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Short communication

Growth, yield and fruit quality of Kinnow mandarin as affected through foliar application of zinc and boron

M.K. Gurjar, R.A. Kaushik*, R.S. Rathore and D.K. Sarolia

Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur 313001, Rajasthan

ABSTRACT

The investigation was undertaken with a view to determine the growth, yield and fruit quality of Kinnow mandarin as affected through foliar application of zinc and boron. The results revealed that combined application of 0.2 per cent boric acid + 0.5 per cent zinc sulphate at fruit set and peach size stage of fruit through foliar spray exerted significant influence on plant height, tree spread and shoot length. The maximum fruit retention (71.77 %), number of fruits plant^{-1}(486.24), fruit weight (163.23 g), fruit volume (194.79 cc), fruit diameter (7.16 cm), yield plant^{-1} (79.32 kg) and yield ha^{-1} (31.73 t) were recorded in treatment T_9 (0.2 per cent boric acid + 0.5 per cent zinc). The same treatment had markedly influenced the quality of Kinnow fruit and the maximum TSS (12.18 °Brix), TSS/acid ratio (16.66), reducing sugars (3.87%), total sugar (7.22%), ascorbic acid (25.16mg/100 g) and juice content (41.43%) were recoreded in this traetement (T_9). The lowest acidity (0.73 %) and rind thickness (2.79 mm) were also recorded in treatment T_9 (0.2 per cent boric acid + 0.5 per cent zinc). This treatment also increased the zinc (100.08 ppm) and boron (80.81 ppm) level of kinnow mandarin leaves.

Key words: Boric acid, zinc sulphate, foliar spray.

Kinnow a mandarin hybrid (*C. nobilis* Lour. × *C. deliciosa* Tenora) is one of the most important and finest varieties of mandarin grown especially in North India. It has assumed great importance among North Indian growers and a large acreage is being brought under its cultivation particularly in Punjab, Haryana, Rajasthan and Himachal Pradesh. Its pulp is used to make delicious desserts, jams and sauces and skin can be used to make cosmetics and essence. It is a well established fact that deficiency of micronutrient adversely affects the vegetative growth, fruit quality and yield of fruit. The deficiency of micronutrients causes heavy flower and fruit drop, which result in production of poor quality fruit coupled with yield losses. Deficiency of zinc and boron is widespread in citrus orchards of country. Zinc is one of the important micro-element essential for plants due to its involvement in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis (Pedler *et al*., 8). 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, 3). Similarly, boron (B) as a micronutrient is a part and parcel of the growth behavior and productivity of citrus trees. It increases pollen grain germination, pollen tube elongation, consequently fruit set percentage and finally the yield (Abd-Allah, 2). Foliar spray of micronutrients has been reported to be more effective than soil application in curing deficiencies in citrus. Keeping in view, the unfavourable physico-chemical conditions of our soils, it is very important to supply micronutrients in proper amount through foliar spray to increase citrus production. At present, little is known about the effects of combined application of B and Zn on citrus in general and mandarin in particular under Rajasthan conditions. Therefore, keeping the above factors in view the present study on growth, yield and fruit quality of Kinnow mandarin as affected through foliar application of zinc and boron was carried out at KVK, Chittorgarh, Maharana Pratap University of Agriculture and Technology, Udaipur during the year 2013-14.

Five-year old twenty seven uniform and healthy Kinnow mandarin trees grafted on rough lemon (*Citrus jambhiri* L.) root stock planted in square system at 5 m distance and grown under uniform soil conditions were selected and nine treatments comprising T_1 (control), T_2 (0.1% boric acid), T_3 (0.2% boric acid), T_4 (0.4% zinc sulphate), T_5 (0.5% zinc sulphate), T_6 (0.1% boric acid + 0.4% zinc sulphate), T_7 (0.1% boric acid + 0.5% zinc sulphate), T_8 (0.2% boric acid + 0.4% zinc sulphate), T_9 (0.2% boric acid + 0.5% zinc sulphate) applied at fruit set and peach size stage of fruit through foliar spray. These treatments were evaluated under one way analysis of variance replicated thrice with uniform cultural schedules during the experimentation. The

*Corresponding author's E-mail: kaushik_ra@yahoo.co.in

vegetative parameters regarding the tree height (m), tree spread [N-S & E-W (m)] were measured at the beginning and at end of the experiment and average increase in the tree height (m), tree spread (m) were recorded. Five newly emerged flushes were tagged from each side (North, South, East and West) of experimental trees to record the shoot length. The yield attributes per cent fruit retention was calculated on the basis of initial number of fruit set and total numbers of fruits at the time of fruit maturity. Average fruit weight was calculated by weighing fruit on digital electronic balance and fruit volume was measured by water displacement method. Fruit diameter and rind thickness were measured by digital vernier caliper. The total fruit yield tree-$^{-1}$ was calculated by multiplying total number of fruits tree-$^{-1}$ with the average fruit weight and estimated yield ha^{-1} was calculated by multiplying total fruit yield per tree with number of plant ha^{-1}. All quality parameters of fruits were analyzed as per standards methods given in (A.O.A.C., 1). Juice was extracted from weighed fruits and percentage was calculated. Data were collected for leaf nutrient analysis (Zn and B) before and after treatment application. Uniform, healthy and physiologically mature leaves (50 to 70 leaves per tree) of similar age from the experimental trees were collected at random for Zn and B determination. The micronutrient (Zn) was determined by using Atomic Absorption Spectrophotometer with specific lamp. Whereas, the amount of B in the leaves were determined by the method reported by Saxena *et al.* (11). Data were analyzed as per standard statistical methodology.

Foliar application of zinc and boron significantly affected the vegetative growth parameters of kinnow mandarin (Table 1). Trees sprayed with 0.2 per cent boric acid + 0.5 per cent zinc sulphate at fruit set and peach size stage of fruit (T_9) revealed the maximum increase in tree height (3.55 m), tree spread (3.98 and 3.98 m) N-S and E-W, respectively and shoot length (102.92 cm) of Kinnow mandarin as compared to minimum in control. However, T_6, T_7, T_8 and T_9 treatment were found to be at par with respect to all the growth parameters. This might be due to the favourable influence of applied micronutrients (zinc + boron) on vegetative characteristics because of their catalytic or stimulatory effect on most of the physiological and metabolic process of plants. Zinc and boron are essential component of enzymes responsible for nitrogen and carbohydrates metabolism respectively, thereby resulting into increased uptake of nitrogen by the plant. Further, involvement of Zn in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis, consequently increased tissue growth and development. Boron increases the phenolic compounds which regulate polar auxin transport. The increased auxin activity results in increased vegetative growth characters. Khan *et al*. (6) also reported a synergistic effect of B and Zn on the vegetative growth in Feutrell's Early mandarin when applied at fruit set stage.

Table 1. Effect of zinc and boron on growth and yield attributes of Kinnow mandarin.

Treatment	Tree height (m)	Tree spread (m)		Shoot length (cm)	Fruit retention (%)	No. of fruits plant^{-1}	Fruit weight (g)	Fruit vol. (cc)	Fruit dia. (cm)		Yield plant^{-1} (kg)	Yield ha^{-1} (t)
		N-S	E-W						Equatorial	Polar		
A. Absolute control v/s rest treatments:												
Control	3.46	3.90	3.86	96.35	65.83	446.00	145.53	174.64	6.25	5.33	64.92	25.97
Treatment	3.51	3.95	3.92	99.64	68.73	465.31	154.90	185.42	6.69	5.80	72.14	28.85
CD at 5%	0.04	0.05	NS	NS	NS	NS	NS	5.97	0.34	0.29	NS	3.47
B. Among treatments:												
T_2	3.49	3.92	3.87	96.75	67.61	457.71	147.50	177.00	6.34	5.55	67.48	26.99
T_3	3.53	3.94	3.91	97.05	68.18	460.96	148.83	178.59	6.44	5.57	68.64	27.45
T_4	3.49	3.92	3.90	97.43	67.00	453.59	151.37	181.64	6.56	5.65	68.68	27.47
T_5	3.51	3.95	3.91	99.26	67.13	454.47	154.13	183.93	6.62	5.90	70.12	28.05
T_6	3.51	3.96	3.92	100.45	68.92	466.58	156.33	187.58	6.71	5.78	72.99	29.20
T_7	3.53	3.97	3.93	101.11	69.27	468.95	157.73	188.75	6.78	5.83	74.00	29.60
T_8	3.52	3.98	3.96	102.20	70.02	474.03	160.14	191.08	6.91	6.08	75.94	30.37
T_9	3.55	3.98	3.98	102.92	71.77	486.24	163.23	194.79	7.16	6.10	79.32	31.73
CD at 5%	0.037	0.04	0.06	4.01	3.30	22.29	10.01	4.87	0.28	0.24	7.01	2.80

Maximum fruit retention (71.77%) and maximum number of fruits plant^{-1} (486.24) were recorded with foliar application of 0.2 per cent boric acid + 0.5 per cent zinc sulphate at fruit set and peach size stage of fruit (T_9) as compared to minimum in control (Table 1). Increase in fruit retention and fruit number might be due to reduction in the fruit drop (Data not presented). Earlier, Nijjar (7) reported that Zn is required for preventing the abscission layer formation and consequently, the reduction in pre-harvest fruit drop. Zinc and boron application reduced fruit drop and increased fruit retention which might be due to the fact that zinc play important role in biosynthesis of IAA. These finding are in conformity with those of Sajid *et al.* (10) in sweet orange.

The fruit weight and fruit volume of Kinnow differed significantly with the sprays of zinc and boron alone or in combination. The maximum fruit weight (163.23 g) and volume (194.79) were recorded when 0.2 per cent boric acid + 0.5 per cent zinc sulphate (T_9) was sprayed. It was followed by 0.2 per cent boric acid + 0.4 per cent zinc sulphate (T_8) while, the minimum were measured under control (Table 1). The increase in fruit weight and volume might be due to increased rate of cell division and cell enlargement leading to more accumulation of metabolites in the fruit (Babu and Singh, 5).

The foliar spray of zinc and boron showed better response in improving the fruit diameter, yield plant^{-1} and estimated yield ha^{-1}. The maximum increase in fruit diameter (7.16 and 6.10 cm) equatorial and polar, respectively, yield plant^{-1} (79.32 kg) and estimated yield ha^{-1} (31.73 t) were observed with T_9 (0.2 % B + 0.5% Zn) which was at par with T_8 (0.5% 0.2% B + 0.4% Zn) treatments and minimum in control (Table 1). The higher fruit diameter due to combined application of zinc and boron may be attributed to their stimulatory effect of plant metabolism. The increase in yield is obviously due to the consolidated effect of increased size and weight of fruits caused by foliar spray of zinc and boron. Moreover, increased fruit set and reduced fruit drop as a result of zinc and boron spray could give higher number of fruits and consequently the yield. The present results are in conformity with the findings of Rajkumar *et al.* (9) in guava. It is evident from the data presented in the Table 2 that different treatments had significant effect on physico-chemical characteristics of fruits. Maximum TSS (12.18 °B), minimum acidity (0.73%), highest TSS/Acid ratio (16.66), maximum reducing sugar (3.87%) and total sugar (7.22 %) were recorded with foliar application of 0.2 per cent boric acid + 0.5 per cent zinc sulphate at fruit set and peach size stage of fruit (T_9) as compared to other treatments. However, application of zinc and boron micronutrients could not bring significant variation in respect to reducing sugar content of fruit. Among treatments T_8 and T_9 were better over control and at par with each other.

The plant which received 0.2 per cent boric acid + 0.5 per cent zinc sulphate (T_9) resulted in maximum juice content (41.43%). Among the treatments maximum ascorbic acid content (25.23 mg/100 g)

Table 2. Effect of zinc and boron on physico-chemical characteristics and leaf nutrients content of kinnow.

Treatment	TSS (°Brix)	Acidity (%)	TSS/ Acid ratio	Reducing sugars (%)	Total of fruit sugars (%)	Ascorbic acid (mg/ 100 g)	Rind thickness (mm)	Juice content (%)	Leaf Zn (ppm)	Leaf B (ppm)
A. Absolute control v/s rest treatments:										
Control	10.30	0.77	13.42	3.74	6.56	20.22	3.14	32.86	16.19	27.04
Treatment	11.62	0.75	15.49	3.82	7.08	24.55	2.96	37.51	67.21	65.56
CD at 5%	0.69	NS	1.73	NS	0.25	1.34	0.15	1.38	2.22	2.63
B. Among treatments:										
T_2	11.31	0.75	15.09	3.78	6.92	23.52	3.20	33.13	22.71	67.41
T_3	11.80	0.74	16.03	3.83	7.11	24.50	2.95	34.70	27.21	78.52
T_4	11.38	0.80	14.30	3.77	6.80	23.53	3.25	35.80	64.37	35.16
T_5	11.20	0.78	14.30	3.81	7.09	24.66	2.99	37.10	77.91	39.92
T_6	11.40	0.74	15.36	3.83	7.14	24.78	2.92	38.30	70.35	69.77
T_7	11.70	0.74	15.75	3.84	7.18	25.06	2.86	38.94	81.62	73.54
T_8	12.00	0.73	16.45	3.82	7.21	25.23	2.79	40.69	93.44	79.01
T_9	12.18	0.73	16.66	3.87	7.22	25.16	2.79	41.43	100.08	80.81
CD at 5%	0.56	0.05	1.41	NS	0.21	1.09	0.12	1.13	1.81	2.15

was recorded in treatment T_8 (0.2% B + 0.4% Zn) closely followed by treatment T_9 (25.16 mg/100 g) and minimum in control (Table 2), while minimum rind thickness (2.79 mm) recorded in treatment T_8 and T_9 (2.79 mm) as compared to other treatments.

The improvement in quality of fruit might be due to the fact that micronutrients directly play an important role in plant metabolism as zinc is needed in enzymatic reaction like hexokinase, formation of carbohydrate and protein synthesis. Further, boron facilitated sugar transport through boron-sugar complex and it also increase hydrolysis of saccharides into simple sugar. The reduction in acidity might be due to accumulation of reducing and non-reducing sugars. The increase in juice percentage due to zinc and boron might have regulated the water relations in plants and augmentation of ascorbic acid percentage of kinnow fruit might have been due to higher synthesis of nucleic acid, on account of maximum availability of plant metabolism. The findings of present study are in accordance with those of Babu and Yadav (4) in khasi mandarin and Sajid *et al.,* (10) in sweet orange.

The results of the present experiment revealed that leaf nutrient status with respect to zinc and boron contents increased due to various treatments over control (Table 2). Among the different nutritional treatments, the application of 0.2 per cent boric acid + 0.5 per cent zinc sulphate (T_9) showed maximum zinc content (100.08 ppm) and boron content (80.81 ppm) of leaves whereas, minimum zinc and boron content was recorded with control. The increase of zinc and boron content with foliar spray might be due to the absorption of good amount of these elements by the leaves. Similarly, Khan *et al.* (6) reported increase in boron content in Feutrell' Early leaves with 0.5 per cent zinc spray.

Based on the above findings, it could be recommended that Kinnow plant should be foliar sprayed with 0.2 per cent boric acid + 0.5 per cent zinc sulphate at fruit set and peach size stage of fruit for better growth, sustaining higher fruit yield and quality in Kinnow mandarin under Southern Rajasthan conditions

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