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Foliar sprays of zinc and iron improve the quality attributes of kinnow

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Abstract
The experiment was conducted during the year 2019-2020 at the KVK, Badgaon, MPUAT, Udaipur to study "Foliar sprays of Zinc and Iron improve the Quality attributes of Kinnow" The design of the experiment was laid on RBD with 3 replications and 16 treatments to assess the effect of different combination of FS_1 - (Control), FS_2 - (0.25% Zinc sulphate), FS_3 - (0.5% Zinc sulphate), FS_4 - (0.75% Zinc sulphate), FS_5 - (0.5% Ferrous sulphate), FS_6 - (0.75% Ferrous sulphate), FS_7 - (1% Ferrous sulphate), FS_8 - (0.25% $ZnSO_4$ + 0.5% $FeSO_4$), FS_9 - (0.25% $ZnSO_4$ + 0.75% $FeSO_4$), FS_{10} - (0.25% $ZnSO_4$ + 1% $FeSO_4$), FS_{11} - (0.5% $ZnSO_4$ + 0.5% $FeSO_4$), FS_{12} - (0.5% $ZnSO_4$ + 0.75% $FeSO_4$), FS_{13} - (0.5% $ZnSO_4$ + 1% $FeSO_4$), FS_{14} - (0.75% $ZnSO_4$ + 0.5% $FeSO_4$), FS_{15} - (0.75% $ZnSO_4$ + 0.75% $FeSO_4$), FS_{16} - (0.75% $ZnSO_4$ + 1% $FeSO_4$) applied at fruit set and peach size stage of fruit through foliar spray. Maximum increase quality attributes *viz.* fruit juice (%), ascorbic acid (mg/100 g pulp), reducing sugar (%), non-reducing sugar (%), total sugar (%), TSS (°Brix), Acidity (%) and TSS: Acid were observed by application of FS_{13} (0.5% $ZnSO_4$ + 1% $FeSO_4$). The minimum rind thickness and maximum number of seeds per fruit (31.67) were observed under FS15 (0.75% $ZnSO_4$ + 0.75% FeSO4).

Keywords: Zinc, iron, kinnow, micronutrients, quality parameters, etc.

Introduction
Among the fruit crops, Citrus is one of the most important and finest variety of mandarin grown especially in North India and having chromosome number 2n=18. It is the first-generation hybrid of king mandarin (*Citrus nobilis* Lour) and willow leaf mandarin (*Citrus delicious* Tenora). It was developed by H. B. Frost at Regional Fruit Station, California, USA in 1914 and released as a variety in 1935. In India, it was introduced during 1959 at the Fruit Station Punjab and Agriculture College and Research Institute, Lyllpur by S. Bhadur Lal Singh (Singh *et al*., 1978) [11]. The pulp of Kinnow used to make delicious desserts, jams, sauces and the peel can be used to make cosmetics and essence. It has lycopene and flavonoids, which are known to reduce prostate and breast cancer and improve capillary activity. It also rich in fiber, which is important for production and maintenance of collagen (Sharma *et al*., 2007) [9]. Due to the increasing demand from consumers and the highest content of limonene (a compound which has anticancer properties) Kinnow cultivation is providing to be a major attraction for fruit growers in India. It is well established fact that deficiency of micronutrient deteriorates vegetative growth, quality and production of fruit and causes flower and fruit drop. Among micronutrients, zinc and ferrous have much significance due to most wide spread deficiency of these micronutrients in the citrus cultivated areas in India. Zinc is an important micro element essential for plants due to its involvement in the synthesis of tryptophan which is a precursor of Indole acetic acid synthesis (Ahmad *et al*., 2012) [2]. Zn is required for the activity of various enzymes such as dehydrogenases, aldolases, isomerases, transphosphorylases, RNA and DNA polymerases (Swietlik, 1999) [13]. It has important role in starch metabolism and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis (Alloway, 2008) [3]. The Iron is also one of the most important micronutrients for plant growth. It is involved in various physiological processes of plant systems, namely chlorophyll formation and degradation synthesis of protein which contains chloroplast and electron carries enzyme systems (Somasundaram *et al*., 2011) [12]. Fe plays a key role in several enzyme – systems, in which haemin is the prosthetic group (Khurshid *et al*., 2008) [7]. At present, little is known about the effects of combined application of Zn and Fe on citrus in general and mandarin particular under Rajasthan conditions. Therefore, keeping the above factors in view the study "Foliar sprays of Zinc and Iron improve the Quality attributes

of Kinnow" was carried out at KVK, Badgaon, MPUAT-Udaipur during the year 2019- 2020.

Materials and Methods

In this experiment five-year old, forty-eight uniform and healthy Kinnow (king × willow leaf) mandarin trees grafted on rough lemon (*Citrus jambhiri* L.) root stock, planted according to square system of layout at 5 m distance at the KVK, Badgaon, MPUAT-Udaipur were used. The experiment consisted of 16 treatments comprising FS_1 - (Control), FS_2 - (0.25% Zinc sulphate), FS_3 - (0.5% Zinc sulphate), FS_4 - (0.75% Zinc sulphate), FS_5 - (0.5% Ferrous sulphate), FS_6 - (0.75% Ferrous sulphate), FS_7 - (1% Ferrous sulphate), FS_8 - (0.25% $ZnSO_4$ + 0.5% $FeSO_4$), FS_9 - (0.25% $ZnSO_4$ + 0.75% $FeSO_4$), FS_{10} - (0.25% $ZnSO_4$ + 1% $FeSO_4$), FS_{11} - (0.5% $ZnSO_4$ + 0.5% $FeSO_4$), FS_{12} - (0.5% $ZnSO_4$ + 0.75% $FeSO_4$), FS_{13} - (0.5% $ZnSO_4$ + 1% $FeSO_4$), FS_{14} - (0.75% $ZnSO_4$ + 0.5% $FeSO_4$), FS_{15} - (0.75% $ZnSO_4$ + 0.75% $FeSO_4$), FS_{16} - (0.75% $ZnSO_4$ + 1% $FeSO_4$) applied at fruit set and peach size stage of fruit through foliar spray, separately on uniform Kinnow mandarin plants. These treatments were evaluated under Random Block Design replicated thrice with adopting uniform cultural schedules during the experimentation. The quality attributes were estimated from four selected fruits. For Rind/peel thickness (mm), randomly selected 4 fruits were peeled out with the help of hand and then it was measured by digital vernier calliper. Average was worked out and expressed in millimetre. Seeds were extracted from four randomly selected mature fruits of each treatment, separately. Extracted seeds were washed, dried counted and averaged. Juice was extracted from weighed fruit and% was calculated. Ascorbic acid (mg/100 ml juice) content of Kinnow fruit were determined as per (A. O. A. C. 2007) [1]. Method suggested by Miller (1959) [8] were used for determining the reducing sugar (%) using Dinitrosalicylic acid, Anthrone reagents method (Dubois *et al.*, 1951) [4] for total sugars (%) and non-reducing sugar (%) of fruits were calculated by subtract the value of reducing sugar from total sugar. The total soluble solids (TSS in ºBrix or%) by using Hand Refractometer, Acidity of fruit juice (%) and TSS/Acid ratio were calculated by dividing the value of TSS content (%) by per cent acidity. Data were analysed as per standard statistical methodology.

Results and Discussion

The effect of foliar application of zinc and ferrous at different concentrations on quality attributes of Kinnow fruits such as rind thickness, number of seeds/ fruit, juice content, ascorbic acid, sugar content (reducing, non-reducing and total sugar), total soluble solids, acidity, TSS: Acid were studied in the investigation and data has been depicted in table 1 to 3.

According to table 1, the plants which were sprayed with 0.5% $ZnSO_4$ + 0.5% FeSO4 (FS11) resulted in maximum rind thickness (3.26 mm) followed by FS16 (3.18mm) and minimum in (2.64 mm) in FS15 (0.75% $ZnSO_4$ + 0.75% FeSO4). Treatment FS15 registered 17.42 per cent lower rind thickness over control. Foliar application of Zn and Fe significantly influenced in number of seeds per fruit. Among the treatments maximum number of seeds per fruit (31.67) was recorded under FS15 (0.75% $ZnSO_4$ + 0.75% FeSO4) followed by treatments FS14 (28.33) while minimum in FS13 (23.00). The foliar application of zinc and ferrous have significant variation in juice and ascorbic acid content of Kinnow. Foliar application of 0.5% $ZnSO_4$ + 1% FeSO4 i.e. FS13 gave highest fruit juice (42.65%), that was followed with narrow margin by FS14, FS15 and FS12 (41.52%, 41.05% and 40.77%, respectively). The best treatment resulted into 25.03% increase as compared to control. Significantly highest ascorbic acid (24.75 mg/100 ml) was recorded in treatment FS13 (0.5% $ZnSO_4$ + 1% FeSO4) closely followed by FS7 (24.58 mg/100 ml), FS8 (24.38 mg/100 ml) and minimum (22.03 mg/100 ml) ascorbic acid in control. However, treatments FS7, FS8 and FS5 were statically at par among each other. Treatment FS13 registered 11.57 per cent higher ascorbic acid content over control.

The data depicted in Table 2, explicit that the different concentration of Zn and Fe influenced reducing sugar, non-reducing sugar and total sugar content of Kinnow fruits. Among the treatments maximum reducing sugar (3.84%) was recorded in treatments FS13 (0.5% $ZnSO_4$ + 1% FeSO4) followed by FS12 (3.82%), FS11 (3.80%) and minimum (3.30%) was recorded in control. The magnitude of increase in treatment FS13 over the control was 0.54%. The plants which received the application with 0.5% $ZnSO_4$ + 1% FeSO4 (FS13) recorded maximum non reducing sugar (3.26%) closely followed by FS12 (3.25%), FS11 (3.25%) with minimum (2.51%) in control. Treatment FS13 registered 29.28% higher non reducing sugar content over control. The maximum total sugar (7.10%) was recorded in treatment FS13 (0.5% $ZnSO_4$ + 1% FeSO4) followed by FS12 (7.06%), FS11 (7.05%), FS16 (7.02%) and minimum in control (5.81%). The magnitude of increase in total sugar was 22.20 per cent higher over control.

The data presented in Table 3, reported that application of different concentration of zinc and iron significantly influenced the total soluble solid, acidity and TSS: Acid ratio of fruits content of Kinnow fruits. The TSS content of the Kinnow fruit was increased by 28.52% over control (11.57 °Brix) by the application of FS13 (0.5% $ZnSO_4$ + 0.1% FeSO4) which was found to be the best treatment with highest TSS (14.87 °Brix). FS14 (14.23 °Brix), FS5 (14.20 °Brix) and FS7 (14.13 °Brix) were also found significantly superior over control. The treatment FS13 (0.5% $ZnSO_4$ + 1% FeSO4) recorded minimum acidity (0.62%) closely followed FS14 (0.65%), FS12 (0.65%). Maximum (1.02%) acidity was recorded in control. The treatment FS13 (0.5% $ZnSO_4$ + 1% FeSO4) recorded maximum (24.15) TSS: Acid ratio followed by FS14 (21.89), FS5 (21.76), FS7 (20.73) whereas minimum (11.39) in control.

Various enzymatic reactions, carbohydrate formation and synthesis of protein are governed by micronutrients and thus they play a significant role in fruit quality. The decrease in acidity might be due to the fact that acids are quickly converted into sugars and its derivatives. The increase in juice percent due to zinc and ferrous application can also be responsible for decreased acidity.

The foliar spray of 0.5% ZnSO4 and 0.5% FeSO4 increased TSS (9.97°Brix), reducing sugar (3.59%), total sugar (9.27%) and highest ascorbic acid (80.63 mg/100 ml pulp) in Kinnow mandarin (Siddappa *et al*., 2014). Similar response on quality has been observed in the present investigation. The maximum availability of plant metabolites because of higher nucleic acid synthesis due to the involvement of Zn and Fe resulted into increase in sugars, ascorbic acid and juice percentage in Kinnow fruits. Results are in agreement with Kaur *et al*. (2015) [6] and Heerendra *et al*. (2013) [5] in Kinnow.

Table 1: Response of zinc and iron on quality attributes of Kinnow

Treatments	Rind thickness (mm)	Seeds /fruit	Juice content (%)	Ascorbic acid (mg/100 ml)
FS_1 - Control (water spray)	3.10	25.67	33.95	22.03
FS_2 - 0.25% $ZnSO_4$	2.85	27.33	34.27	23.77
FS_3 - 0.5% $ZnSO_4$	2.84	28.00	34.83	22.24
FS_4 - 0.75% $ZnSO_4$	2.88	26.33	36.75	23.24
FS_5 - 0.5% $FeSO_4$	2.93	27.00	36.74	24.09
FS_6 - 0.75% $FeSO_4$	2.76	25.67	37.35	23.70
FS_7 - 1% $FeSO_4$	2.92	27.00	37.52	24.58
FS_8 - 0.25% $ZnSO_4$ + 0.5% $FeSO_4$	2.99	25.33	37.53	24.38
FS_9 - 0.25% $ZnSO_4$ + 0.75% $FeSO_4$	2.68	27.67	37.60	23.69
FS_{10} - 0.25% $ZnSO_4$ + 1% $FeSO_4$	3.07	27.33	38.70	23.24
FS_{11} - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$	3.26	23.00	38.93	23.53
FS_{12} - 0.5% $ZnSO_4$ + 0.75% $FeSO_4$	3.00	25.33	40.77	23.85
FS_{13} - 0.5% $ZnSO_4$ + 1% $FeSO_4$	2.92	23.00	42.45	24.75
FS_{14} - 0.75% $ZnSO_4$ + 0.5% $FeSO_4$	2.81	28.33	41.52	23.61
FS_{15} - 0.75% $ZnSO_4$ + 0.75% $FeSO_4$	2.64	31.67	41.04	23.79
FS_{16} - 0.75% $ZnSO_4$ + 1% $FeSO_4$	3.18	28.00	40.12	22.91
S.Em±	0.06	1.23	1.10	0.39
CD at 5%	0.17	3.55	3.18	1.13

Table 2: Response of zinc and iron on quality attributes of Kinnow

Treatments	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
FS_1 - Control (water spray)	3.30	2.51	5.81
FS_2 - 0.25% $ZnSO_4$	3.36	2.66	6.02
FS_3 - 0.5% $ZnSO_4$	3.37	2.70	6.07
FS_4 - 0.75% $ZnSO_4$	3.52	2.78	6.30
FS_5 - 0.5% $FeSO_4$	3.58	2.84	6.42
FS_6 - 0.75% $FeSO_4$	3.66	2.91	6.57
FS_7 - 1% $FeSO_4$	3.76	3.21	6.97
FS_8 - 0.25% $ZnSO_4$ + 0.5% $FeSO_4$	3.77	3.23	7.00
FS_9 - 0.25% $ZnSO_4$ + 0.75% $FeSO_4$	3.73	3.18	6.90
FS_{10} - 0.25% $ZnSO_4$ + 1% $FeSO_4$	3.72	3.17	6.89
FS_{11} - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$	3.80	3.25	7.05
FS_{12} - 0.5% $ZnSO_4$ + 0.75% $FeSO_4$	3.82	3.25	7.06
FS_{13} - 0.5% $ZnSO_4$ + 1% $FeSO_4$	3.84	3.26	7.10
FS_{14} - 0.75% $ZnSO_4$ + 0.5% $FeSO_4$	3.50	2.77	6.27
FS_{15} - 0.75% ZnSO4 + 0.75% $FeSO_4$	3.62	2.89	6.50
FS_{16} - 0.75% $ZnSO_4$ + 1% $FeSO_4$	3.78	3.24	7.02
S.Em±	0.052	0.048	0.115
CD at 5%	0.151	0.139	0.332

Table 3: Response of zinc and iron on quality attributes of Kinnow

Treatments	TSS (^{0}Brix)	Acidity (%)	TSS: Acid
FS_1 - Control (water spray)	11.57	1.02	11.39
FS_2 - 0.25% $ZnSO_4$	12.13	0.88	13.79
FS_3 - 0.5% $ZnSO_4$	12.67	0.72	17.73
FS_4 - 0.75% $ZnSO_4$	12.17	0.76	15.97
FS_5 - 0.5% $FeSO_4$	14.20	0.65	21.76
FS_6 - 0.75% $FeSO_4$	13.27	0.78	16.98
FS_7 - 1% $FeSO_4$	14.13	0.68	20.73
FS_8 - 0.25% $ZnSO_4$ + 0.5% $FeSO_4$	12.03	0.75	16.13
FS_9 - 0.25% $ZnSO_4$ + 0.75% $FeSO_4$	13.20	0.67	19.75
FS_{10} - 0.25% $ZnSO_4$ + 1% $FeSO_4$	12.23	0.76	16.09
FS_{11} - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$	13.50	0.78	17.21
FS_{12} - 0.5% $ZnSO_4$ + 0.75% $FeSO_4$	12.97	0.65	19.93
FS_{13} - 0.5% $ZnSO_4$ + 1% $FeSO_4$	14.87	0.62	24.15
FS_{14} - 0.75% $ZnSO_4$ + 0.5% $FeSO_4$	14.23	0.65	21.89
FS_{15} - 0.75% $ZnSO_4$ + 0.75% $FeSO_4$	13.07	0.75	17.54
FS_{16} - 0.75% $ZnSO_4$ + 1% $FeSO_4$	12.17	0.73	16.67
S.Em±	0.42	0.02	0.51
CD at 5%	1.22	0.06	1.48

Conclusion

From the investigation, the minimum rind thickness in FS15 (0.75% $ZnSO_4$ + 0.75% FeSO4) and maximum number of seeds fruits $^{-1}$ (31.67) was recorded under FS15 (0.75% $ZnSO_4$ + 0.75% FeSO4). The best quality attributes in terms of fruit juice, ascorbic acid, reducing sugar, non-reducing

sugar, total sugar, TSS, Acidity and TTS: Acid were observed by application of FS_{13} (0.5% $ZnSO_4$ + 1% $FeSO_4$) at fruit set and peach size stage of fruit in Kinnow mandarin under Southern Rajasthan conditions.

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