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Impact of Foliar Fertilization on Leaf Nutrient Status of Kinnow Mandarin

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Authors' contributions

This work was carried out in collaboration among all authors. This study was hypothesized by authors GSR and Reetika. The work was done by author Reetika below the guidance of author GSR. Data and statistical analysis were performed and first draft of the manuscript composed by the author Reetika. Authors Rakesh Kumar and Ravi Kumar reviewed, edited, administered the writing evidence and also assisted in the writing of the paper. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To study the impact of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$ and boric acid on leaf nutrient status of Kinnow mandarin.
Study Design: The experiment was performed in randomized block design with three replications per treatment on Kinnow mandarin.
Place and Duration of Study: The current study was carried out on seven years' old earmarked plants at the Horticultural Orchard and in Soil Testing Laboratory of College of Agriculture, CCS Haryana Agricultural University, Hisar during the year 2016-17.
Methodology: The eleven fertilizer treatments in different combinations of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$ and boric acid were arranged in randomized block design with three replications on seven years old uniformly grown Kinnow mandarin trees. All the chemicals were sprayed twice, *i.e.*, first in last week of April and second in the last week of July. Leaf samples were taken in the month of October for analysis of leaf N, P, K, Zn and Fe content.

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Results: 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 the recorded parameters. The content of nitrogen, zinc and iron in Kinnow mandarin leaves was recorded maximum when the plants were sprayed with Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75%, Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0% + Boric Acid 0.4% and Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0%, respectively, while phosphorous and potassium content in leaves of Kinnow mandarin remained unaffected by the foliar application of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$ and boric acid.

Conclusion: Based on this study, it is concluded that the foliar application of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$ and boric acid had a significantly positive influence on leaf mineral nutrient status of Kinnow mandarin plants.

Keywords: Foliar spray; Kinnow mandarin; leaf nutrients.

1. INTRODUCTION

Nutrients play multifaceted roles in the production and composition of plant. Citrus is a crop that is moderately high nutrients-demanding [1] and takes into account the applied supplements in the form of fertilizers. Among the citrus fruits, Kinnow has accomplished a leading position in northwestern states of Punjab, Haryana, Rajasthan, Uttar Pradesh and Himachal Pradesh. Growing with advanced yield and quality of fruitage can be obtained with the appropriate use of proper compound fertilizers in light of the known fact that any nutrition either inadequate or abundance can prompt a decrease in crop yield combined with mediocre quality of fruits. The utilization of macronutrients especially nitrogen, phosphorus and potassium plays a role that is significant in yield notably the quality of fruits [2]. In any case, nitrogen is the element that is key for citrus growers, since it has a greater impact on plant growth, outlook and quality of fruit than somewhat additional factor [3]. Potassium is imperative for vital roles that are physiological, for example, the sugars and starch formation, proteins synthesis and cell division. It is likewise significant for fruit formation and upgrading fruit size and colour [4]. Its insufficiency facilitates the production of small fruits with thin skin, while an excess production of potassium results in the production of large fruits with dense skin and a coarse texture. Moderately, a limited number of micronutrients is required when compared with those of primary nutrients however these are similarly significant for plant metabolism [5]. Iron acts as a catalyst in oxidation and reduction reactions and it is associated with respiration, photosynthesis and the decrease of nitrate and sulfate. Boron plays a critical role in growth and productivity of citrus by increasing pollen grain germination, pollen tube elongation, fruit set and finally the yield [6].

Although the vast majority of micronutrients participate in the implementation of a number of enzyme systems yet the diversity that exists in certain activities of the micronutrients in crop and microbial development programs, *e.g.*, copper, iron and molybdenum are equipped for acting as electron carriers in the enzyme system which deliver oxidation-reduction plant reactions, which are vital steps in photosynthesis and many other metabolic processes. Zinc and manganese work in many enzyme systems as bridge to connect the enzyme and substrate where it is intended to act [7]. An expansion in the level of macronutrients with foliar utilization of zinc might be due to some synergetic connection between N, P, K and Zn. Foliar use of zinc was accounted for to have beneficial outcome on the leaf mineral contents of Balady mandarin and Valencia orange trees [8,9]. Scientists found that the foliar spray of $MnSO_4$ 2%, $CuSO_4$ 0.4%, $ZnSO_4$ 0.5%, boric acid 0.1%, and $FeSO_4$ 0.25% either separately or in different mixes fundamentally expanded the N, P and K content in leaves of mandarin orange [10]. By the foliar application of Zn both alone or with B, the sweet orange plants became healthy and nutrient status in leaves was increased and eventually increase in the production and the bearing life [11,12]. The use of foliar micronutrients such as zinc, iron and boron was noticeably better to that of soil use because they are all readily available in plants and are effective in reducing the symptoms of toxicity [13]. As a result, the effective management of nutrients in citrus, including how to find the right amount, and also the assortment of appropriate blend of fertilizers, is necessary to obtain the desired fruit productivity and quality. Therefore, the existing trial was designed to appraise the outcome of macronutrients and micronutrients on leaf mineral nutrient status of Kinnow mandarin.

2. MATERIALS AND METHODS

The current study was conducted at the Horticultural Orchard and in Soil Testing Laboratory of College of Agriculture, CCS HAU, Hisar, Haryana during 2016-17. These Kinnow mandarin plants were assigned in February 2016 for gathering the information on several leaf parameters. The experimental orchard located 215.2 m above mean sea level with coordinates of 29º10' n latitude and 75º46' e longitudes, with a normally warm climate and hot and dry summer and a very pleasant winter. The general soil status was sandy loam, low in organic carbon (0.7%), low in available nitrogen (134.6 kg/ha) and medium in phosphorus (11.2 kg/ha) and high in available potassium (534.6 kg/ha) with soil pH (7.8) and EC (0.32 dSm^{-1}). Eleven fertilizer treatments in various combinations were presented in a randomized block design with three replications each. Uniform Seven-year-old 33 trees at 6x6 m spacing in a block of one hectare were selected for the existing research. Plants were maintained under the uniform orchard management during the study period, in which all the cultural practices were performed as per the package of practices. All the chemicals were sprayed twice, *i.e.*, first in the Stage-1 (April-May): cell division stage and second in Stage-II (June-September): cell enlargement stage, as per the phenological events appeared in Kinnow on the same plants. The observations were recorded on leaf N, P, K, Zn, and Fe contents.The recorded data were analyzed in statistical tests using a single RBD analysis with software named OP Stat, CCS HAU Hisar [14].

2.1 Plant Leaf Analysis

The nitrogen, phosphorus, potassium, zinc, and iron content was estimated in the month of October from the Kinnow mandarin leaves.

2.2 Procedure

For estimating the nutrients status of leaf, healthy leaf samples of five to six-month age from the non-fruiting shoots of Kinnow plants were collected in October and washed underneath tap water and then with 0.1% HCl and two distilled water baths. Samples of the washed leaf were first surface driedand then dried in an oven at 70°C for 48 hours. The dried samples were pulverized and strained through muslin cloth for further study as suggested by Chapman [15].

2.3 Digestion of Plant Material

The 0.5 g quantity of ground leaf sample was taken in 50 ml separate conical flasks and 10 ml diacid mixture (H_2SO_4 : $HClO_4$ in 9:1 ratio) was added to each flask. Digestion on a hot plate was carried out as described by Jackson [16] for the determination of nitrogen, phosphorus and potash. The total volume of aliquot was made to 50 ml. For the determination of micronutrients *viz*., Fe and Zn, the 0.5 g of ground leaf sample was taken in 50 ml separate conical flasks and these were digested on a hot plate by adding 15 ml diacid mixture (HNO_3 : $HClO_4$ in 4:1 ratio) as per the procedure described by Piper [17]. The total volume of aliquot for microelements was made to 50 ml.

2.4 Methods of Leaf Nutrients Determination

2.4.1 Nitrogen

The nitrogen content was determined by using the method as described by Jackson [18].

2.4.2 Phosphorus

The phosphorus content was determined by vando-molybdophosphoric acid yellow colour method as described by Jackson [5].

2.4.3 Potassium

The potassium content was determined from the digested extract on flame photometer as described by Piper [17]. The content was calculated and expressed in per cent on dry weight basis.

2.4.4 Available zinc and Iron

The DTPA extractable Zinc and Iron were assessed by utilizing the Lindsay and Norvell method [19]. The digested samples of leaf were investigated to determine the absorption of zinc and iron on the atomic absorption spectrophotometer (AAS) and their amount were articulated in ppm.

3. RESULTS AND DISCUSSION

3.1 Leaf Nitrogen Content (%)

The data presented in Table 1 indicate that the foliar use of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$, and boric acid considerably affected the nitrogen content of Kinnow mandarin leaf. The highest N content was recorded in the leaf of plant treated with T_6- Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75%, (2.45%), and the lowest N content in the control plant leaf (2.24%). The increase in nitrogen content with urea might be due to the additional supply of nitrogen to the leaves. The outcomes of the existing research confirm the discoveries of the investigator [20] who testified that all the trees were sprayed with 0.4% zinc sulfate exhibited 1.5-fold higher N content in leaves than the leaves of control trees. The results are in accordance with the findings of scientists, who showed that potassium applied as K_2SO_4 improved nitrogen content in the leaves of mango [21], who concluded that foliar application of KNO_3 raised the N level in Balady mandarin leaves [22,23] plus conveyed that foliar application of zinc alone or in the combination of potassium increased leaf nitrogen, phosphorus, potassium, and zinc content in Washington Navel orange [24]. The results of the present finding are contrary from a study that reported that the splash of KCl 0.5%, K_2SO_4 0.5%, and KNO_3 0.5% had no effect on the content of leaf nitrogen in Washington Navel orange [25]. The presence of boric acid in any combination containing potassium citrate increased nitrogen content in mango leaves [26]. The working group reported that the mineral content of Hamlin orange trees in relation to nitrogen content in the leave scan be significantly enhanced by splashes of NPK especially urea 0.5% + K_2HPO_4 1 or 1.5% [27].

3.2 Leaf Phosphorus Content (%)

The data concerning phosphorus content in leaf of Kinnow mandarin plant are presented in Table 1. Statistically, there was no significant change in the effect of different concentrations of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$, and boric acid as a foliar spray on phosphorus content of Kinnow mandarin leaf. Similar results were obtained in Washington Navel orange [25]. In Clementine citrus, the level of P in leaf was not affected by foliar application of KNO_3 5-8% and $K_2SO_4$2.5-4% twice or thrice [28]. The results of the present findings differ from investigators who stated that the mineral status of Hamlin tree in relation to phosphorus content in the leaves could be significantly improved by NPK sprays especially urea 0.5% + K_2HPO_4 1 or 1.5% [27]. Spraying potassium in several forms, *i.e.*,KH_2PO_4, K_2HPO_4, or KNO_3, raised phosphorus level in leaves of Balady mandarin [22,23].

3.3 Leaf Potassium Content (%)

The data pertaining to potassium content in the leaf of the Kinnow mandarin plant are presented in Table 1. The effect of foliar application of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$, and boric acid on potassium content in leaves of Kinnow mandarin was not significant. These results are in accordance with the findings of scientists who concluded that spraying KNO_3 raised the level of K in leaves of Balady mandarin [22,23] and who suggested that spraying either KNO_3 or K_2SO_4

Table 1. Effect of nutrients on leaf nutrients in Kinnow mandarin

Treatments	%			ppm	
	N	P	K	Zn	Fe
T_1: Urea 1.0%	2.28	0.15	0.98	12.44	101.8
T_2: Urea 1.5%	2.40	0.15	0.97	12.04	102.4
T_3: Urea 1.0% + K_2SO_4 1.0%	2.32	0.14	1.02	12.04	103.6
T_4: Urea 1.5% + K_2SO_4 1.5%	2.34	0.14	1.05	12.00	103.8
T_5: Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5%	2.35	0.15	1.06	14.08	101.2
T_6: Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75%	2.45	0.14	1.08	14.50	101.1
T_7: Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5%	2.32	0.14	1.05	13.48	104.3
T_8: Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0%	2.40	0.14	1.07	13.50	108.0
T_9: Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2%	2.32	0.15	1.02	14.50	104.2
T_{10}: Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0% + H_3BO_3 0.4%	2.34	0.14	1.03	14.74	105.6
T_{11}: Control (water spray)	2.24	0.14	0.96	11.75	97.8
C.D. at 5% level of significance	**0.1**	**NS**	**NS**	**1.20**	**4**

was more effective in raising K content of leaves in Balady mandarin [29]. The results of present finding are contrary to researcher, who stated that spray of KCl 0.5%, K_2SO_4 0.5% and KNO_3 0.5% on plant increased the content of potassium in leaves of Washington Navel orange [25]. Abd-El-Migeed et al. [27] conveyed that the mineral status of Hamlin orange trees in terms of leafy K content can be significantly improved by NPK spraying especially urea 0.5% + K_2HPO_4 1 or 1.5%. In Washington Navel orange, a researcher also recorded highest potassium content in leaves when K_2HPO_4 was sprayed solely on plant during full bloom stage [26]. In Balady mandarin, scientists reported the highest values for leaves potassium content (1.73%) when plants were sprayed with KNO_3 1.5% [29].

3.4 Leaf Zinc Content (ppm)

The data presented in Table 1 demonstrate that the foliar application of different concentrations of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$, and boric acid significantly affected the zinc content of Kinnow mandarin leaf. The highest zinc content in leaf of Kinnow mandarin was recorded under the treatment T_{10}- Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0% + H_3BO_3 0.4% (14.74 ppm), and the minimum in the leaf of control plant (11.75 ppm). Similar results were obtained byDube and Saxena [30] who reported an increase in zinc content of leaves with increasing concentration of zinc sulphate (0.25 to 0.50%) sprayed twice at the end of April and May in sweet orange, Kotur [31] noted increased zinc content in leaves of Coorg mandarin when sprayed with zinc sulphate 0.5% twice a year in May and October. Foliar application of zinc alone or in combination with other micronutrients significantly increased zinc content in leaves of Coorg mandarin [32]. Yadav et al. [33] also recorded an increase in leaf zinc content with the increase in doses of zinc sulphate in sweet orange. Khan et al. [34] reported that the application of boric acid 0.3% + zinc sulphate 0.5% at fruit set stage effectively increased the leaf Zn level of Futrell's Early mandarin leaves and brought them from deficient to optimum range.

3.5 Leaf Fe Content (ppm)

Soil applied zinc is less available to plants due to its less mobility and high fixation in soil. The data presented in Table 1 illustrate that the foliar application of different concentrations of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$, and boric acid significantly affected the iron content of Kinnow mandarin leaf. The maximum iron content in leaf of Kinnow mandarin was recorded under the treatment T_8- Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0% (108.0 ppm) and the minimum in the leaf of control plant (97.8 ppm). These results agree with the outcomes by researchers who stated that foliar application of zinc increased the zinc and iron level in lemon seedlings [7] and Razzaq et al. [20] who found that trees sprayed with $ZnSO_4$ 0.6% showed highest zinc and iron content in leaf of Kinnow mandarin as compared to zinc and iron content in leaf of untreated trees.

4. CONCLUSION

Based on this study, it is concluded that the use of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$, and boric acidhad the best effect on the recorded parameters. The content of nitrogen, zinc and iron in Kinnow mandarin leaves was recorded maximum when the plants were sprayed with Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75%, Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0% + Boric Acid 0.4% and Urea 1.5% + K_2SO_4 1.5% + $ZnSO_4$ 0.75% + $FeSO_4$ 1.0%, respectively, while the phosphorous and potassium content in leaves of Kinnow mandarin remains unaffected by the foliar utilisation of Urea, K_2SO_4, $ZnSO_4$, $FeSO_4$, and boric acid. The outcomes of the research will be beneficial for researchers and farmers to progress the condition of the Kinnow mandarin leaf by sprinkling with macro-nutrients and micro-nutrients.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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