The Pharma Innovation Journal 2021; 10(10): 1122-1127

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(10): 1122-1127

www.thepharmajournal.com
Received: 11-08-2021
Accepted: 15-09-2021

Durgashankar Meena
Department of Fruit Science, College of Horticulture and Forestry, Jhalawar, Agriculture University, Kota, Rajasthan, India

Prerak Bhatnagar
Department of Fruit Science, College of Horticulture and Forestry, Jhalawar, Agriculture University, Kota, Rajasthan, India

Nirmal Kumar
Department of Fruit Science, College of Horticulture and Forestry, Jhalawar, Agriculture University, Kota, Rajasthan, India

Lokesh Meena
Department of Fruit Science, College of Horticulture and Forestry, Jhalawar, Agriculture University, Kota, Rajasthan, India

Corresponding Author:
Durgashankar Meena
Department of Fruit Science, College of Horticulture and Forestry, Jhalawar, Agriculture University, Kota, Rajasthan, India

Effect of foliar spray of nutrients on yield and quality of Nagpur mandarin (*Citrus reticulata* Blanco.)

Durgashankar Meena, Prerak Bhatnagar, Nirmal Kumar and Lokesh Meena

Abstract
A field experiment entitled ''Effect of foliar spray of nutrients on yield and quality of Nagpur mandarin (*Citrus reticulata* Blanco.)'' was conducted during the year 2018-19, at the Fruit Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar. The experiment consisted of different treatments of nutrients including macro and micro-nutrients and was laid out in Randomized Block Design. Amongst different treatments application, treatment T_{21} ($ZnSO_4$ 0.5% + K_2SO_4 1.0%) foliar application was found significantly superior over other treatments in terms of quality parameters such TSS/Acidity ratio, ascorbic acid, total sugars, reducing sugars, non-reducing sugars and juice pH. Whereas, minimum acidity percentage was found under the same treatment. Overall, T_{21} treatment exhibited better fruit quality of Nagpur mandarin fruit tree.

Keywords: Mandarin, potassium sulphate, micro-nutrients, fruit, quality

Introduction
Nagpur mandarin (*Citrus reticulata* Blanco.) belongs to family Rutaceae having shizolysigenic oil gland and particular aroma indicating flavour of particular citrus species. It is considered to be one of the most important cultivated species among citrus and is being commercially grown in specific region of the country like Nagpur mandarin in Central India, Khasi mandarin in North Eastern regions and Coorg mandarin in Southern regions (Vikee *et al.*, 2018). Though, it is grown in every state, certain pockets have emerged as the leading producers. Nagpur mandarin is chiefly grown in Satpura hills (Vidarbha region) of Central India, hilly slopes of Darjeeling (West Bengal), Coorg (Karnataka) and Jhalawar (Rajasthan). In Jhalawar district of Rajasthan state, it is the major fruit crop highly acclimated under vertisols. Jhalawar district receives annual rainfall of 950 mm and black vertisols with enriched calcium carbonate is highly suitable for Nagpur mandarin cultivation. In South India, Wynad, Nilgiri, Palaney and Shevroy hills are major mandarin growing belts, while hills of North eastern states particularly Meghalaya (Khasi, Dusha, Garo, Jaintia), Mizoram, Tripura, Sikkim and Arunachal Pradesh have predominance of mandarins under forest belts.

Nagpur Mandarin is one of the finest varieties in term of sugars acid blend possessing tangy taste and very popular in India as well as in world. Its fruit is big, sub-globose, weigh 110-125g, rind medium thick, peel fairly loosely adherent, surface is also relatively smooth but dominant sometimes with expression of root stock characteristics. In a single fruit there are 10-11 segments and there are 1-2 seeds per segment. The colour of peel is pale orange and fruits have mild flavour, excellent quality, juicy pulp TSS 10-12^0 Brix, and acidity in the range 0.50-0.70 per cent. Fully mature tree bears 125 kg fruits.

The total production of mandarin in India is 51.01 lakh tonnes from an area of 4.28 lakh hectares with the productivity of 14.84 MT/ha (Anonymous, 2018). In Rajasthan state, the acreage of Nagpur mandarin is around 23,900 ha area and the production is 4.7 lac tonnes.

Plant nutrients are categorized as macro and micro nutrients. Besides, nitrogen, phosphorous and potassium are also required in large amounts, however micro nutrients specially zinc, iron, copper and manganese are required in small amounts. Citrus is considered highly nutrient responsive crop and site-specific nutrient management involving combination of macro and micro nutrients is must to solve nutrient deficiencies as well as to improve nutritional quality of mandarin.

In Nagpur mandarin, the role of nutrients especially potassium in enhancement of fruit quality is well known.

Potassium is one of the key elements which plays an important role in determining yield and quality. Nutritional K-sprays are required to increase fruit yield as well quality attributes specially juice recovery percentage and ascorbic acid content. Potassium is needed for enzyme activation, cell division, photosynthesis, photosynthates transport and osmo-regulations (Marques *et al*., 2018). Potassium is responsible for many important internal and external fruit characteristics including fruit size, rind thickness and colour (Mongi and Obreza, 2003).

Among essential nutrients, zinc (Zn) after nitrogen (N) is undoubtedly the most widely reported deficient nutrient in citrus orchards. In citrus, the role of zinc is performed both in term of growth and yield potential. Low level of zinc reduces fruit number per tree and reduces fruit quality. Zinc plays an important role as a co-factor of number enzymes and also involved in the production of growth regulation and chloroplast development. Foliar application of zinc is most effective in controlling zinc deficiency (rosette formation) and improvement of vegetative growth attributes, fruit morphological attributes and internal fruit quality attributes like total soluble solid and ascorbic acid content. Zinc also plays an important role in reducing pre harvest fruit drop (Mongi and Obreza, 2003).

Iron plays an important role in citrus production. It acts as a catalyst in oxidation reduction reactions. It is also involved in respiration, photosynthesis and the reduction of nitrate and sulphate. It is also a co-factor in many enzymes. Iron deficiency is common in calcareous soils. Jhalawar soil contains a high concentration of calcium carbonate and has an average pH of about 8.3. These soils may contain appreciable amounts of iron, but it exists in a form that is slightly available to plants, Iron deficiency in Nagpur mandarin plants can be induced by high phosphorus or accumulation of copper in the soil.

The most obvious effect of iron deficiency is lime induced chlorosis *i.e.* "iron chlorosis". Young leaves manifest itself into light yellow to white colour of leaves and the veins greener than remaining portion of the leaf. Canopy volume decreases and fruit set as well as mandarin yield are reduced. In severe cases, the entire tree is affected. Trees suffer from iron deficiency in calcareous soil with high pH values. Under such conditions, iron required to form chlorophyll becomes unavailable to the plant (Mongi and Obreza, 2003).

Copper plays an important role in photosynthesis, carboxylation efficiency, pollen viability, fruit set, respiration and water use efficiency. Copper deficiency is known as 'die back', 'ammoniation' and 'exanthema'. These names are synchronously synthesized from dying back of the twigs, frequent association with excess application of nitrogen and exudates on the surface of the twigs and fruits. The first symptoms of copper deficiency are formation of unusually vigorous, large, dark green foliage with a "bowing up" of the midrib. Twigs are unusually vigorous, long, angular, soft, frequently "S" shaped and somewhat drooping type. As deficiency become severe, the twig starts to die, some of the weak twigs will bear very small, yellowish green leaves that drop quickly, leaving the entire twig defoliated. The symptoms of copper deficiencies are most pronounced in orange. Brown stained area of hardened gum on the fruit rind may precede the appearance of leaf and twig symptoms (Mongi and Obreza, 2009).

Insufficient application of micro-nutrients and macro-nutrients to mandarin trees results in extreme depletion of macronutrients and micronutrients and multiple nutrient deficiencies may appear. Since mineral nutrients are major factor in maximizing quality and yield of citrus fruits. Citrus especially Nagpur mandarin is highly nutrient responsive crop both in terms of macro and micro nutrients, therefore, present investigation was being undertaken on Nagpur mandarin plants at Fruit Instructional Farm of College of Horticulture and Forestry, Jhalawar to study the foliar effect of potassium, zinc, iron and copper alone and in combination among these nutrients for fruit quality and yield enhancement of mandarin.

Materials and methods

The experimental entitled ''Effect of foliar spray of nutrients on yield and quality of Nagpur mandarin (*Citrus reticulata* Blanco.)'' was conducted during the year 2018-19, at the Fruit Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar. The solutions of 0.25% $ZnSO_4$, 0.5% $ZnSO_4$, 0.25% $CuSO_4$ and 0.5% $CuSO_4$ were prepared by diluting 25 g $ZnSO_4$, 50 g $ZnSO_4$, 25 g $CuSO_4$ and 50 g $CuSO_4$ in 10 liter of water for two mandarin plants and solutions were used after neutralizing with overnight soaking in lime to avoid leaf scorching and to increase absorption. Foliar application of potassium sulphate and micro-nutrients treatments were done with battery operated hand Knapsac sprayer at gravel stage during first week of May and at marvel stage during first week of July in eleven year old Nagpur mandarin tree.

The solution of 0.50% K_2SO_4 and 1.0% K_2SO_4 were prepared by diluting 50 g K_2SO_4 and 100 g K_2SO_4 in 10 liter of water for two mandarin plants.

The treatments combinations were:

Sr. No.	Treatment Notation	Treatment Contents
1	T_1	Control
2	T_2	$ZnSO_4$ (0.25%)
3	T_3	$ZnSO_4$ (0.50%)
4	T_4	$FeSO_4$ (0.25%)
5	T_5	$FeSO_4$ (0.50%)
6	T_6	$CuSO_4$ (0.25%)
7	T_7	$CuSO_4$ (0.50%)
8	T_8	K_2SO_4 (0.50%)
9	T_9	K_2SO_4 (1.0%)
10	T_{10}	$ZnSO_4$ (0.25%) + $FeSO_4$ (0.25%)
11	T_{11}	$ZnSO_4$ (0.25%) + $FeSO_4$ (0.50%)
12	T_{12}	$ZnSO_4$ (0.50%) + $FeSO_4$ (0.25%)
13	T_{13}	$ZnSO_4$ (0.50%) + $FeSO_4$ (0.50%)
14	T_{14}	$ZnSO_4$ (0.25%) + $CuSO_4$ (0.25%)
15	T_{15}	$ZnSO_4$ (0.25%) + $CuSO_4$ (0.50%)
16	T_{16}	$ZnSO_4$ (0.50%) + $CuSO_4$ (0.25%)
17	T_{17}	$ZnSO_4$ (0.50%) + $CuSO_4$ (0.50%)
18	T_{18}	$ZnSO_4$ (0.25%) + K_2SO_4 (0.50%)
19	T_{19}	$ZnSO_4$ (0.25%) + K_2SO_4 (1.0%)
20	T_{20}	$ZnSO_4$ (0.50%) + K_2SO_4 (0.50%)
21	T_{21}	$ZnSO_4$ (0.50%) + K_2SO_4 (1.0%)
22	T_{22}	$FeSO_4$ (0.25%) + $CuSO_4$ (0.25%)
23	T_{23}	$FeSO_4$ (0.25%) + $CuSO_4$ (0.50%)
24	T_{24}	$FeSO_4$ (0.50%) + $CuSO_4$ (0.25%)
25	T_{25}	$FeSO_4$ (0.50%) + $CuSO_4$ (0.50%)
26	T_{26}	$FeSO_4$ (0.25%) + K_2SO_4 (0.50%)
27	T_{27}	$FeSO_4$ (0.25%) + K_2SO_4 (1.0%)
28	T_{28}	$FeSO_4$ (0.50%) + K_2SO_4 (0.50%)
29	T_{29}	$FeSO_4$ (0.50%) + K_2SO_4 (1.0%)
30	T_{30}	$CuSO_4$ (0.25%) + K_2SO_4 (0.50%)
31	T_{31}	$CuSO_4$ (0.25%) + K_2SO_4 (1.0%)
32	T_{32}	$CuSO_4$ (0.50%) + K_2SO_4 (0.50%)
33	T_{33}	$CuSO_4$ (0.50%) + K_2SO_4 (1.0%)

The experiment was laid down in randomized block design with three replications. Mandarin quality parameters such as, TSS (°brix), acidity (%), TSS/Acidity ratio, ascorbic acid (mg/100 g), total sugars (%), reducing sugar (%), non-reducing sugar (%) and juice pH were recorded at horticultural maturity of Nagpur mandarin fruits. The chemical composition of Nagpur mandarin fruits with respect to total soluble solids (°brix), acidity (%), TSS/Acidity ratio, ascorbic acid (mg/100 g), total sugars (%), reducing sugar (%), non-reducing sugar (%) and juice pH were determined by (AOAC 1980) by taking the samples from extracted juice of fruits. The data generated during the experimentation were subjected to statistically analysed by Panse and Sukhatme (1954).

The present investigations were undertaken at Fruit Instructional Farm, College of Horticulture and Forestry, Jhalawar on eleven old plants of Nagpur mandarin planted at spacing of 6 X 6 meter under square system of planting. The total number of plants included in the experiment was 99. All the mandarin plants were selected on the basis of desired uniformity in growth and vigour and bearer. All the treatments were applied in first week of May, 2018 and first week of July, 2018.

Results And Discussion

The phenomenal quality attributes total soluble solids (°brix), acidity percentage, TSS/Acidity ratio, ascorbic acid (mg/100g), total sugars, reducing sugar, non-reducing sugars and juice pH are elucidated and discussed under suitable sub headings. The observations pertaining to mandarin yield are given in Table 1 & 2. The results obtained under present investigations are presented and discussed under in suitable sub headings.

1. Total Soluble Solids (°brix)

The maximum total soluble solids content (11.46 °brix) was estimated in T_{21} treatment ($ZnSO_4$ 0.5% + K_2SO_4 1.0%). This might be due to combined application of $ZnSO_4$ and K_2SO_4 in T_{21} treatment which supports the fact that macro-nutrients and micro-nutrients directly play an important role in plant metabolism. Pamila *et al.*, (1992) [41] supports present investigations that zinc is needed in enzymatic reaction like hexokinase, formation of carbohydrate and protein synthesis which facilitate hydrolysis of carbohydrates into simple sugar. The present results are in line with the finding of Lester, 2005 who reported that application of potassium decreased starch and phenol content of the fruit and increased the total soluble solids, total sugars and β-carotene content of Kinnow mandarin.

2. Acidity (%)

The minimum acidity percentage (0.33%) was observed in T_{21} treatment ($ZnSO_4$ @ 0.25% + K_2SO_4 @ 0.50%). The reduction in acidity might be obtained due to accumulation of reducing and non-reducing sugars. Thus, the fruit quality in terms of TSS, minimum acidity percentage and sugar content was improved by foliar sprays of Zinc and potassium sulphate treatment. The probable reason for decreased acidity in T_{21} treatment might be due to their utilization in respiration and rapid metabolic transformation of organic acids into sugars (Brahmachari *et al.*, 1997) [10]. Similar results were also reported by Patil *et al.*, (2016) [46] in Nagpur mandarin.

3. TSS/Acidity ratio

The TSS/Acidity is a vital characteristic determining the taste, texture and feel of fruit segments in Nagpur mandarin. It is the sugar: acid ratio which governs and contributes in mandarin fruits their peculiar flavor and taste. The maximum TSS/Acidity ratio (36.35) was estimated in T_{21} treatment ($ZnSO_4$ @ 0.5% + K_2SO_4 @ 1.0%) under present studies in response to foliar zinc spray $ZnSO_4$ @ @ 0.5% + K_2SO_4 @ 1.0%. The improvement in quality mandarin fruits might be due to the fact that nutrients play an important role in plant metabolism. The significantly higher ratio of TSS estimated in T_{21} treatment observed by combined foliar spray of Zn + K may probably be due to the fact that zinc has an important role in photosynthesis, resulting in increasing sugar content and decreasing acidity and potassium also regulated the carbohydrate metabolism in both source and sink ratio of mineral translocates tissues of the plants. The results of present findings are in accordance with those reported by Marschner (1996), Sangwan *et al.*, (2008) and Hamza *et al.*, (2012) [21].

4. Ascorbic acid (mg/100 g)

The ascorbic acid content was found maximum (44.96 mg/100g) in T_{21} treatment ($ZnSO_4$ @ 0.50% + K_2SO_4 @ 1.0%). The better ascorbic acid content in this treatment might be due to better sugar metabolism in plant as a results of foliar feeding of potassium sulphate in consonance with zinc application. Similar findings were reported by Mengel (1997) who ascribed vitamin C content correlated vitamin with sugar metabolism as a results proper K management. The report of Alva and Tucker (1999) [5] also supports the finding of present investigation that citrus fruits remove large amounts of K as compared to other nutrients. The role of potassium in formation of sugars, synthesis of proteins thereby increasing the source-sink ratio via influencing photosynthesis, accentuating enzymatic activities and neutralization of organic acids (Liu *et al.*, 2000) [30] can be taken as possible reason behind the finding as observed in T_{21} treatment. Results clearly showed that combined application of ($ZnSO_4$ @ 0.5% + K_2SO_4 @ 1.0%) was effective in increasing ascorbic acid content of Nagpur mandarin. The results indicate highest ascorbic acid under T_{21} treatment may attributed to effect of potassium in combination of zinc along with nitration of environmental factor, time of fruit harvest and age of the plant (Wang R., 2006)

5. Total sugars

The total sugar percentage among different treatments got significantly influenced by foliar application of micro-nutrients, potassium sulphate and their treatments combinations. The maximum total sugar content (7.82%) was obtained under T_{21} ($ZnSO_4$ 0.5% + K_2SO_4 1.0%) and minimum total sugar content (6.82%) was obtained under T_1 (control). The increase in sugar component by the foliar feeding of $ZnSO_4$ (0.5%) and K_2SO_4 (1.0%) might be due to their active involvement in photosynthesis of accumulates and rapid translocation of sugars from other parts of the plants to the developing fruits. Higher fruit quality especially total sugar content observed under T_{21} treatment for Nagpur mandarin. Fruits can be explained by the role of K in carbohydrate synthesis, breakdown, translocation and synthesis of protein and neutralization of physiologically important organic acids envisaged by (Tisdale and Nelson, 1966). These results are in conformity with the findings of El-Rahman (2003) [15] in Navel orange, Monga and Josan (2000) [35] in Kinnow mandarin, Dalal *et al.*, (2017) [13] in sweet orange.

6. Reducing sugars and 7. Non-reducing sugars

The reducing sugars and non- reducing sugars percentage of Nagpur mandarin fruits got significantly affected by foliar application of micro-nutrients, potassium sulphate and their treatment combinations. The maximum reducing sugar content (5.47%) and non-reducing sugars contents (2.35%) were obtained under T_{21} treatment ($ZnSO_4$ 0.5% + K_2SO_4 1.0%). Foliar sprays of K along with zinc also favours the conversion of starch into sugar during ripening by activating the sucrose synthesis enzyme. The finding s of present study are in consonance with those Sajid *et al.*, (2012) in sweet orange, Gill *et al.*, (2012) [17] in Kinnow mandarin, Bakshi *et al.*, (2013) in strawberry. The high reducing sugar under T_{21} treatment might be attributed to increase potassium uptake and better photosynthetic mechanism as influenced by zinc sulphate foliar spray. Present results are supported by the finding of Razzag *et al*. (2013) where co-workers reported that the foliar application of zinc sulphate upto @ 0.6% improved the fruit quality in Kinnow mandarin.

8. Juice pH

The juice pH content got significantly influence by application of micro-nutrients and potassium sulphate foliar feeding in Nagpur mandarin leaves. The maximum juice pH (4.06) was recorded under T_{21}treatment ($ZnSO_4$ 0.50% + $K_2SO_4$1.0%). The higher juice pH observed under T_{21} treatment could be attributed to the synergetic effect of zinc and potassium in increasing osmolyte concentration of juice when applied after fruit set stage. The role of zinc and potassium may be ascribed to being essential component of enzymes responsible for carbohydrates (K) and nitrogen (Zn) metabolism thereby resulting into increasing nitrogen uptake by the plants. Nitrogen is one of the chief nutrients absorbed by citrus roots perfectly in the form of nitrate (NO_3^-) anion. It is constituent of amino acids, proteins, nucleic acids, nucleotides, hexaamines and co-enzymes which facilitate metabolism of other nutrients into the juice vesicles thereby causing to increase the juice pH. Further role of zinc in accelerating photosynthesis process, nucleic acid metabolism and protein metabolism also supports the nutrient enrichment of juice leading to increased juice pH. The results of present findings are in accordance with those reported by Rathore and Chandra (2002), Alloway (2008) [3] and Razzaq *et al.*, (2013).

Table 1: Effect of foliar spray of nutrients on quality parameters in Nagpur mandarin.

Sr. No.	Treatments	TSS (°brix)	Acidity (%)	TSS/Acidity ratio	Ascorbic acid (mg/100ml)
1	Control	9.89	0.60	17.63	37.20
2	$ZnSO_4$ (0.25%)	10.58	0.55	19.36	38.91
3	$ZnSO_4$ (0.50%)	10.65	0.45	23.56	38.82
4	$FeSO_4$ (0.25%)	10.29	0.54	18.99	38.47
5	$FeSO_4$ (0.50%)	10.47	0.48	21.71	39.25
6	$CuSO_4$ (0.25%)	10.58	0.46	22.96	39.14
7	$CuSO_4$ (0.50%)	10.70	0.59	18.07	40.02
8	K_2SO_4 (0.50%)	10.79	0.45	24.05	38.90
9	K_2SO_4 (1.0%)	10.64	0.53	19.52	40.27
10	$ZnSO_4$ (0.25%) + $FeSO_4$ (0.25%)	10.65	0.59	17.01	40.09
11	$ZnSO_4$ (0.25%) + $FeSO_4$ (0.50%)	10.71	0.46	26.91	40.79
12	$ZnSO_4$ (0.50%) + $FeSO_4$ (0.25%)	10.69	0.49	23.58	40.50
13	$ZnSO_4$ (0.50%) + $FeSO_4$ (0.50%)	10.43	0.41	23.72	39.70
14	$ZnSO_4$ (0.25%) + $CuSO_4$ (0.25%)	10.81	0.48	22.60	40.15
15	$ZnSO_4$ (0.25%) + $CuSO_4$ (0.50%)	10.85	0.58	18.01	40.70
16	$ZnSO_4$ (0.50%) + $CuSO_4$ (0.25%)	10.76	0.46	23.60	41.07
17	$ZnSO_4$ (0.50%) + $CuSO_4$ (0.50%)	10.38	0.57	17.87	41.41
18	$ZnSO_4$ (0.25%) + K_2SO_4 (0.50%)	10.72	0.47	22.94	40.75
19	$ZnSO_4$ (0.25%) + K_2SO_4 (1.0%)	10.91	0.50	21.31	42.73
20	$ZnSO_4$ (0.50%) + K_2SO_4 (0.50%)	11.01	0.38	30.62	43.15
21	$ZnSO_4$ (0.50%) + K_2SO_4 (1.0%)	11.46	0.33	36.35	44.96
22	$FeSO_4$ (0.25%) + $CuSO_4$ (0.25%)	11.13	0.38	27.97	39.86
23	$FeSO_4$ (0.25%) + $CuSO_4$ (0.50%)	10.90	0.52	18.13	40.39
24	$FeSO_4$ (0.50%) + $CuSO_4$ (0.25%)	10.79	0.43	27.29	40.41
25	$FeSO_4$ (0.50%) + $CuSO_4$ (0.50%)	10.82	0.58	18.51	39.47
26	$FeSO_4$ (0.25%) + K_2SO_4 (0.50%)	10.86	0.41	25.56	41.32
27	$FeSO_4$ (0.25%) + K_2SO_4 (1.0%)	10.51	0.51	24.09	40.80
28	$FeSO_4$ (0.50%) + K_2SO_4 (0.50%)	10.74	0.39	28.90	41.21
29	$FeSO_4$ (0.50%) + K_2SO_4 (1.0%)	10.81	0.51	19.48	40.78
30	$CuSO_4$ (0.25%) + K_2SO_4 (0.50%)	10.47	0.37	30.52	40.10
31	$CuSO_4$ (0.25%) + K_2SO_4 (1.0%)	10.80	0.50	17.76	38.89
32	$CuSO_4$ (0.50%) + K_2SO_4 (0.50%)	10.79	0.44	24.25	39.54
33	$CuSO_4$ (0.50%) + K_2SO_4 (1.0%)	10.72	0.43	24.63	38.91
S.Em±		0.15	0.03	1.32	0.60
CD at 5%		0.44	0.11	3.74	1.70

Table 2: Effect of foliar spray of nutrients on quality parameters in Nagpur mandarin

Sr. No.	Treatments	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Juice pH
1	Control	6.62	4.62	2.00	3.59
2	$ZnSO_4$ (0.25%)	7.30	5.10	2.19	3.64
3	$ZnSO_4$ (0.50%)	7.34	5.13	2.21	3.64
4	$FeSO_4$ (0.25%)	7.10	4.96	2.13	3.72
5	$FeSO_4$ (0.50%)	7.22	5.05	2.18	3.71
6	$CuSO_4$ (0.25%)	7.26	5.07	2.18	3.65
7	$CuSO_4$ (0.50%)	7.34	5.13	2.21	3.72
8	K_2SO_4 (0.50%)	7.41	5.18	2.22	3.74
9	K_2SO_4 (1.0%)	7.26	5.08	2.18	3.73
10	$ZnSO_4$ (0.25%) + $FeSO_4$ (0.25%)	7.31	5.11	2.16	3.78
11	$ZnSO_4$ (0.25%) + $FeSO_4$ (0.50%)	7.35	5.14	2.20	3.76
12	$ZnSO_4$ (0.50%) + $FeSO_4$ (0.25%)	7.30	5.13	2.17	3.73
13	$ZnSO_4$ (0.50%) + $FeSO_4$ (0.50%)	7.16	5.00	2.15	3.76
14	$ZnSO_4$ (0.25%) + $CuSO_4$ (0.25%)	7.35	5.14	2.16	3.82
15	$ZnSO_4$ (0.25%) + $CuSO_4$ (0.50%)	7.41	5.18	2.23	3.82
16	$ZnSO_4$ (0.50%) + $CuSO_4$ (0.25%)	7.35	5.14	2.21	3.82
17	$ZnSO_4$ (0.50%) + $CuSO_4$ (0.50%)	7.09	4.89	2.20	3.81
18	$ZnSO_4$ (0.25%) + K_2SO_4 (0.50%)	7.35	5.14	2.21	3.90
19	$ZnSO_4$ (0.25%) + K_2SO_4 (1.0%)	7.45	5.18	2.26	3.79
20	$ZnSO_4$ (0.50%) + K_2SO_4 (0.50%)	7.48	5.16	2.32	4.04
21	$ZnSO_4$ (0.50%) + K_2SO_4 (1.0%)	7.82	5.47	2.35	4.06
22	$FeSO_4$ (0.25%) + $CuSO_4$ (0.25%)	7.60	5.29	2.31	3.81
23	$FeSO_4$ (0.25%) + $CuSO_4$ (0.50%)	7.45	5.21	2.24	3.76
24	$FeSO_4$ (0.50%) + $CuSO_4$ (0.25%)	7.40	5.17	2.22	3.71
25	$FeSO_4$ (0.50%) + $CuSO_4$ (0.50%)	7.28	5.09	2.18	3.72
26	$FeSO_4$ (0.25%) + K_2SO_4 (0.50%)	7.20	5.03	2.19	3.73
27	$FeSO_4$ (0.25%) + K_2SO_4 (1.0%)	7.04	4.92	2.11	3.76
28	$FeSO_4$ (0.50%) + K_2SO_4 (0.50%)	7.08	4.95	2.13	3.77
29	$FeSO_4$ (0.50%) + K_2SO_4 (1.0%)	7.00	4.89	2.10	3.75
30	$CuSO_4$ (0.25%) + K_2SO_4 (0.50%)	6.94	4.85	2.08	3.75
31	$CuSO_4$ (0.25%) + K_2SO_4 (1.0%)	7.51	4.97	2.14	3.76
32	$CuSO_4$ (0.50%) + K_2SO_4 (0.50%)	7.01	4.88	2.13	3.73
33	$CuSO_4$ (0.50%) + K_2SO_4 (1.0%)	7.00	4.82	2.17	3.70
S.Em±		0.12	0.08	0.06	0.02
CD at 5%		0.34	0.24	0.17	0.06

Acknowledgement
The author is grateful to Dr. I. B. Morya, Dean, College Of Horticulture and Forestry, Jhalawar for providing all the necessary facilities for conducting the research.

Conflict of Interest
Author has no conflict of interest of any type.

References
1. AOAC. Official methods of analysis. Edn. 14th, Association of official Analytical chemists, Washington, D. C 1990.
2. Ahmed AMH, Khalil MK, Abd-El Rahman AM, Nadia AMH. Effect of zinc, tryptophan and mdol acetic acid in growth, yield and chemical composition of Valencia orange trees. Journal of Applied Sciences research, 2012;8(2):901-914.
3. Alloway BJ. Zinc in soils and crop nutrition. *International Zinc Association* Brussel, Belgium 2008.
4. Alobeed RS, Aziz Ahmed MA, Kassem H, Al-Saif MA. Improvement of “Kinnow” mandarin fruit productivity and quality by urea, boron and zinc foliar spray. Journal of Plant Nutrition 2017. DOI: 10.1080/01904167.2017.1406111
5. Alva AK, Tueker DPH. Soils and citrus nutrition. In Timmer, LW, Duncan, LW (eds), Citrus Health Management. APS Press 1999, 59-71, ISBNO-89054-227-9.
6. Anonymous *Indian Horticulture Database*, 2014. Published From National Horticulture Board, Gurgaon, 2015, 118-121.
7. Ashraf MY, Hussain F, Ashraf M, Akhter J, Ebert G. Modulation in yield and juice quality characteristics of citrus fruit from trees supplied with zinc and potassium foliarly. Journal of Plant Nutrition 2013;36(13):1996-2012.
8. Babu KD, Yadav DS. Foliar spray of micronutrients for yield and quality improvement in Khasi mandarin (*Citrus reticulata* Blanco.). Indian Journal of Horticulture 2005;62(3):280-281.
9. Babu KD, Dubey AK, Yadav DS. Effect of micro-nutrients on enhancing the productivity and quality of Kinnow mandarin. Indian Journal of Horticulture, 2007;64(3):353-356.
10. Banik BC, Sen SK. Effect of three level of zinc, iron, boron and their interaction on growth, flowering and yield of mango cv. Fazli. Horticulturae Journal 1997;10(1):23-29.
11. Bhanukar B, Rana GS, Sehrawat SK, Preeti. Effect of exogenous application of micronutrients on growth and yield of sweet orange CV. Blood Red. Journal of Pharmacognosy and Phytochemistry 2018;7(2):610-612.
12. Bhatnagar P, Singh J, Jain SK. Physio-chemical variations in fresh ‘Nagpur mandarin’ fruits of Jhalawar district. Hort Flora Research Spectrum 2015;4(4):293-300.

13. Dalal RPS, Vijay, Beniwal BS. Influence of foliar sprays of different potassium fertilizers on quality and leaf mineral composition of Sweet Orange (*Citrus sinensis*) cv. Jaffa, Int. J. Pure App. Biosci. 2017;5(5):587-594.
14. Devi DD, Srinivasan PS, Balkrishan K. Effect of zinc, iron and manganese on yield and quality of sweet orange cv. Sathgudi. Madras Agri. J. 1997;84(8):460-463.
15. El-Rahman AMA. Effects of some nutrients and growth substances application on fruiting, yield and fruit quality of Navel orange trees. Bulletin of Faculty of Agriculture, Cairo University 2003;54(2):175-187.
16. El-Saida SAG. Effect of some growth regulators and zinc sulphate treatments on yield and quality of washington navel orange. Annals of Agricultural Science 2001;39:1199-1212.
17. Gill PPS, Ganaie MY, Dhillon WS, Singh NP. Effect of foliar sprays of potassium on fruit size and quality of 'Patharnakh' pear. Indian J. Hort 2012;69(4):512-516.
18. Gill PS, Singh SN, Dhatt AS. Effect of foliar application of K and N fertilizers on fruit quality of Kinnow mandarin. Indian J. Hort 2005;62(3):282-285.
19. Gurjar PS, Rana GS. Influence of foliar application of nutrients and growth regulator on fruit drop, yield and fruit size and quality in Kinnow mandarin. Indian Journal of Horticulture 2014;71(1):109-111.
20. Haque R, Roy A, Pramanick M. Response of foliar application of Ca, Zn, and B on improvement of growth, yield and quality of mandarin orange in Darjeeling hills of West Bengal. Horticultural Journal 2000;13(2):15-20.
21. Hamza A, Bamouh A, Guili Mel, Bouabid R. Response of Clementine citrus to foliar potassium fertilization. Effects on fruit production and quality. E-itc No. 2012;31:8-15
22. Ingle HV, Kokate SS, Athwale RB, Katole SR. Effect of foliar application of zinc and iron on growth, yield and quality of acid lime. Indian Journal of Citriculture 2002;1(1):43-45.
23. Ismail MM. Imorovement in Velencia oranges though foliar supplication of potassium and zinc. *Pakisthan* Journal of Botany 1994;40(2):1505-1515.
24. Jian Wei, Lu Chen Fang, Lue Dong Bi, Wan Yun, Fan Yu Chang Bing, Wang, *et al*. Effect of application of potassium sulphate, zinc and potassium chloride on growth of citrus tree, yield and quality of fruits. Soils and fertilizers (Beiging) 2002;1(4):34-40.
25. Kaur N, Monga PK, Aroraand PK, Kumar K. Effect of micronutrients on leaf composition, fruit quality and yield of Kinnow mandarin. Journal of Applied and Natural Science 2015;7(2):639-643.
26. Kazi SS, Ismail S, Joshi KG. Effect of multi-micronutrients on yield and quality attributes of the sweet orange. African Journal of Agricultural Research 2012;7(29):1418-1423.
27. Khan AS, Ullah W, Malik A, Ahmad R, Ishtiaq A. Exogenous applications of boron and zinc influence leaf nutrient status, tree growth and fruit quality of Feutrell's early (*Citrus reticulata* Blanco). Pak. J. Agri. Sci 2012;49(2):113-119.
28. Kumar CJ, Rajanagan J, Balakrishnan K, Sampath PM, Kavya MV. Influence of Foliar Application of Micronutrients on Tree Growth and Chlorophyll Status of Mandarin Orange (*Citrus reticulata* Blanco.) under Lower Pulney Hills. Int. J. Pure App. Biosci. 2016;5(2):1100-1104.
29. Lester GE. Whole Plant Applied Potassium: Effects on Cantaloupe Fruit Sugar Content and Related Human Wellness Compounds. Acta Hort 2005;682:487-492.
30. Lui K, Huihua F, Bixin, Luan S. Inward potassium channel in guard cells as a taeget polyamine regulation of stomatal movements. Plant physiol 2000;124:1315-1326.
31. Malik RP, Ahlawat VP, Nain AS. Effect of foliar spray of urea and zinc sulphate on yield and fruit quality of Kinnow mandarin hybrid. Haryana Journal of Horticultural Science 2000;29(12):37-38.
32. Meena MK, Jain MC, Singh J, Sharma M, Singh B, Moriya IB. Influence of Pre-harvest spray of Calcium nitrate, Boric acid and Zinc sulphate on Quality and Storage life of Nagpur mandarin (*Citrus reticulata* Blanco). Che. Sci. Rev. and Lett. 2015;6(22):818-826.
33. Meston AJ. Methods of chemical analysis for soil survey samples. Department of Sci. Md. Res. Soil Bur. 1956, 12.
34. Mishra LN, Singh SK, Sharma HC, Goswami AM, Pratap B. Effect of micronutrients and rootstocks on fruit yield and quality of Kinnow under high density planting. Indian Journal of Horticulture 2003;60(2):131-134.
35. Monga PK, Josan JS. Effect of micronutrients on leaf composition, fruit yield and quality of Kinnow mandarin. Journal of Applied Horticulture 2000;2(2):132-133.
36. Muhammad SAR, Muhammad A, Ferguson A, Ahmed LM. Effect of foliar application of Zn and B on fruit production and physiological disorders in sweet orange cv. Blood orange. Sarhad Journal of Agriculture 2010;26(3):355-360.
37. Obrza TA, Zekri M, Hanlon EA, Morgan K, Schumann A, Rouse R. Soil and leaf tissue testing for commercial cirus production. University of Florida Extension Service, 2010;Sl:253-254.
38. Olsen SR, Code CV, Wantanabe FS, Dean LA. Estimation of available phosphorus in soil by extraction with $NaHCo_3$, V.S. Dept. agric 1954, 239.
39. Omaima MH, El-Metwally IM. Efficiency of zinc and potassium sprays alone or in combination with some weed control treatments on weeds growth, yield and fruit quality of Washington Navel orange orchards. Journal of Applied Sciences Research 2007, 613-621.
40. Opazo AJD, Razeto MB. Effect of different potassium fertilizers and zinc on foliar content of nutrients, yield and fruit quality in orange tree, cv. Velencia, Agriculture Technica 2010;66(4):470-478.
41. Pamila S, Chattergee SR, Deb DL. Seed yield, harvest index, protein content and amino acid composition of cheekpea as affected by sulphur and micronutrients. 1992;3(1):7-11
42. Panse, Sukhatme. Analyzed by following analytical method as followed for Randomized Block Design (RBD) as per method 1995.
43. Pant V, Lavania ML. Effect of foliar sprays of iron, zinc and boron on growth and yield of papaya (*Carica papaya* L.). Journal of South Indian Hortculture 1998;46(1):1-2 5-8.
44. Pathak M, Bauri FK, Misra DK, Bandyopadhyay B, Chakraborty K. Application of micronutrients on growth, yield and quality of banana. Journal of Crop and Weed 2011;7(1):52-54.
45. Patil MS, Shafeeq LB, Swamy GSK. Studies on the influence of micronutrient on growth, yield and quality of Kinnow mandarin. Trends in Biosciences 2014;7(9):786-788.
46. Patil SR, Sonkamble AM, Debage PP. Fruit development and maturity of mrig bahar Nagpur mandarin fruits. The Asian journal of Horticulture 2016;2(1):151-153.