 25 DAS and 35 DAS were tried. The results pertaining to quality parameters indicated that among the all treatment combination, foliar spraying of M_6 (Zinc, Iron, Manganese each at 250 ppm + Copper at 200 ppm + Boron at 400 ppm) at 35 days after sowing registered significantly highest total soluble solids (9.78 ^{o}Brix) reducing sugars (1.92 %), total sugars (7.50 %) and ascorbic acid content (4.62 mg $100g^{-1}$). Where as titratable acidity and root rotting were found to be non-significant.

Keywords: Beet root, crimson globe, micronutrients, foliar spray, schedule of spray, quality

Introduction
Beetroot (*Beta vulgaris* L.) belongs to the family Chenopodiaceae. The chromosome number is 2n= 18 and same is found in spinach, palak, swiss chard, parsley, and celery. Beetroot can be eaten raw, boiled, steamed and roasted. Red beetroot is richest source of minerals like magnesium, manganese, sodium, potassium, iron and copper (Mathangi, 2019) [13].

Beetroot is belongs to the origin Mediterranean region of Western European and North African coast. (Zohary *et al*., 2012; Chawla *et al*., 2016) [26, 6]. Beetroot is grown on 0.079 lakh hectares across the country with an annual production of 1.51 lakh million tonnes, with Telangana accounting for 425 hectares with an annual production of 11,132 million tonnes (HAPIS portal statistics, 2018) [8].

Beet roots are high in Carbohydrates (9.96 g), Protein (1.68 g) and contain 87.7% water. According to early studies, beetroot contains various vitamins, including vitamin A (2 g), thiamine (0.31 mg), riboflavin (0.27 mg), niacin (0.330 mg), pantothenic acid (0.145 mg), vitamin B_6 (0.067 mg), ascorbic acid (3.6 mg), and folate (80 g), as well as minerals like sodium (77 mg), calcium (16 mg), iron (0.79 mg), phosphorus (38 mg), potassium (305 mg per 100 g of edible portion (Yashwant, 2015 and Chauhan *et al*., 2020) [23, 5]. The beetroot is an alkaline food with a pH of 7.5-8.0 and contains significant amount of vitamin C, vitamin B_1, B_2, niacin, B_6, B_{12} and leaves are excellent source of vitamin A. The intense red color of beet root is due to presence of a significant amount of betalains, a class of phenolic secondary plant metabolites. (Georgiev *et al*., 2010; Zielinska *et al*., 2009) [9, 25]. The beetroot juice can be consumed as a natural remedy to expel kidney and bladder stones and for sexual weakness.

One of the most important factors impacting the amount and quality of agricultural products is the mineral nutrition of crops (Mousavi *et al*., 2011) [15]. As a result, enormous quantities of chemical fertilizers are utilized annually to promote agricultural development. It's over usage in agricultural ecosystems harms the soil's food balance, which leading to lack of micronutrients in the soil (Adiloglu, 2003) [1]. About 50% soils of India are deficient in micronutrients and these soils are under intensive cultivation with no or little application of micronutrients.

Beet root is one of the important root vegetable crop and is easy to grow and ranked as one of the top ten vegetables grown in India making advantage of micro fertilizers is a reserve for increasing yields and improving the quality of root crops.

Micronutrients are essential for plant growth and development as well as macronutrients. These are, however, required in very small quantities. Previously, it was considered that most of the soils can supply these minute amounts easily. It is now feared that high yielding crop varieties are mining our soils of all the nutrients especially the micronutrients because their addition as fertilizer element is negligible. Foliar application of micronutrient to crop plants is gaining popularity in increasing crop yield and quality with improved shelf life of the produce. Spraying of minor elements corrects the nutritional disorders.

Beet root is sensitive to micro elements (Imran and Gurmani, 2011) [10] Therefore, their use is indispensable for the cultivation of this culture, while using foliar fertilization. Microelements activate and support photosynthesis, increase the efficiency of macro fertilizers, create an anti-stress effect from the use of pesticides, increase the quantity and quality of the crop (Ovcharuk *et al*., 2019; Archer, 1988) [17, 2]. Micronutrients application in Telangana state on vegetable crops is very limited, especially on Beet root and the research on these aspects will benefit the Beet root farmers in Telangana.

Keeping in view of the above information, the research programme entitled “Studies on the effect of foliar application of micronutrients and their schedule of spray on quality of beetroot (*Beta vulgaris* L.) cv. Crimson Globe under Telangana conditions”.

Materials and Methods

The present investigation was carried out during *rabi* season in the year 2021-2022 at P.G research farm, College of Horticulture, Rajendranagar, Hyderabad. Sri Konda Laxman Telangana State Horticultural University. The experimental site is situated at a latitude of 17^0 .32’ North, longitude of 78^0 .40’ East and altitude of 536 m above mean sea level. The place is characterized by semi-arid tropical zone. The soil of the experimental site was sandy loam having soil pH 7.48, organic carbon 0.27% and available N, P and K content of 224, 36.00 and 160 kg ha^{-1} and available micronutrient content of Zn, Fe, Mn, Cu, B of 0.9, 4.5, 1.2, 0.5, 0.4 ppm respectively.

The field experiment was laid out in factorial randomized block design with three (3) replications and fourteen (14) treatment combinations. Seven (7) micronutrient concentrations are M_1: Zinc, Iron, Manganese each at 150 ppm, M_2: Zinc, Iron, Manganese each at 250 ppm, M_3: Zinc, Iron, Manganese each at 150 ppm + Copper at 100 ppm, M_4: Zinc, Iron, Manganese each at 250 ppm + Copper at 200 ppm, M_5: Zinc, Iron, Manganese each at 150 ppm + Copper at 100 ppm + Boron at 200 ppm, M_6: Zinc, Iron, Manganese each at 250 ppm + Copper at 200 ppm + Boron at 400 ppm, M_7: Control (No micronutrients spray) and two (2) schedule of sprays at 25 DAS and 35 DAS were tried.

The beet root crop cv. Crimson Globe seed was procured and used in the experiment, which was developed from IARI regional station, Katrain, Himachal Pradesh. All micronutrients used in experiment were procured from Laboratory, College of Horticulture, Rajendranagar, Hyderabad.

Different micronutrients used in experimentation

S. No.	Micronutrients Name	Molecular formula	Molecular Weight(g/mol)	Nature of solubility
1	Zinc	$ZnSO_4.7H_2O$	287.54	Water
2	Iron	$FeSO_4.7H_2O$	278.01	Water
3	Manganese	$MnSO_4.H_2O$	169.09	Water
4	Copper	$CuSO_4.5H_2O$	159.61	Water
5	Boron	H_3BO_3	61.83	Water

The experimental site was ploughed and harrowed three to four times to achieve fine tilth, and then a basal dose of well decomposed FYM @ 25 t ha^{-1} was administered. The experimental plot was levelled and divided into 42 sections of 3 m x 3 m. Irrigation channel of 0.5 m is provided between two beds. To encourage greater germination, beetroot seeds were soaked in water for 12 hours before being sown using the dibbling method. Seeds were sown in ridge and furrow method at a spacing of 45 X 10 cm with a depth of 1.5 cm on ridge. Adopted seed rate was 7kg/ha.

Before planting, a half dose of nitrogen and a full dose of P_2O_5 and K_2O were applied as a basal dose, with the remaining half dose of nitrogen applied 30 days later. Urea, SSP (single super phosphate), and MOP (murate of potash) are used to deliver N, P, and K dosages, respectively. Top dressing of half dose of nitrogen was given in the form of Urea at 30 days after sowing. The recommended dose of fertilizers @ 70: 110: 70 kg N, P, K and farm yard manure at 10 t per ha was supplemented, uniformly for all the treatments. All other cultural and plant protection measures were done as per the recommended package of practices for the healthy crop.

The data were recorded on five plants per treatment per plot in each replication on quality parameters. Observations were recorded on total soluble solid (TSS) was determined by using hand refractometer and results expressed in brix, reducing sugars and total sugars were analysed by using procedure outlined by Lane and Eynon method (Ranganna, 1986) [19] and expressed in (%) ascorbic acid content was determined by xylene extraction method suggested by (Ranganna, 1986) [19] and expressed in (mg/100 g) Titratable acidity of the sample was determined by titration method using 0.1N sodium hydroxide (NaOH) as suggested by Ranganna (1986) [19] and expressed in (%) and Root rotting percentage was calculated by using formula Number of rotten roots per plot divided by number of total roots per plot. The data was analyzed statistically by following the analysis of variance (ANOVA) technique as asserted by Panse and Sukhatme (1985) [18].

Statistical significance was tested with 'F' value at 5 per cent level of significance and whenever the F value was found significant, critical difference was worked out at five per cent level of significance.

Results and Discussion

The foliar application micronutrients and their schedule of spray had significant effect on quality parameters (Table 1, 2, 3 and 4).

The results pertaining to quality parameters indicated that the highest Total soluble solids (9.66 ^{o}Brix), titratable acidity (0.28 mg/100g fresh weight), reducing sugars (1.89 %), total sugars (7.20 %) and ascorbic acid content (4.56 mg $100g^{-1}$) were recorded in micronutrient concentration of M_6- Zinc, Iron, Manganese each at 250 ppm + Copper at 200 ppm + Boron at 400 ppm. The highest total soluble solid (8.79 ^{0}Brix), reducing sugars (1.57 %), total sugars (6.02 %), ascorbic acid content (3.84 mg $100g^{-1}$) were recorded in schedule of spray at 35 days after sowing, where as titratable acidity was found to be non-significant. The interaction effect on quality parameters was found to be significant in treatment combination of M_6S_2 (Zinc, Iron, Manganese each at 250 ppm + Copper at 200 ppm + Boron at 400 ppm, sprayed at 35 DAS) recording significantly maximum total soluble solids (9.78 ^{0}Brix), reducing sugars (1.92 %), total sugars (7.50 %) and ascorbic acid content (4.62 mg $100g^{-1}$). Where as titratable acidity and root rotting were found to be non-significant.

The data (Table 1) on total soluble solids revealed that M_6 (zinc, iron, manganese @ 250 ppm + copper @ 200 ppm + boron @ 400 ppm) was sprayed at 35 days after sowing recorded the highest value which was due to the maximum translocation of photo assimilates, sugars and other soluble solids towards the root portion, resulted in increased TSS. which was due to the maximum translocation of photo assimilates, sugars and other soluble solids towards the root portion resulting in increased TSS. The improved TSS as a result of applying micronutrients is attributed to presence of elements such as boron that increased the transfer of sugars produced in the leaves to root.

Similar observation was observed by Masri and Hamza (2015) [12], EI-Sherief *et al.* (2016) [7] in sugar beet; Subba *et al*. (2016) [21] in carrot; Moustafa *et al*. (2019) [16] and Zewail *et al.* (2020) [24] in sugar beet where application of higher concentration of iron and zinc increased the TSS. Bhatanagar *et al.* (2020) [4] also observed boron foliar application increased the TSS in beetroot.

It was evident from Table 1. that there was significant difference observed due to micronutrient concentration on titrable acidity. Significantly the highest titrable acidity (0.28 %) was observed in the micronutrient concentration, M_6 (zinc, iron, manganese @ 250 ppm + copper @ 200 ppm + boron @ 400 ppm) Schedule of spray and the interaction between micronutrient concentration and schedule of spray was found to be non-significant titratable acidity. This is might be due to the application of zinc, copper, boron and iron and other micronutrients which increased the titrable acidity. Similar results were reported by Salam *et al*. (2010) [20] and Verma *et al*. (2022) [22] in tomato.

Table 1: Effect of foliar application of micronutrients and their schedule of spray on Total soluble solids (^{0}brix) and Titrable acidity (mg 100g fresh weight^{-1}) of beet root cv. Crimson Globe

Micronutrient concentrations (M)	Total soluble solids (^{0} Brix)			Terrible acidity (mg 100g freshweight^{-1})		
	Schedule of spray (S)			Schedule of spray (S)		
	S_1	S_2	Mean	S_1	S_2	Mean
M_1	8.20	8.32	8.26^{f}	0.19	0.20	0.19^{e}
M_2	8.50	8.74	8.62^{e}	0.20	0.22	0.21^{d}
M_3	8.75	8.92	8.84^{d}	0.22	0.23	0.23^{c}
M_4	8.92	9.23	9.0^{c}	0.24	0.25	0.25^{b}
M_5	9.26	9.44	9.35^{b}	0.26	0.27	0.27^{ab}
M_6	9.54	9.78	9.66^{a}	0.27	0.28	0.28^{a}
M_7	7.01	7.20	7.11^{g}	0.14	0.15	0.15^{f}
Mean	8.60^{b}	8.80^{a}		0.22	0.23	
	SEm ±	CD @ 5%		SEm ±	CD @ 5%	
Micronutrient concentration (M)	0.10	0.28		0.003	0.008	
Schedule of spray (S)	0.05	0.15		0.002	NS	
M X S	0.13	0.39		0.004	NS	

The data recorded on reducing sugars is presented in the Table 2. revealed that Micronutrient concentration, M_6 (zinc, iron, manganese @ 250 ppm + copper @ 200 ppm + boron @ 400 ppm) was sprayed at 35 DAS, recorded the highest value which was due to the maximum translocation of photo assimilates, sugars towards the root portion, resulted in increased reducing sugars. Presence of boron in micronutrient combination also increased the transfer of sugars produced in the leaves to the roots which helped to increase the reducing sugars content in root.

The present findings are comparable with that Ballabh *et al.* (2013) [3] in onion; Zewail *et al*. (2020) [24] in sugar beet; Maurya and Lal (1975) [14] observed increased content of reducing sugars by zinc nutrition in onion.

The data on total sugars (Table 2) revealed that, micronutrient concentration, M_6 (zinc, iron, manganese @ 250 ppm + copper @ 200 ppm + boron @ 400 ppm) sprayed at 35 DAS, recorded the highest value which was due to the maximum translocation of photo assimilates, sugars towards the root portion, and increase in the total sugars or extractable sucrose in roots ultimately increased in content of total sugars in roots hence quality also increased. In micronutrient combination, presence of boron increases the transfer of sugars produced in the leaves to the root and helps to increase the total sugars in roots.

The present findings are comparable with that Ballabh *et al.* (2013) [3] in onion; Zewail *et al.* (2020) [24] in sugar beet; Maurya and Lal (1975) [14] who observed increased content of total sugars by zinc nutrition in onion.

Table 2: Effect of foliar application micronutrients and their schedule of spray on reducing sugars (%) and total sugars (%) of beet root cv. Crimson Globe.

Micronutrient concentrations (M)	Reducing sugars (%)			Total sugars (%)		
	Schedule of spray (S)			Schedule of spray (S)		
	S_1	S_2	Mean	S_1	S_2	Mean
M_1	1.32	1.36	1.34[f]	4.80	5.00	4.90[f]
M_2	1.44	1.49	1.47[e]	5.30	5.60	5.45[e]
M_3	1.53	1.57	1.55[d]	5.70	6.20	5.95[d]
M_4	1.62	1.66	1.64[c]	6.00	6.40	6.20[c]
M_5	1.74	1.80	1.77[b]	6.50	7.20	6.85[b]
M_6	1.86	1.92	1.89[a]	6.90	7.50	7.20[a]
M_7	1.20	1.22	1.21[g]	4.23	4.20	4.22[g]
Mean	1.53[b]	1.57[a]		5.63[b]	6.02[a]	
	SEm ±	CD @ 5%		SEm ±	CD @ 5%	
Micronutrient concentration (M)	0.01	0.04		0.06	0.18	
Schedule of spray (S)	0.01	0.02		0.03	0.09	
M X S	0.02	0.06		0.09	0.25	

From the table 3. The highest ascorbic acid content was recorded in Micronutrient concentration, M_6 (zinc, iron, manganese @ 250 ppm + copper @ 200 ppm + boron @ 400 ppm) sprayed at 35 DAS was due to the availability of more number of micronutrients to the plant, resulting in higher photosynthesis rate led to the increased ascorbic acid content.

The other reason might be due to the close relationship between the carbohydrates metabolism and the formation of ascorbic acid. Similar observation was reported by Ballabh (2013) [3] in onion; Subba *et al*. (2016) [21] in carrot; Malick (1976) [11] observed increased ascorbic acid content in tomato with increasing level of $ZnSO_4$ application; Bhatanagar *et al*. (2020) [4] also reported boron foliar application increased the ascorbic content in beetroot.

Table 3: Effect of foliar application of micronutrients and their schedule of spray on Ascorbic acid content (mg $100g^{-1}$) of beet root cv. Crimson Globe.

Micronutrient concentrations (M)	Ascorbic acid content (mg $100g^{-1}$)		
	Schedule of spray (S)		
	S_1	S_2	Mean
M_1	3.20	3.43	3.32[f]
M_2	3.49	3.64	3.57[e]
M_3	3.70	3.89	3.80[d]
M_4	3.95	4.03	3.99[c]
M_5	4.28	4.43	4.36[b]
M_6	4.49	4.62	4.56[a]
M_7	2.80	2.83	2.82[g]
Mean	3.70[b]	3.84[a]	
	SEm ±	CD @ 5%	
Micronutrient concentration (M)	0.04	0.12	
Schedule of spray (S)	0.02	0.06	
M X S	0.06	0.16	

The result related to percentage of root rotting (table 4) indicated that, except M_7 (control- No micronutrients spray) which showed higher value (1.05 %) of root rotting and the rest of treatments recorded lesser root rotting incidence and also all other micronutrient concentrations were statistically on par with each other. There was non- significant difference was observed in schedules of spray and Interaction between micronutrient concentrations and schedule of spray with respect to root rotting in beet root.

Table 4: Effect of foliar application of micronutrients and their schedule of spray on root rotting (%) of beet root cv. Crimson Globe.

Micronutrient concentrations (M)	Root rotting (%)		
	Schedule of spray (S)		
	S_1	S_2	Mean
M_1	0.17	0.18	0.18[ab]
M_2	0.07	0.03	0.05[a]
M_3	0.13	0.10	0.12[ab]
M_4	0.20	0.10	0.15[ab]
M_5	0.07	0.05	0.05[a]
M_6	0.10	0.05	0.08[a]
M_7	0.97	1.13	1.05[c]
Mean	0.25	0.23	
	SEm ±	CD @ 5%	
Micronutrient concentration (M)	0.12	0.34	
Schedule of spray (S)	0.06	NS	
MXS	0.17	NS	

Conclusion

It could be concluded from the present investigation of effect of foliar application of micronutrients and their schedule of spray recorded significant influence on quality of beet root (*Beta vulgaris* L.) cv. Crimson Globe under Telangana conditions. Among the different micronutrient concentrations M_6- Zinc, Iron, Manganese each at 250 ppm + Copper at 200 ppm + Boron at 400 ppm was observed to be superior for quality characters. Between the schedule of spray, micronutrients sprayed at 35 days after sowing was observed to be superior for quality characters. Based on the results, it can be concluded from interaction effects that treatment combination of M_6S_2 (zinc, iron, manganese each at 250 ppm + copper at 200 ppm + boron at 400 ppm, sprayed at 35 DAS) produced significantly superior quality characters.

Future Line of Work

- Study on use of organic manures, secondary nutrients and micronutrients may be included in future study.
- Other varieties of beet root can also be tried for foliar application of micronutrients.
- Study on use of nano-fertilizers foliar spraying with increased schedule of sprays in beetroot may be included in future study.

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