EFFECT OF NANO BORON AND NANO ZINC ON LEAF NUTRIENT STATUS IN KINNOW MANDARIN

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Abstract

Nano Boron and Nano Zinc were applied to study their effect on leaf nutrient status in Kinnow mandarin plants. A total of 12 treatment combinations were undertaken in the experiment with 3 replications. Leaf nutrient status of Kinnow mandarin was estimated for the various treatments under taken in the experimentation. It was found that the boron and zinc have a synergistic interaction among N, P, and K. The application of boron and zinc increased the concentration on macro nutrients (NPK) in the leaves of Kinnow mandarin plants. The results obtained from the trees treated with zinc (Zn) and boron (B) indicate the potential benefits of applying foliar application of these nutrients to improve tree health and nutrition.. In the study it was found that, treatment T_8, which included the application of RDF, *Azotobacter*, nano boron @ 40 ppm and nano zinc @ 150 ppm recorded the maximum uptake of nitrogen, phosphorous, boron, and zinc. It was also observed that in the same treatment, maximum yield was recorded which is further linked to the availability of nutrients to the Kinnow mandarin plants.

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Introduction

Citrus species are extensively grown in the tropical and sub-tropical regions worldwide, with their origins traced back to Southeast Asia and India. However, commercial citrus production mainly takes place in sub-tropical regions with latitudes greater than 20° N and 20° S but less than 45° N and 35° S, at elevations ranging from sea level to 600-750 m above mean sea level. About 140 countries engage in commercial citrus tree cultivation, making citrus trees (Citrus spp.) an important global fruit crop. The Citrus genus belongs to the Rutaceae family, with most commercially grown species, such as Sweet orange, Mandarin, Lime, Lemon, Sweet lime, Grapefruit, belonging to this genus. Citriculture is impacted by various abiotic and biotic factors, including temperature, drought, soil salinity, agricultural practices, pests, and diseases.

It is important to note that the nutritional composition of kinnow fruit is not only limited to its sugar content. Kinnow is also a good source of vitamins and minerals. For instance, it is rich in vitamin C, containing up to 80-200 mg/100 ml of juice (Lado et al., 2016; Ladaniya, 2011). Additionally, kinnow fruit is a good source of dietary fiber, potassium, calcium, and folate (Shen et al., 2013; Ladaniya, 2011). The health benefits associated with kinnow consumption are numerous, including antioxidant properties, anti-inflammatory effects, and protection against various chronic diseases (Shen et al., 2013; Ladaniya, 2011). Overall, kinnow is a highly nutritious and tasty fruit with a variety of potential health benefits. However, growers in this region often neglect micro-nutrient application and instead apply large amounts of macro nutrients, such as nitrogen, phosphorus, and potassium. This practice is complicated by the calcareous soil and high pH in the region, which limits the availability of micronutrients applied to the soil. Arid regions often suffer from nutrient deficiencies in their soils, which can limit plant growth and ultimately reduce fruit production. In particular, micronutrient availability can be limited due to the presence of calcium carbonate concretions in subsoil. Deficiency symptoms of micronutrients are common in orchards and can directly or indirectly impact fruit production. In such cases, foliar feeding of micronutrients can be an effective and convenient solution to save on chemical inputs and ensure nutrient availability for plants. (Akhtar et al., 2016; Hussain et al., 2015; Rengel and Zhang, 2003)

Encapsulated nanofertilizers are used to enhance fertiliser formulations for increased nutrient uptake by plant cells and decreased nutrient loss during fertilisation (Rai et al., 2015). Tomato plants have been demonstrated to lose less of the nutrients they take in when using surface-modified nanomaterials like nanocomposites made of macronutrients (N, P, K) and micronutrients (Barrios et al., 2016). Nano fertilisers, when used in gardening, have been shown to boost fruit tree productivity and quality (Zagzog et al., 2017; Zahedi et al., 2020) by increasing vegetative growth, flower pollination, and fertility. Plant growth is stimulated and soil fertility is improved when applied together with biofertilizers that colonise the rhizosphere or the interior of the plant, increasing the availability of NPK to the host plant. The purpose of this research was to determine whether or not Kinnow plant leaf nutrient levels improved after being treated with nano micronutrients and biofertilizers. The impact of these treatments on yield and yield-related plant traits was another objective of the study.

Materials and methodology

The present studies were conducted at the Kinnow orchard situated within the premises of Lovely Professional University, Phagwara, Distt. Kapurthala, Punjab, during the period from 2021 to 2022. The research site, situated within the sub-tropical region, exhibits distinct climatic characteristics, featuring cool winters and hot summers. Rainfall is primarily observed during the months of July, August, and September. The experiment was divided in to 12 treatments replicated thrice having 2 plants per replication (Table 1). With the exception of treatment applications, all other cultural practices were uniformly followed to all selected plants. N:P: K was uniformly administered across all treatments. The application of biofertilizer (Azotobacter) was executed according to the predetermined plan. Foliar application of nano boron and nano zinc was done twice (for Boron-first spray in 1st week of March and second twenty days after full bloom) (for Zinc first spray at the end of March and second at mid-August). A uniform dose of 100 grams per plant of Azotobacter culture was thoroughly blended with a 10 percent solution of jaggery (gur slurry), which was prepared individually for each tree. Recommended dose of fertilizers (RDF) was applied as per recommendations of Punjab Agricultural University). In control treatment, sodium borate (0.25%) and zinc sulphate (4.7g per litre) were applied. For nano applications, three levels of Boron (20,40 and 60 mg/l) and three levels of zinc (100, 150 and 200 mg/litre) were used.

Table no. 1: Treatment details:

Treatment	Treatment details	Treatment	Treatment details
T_1	RDF + B + Zn	T_7	RDF+ *Azotobacter*+ B_2 + Zn_1
T_2	RDF + *Azotobacter* + B + Zn	T_8	RDF+ *Azotobacter*+ B_2 + Zn_2
T_3	RDF + *Azotobacter*	T_9	RDF+ *Azotobacter*+ B_2 + Zn_3
T_4	RDF +*Azotobacter*+ B_1 + Zn_1	T_{10}	RDF+ *Azotobacter*+ B_3 + Zn_1
T_5	RDF+ *Azotobacter*+ B_1 + Zn_2	T_{11}	RDF+ *Azotobacter*+ B_3 + Zn_2
T_6	RDF+ *Azotobacter*+ B_1 + Zn_3	T_{12}	RDF+ *Azotobacter*+ B_3 + Zn_3

For the purpose of nutrient estimation of leaves, fifty fully mature leaves were selectively harvested from seven-month old non-fruiting terminals of the spring flush on all the directions in the month of July, following the methodology described by Chahill et al. (1988). The collected leaves were thoroughly washed with running tap water, followed by rinsing with 0.1 per cent HCl and two additional rinses with distilled water. Subsequently, the washed leaf samples were surface dried and subjected to oven drying at 70°C for duration of 48 hours. The leaf samples were processed following the methods described by Chapman (1964), which involved washing, cleaning, drying, grinding, and subsequent storage. Number of fruits were counted on each tagged plant and fruit development was followed for arriving at fruit drop per centage and fruit yield. The data was statistically analyzed using SPSS v. 21 software to arrive at homogenous subsets.

Results

Following application of nano micronutrients (B and Zn) to Kinnow mandarin plants, an elevated leaf nitrogen content of 34700 ppm was recorded in plants treated with RDF + *Azotobacter* + 40 mg/l B + 150 mg/l Zn (Table 2). This treatment application also resulted in maximum phosphorus content of 336.50 ppm. However, application of RDF along with azotobacter supplemented with 20 mg/l B and 100 mg/l Zn resulted in maximum potassium content in leaves. Plants a sprayed with medium levels of nano boron and nano zinc showed maximum leaf boron levels of 36.84 ppm and leaf zinc level of 26.04 ppm. The findings of the study demonstrated a significant enhancement in the levels of nitrogen, phosphorus and potassium in the leaves of the plants through the application of boron (B) and zinc (Zn) via foliar spraying. This can be attributed to synergetic interaction between macro and micro nutrients. Favourable effect of Boron and Zinc application on mineral composition of leaves has been demonstrated in Kinnow mandarin and oranges (Razzaq et al., 2013; Ullah et al., 2012). In line with previous studies, research has shown that zinc when applied in foliar form, either alone or in conjugation with potassium (K), has led to increases levels of nitrogen, phosphorus, zinc and potassium in the leaves of orange trees (Omaima and El-Metwally, 2007). The observed rise in the levels of Zinc and Boron in experimental trees suggests the advantages of exogenously applied boron and zinc to enhance tree health and nutrition.

Table 2: Effect of nano boron and nano zinc on leaf nutrient status of Kinnow mandarin

Treatments	Nitrogen (PPM)	Phosphorus (PPM)	Potassium (PPM)	Zinc (PPM)	Boron (PPM)
T_1	32000^{ab}	321.80	1105.00	21.26^{c}	32.05^{d}
T_2	32700^{abc}	320.70	1141.00	22.19^{d}	32.51^{d}
T_3	31000^{a}	303.80	1060.70	14.58^{a}	19.98^{a}
T_4	33200^{bcd}	331.70	1197.00	24.43^{e}	28.75^{c}
T_5	34300^{cd}	322.50	1103.60	26.00^{f}	29.59^{c}
T_6	32500^{abc}	332.80	1185.00	18.58^{b}	28.63^{c}
T_7	34300^{cd}	320.40	1120.00	24.20^{e}	36.17^{ef}
T_8	34700^{d}	336.50	1168.00	26.04^{f}	36.84^{f}
T_9	34000^{cd}	327.20	1106.00	18.72^{b}	35.23^{e}
T_{10}	32000^{ab}	315.70	1105.70	23.93^{e}	25.98^{b}
T_{11}	32000^{ab}	327.60	1113.60	25.91^{f}	26.08^{b}
T_{12}	32800^{abc}	315.50	1126.00	18.40^{b}	25.63^{b}
S. Em (±)	563.73	4.34	15.24	0.33	0.48
C.D (5%)	1664.03	12.82	44.98	0.96	1.425

T_1 (RDF + B + Zn), T_2 (RDF + B + Zn + *Azotobacter*), T_3 (RDF+ *Azotobacter*), T_4 (RDF+ *Azotobacter* + B1 + Zn1), T_5 (RDF+ *Azotobacter* + B1 + Zn2), T_6 (RDF+ *Azotobacter* + B1 + Zn3), T_7 (RDF+ *Azotobacter* + B2 + Zn1), T_8 (RDF+ *Azotobacter* + B2 + Zn2), T_9 (RDF+ *Azotobacter* + B2 + Zn3), T_{10} (RDF+ *Azotobacter* + B3 + Zn1), T_{11} (RDF+ *Azotobacter* + B3 + Zn2), T_{12} (RDF+ *Azotobacter* + B3 + Zn3)

Correlation among leaf nutrient status and yield attributing characters

Based on the leaf nutrient content, a correlation was drawn with yield attributing characters for Kinnow mandarin (Table 3). Fruit drop was negatively correlated with leaf nitrogen (-0.494**), leaf phosphorus (-0.488**), leaf potassium (-0.218), leaf zinc (-0.855**) and leaf boron (-0.524**). All the mentioned leaf nutrients had a strong negative correlation with fruit drop in Kinnow mandarin. Number of fruits per plant was positively correlated with leaf nutrient contents. It was observed that number of fruits per plant had a positive correlation with leaf nitrogen (0.404*), leaf phosphorus (0.430**), leaf potassium (0.153), leaf zinc (0.831**) and leaf boron (0.470**). The number of fruits per plant showed a strong positive correlation with all leaf nutrients, except for leaf potassium. For fruit yield per plant, a positive correlation was observed with leaf nitrogen (0.491**), leaf phosphorus (0.475**), leaf potassium (0.237), leaf zinc (0.816**) and leaf boron (0.589**). Based on the data presented in the table, it can be concluded that nitrogen (N), phosphorus (P), zinc (Zn), and boron (B) had a significant impact in reducing fruit drop, increasing the number of fruits per plant, and enhancing the yield per plant. Comparatively, leaf K content had minor effect on all the yield attributing characters listed. Nitrogen being a component of chlorophyll helps in improving the growth and yield of the plants. Similarly, phosphorus, Zn and B are involved in the physiological processes leading to fruit retention, fruit formation and yield of the plant. Similar results been reported by Shukla et al., 2020 in mango crop where boron application showed positive significant correlation with fruit pulp. Also, similar results were reported by Dar et al., 2015 where N (r^2= 0.915), P (r^2= 0.714), K (r^2= 0.812) and Zn (r^2= 0.774) were positively correlated with the yield of pear fruits. For the number of fruits, as per Rani et al. (2020), higher fruits per plant in mango were recorded with soil application of nutrients viz., nitrogen (r^2= 0.814), phosphorus (r^2= 0.934), potassium (r^2= 0.712).

Table 3: Correlation between leaf nutrients and yield attributing characters in Kinnow mandarin.

Leaf nutrient	Fruit drop (%)	Fruits per plant	Fruit yield per plant (kg)
N	-0.494**	0.404*	0.491**
P	-0.488**	0.430**	0.475**
K	-0.218	0.153	0.237
Zn	-0.855**	0.831**	0.816**
B	-0.524**	0.470**	0.589**

Conclusion

The results of the findings have clearly shown the positive impact of nano micronutrients on yield and leaf nutrients of Kinnow mandarin. The improvement in leaf nutrient contents was obtained with treatments which involved the use of nano micronutrients. This resulted in the uptake of macro nutrients due to synergetic relationship with boron and zinc, which further helped to increase the yield of Kinnow mandarin. In the study, treatment T_8 (RDF, *Azotobactor*, nano boron @ 40 ppm and nano zinc @ 150 ppm) was found to be best among all the treatments.

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