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Studies on the effect of micronutrients and their schedule of spray on quality of carrot (*Daucus carota* L.) Cv. new Kuroda under Southern Telangana conditions

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Abstract
A field experiment was conducted during *rabi* 2018-2019 at SKLTS Horticultural University, Hyderabad, Telangana, India, to study on the effect of micronutrients and their schedule of spray on quality of carrot (*Daucus carota* L.) cv. New Kuroda. The experiment consists of 14 treatments with seven levels of different combinations of nutrient and two levels of schedule of spray. Among the treatments, foliar spraying of T_6 (zinc, iron, magnesium @ 0.5% + copper @ 0.2% + boron @ 0.5%) at 45 days after sowing registered significantly higher percentage of total soluble solids (13.07%), ascorbic acid content (6.83 mg 100^{-g}), carotene content (4.33 mg100^{-g}), cortex to core ratio (0.97%), lower percentage of cracked roots (0.13%) and forked roots (3.10%).

Keywords: Micronutrients, new Kuroda, quality, cracking and forking

Introduction
Carrot (*Daucus carota* L.) is one of the important root vegetable crops belonging to the family Apiaceae (Peirce, 1987) [4] and is native to the Mediterranean region (Shinohara, 1984) [6]. It is an excellent source of iron, vitamin-A, Vitamin-B, Vitamin-C and sugar (Yawalker, 1985) [10]. Carrot root plays an important role in controlling the blindness of children by providing vitamin-A (Bose and Som, 1990) [1]. Economical plant part of carrot is used as a soup, stews, curries and pies. Moreover grated roots are used as salad and tender roots are used for preparation of Gajar halwa which is a delicious dish. Carrot juice is a rich source of carotene and sometimes it is used for colouring butter and other food. Because of rapid alkalizing effect of carrot juice, it is used in controlling of anaemia, liver trouble, acidosis, blood poisoning, circulatory disorders and ulcers. Micronutrients are very much essential for plant growth and they are required in smaller quantities. They play a vital role in enhancing crop productivity. Most of the growers follow recommended doses of macronutrients to achieve more yield but they may not consider that, one or more micronutrients also be limiting the crop yield. In many situations, deficiency of certain nutrients is the major factor responsible for ineffective utilization of some secondary and micronutrients supplied in fertilizer programmes. Although only required in small amounts by plants, their deficiency have much more effect on crop productivity as any of the major elements. Keeping these points in view the present investigation was designed with "Studies on the effect of micronutrients and their schedule of spray on quality parameters of carrot (*Daucus carota* L.) Cv. New Kuroda under Southern Telangana Conditions'.

Materials and Methods
The present investigation was conducted on studies on the effect of micronutrients and their schedule of spray on quality parameters of carrot (*Daucus carota* L.) cv. New kuroda under Southern Telangana Conditions at Vegetable Research Block, College of Horticulture – Mojerla, SKLTS Horticultural University, Hyderabad (Telangana) situated at 780 29' East longitude and 170 19' North latitude with an altitude of 542.3 m above the mean sea level. The location is characterized by semi arid climate. The soil of the experimental site was sandy loam having soil pH 6.5, organic carbon 0.27% and available N, P and K content of 206, 26.00 and 220 kg ha^{-1} respectively.

The carrot variety new kuroda used as experimental material and the experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications. The whole experiment was arranged over 14 treatments consisting of seven levels of different combinations of nutrient concentrations (C) C_1 – Zinc, Iron, Magnesium each at 0.25%, C_2 – Zinc, Iron, Magnesium each at 0.5%, C_3 – Zinc, Iron, Magnesium each at 0.25% + Copper at 0.1%, C_4 –Zinc, Iron, Magnesium each at 0.5% + Copper at 0.2%, C_5 – Zinc, Iron, Magnesium each at 0.25% + Copper 0.1% +Boron at 0.3%, C_6 – Zinc, Iron, Magnesium each at 0.5% + Copper at 0.2% + Boron at 0.5%, C_7 – Control with two levels of Schedule of spray (S) S_1: 30 days after sowing and S_2: 45 days after sowing. Seeds were sown at the spacing of 30 x 5cm and thinning was done 10 days after sowing to maintain spacing. 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 ºbrix, ascorbic acid content was determined by 2, 6- dichlorophenol-indophenol visual titration method (Ranganna, 1986) [5], carotene content was determined by spectrophotometer method (Srivastava and Kumar 2002) [7] and expressed in mg/100 g, root rotting, cracking, root forking and cortex to core ratio. The data was analyzed statistically by following the analysis of variance (ANOVA) technique as asserted by Panse and Sukhatme (1985) [3].

Results and Discussion

The micronutrients and their schedule of spray had significant effect on quality parameters (Table 1, 2 &3). Among the treatments, T_6 (zinc, iron, magnesium @ 0.5% + copper @ 0.2% + boron @ 0.5%) recorded higher percentage of total soluble solids (12.85%), ascorbic acid content (6.57 mg 100^{-g}), carotene content (4.25 mg 100^{-g}), cortex to core ratio (0.94%), lower percentage of cracked roots (0.22%) and forked roots (3.30%).Between schedules of spray of micronutrients, micronutrients spray at 45 days after sowing recorded significantly maximum percentage of total soluble solids (10.17%), ascorbic acid content (4.75 mg100 $^{-g}$), carotene content (3.11 mg 100^{-g}), cortex to core ratio (0.61%), minimum percentage of cracked roots (3.87%) and forked roots (5.67%) over micronutrients spray at 30 days after sowing. The interaction between micronutrient concentration treatments and schedule of spray had a significant influence on quality parameters. Foliar application of T_6 (zinc, iron, magnesium each @ 0.5% + copper @ 0.2% + boron @ 0.5%) at 45 days after sowing registered significantly higher percentage of total soluble solids (13.07%), ascorbic acid content (6.83 mg 100^{-g}), carotene content (4.33 mg100^{-g}), cortex to core ratio (0.97%), lower percentage of cracked roots (0.13%) and forked roots (3.10%).

The data (Table 1) on total soluble solids percentage revealed that T_6 (zinc, iron, and magnesium @ 0.5% + copper @ 0.2% + boron @ 0.5%) 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. The present findings are comparable with that of Subba *et al.* (2016) [9] in carrot.

From the (table 1) highest ascorbic acid content was recorded in T_6 treatment which was due to the availability of more number of micronutrients to the plant, resulted 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 also reported by Subba *et al.* (2016) [9] in carrot.

The data (Table 1) enunciated on carotene content revealed that among the treatments, T_6 treatment registered maximum carotene content which was due to the more photosynthetic activity and enzymatic reaction triggered off by magnesium and copper, ultimately led to transformation of carbohydrates into carotene synthesis. These results were in accordance with the findings of Subba *et al.* (2016) [9] in carrot.

The result related to percentage of root rotting (table 2) indicated that, except T_7 treatment (control) (1.05%) all other treatments were statistically on par with each other and there was a non significant difference observed between treatments and schedule of spray during the course of study.

The data (Table 2) pertaining to root cracking percentage was recorded to be lowest in T_6 treatment which was due to the role of boron involved in the synthesis of pectic substances, resulted in the reduced root cracking percentage. The results are in accordance with that of Subba *et al.* (2017) [8] in carrot.

Table 1: Effect of micronutrients and their schedule of spray on total soluble solids (%), ascorbic acid content (mg 100^{-g}) and carotene content (mg 100^{-g}) of carrot Cv. New Kuroda

Micronutrient concentrations or Treatments (T)	Total soluble solids (%)			Ascorbic acid content (mg 100^{-g})			Carotene content (mg 100^{-g})		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	8.23	8.57	8.40	2.83	3.20	3.02	2.17	2.27	2.22
T_2	9.00	9.33	9.17	3.50	4.03	3.77	2.37	2.57	2.47
T_3	9.67	9.90	9.78	4.57	4.93	4.75	2.70	2.97	2.83
T_4	10.27	10.63	10.45	5.17	5.43	5.30	3.23	3.60	3.42
T_5	11.13	11.80	11.47	5.70	5.97	5.83	3.87	4.00	3.93
T_6	12.63	13.07	12.85	6.30	6.83	6.57	4.17	4.33	4.25
T_7	7.73	7.87	7.80	2.67	2.83	2.75	2.10	2.03	2.07
Mean	9.81	10.17		4.39	4.75		2.94	3.11	
	S.Em±		CD at 5%	S.Em±		CD at 5%	S.Em±		CD at 5%
Treatments (T)	0.05		0.15	0.04		0.11	0.048		0.11
Schedule of spray (S)	0.03		0.08	0.02		0.06	0.02		0.06
T X S	0.07		0.21	0.05		0.16	0.05		0.16

Note: T_1- zinc, iron, magnesium @ 0.25%, T_2-zinc, iron, magnesium @ 0.5%, T_3-zinc, iron, magnesium @ 0.25% + copper @ 0.1%, T_4- zinc, iron, magnesium @ 0.5% + copper @ 0.2%, T_5- zinc, iron, magnesium @ 0.25% + copper @ 0.1% + boron @ 0.3%, T_6- zinc, iron, magnesium @ 0.5% + copper @ 0.2% + boron @ 0.5%, T_7- control S_1- Spraying at 30 days after sowing and S_2- Spraying at 45 days after sowing

Table 2: Effect of micronutrients and their schedule of spray on root rotting (%), Root cracking (%) and Root forking (%) of carrot Cv. New Kuroda

Micronutrient concentrations or Treatments (T)	Root rotting (%)			Root cracking (%)			Root forking (%)		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_1	0.17	0.18	0.18	6.37	6.10	6.23	7.73	7.43	7.58
T_2	0.07	0.03	0.05	5.60	5.20	5.40	6.90	6.40	6.65
T_3	0.13	0.10	0.12	4.80	4.40	4.60	6.03	5.57	5.80
T_4	0.20	0.10	0.15	3.83	3.27	3.55	5.10	4.67	4.88
T_5	0.00	0.00	0.00	0.87	0.53	0.70	4.20	3.97	4.08
T_6	0.10	0.00	0.05	0.30	0.13	0.22	3.50	3.10	3.30
T_7	0.97	1.13	1.05	6.90	6.97	6.93	8.10	8.57	8.33
Mean	0.23	0.22		4.10	3.80		5.94	5.67	
	S.Em±	CD at 5%		S.Em±	CD at 5%		S.Em±	CD at 5%	
Treatments (T)	0.07	0.20		0.05	0.13		0.05	0.14	
Schedule of spray (S)	0.04	N.S		0.02	0.07		0.03	0.08	
T X S	0.09	N.S		0.06	0.19		0.07	0.20	

Note: T_1- zinc, iron, magnesium @ 0.25%, T_2-zinc, iron, magnesium @ 0.5%, T_3-zinc, iron, magnesium @ 0.25% + copper @ 0.1%, T_4- zinc, iron, magnesium @ 0.5% + copper @ 0.2%, T_5- zinc, iron, magnesium @ 0.25% + copper @ 0.1% + boron @ 0.3%, T_6- zinc, iron, magnesium @ 0.5% + copper @ 0.2% + boron @ 0.5%, T_7- control S_1- Spraying at 30 days after sowing and S_2- Spraying at 45 days after sowing

The data (Table 2) on root forking percentage revealed that T_6 treatment registered minimum root forking percentage which was due to the increased levels of nitrogen through foliar spray of micronutrients could be attributed to more availability of nitrogen at rhizosphere. Similar results were also reported by AL-Noman (2015) [2] in carrot and also Subba *et al.* (2017) [8] in carrot who reported that forked root per cent decreased with increasing levels of boron.

Table 3: Effect of micronutrients and their schedule of spray on cortex to core ratio (%) of carrot Cv. New Kuroda

Micronutrient concentrations/Treatments (T)	Cortex to core ratio (%)		
	S_1	S_2	Mean
T_1	0.29	0.34	0.32
T_2	0.40	0.45	0.42
T_3	0.53	0.66	0.60
T_4	0.70	0.72	0.71
T_5	0.83	0.88	0.86
T_6	0.90	0.97	0.94
T_7	0.21	0.26	0.23
Mean	0.55	0.61	
	S.Em ±	CD @ 5%	
Treatments (T)	0.01	0.03	
Schedule of spray (S)	0.01	0.01	
T X S	0.01	0.04	

Note: T_1- zinc, iron, magnesium @ 0.25%, T_2-zinc, iron, magnesium @ 0.5%, T_3-zinc, iron, magnesium @ 0.25% + copper @ 0.1%, T_4- zinc, iron, magnesium @ 0.5% + copper @ 0.2%, T_5- zinc, iron, magnesium @ 0.25% + copper @ 0.1% + boron @ 0.3%, T_6- zinc, iron, magnesium @ 0.5% + copper @ 0.2% + boron @ 0.5%, T_7- control S_1- Spraying at 30 days after sowing and S_2- Spraying at 45 days after sowing

The observations from table 3 confirmed that, the highest cortex to core ratio was recorded in T_6 treatment (zinc, iron, magnesium @ 0.5% + copper @ 0.2% + boron @ 0.5%) which was due to the same treatment registered the best values in terms of growth and yield parameters, resulted in higher cortex to core ratio than other treatments.

Future line of work

Varietal response of carrot to different micronutrients under Southern Telangana Conditions might be experimented.

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