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Effect of Foliar Application of Macro and Micronutrients on Fruit Drop and Yield of Kinnow Mandarin

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ABSTRACT

The experiment comprising of eleven fertilizer treatments in different combinations was conducted on seven years old earmarked plants at Experimental Orchard and in Post-harvest Technology Laboratory of the Department of Horticulture, CCS Haryana Agricultural University, Hisar during the year 2016-17 to study the effect of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$ and boric acid on fruit drop and yield of Kinnow mandarin. The data were recorded on June drop, pre-harvest drop, number of fruits per plant, percent fruit retention, size of fruits (fruit length and breadth), fruit weight and fruit yield. The recorded data were subjected to statistical analysis using RBD. The results of the experiment indicate that the foliar application of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$ and boric acid had a significantly positive influence on most of the recorded parameters. The maximum potential of Kinnow mandarin plants in respect of number of fruits per plant, fruit retention, size of fruits (fruit length and breadth), average fruit weight and fruit yield per plant was exploited to a maximum level and the June and pre-harvest fruit drop to a minimum level with foliar application of Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2%.

Key words: *Kinnow mandarin, Fertilizers, Fruit drop, Fruit size and Fruit yield*

INTRODUCTION

Kinnow, a mandarin hybrid between King Mandarin (*Citrus nobilis* Lour) and Willow Leaf Mandarin (*Citrus deliciosa* Tenora) was introduced in India in 1958 at the Regional Fruit Research Station, Abohar (Punjab). Its introduction inspired the farmers of adjoining areas to grow it. Thereafter, it became the most favourite citrus among the fruit growers as it had well adapted to the conditions of semi-arid and sub-mountainous foot hill where other citrus have failed. At present, the area under citrus in India is 1077.7 thousand hectare with a production of 11147.1 thousand tonnes and productivity of 10.3 million tonnes per hectare, while the area under citrus in Haryana is 19.4 thousand hectare with a production of 235.4 thousand tonnes and productivity of 12.1 million tonnes per hectare[25].

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Kinnow now has attained a prime position in northwestern states of Punjab, Haryana, Rajasthan, Uttar Pradesh and Himachal Pradesh since its fruit is very refreshing, juicy, melting and aromatic flavour with a fine sugar-acid blend, total soluble solids (10-12%) and acidity (0.75-1.2%). However, with the change in climate, the growers are facing various problems like erratic bearing, severe fruit drop, decline and poor fruit size. Among these, fruit drop and small fruit size are of great concern, which result in huge economic loss to the farmers. Citrus are relatively high nutrients-demanding crops[31] and highly responsive to applied nutrients in the form of fertilizers. Enhanced growth with improved fruit yield can be obtained with the application of proper compound fertilizers because any nutrient either deficient or excess can lead to huge reduction in crop yield. Inadequate nutrition is one of the major constraints limiting the potential productivity of a Kinnow orchard, thus, the judicious application of fertilizers plays a pivotal role in the productivity of Kinnow plantation[27]. The application of macro-nutrients particularly nitrogen, phosphorus and potassium plays an important role in yield[16], however, nitrogen is the key component for citrus growers, as it has more influence on tree growth and fruit yield than any other element[18]. A significant increase in shoot growth of different citrus species by urea sprays was also reported by Dubey *et al*.[8.] Inadequacy of potassium is one of the most striking factors that regulate the fruit size. Foliar spray of potassium two months after flowering increases fruit size of Valencia oranges[17]. Potassium is also important for fruit formation and enhancing fruit size[1]. Its deficiency leads to the production of small fruits with thin skin, while its excess results in the production of large fruits with thick skin and a coarse texture. Micronutrients are comparatively required in small amount as compared to macro-nutrients but these are equally important for plant metabolism[14]. Zinc helps in the synthesis of tryptophan, which is a precursor of auxin and hence helps in checking the fruit drop. Foliar application of micronutrients like zinc, boron and iron was much better than that of soil application because it was more rapidly available to the plants and effective to reduce toxicity symptoms[20]. However, limited information is available on these aspects under agro-climatic conditions of Haryana. Therefore, effective nutrients management in citrus is required to get desired productivity. Therefore, the present study was planned to evaluate the effect of micronutrients along with major nutrients on fruit drop and yield parameters of Kinnow mandarin.

MATERIAL AND METHODS

The experiment comprising of was conducted at Experimental Orchard and in Post-harvest Technology Laboratory of the Department of Horticulture, CCS Haryana Agricultural University, Hisar during the year 2016-17. These plants were earmarked in February 2016 for collecting the data on various physiological and biochemical parameters. Hisar has a typical semi-arid climate with hot and dry summer and extremely cold winter, which affects the fruit set and yield of Kinnow Mandarin. The eleven fertilizer treatments in different combinations were laid out in randomized block design with three replications. Seven years old uniformly grown trees spaced at 6x6 m were selected for the present study. Plants were kept under uniform orchard management practices during the study, where all the cultural practices were carried out as per package of practices. The observations were recorded on fruit drop, *i.e.*, (i) June drop (%) and (ii) pre-harvest drop (%), number of fruits per plant, final fruit retention (%), fruit size, *i.e.*, (i) fruit length (cm) and (ii) fruit diameter (cm), fruit weight (g) and fruit yield (kg/plant). The recorded data were subjected to statistical analysis by using the technique of analysis of variance.

RESULTS AND DISCUSSION

Fruit drop (%), final fruit retention (%) and number of fruits per plant

Different concentrations of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$ and boric acid significantly affected the June and pre-harvest fruit drop, final fruit retention and number of fruits per plant.

The minimum fruit drop in June month and pre-harvest period was recorded under the treatment T_9- foliar application of Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2% (39.00%) closely followed by the treatment T_7- Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% (41.00%) and T_{10}- Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0% + H_3BO_3 0.4% (41.00%) in June and only T_7- Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% (13.00%) in pre-harvest period. The treatment T_1, T_2, T_4 and T_{11}, T_2, T_3 and T_4, T_3, T_4, T_6, and T_8, T_4 and T_8, T_5, T_6, T_7, T_8, T_9 and T_{10}, T_6, T_7, T_8 and T_{10}, T_7, T_8, T_9 and T_{10}, T_8 and T_{10} and T_9 and T_{10} in June month and the treatment T_1, T_2, T_3, T_4 and T_{11}, T_2, T_3, T_4 and T_{11}, T_3, T_4, T_5, T_6, T_8, T_{10} and T_{11}, T_4, T_6, T_8 and T_{11}, T_5, T_6, T_7, T_8 and T_{10}, T_6, T_7, T_8 and T_{10}, T_7, T_8, T_9 and T_{10} and T_8 and T_{10} in pre-harvest period had statistically similar effect on percent fruit drop in Kinnow mandarin.

Table 1: Effect of nutrients on percent fruit drop and percent final fruit retention in Kinnow mandarin

Treatments	**June drop (%)**	**Pre-harvest drop (%)**	**Final fruit retention (%)**	**Number of fruits per plant**
T_1: Urea 1.0%	50.00	15.50	20.72	530.33
T_2: Urea 1.5%	49.00	15.25	20.85	531.67
T_3: Urea 1.0% + K_2SO_4 1.0%	46.00	14.75	22.03	579.33
T_4: Urea 1.5% + K_2SO_4 1.5%	47.00	15.00	22.18	547.33
T_5: Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5%	42.00	13.55	24.76	585.67
T_6: Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75%	43.00	13.75	23.94	574.67
T_7: Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%	41.00	13.00	24.21	598.33
T_8: Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0%	44.00	14.00	23.09	569.33
T_9: Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2%	39.00	12.00	25.95	598.67
T_{10}: Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0% + H_3BO_3 0.4%	41.00	13.50	24.55	569.33
T_{11}: Control (water spray)	52.00	16.00	19.86	523.67
C.D. at 5% level of significance	**3.6**	**1.43**	**0.75**	**6.61**

The significantly maximum final fruit retention was registered with (Table 1) treatment T_9 where the plants were sprayed with a combination of Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2% (25.95%), while the minimum final fruit retention was registered with T_{11}- control treatment (19.86%). The treatment T_1 and T_2, T_3 and T_4, T_5 and T_{10}, T_6, T_7 and T_{10} and T_7 and T_{10} had statistically similar effect on percent fruit retention in Kinnow mandarin.

The significantly highest number of fruits per plant was obtained from the plant sprayed with treatment T_9- Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2% (598.67), which was closely followed by the treatment T_7- Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% (598.33), while the minimum number of fruits per plant was recorded under control treatment (523.67). The treatment T_1 and T_2, T_3, T_5 and T_6, T_6, T_8 and T_{10}, T_7 and T_{10} and T_8 and T_{10} were statistically alike in their effect on number of Kinnow mandarin fruits per plant.

The earlier reports indicate that citrus crops suffer with the deficiency of essential nutrients that the plants take up from the soil[12,4,21]. Citrus crops are relatively high nutrients demanding[31] and highly responsive to applied nutrients in the form of fertilizers. The results of present investigation indicate that the foliar application of Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2% was quite effective in minimizing fruit drop and increasing fruit retention and number of fruits per plant (Table 1) in Kinnow mandarin. The decrease in fruit drop and increase in fruit retention and number of fruits per plant with the application of different nutrients in combination might be attributed to the fact that making up the deficiency of these nutrients in the plants, which are required for the synthesis of carbohydrates, which are essential for reducing fruit drop and increasing fruit retention and number of fruits per plant. The effect of zinc sulphate and boric acid in reducing pre-mature fruit drop might be due to their role in the retardation of abscission layer formation in pedicel at the point of attachment with fruit[10]. Further, zinc is also involved in photosynthesis, activation of enzyme systems, protein synthesis and carbohydrate translocation [29] and for the production of tryptophan, a precursor of auxin (indole-3-acetic acid), the deficiency of which results in low auxin level, causing fruits to drop prematurely[6]. The significant check on the economically important pre-harvest fruit drop by the combined foliar spray of these nutrients can be attributed to the activation of auxins responsible for inhibiting fruit drop by strengthening the fruit pedicels through their synergistic relationship between them[26]. The results of present study are in conformation with the findings of Gurjar and Rana[11] who reported lowest fruit drop with $ZnSO_4$ 0.5%, Razzaq *et al.*[22] and Ullah *et al.*[30] who reported that foliar application of boron or zinc reduced fruit drop in Kinnow mandarin, Abd-Allah[2] who reported that application of boron increases fruit set by its role in pollen tube germination and elongation and Saraswathi *et al.*[24] who also observed that supplementation of essential microelements significantly increased the number of fruits per plant in mandarin orange.

Table 2: Effect of nutrients on fruit size, fruit weight (g) and fruit yield per plant in Kinnow mandarin

Treatments	Fruit size (cm)		Fruit weight (g)	Fruit yield per plant (kg)
	Length	Diameter		
T_1: Urea 1.0%	6.04	6.76	153.67	81.51
T_2: Urea 1.5%	5.97	6.95	150.67	80.17
T_3: Urea 1.0% + K_2SO_4 1.0%	6.15	7.09	157.00	90.95
T_4: Urea 1.5% + K_2SO_4 1.5%	6.08	7.02	155.50	85.11
T_5: Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5%	6.18	7.09	158.33	92.73
T_6: Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75%	6.09	7.08	156.00	89.64
T_7: Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%	6.20	7.10	160.33	95.93
T_8: Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0%	5.91	7.03	157.67	89.67
T_9: Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2%	6.28	7.15	163.67	97.83
T_{10}: Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0% + H_3BO_3 0.4%	6.03	7.07	159.00	90.58
T_{11}: Control (water spray)	5.80	6.70	149.23	78.15
C.D. at 5% level of significance	**0.08**	**0.04**	**2.59**	**1.9**

Fruit size, fruit weight (g) and fruit yield per plant

Length, breadth and weight of fruit and fruit yield per plant (Table 2) were recorded significantly maximum under the treatment T_9- Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2% (6.28 cm, 7.15 cm, 163.00 g and 97.83 kg/plant, respectively), which was closely followed by the treatment T_7- Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% (6.20 cm) only for fruit length and the treatment T_2- Urea 1.5% (150.67 g) only for fruit weight. The treatment T_1, T_4, T_6 and T_{10}, T_2, T_8 and T_{10}, T_1, T_2, T_3, T_4, T_5, T_6 and T_7, T_4, T_6 and T_{10}, T_5 and T_7 and T_6 and T_{10} were statistically at par with each other in respect of fruit length, the treatment T_3, T_5, T_6, T_7 and T_{10}, T_4 and T_8, T_5, T_6, T_7 and T_{10}, T_7 and T_{10} and T_8 and T_{10} in respect of fruit breadth, the treatment T_1, T_4 and T_6, T_2 and T_{11}, T_3, T_4, T_5, T_6, T_8 and T_{10}, T_4, T_6 and T_8, T_5, T_6, T_7, T_8 and T_{10}, T_7, T_8 and T_{10} and T_8 and T_{10} in respect of fruit weight and the treatment T_1 and T_2, T_3, T_5 and T_6, T_6, T_8 and T_{10}, T_7 and T_9 and T_8 and T_{10} in respect of fruit yield per plant.

The productivity of citrus crops depends on many abiotic and biotic factors[7,13]. Among them, boron as a micronutrient plays significant role in growth and productivity of citrus, as it increases pollen germination, pollen tube length, consequently fruit set and finally the yield[2]. Zinc is another important microelement essential for plants due to its involvement in the synthesis of tryptophan- a precursor of indole acetic acid synthesis and in the activities of enzymes such as, dehydrogenase, aldolase, isomerase, transphosphorylase, RNA and DNA polymerase[28] and it also plays an important role in starch metabolism and acts as co-factor for many enzymes, affecting photosynthesis, nucleic acid metabolism and protein biosynthesis[3]. Foliar application of micronutrients 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[20]. Curing micronutrients deficiency through foliar application is a common practice in getting profitable yield and good quality fruits[15]. The results of present investigation indicate that the foliar application of Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2% was quite effective in increasing all the yield parameters, *i.e.,* number of fruits per plant, size of fruits (fruit length and breadth), average fruit weight and yield per plant significantly (Table 3 and 4). The enhanced yield with foliar application of micronutrients might be attributed to their effects on balancing the nutritional status and in increasing the chlorophyll content of leaves, photosynthetic efficiency and translocation of metabolites from source to the sink as and when required, which might be responsible for retaining more number of fruits, increasing fruit size, fruit weight and yield of the crop. The enhanced yield might also be due to the large plant spread obtained by supplying essential elements in ample amount, resulting in improved growth, better flowering and higher fruit set over the control. The results of present study are in line with the findings of Sahota and Arora[23] who stated that foliar application of zinc increased the fruit yield by increasing fruit weight and fruit size in sweet orange, El-Saida[9] who reported that foliar spray of micronutrients was beneficial in enhancing citrus fruit setting and yield, Wei *et al.*[32] and Obreza *et al.*[19] who reported that increasing rates and frequencies of foliar application of potassium is accompanied by an increase in citrus fruit size, which might be due to the role of potassium in cell wall construction[5], Razzaq *et al.*[22] and Ullah *et al.*[30] who noticed an increase in fruit size of sweet orange and mandarin with the foliar application of zinc or boron and Gurjar and Rana[11] who reported that the increase in fruit weight might be due to increased photosynthesis with potassium application, which led to accumulation of more carbohydrates.

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