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EFFECT OF ZINC, IRON AND BORON ON FRUIT CHARACTERISTICS OF KINNOW MANDARIN (*CITRUS RETICULATA* BLANCO) UNDER RAINFED CONDITIONS

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ABSTRACT

Experiment was conducted on 9-10 year old Kinnow plants wherein different levels of Zinc, Iron and Boron concentrations were applied through foliar sprays, individually and in combination to assess their on fruit quality and yield of Kinnow mandarin under rainfed conditions of Jammu Sub-tropics. Fruit quality parameters improved with the application of micronutrients, individually and in combinations, however, better results were obtained where combined application of Zinc, Iron and Boron was done. Among physical fruit characters highest fruit weight (157.52g), fruit length (6.23cm) and fruit diameter (7.62cm) were obtained with the application of 0.4 percent Zinc sulphate + 0.6 percent Iron sulphate + 0.2 percent Boric acid. Similarly, maximum fruit juice content (61.97%), TSS (12.03^{o}B), Ascorbic acid content (29.17mg/g), total sugars (9.03%) and fruit yield per plant (20.54 Kg/tree) were also recorded under 0.4 percent Zinc sulphate + 0.6 percent Iron sulphate + 0.2 percent Boric acid application. Despite improvement in physico-chemical fruit characteristics and yield, some horticulturally disadvantageous characters like peel thickness (1.56cm), peel weight (22.80g) and rag weight (29.85g) also increased with the application of 0.4 percent Zinc sulphate + 0.6 percent Iron sulphate + 0.2 percent Boric acid, however no significant effect were observed on seed weight and number of seeds.

Key words : Kinnow, Micronutrient, Foliar feeding, Fruit quality, Yield.

Introduction

Kinnow (*Citrus reticulata* Blanco), a mandarin hybrid between King orange (*Citrus nobilis* Lour) and Willow leaf mandarin (*Citrus deliciosa* Tenore) is an economically important sub-tropical fruit, which is grown all over the arid and semi-arid regions having assured irrigation facilities. Kinnow, belonging to family Rutaceae and sub-family Aurantoideae is rich in vitamin C with fair amounts of vitamins A and B and is liked for its juicy fruits, pleasant flavour and sour-sweet taste. Mostly eaten fresh and also processed into many products. Productivity and quality of fruits depends on many abiotic (climate, site, soil, nutrition and irrigation management) and biotic (rootstock, cultivar, insect pest and disease management) factors, among which the adequate supply of micro nutrients and irrigation is one of the most important in Kinnow mandarin. Among micronutrients, zinc is an important microelement essential for optimum growth and development of plants due to its involvement in the synthesis of tryptophan, which is a precursor of indole acetic acid. Zinc is required for the activity of various enzymes, such as dehydrogenases, aldolases, isomerases, transphosphorylases, RNA and DNA polymerases (Swietlik, 1999). Iron plays vital role in the synthesis of chlorophyll, carbohydrate production, cell respiration, reduction of nitrate sulphate and N assimilation. Boron as a micronutrient plays significant role in growth and productivity of citrus. The boron deficiency is mainly found in acidic and sandy soils, and those with low soil organic matter. In order to overcome the micronutrient deficiencies, foliar application of micronutrients is an ambitious pursuit for researchers and growers to maximize nutrient uptake by crops and minimizes doses and leaching loss. Foliar application of micronutrients like Zn, Cu, Mn, B and Fe has advantages over soil application because of high effectiveness, rapid plant response, convenience and elimination of toxicity symptoms brought about by excessive soil accumulation of such nutrients (Obreza *et al*., 2010). At key stages, foliar application can have a marked positive effect on fruit yield and quality of fruits. Therefore, studies were undertaken to assess the effect of zinc, iron and boron on fruit quality of Kinnow mandarin under rainfed conditions.

Materials and Methods

The present investigation was carried out at the Rainfed Research Sub-station for Sub-tropical Fruits (RRSS) Raya, SKUAST-J, J&K, India, situated at an elevation of 332 m above mean sea level and lies at 32°39'' North latitude and 74°53'' East longitude. The climate of experimental site is sub-tropical with hot and dry summer, hot and humid rainy season and cold winters. The maximum temperature rises up to 45°C during summer and minimum temperature falls upto 1°C during winter. The mean annual rainfall is about 1000-1200 mm concentrated mainly during few weeks of rainy season (July-August). Experiment was laid out in randomized block design on 9-10 year old Kinnow plants on which different concentrations of micronutrients were applied through foliar application, individually and/or in combination (T_1: 0.2% $ZnSO_4$, T_2: 0.4% $ZnSO_4$, T_3: 0.6% $ZnSO_4$, T_4: 0.4% $FeSO_4$, T_5: 0.6% $FeSO_4$, T_6: 0.8% $FeSO_4$, T_7: 0.2% H_3BO_3, T_8: 0.4% H_3BO_3, T_9: 0.6% H_3BO_3, T_{10}: 0.2% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.2% H_3BO_3, T_{11}: 0.2% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.4% H_3BO_3, T_{12}: 0.2% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.2% H_3BO_3, T_{13}: 0.2% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.4% H_3BO_3, T_{14}: 0.4% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.2% H_3BO_3, T_{15}: 0.4% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.4% H_3BO_3, T_{16}: 0.4% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.2% H_3BO_3, T_{17}: 0.4% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.4% H_3BO_3) with each treatment replicated thrice. The control treatment comprised of application of distilled water (T_{18}). Fruit set in the orchard occurred during last week of April month and the first spray was given during second week of May and second spray was done six weeks after the first spray. All the trees were maintained under uniform cultural schedule before and during the course of investigation. Physical fruit quality characters *viz*. fruit weight, fruit length, fruit diameter, peel thickness, peel weight and rag weight were calculated from a sample of ten randomly selected fruits from each tree. Fruit weight was measured by weighing ten representative fruits using electronic balance and the average fruit weight was calculated and expressed in grams. Fruit diameter was measured using digital vernier calliper and average fruit diameter was expressed in centimeters. For measuring peel thickness, fruits were hand peeled and the peel thickness was measured with the help of vernier calliper and expressed in millimeters. Peel weight was observed by weighing the peel using electronic balance and expressed in grams. Rag of each fruit was separated from the peel by using sharp stainless steel knife an drag weight was recorded separately on digital electronic balance and mean weight of rag of each treatment was expressed in grams. Juice content was recorded by extracting the juice with juice extractor, strained through a muslin cloth and measured with the help of electronic balance and the percentage of juice percentage was worked out on weight basis. Seed weight was recordedby removing the seeds with the help of knife from fruit sacs and weighingon electronic balance. Volume of fruit was measured by water displacement method by dipping the fruit in a full water filled beaker and measuring the water spilt out of the beaker. The average of ten fruits from each replication was calculated and expressed in cubic centimeter (cm^3). The total soluble solids (TSS), titratable acidity (%), reducing sugars, total sugars and non-reducing sugars and ascorbic acid content (mg per 100ml fruit juice) were determined as per standard procedure given in A.O.A.C. (1994). The crop load removed from the tree during harvesting season was recorded as yield per tree and expressed in kilogram per plant. The statistical analysis of the data generated during the course of study was analyzed as per the method suggested by Panse and Sukhatme (1967).

Results and Discussion

Physical fruit characters

Fruit weight : The perusal of the data presented in Table 1 and Fig. 1 reveals that application of micronutrients had significant effect on fruit weight of Kinnow mandarin wherein treatment T_{16} resulted in maximum and significantly higher fruit weight (157.52 g) than rest of the treatments, followed by 143.43 gm, 134.14 gm, 131.11

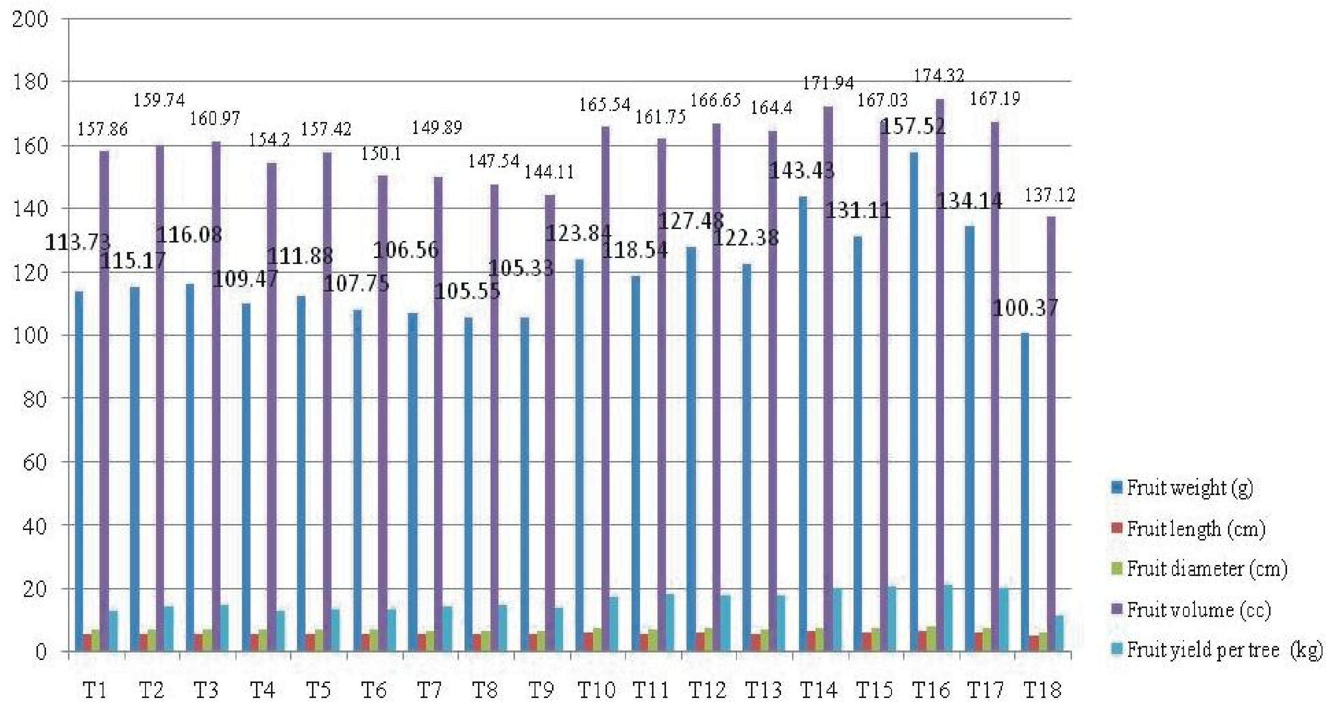

Fig. 1 : Effect of different treatments on the physical fruit parameters of Kinnow mandarin.

Table 1 : Effect of foliar application of zinc, iron and boron on the physical fruit parameters and yield of Kinnow mandarin.

Treatment	**Fruit weight (g)**	**Fruit length (cm)**	**Fruit diameter (cm)**	**Fruit volume (cc)**	**Fruit yield per tree (kg)**
0.2% $ZnSO_4$	113.73	5.39	6.73	157.86	12.70
0.4% $ZnSO_4$	115.17	5.41	6.76	159.74	13.78
0.6% $ZnSO_4$	116.08	5.46	6.81	160.97	14.59
0.4% $FeSO_4$	109.47	5.25	6.63	154.20	12.59
0.6% $FeSO_4$	111.88	5.33	6.67	157.42	12.94
0.8% $FeSO_4$	107.75	5.23	6.53	150.10	12.97
0.2% H_3BO_3	106.56	5.20	6.39	149.89	14.21
0.4% H_3BO_3	105.55	5.15	6.29	147.54	14.39
0.6% H_3BO_3	105.33	5.09	6.11	144.11	13.62
0.2% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.2% H_3BO_3	123.84	5.61	7.06	165.54	16.97
0.2% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.4% H_3BO_3	118.54	5.49	6.87	161.75	17.74
0.2% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.2% H_3BO_3	127.48	5.68	7.20	166.65	17.55
0.2% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.4% H_3BO_3	122.38	5.55	6.93	164.40	17.34
0.4% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.2% H_3BO_3	143.43	6.16	7.48	171.94	19.89
0.4% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.4% H_3BO_3	131.11	5.87	7.29	167.03	20.10
0.4% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.2% H_3BO_3	157.52	6.23	7.62	174.32	20.54
0.4% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.4% H_3BO_3	134.14	5.99	7.35	167.19	19.59
T_{18} (Control)	100.37	4.79	5.60	137.12	10.87
$CD_{0.05}$	**3.78**	**0.11**	**0.25**	**3.01**	**0.55**

gm and 127.48 gm fruit weight under treatments T_{14}, T_{17}, T_{15} and T_{12}, respectively. Control treatment, spray with distilled water (T_{18}) resulted in minimum fruit weight (100.37 g). The cumulative effect of Zn, Fe and B might have resulted into higher fruit weight, as also noted by Gurjar *et al.* (2015).

Fruit length : The combined treatments of different levels of $ZnSO_4$, $FeSO_4$ and H_3BO_3 in Kinnow mandarin also significantly increased the fruit length over the control. The fruit length was maximum (6.23 cm) under treatment

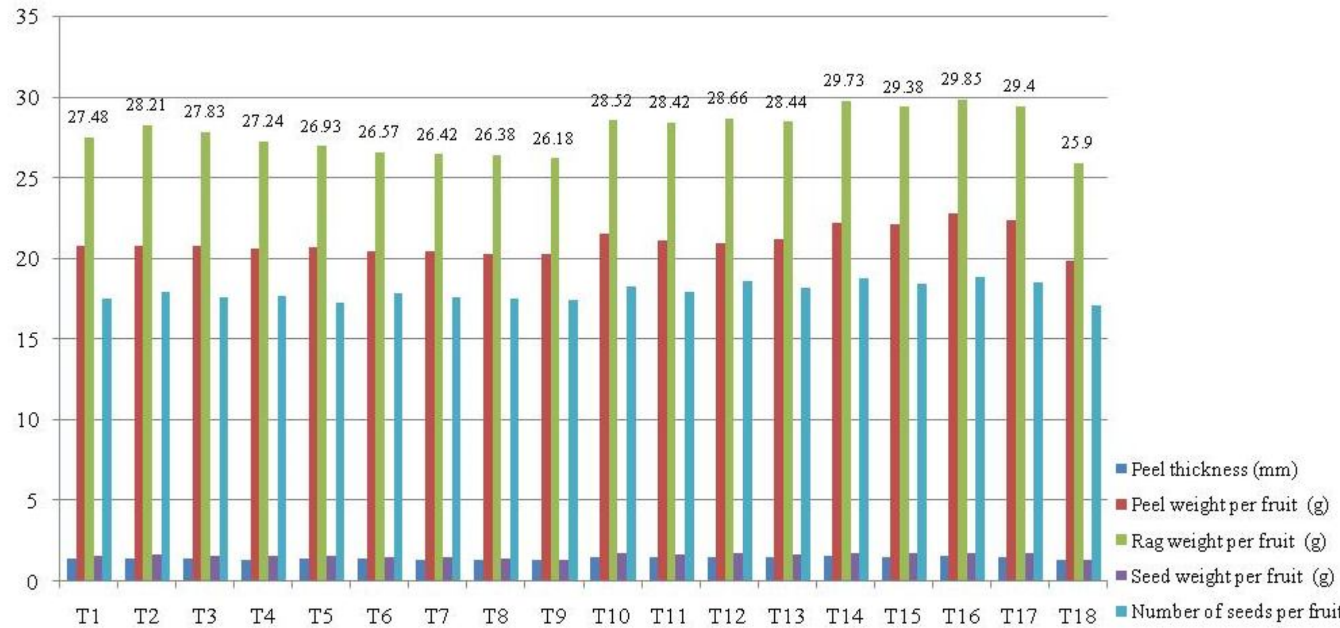

Fig. 2 : Effect of different treatments on peel, rag and seed content of Kinnow mandarin.

T_{16} which was at par with 6.16 cm fruit length under treatment T_{14}, whereas, the minimum fruit length (4.79 cm) was obtained under control (distilled water spray) treatment. The higher fruit length due to combined application of Zinc, Iron and Boron may be attributed to their stimulatory effect on plant metabolism. The increased length of fruit with these micronutrients might be due to their involvement in cell division, cell expansion and increase in volume of intercellular spaces in mesocarpic cells. It could also be due to higher mobilization of food and minerals from other parts of plants towards the developing fruit that are extremely active metabolic sink, as also reported by Singh and Rajput (1976).

Fruit diameter : Data in Table 1 reveals that the fruit diameter of Kinnow mandarin was maximum (7.62 cm) under treatment T_{16}, which was statistically at par with 7.48 cm fruit diameter under treatment T_{14}, while minimum fruit diameter (5.60 cm) was recorded in control treatment. The increase in diameter of fruit as a result of foliar application of micronutrients in present investigation might be because it improved the internal physiology of developing fruit in terms of better supply of water, nutrients, and other compounds vital for their proper growth and development. Gurjar *et al.* (2015) reported that the foliar spray of zinc and boron showed better response in improving the fruit diameter in Kinnow mandarin.

Fruit volume : The highest fruit volume (174.32 cc) was obtained under treatment T_{16} which was statistically at par with 171.94 cc fruit volume under treatment T_{14}. The lowest fruit volume (137.12 cc) of Kinnow mandarin was obtained under the control (distilled water spray) treatment. The increase in fruit volume is directly proportional to fruit weight and fruit size. The increased fruit volume might be due to the involvement of micronutrients in hormonal metabolism, increased cell division and expansion of cell, as also reported by Rani and Brahmachari (2001).

Fruit yield : Application of different levels of zinc, iron and boron applied separately as well as in combination significantly increased the fruit yield per tree as compared to control (Table 1). The fruit yield per tree was maximum (20.54 kg) under treatment T_{16} (0.4% $ZnSO_4$+0.6% $FeSO_4$+0.2% H_3BO_3), which was statistically at par with 20.10 kg fruit yield per tree under treatment T_{15} and was followed by 19.89 kg yield per tree in treatment T_{14}, 19.59 kg per tree in treatment T_{17}, 17.74 kg per tree in treatment T_{11}, 17.55 kg per tree in treatment T_{12}, 17.34 kg per tree in treatment T_{13} and 16.97 kg per tree in treatment T_{10}. The increase in fruit yield with foliar application of zinc sulfate may be ascribed to increase in the fruit retention on the tree consequently reduced the pre-harvest fruit drop. Razzaq *et al.* (2013) reported that spray applications of 0.4% and 0.6% zinc sulphate resulted in the higher numbers and percentage of marketable fruit compared to control trees. These results are also in close conformity with the findings of Gaur *et al*. (2014).

Peel thickness : Data presented in Table 2 and Fig. 2 reveal that peel thickness in Kinnow mandarin fruit was significantly increased as compared to control with the foliar application of different levels of zinc sulphate, ferrous sulphate and boric acid sprayedalone as well as

Table 2 : Effect of foliar application of zinc, iron and boron on peel, rag and seeds of Kinnow mandarin.

Treatment	Peel thickness (mm)	Peel weight per fruit (g)	Rag weight per fruit (g)	Seed weight per fruit (g)	Number of seeds per fruit
0.2% $ZnSO_4$	1.41	20.75	27.48	1.60	17.53
0.4% $ZnSO_4$	1.45	20.80	28.21	1.65	17.90
0.6% $ZnSO_4$	1.42	20.77	27.83	1.63	17.57
0.4% $FeSO_4$	1.38	20.58	27.24	1.55	17.65
0.6% $FeSO_4$	1.41	20.64	26.93	1.56	17.25
0.8% $FeSO_4$	1.40	20.42	26.57	1.51	17.87
0.2% H_3BO_3	1.35	20.40	26.42	1.48	17.58
0.4% H_3BO_3	1.36	20.27	26.38	1.45	17.53
0.6% H_3BO_3	1.34	20.25	26.18	1.38	17.40
0.2% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.2% H_3BO_3	1.50	21.48	28.52	1.72	18.23
0.2% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.4% H_3BO_3	1.49	21.10	28.42	1.66	17.94
0.2% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.2% H_3BO_3	1.51	20.90	28.66	1.72	18.63
0.2% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.4% H_3BO_3	1.49	21.20	28.44	1.70	18.17
0.4% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.2% H_3BO_3	1.55	22.19	29.73	1.79	18.73
0.4% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.4% H_3BO_3	1.53	22.12	29.38	1.76	18.40
0.4% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.2% H_3BO_3	1.56	22.80	29.85	1.80	18.88
0.4% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.4% H_3BO_3	1.53	22.33	29.40	1.79	18.47
T_{18} (Control)	1.32	19.85	25.90	1.34	17.11
$CD_{0.05}$	**0.04**	**0.56**	**0.59**	**NS**	**NS**

in combinations. The peel thickness of Kinnow mandarin fruit was minimum (1.32 mm) under control (distilled water spray) treatment, which was at par with 1.35 mm, 1.36 mm and 1.34 mm peel thickness under treatments T_7, T_8 and T_9, respectively, while the maximum peel thickness (1.56 mm) was obtained undertreatment T_{16}. The peel thickness in other treatments varied from 1.38mm to 1.55 mm which was significantly higherthan the control. Similar results have been obtained by Razzaq *et al.* (2013) in Kinnow mandarin.

Peel weight : The results reveal that the peel weight of Kinnow mandarin fruit was minimum (19.85 g) under control (distilled water spray) treatment which was statistically at par with 20.25 g, 20.27 g, 20.40 g and 20.40 g peel weight per fruit under treatments T_9, T_8 and T_7, respectively, whereas, maximum peel weight (22.80 g) was recorded under treatment T_{16}. The peel weight in Kinnow mandarin fruit under other treatments varied from 20.42g to 22.33 g per fruit, which was significantly higher over control. Similar results have been obtained by Razzaq *et al.* (2013) in Kinnow mandarin fruit.

Rag weight : Control treatments resulted in minimum rag weight (25.90 g) per fruit of Kinnow mandarin, which was at par with 26.18 g, 26.38 g and 26.42 g rag weight per fruit under treatments T_9, T_8 and T_7, respectively. Treatment T_{16} resulted into maximum rag weight (29.85 g) in Kinnow mandarin fruit. The rag weight in other treatments ranged from 26.57g to 29.73 g per fruit, which was significantly higher than the control (distilled water spray). The results obtained in the present investigation are in consonance with the findings of Singh *et al.* (2012).

Seed weight : The results pertaining to seed weight in Kinnow mandarin fruit as a result of different treatments of Zinc sulphate, Iron sulphate and Boric acid at different levels reveal that there was no significant effect on seed weight with the application of micronutrients. These results are in accordance with Razzaq *et al.* (2013), who reported that fruit harvested from the trees sprayed with zinc did not exhibit any significant change in the seed weight, number of healthy and aborted seeds.

Seed number : Like seed weight, number of seeds per fruit in Kinnow mandarin obtained with different levels of Zinc sulphate, Ferrous sulphate and Boric acid sprayed separately as well as in combination had non-significant effect. Similar findings have been reported by Razzaq *et al.* (2013) in Kinnow mandarin.

Fruit yield : The fruit yield per tree in Kinnow mandarin was significantly increased with different levels of zinc, iron and boron sprayed alone as well as in combination over the control. The fruit yield of Kinnow

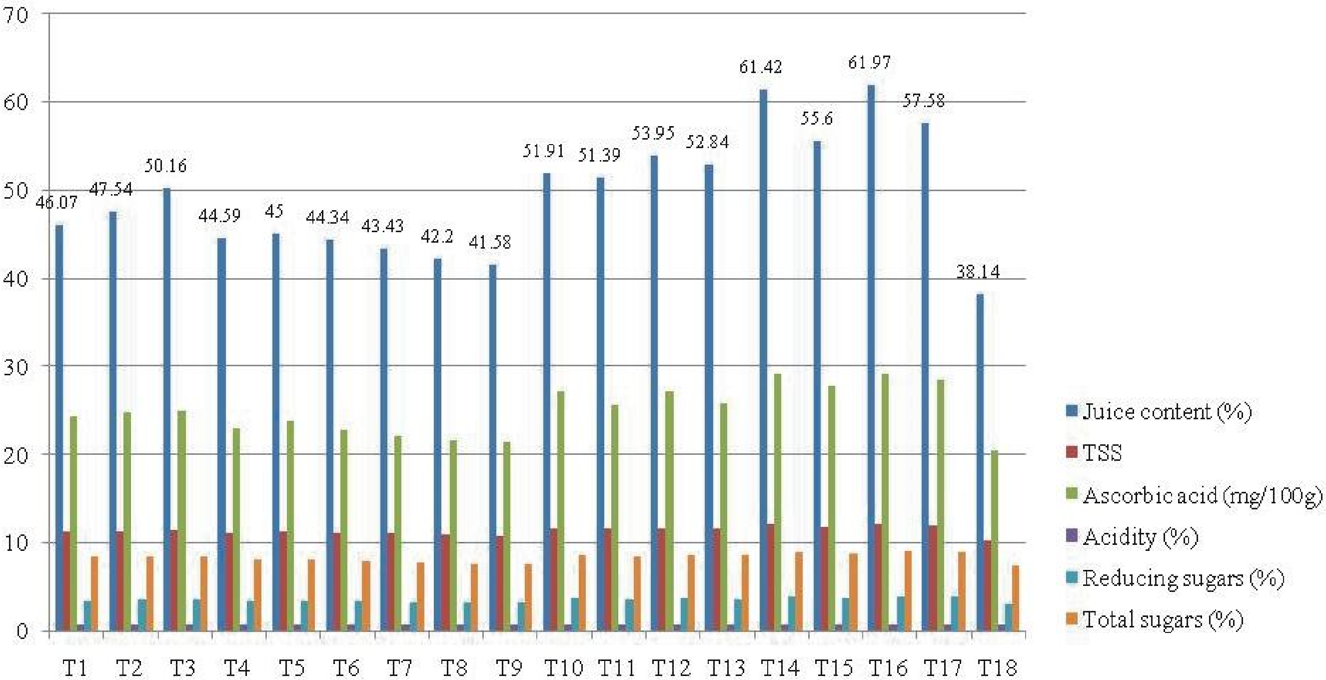

Fig. 3 : Effect of different treatments on juice, TSS, acidity, ascorbic acid and sugar content.

mandarin per tree was maximum (20.54 kg) under treatment T_{16}, which was statistically at par with 20.10 kg fruit yield per tree of Kinnow mandarin under treatment T_{15}, while the control (distilled water spray) resulted in minimum fruit yield (10.87 kg) per tree. The fruit yield per tree in other treatments varied from 12.59 kg to 19.89 kg. Among the separate applications of zinc sulphate, ferrous sulphate and boric acid at different levels, significant increase in fruit yield per tree in Kinnow mandarin was observed under all the treatments, over control. Foliar application of micronutrients might have corrected the deficiencies leading to optimum physiological activities of plant which might have resulted into higher production of fruits in treated plants. The increase in fruit yield with foliar application of zinc sulphate may be ascribed to increase in the fruit retention on the tree consequently reduced the pre-harvest fruit drop. Razzaq *et al.* (2013) reported that spray applications of 0.4% and 0.6% zinc sulphate resulted in the higher numbers and percentage of marketable fruit compared to control trees. The significant increase in fruit yield (kg/tree) of Kinnow mandarin is a cumulative effect of increase in number of fruits because of reduction in fruit drop by the direct and indirect effect of foliar spray of micronutrients.

Bio-chemical fruit characters

Data presented in Table 3 and Fig. 3 shows that juice content was significantly increased with the foliar application of different levels of zinc sulphate, ferrous sulphate and boric acid applied in combination. The results reveal that the juice content in Kinnow mandarin fruit was highest (61.97%) in T_{16}, which was statistically at par with 61.42 percent juice per cent content under treatment T_{14}. The juice content in Kinnow mandarin fruit in other treatments significantly varied over control from 41.58 percent to 57.58 percent and the lowest juice content (38.14%) was obtained under the control (distilled water spray). The increased juice content in Kinnow mandarin fruit might be due to improvement in fruit size and quality through foliar feeding of micronutrients. The results are in conformity with the findings of Babu *et al.* (2007) in Kinnow mandarin. The results revealed that the total soluble solids in Kinnow mandarin fruit was maximum (12.03°B) under treatment T_{16}, which was statistically at par with 11.99°B under treatment T_{14}, while the minimum total soluble solids (10.27°B) resulted under control. The total soluble solids in Kinnow mandarin fruit in other treatments varied from 10.80°B to 11.92°B, which were significantly higher than control. Our findings on total soluble solids are in conformity with the results achieved by Jatt and Kacha (2014). The results indicate significant effect on fruit acidity of Kinnow mandarin sprayed alone as well as in combination with different levels of zinc sulphate, ferrous sulphate and boric acid. The lowest acidity content (0.61%) was obtained under control treatment (T_{17}), which was statistically at par with 0.62 percent acidity under treatments T_{16}, T_{15},T_{14}, T_{13} and T_{12}, whereas, the highest acidity (0.69%) content was resulted in treatment T_{18} (control). The acidity content in other treatments varied from 0.63 percent to 0.67 percent which was significantly higher than the control. Zinc and iron application decreased the acid

Table 3 : Effect of foliar application of zinc, iron and boron on juice, TSS, acidity, ascorbic acid and sugar content of Kinnow mandarin.

Treatment	Juice content (%)	TSS (°B)	Ascorbic acid content (mg/100g)	Acidity (%)	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)
0.2% $ZnSO_4$	46.07	11.27	24.23	0.67	3.40	4.65	8.30
0.4% $ZnSO_4$	47.54	11.30	24.75	0.66	3.44	4.65	8.34
0.6% $ZnSO_4$	50.16	11.42	25.02	0.66	3.49	4.61	8.35
0.4% $FeSO_4$	44.59	11.06	22.97	0.66	3.35	4.39	7.97
0.6% $FeSO_4$	45.00	11.18	23.86	0.66	3.38	4.42	8.03
0.8% $FeSO_4$	44.34	11.00	22.72	0.67	3.32	4.35	7.90
0.2% H_3BO_3	43.43	10.98	22.12	0.65	3.25	4.29	7.76
0.4% H_3BO_3	42.20	10.90	21.63	0.64	3.24	4.14	7.59
0.6% H_3BO_3	41.58	10.80	21.36	0.65	3.21	4.12	7.55
0.2% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.2% H_3BO_3	51.91	11.61	27.12	0.63	3.62	4.70	8.57
0.2% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.4% H_3BO_3	51.39	11.50	25.62	0.63	3.56	4.60	8.40
0.2% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.2% H_3BO_3	53.95	11.63	27.14	0.62	3.69	4.67	8.61
0.2% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.4% H_3BO_3	52.84	11.57	25.87	0.62	3.60	4.64	8.48
0.4% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.2% H_3BO_3	61.42	11.99	29.12	0.62	3.90	4.78	8.93
0.4% $ZnSO_4$ + 0.4% $FeSO_4$ + 0.4% H_3BO_3	55.60	11.70	27.76	0.62	3.76	4.66	8.66
0.4% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.2% H_3BO_3	61.97	12.03	29.17	0.62	3.93	4.85	9.03
0.4% $ZnSO_4$ + 0.6% $FeSO_4$ + 0.4% H_3BO_3	57.58	11.92	28.54	0.61	3.84	4.74	8.82
T_{18} (Control)	38.14	10.27	20.39	0.69	3.08	4.00	7.29
$CD_{0.05}$	**2.85**	**0.04**	**0.54**	**0.01**	**0.04**	**0.05**	**0.04**

content which might be due to the increase in total soluble solids which ultimately reduced the acidity of fruit. Acidity present was reduced with boron treatment which might be due to early ripening induced by this treatment during which degradation of acid might have occurred. It also appears that total soluble solids increased at the expense of acidity in these fruits. The acid under the influence of boron might have been converted into sugars and their derivatives by the reaction involving the reversal of glycolytic pathway or be used in respiration. These results are in close conformity with Kazi *et al.* (2012) in sweet orange. Ascorbic acid content was maximum (29.17 mg/100g) in T_{16}, which was statistically at par with 29.12 mg/100g under treatment T_{14}. The ascorbic acid content under other treatments varied from 21.36 mg/100g to 28.54mg/100gand the minimum ascorbic acid content in Kinnow mandarin fruit (20.39 mg/100g) was obtained under control (distilled water spray). Our results are in conformity with the findings of Babu *et al.* (2007) in Kinnow mandarin. Reducing sugar content under alone as well as combined treatments of different levels of $ZnSO_4$, $FeSO_4$ and H_3BO_3 was significantly increased over the control. The maximum reducing sugar content (3.93%) was resulted under treatment with T_{16}, which was statistically at par with 3.90 percent reducing sugar content under treatment T_{14}, while, the minimum reducing sugar content (3.08%) was obtained under the control (distilled water spray). A variation from 3.84 percent to 3.21 percent reducing sugar content was resulted under other treatments of zinc, iron and boron, significantly higher than control. Reducing sugars in Kinnow mandarin was increased with increasing levels of micronutrients which may be ascribed to the auxin synthesis by zinc that in turn increased metabolites available for reducing sugars formation. Alila *et al.* (2004) also reported maximum reducing sugars in papaya cultivar Ranchi with foliar application of micronutrients B (0.1%), Fe (0.1%) and Zn (0.2%) either singly or in combination. Treatment T_{16} resulted in the highest non-reducing sugar content (4.85%) while control (distilled water spray) gave the minimum non-reducing sugar content (4.00%). The non-reducing sugar in Kinnow mandarin fruit under other treatments varied from 4.78 percent to 4.12 percent, which was significantly higher than the control. Among the separate sprays of $ZnSO_4$, $FeSO_4$ and H_3BO_3 at different levels, all the treatments significantly increased the non-reducing sugar content. Kavitha *et al.* (2005) revealed that the quality characteristics of fruit including non reducing sugars, in association with related biochemical traits of papaya cultivar CO_5 was improved with foliar spray of zinc. Highest total sugar content (9.03%) was resulted in treatment T_{16} and the minimum total sugar content (7.29%) was obtained in control (distilled water spray). The total sugar content in Kinnow mandarin fruit under other treatments ranged from 8.93 percent to 7.55 percent and was significantly higher than the control. The separate sprays of different levels of zinc sulphate, ferrous sulphate and boric acid also significantly increased the total sugar content of Kinnow mandarin fruit, over control. The increase in total sugars in Kinnow mandarin fruit as a result of micronutrient application was found to be associated with increase in reducing sugars and non-reducing sugars. Reduction of starch content at the time of acid deterioration and intensive translocation in fruits might be the possible reason of increase of sugars in fruits. Zinc improves the auxin content and it act as catalyst in oxidation process. Its presence is of great importance in sugar metabolism. The higher sugar content in $FeSO_4$ over the control was due to the iron content in the leaves as chief constituent of chlorophyll and activator of enzymes that may help in assimilation of more sugar in Kinnow mandarin fruits, as also observed by Madarakhandi *et al.* (2014).

Conclusion

From the study, it is concluded that most of the fruit quality parameters and yield of Kinnow mandarin improved with the combined foliar application of Zinc sulphate, Iron sulphate and Boric acid as compared to control. Best results with respect to fruit weight, fruit length, fruit diameter, fruit volume, fruit yield, juice content, total soluble solids, ascorbic acid, total sugars, reducing sugars and non-reducing sugars content are obtained with the application of 0.4 percent Zinc sulphate + 0.6 percent Iron sulphate + 0.2 percent Boric acid, however, peel thickness, peel weight, rag weight also increased with the combined application of Zinc sulphate, Iron sulphate and Boric acid.

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