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## Effect of NAA and zinc sulphate application on nutritional status of fruits and leaves of mulberry (*Morus alba* L.)

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### Abstract

The investigation entitled "Effect of NAA and zinc sulphate application on fruit drop, yield and quality attributes of mulberry (*Morus alba* L.)" was conducted during 2018-19. Significant improvement in the leaves and fruit nutrient (Nitrogen, Phosphorus, Potassium and Zinc) concentrations was obtained with the foliar sprays of zinc sulphate and NAA. Maximum N, P and K content was found with the foliar spray of zinc sulphate @ 0.4 per cent and NAA @ 60 ppm, while maximum zinc content was found with the foliar spray of zinc sulphate @ 0.6 per cent and NAA @ 60 ppm.

**Keywords:** Foliar spray, fruits, leaves, mulberry, NAA, and zinc sulphate

### Introduction

Mulberry (*Morus alba* L.) is a very hardy plant belonging to the genus *Morus* under Moraceae family and Asia is considered to be the centre of origin of mulberry. It is called as "Murics" in France, "Lewwa" in Japan and "Gelso" in Italy. Mulberry is basically a cool season fruit tree but it can be widely grown in both tropical zone covering Karnataka, Andhra Pradesh and Tamil Nadu states, with about 90% area and sub-tropical zone including West Bengal, Himachal Pradesh and north-eastern (Datta, 1999) [5]. Commonly mulberry (Tut) is extensively cultivated in plains and hilly areas and can be grown in several soil conditions upto an elevation of 3300 m above mean sea-level. It requires temperature ranging from 24 °C to 37 °C (Chattopadhyay, 1997) [4]. Mulberry is one of the most common fruit trees found all over India. The total acreage of mulberry in India is around 2.82 lakh hectare and for different states, Karnataka has 1.66 lakh hectare which is a leading state in area and production in mulberry followed by Andhra Pradesh, Manipur, West Bengal, Tamil Nadu, Uttar Pradesh, Jammu and Kashmir, Assam, Madhya Pradesh and Kerala (Saroj and Awasthi, 2006) [16]. Mulberry is a multipurpose fruit tree, mostly cultivated for rearing silkworm, useful timber and in few areas used for roadside plantation but its importance, as a fruit crop should also not be undermined. There are about 100 species of the genus *Morus*, the majority of them occur in Asia, especially 24 species in China and 19 species in Japan. Continental America is also rich in its *Morus* species and the genus *Morus* is poorly signify in Africa, Europe and Middle East. Most of the species of the genus *Morus* and cultivated varieties are diploid. However, triploids are also extensively cultivated for their adaptability, vigorous growth and quality of leaves. Several species of mulberry (*Morus alba*, *Morus indica*, *Morus nigra*, *Morus serrata* and *Morus lavigata*) are grown in India. (Datta, 1999) [5].

Nutrients (ZnSO<sub>4</sub>) and growth regulators (NAA) play a key role in the metabolism, growth, reproduction and chemical composition of fruit. Zinc plays a vital role in enzyme activities and is necessary for growth and development and is also important element for flowering, fruiting, growth, quality of fruits and helps in other nutrient absorption. It also increases the chlorophyll content of leaves (Sharma and Tiwari, 2015) [17]. Zinc acts as a catalyser in the oxidation and reduction process and is also of great importance in sugar metabolism. Increase in the fruit weight by zinc application is due to the significant increase in the fruit diameter and considerable increase in the fruit length. It promotes synthesis of IAA through tryptophan which serves as a precursor for auxin synthesis and directly affects the growth parameters and

soil nutrient absorption. It is essential for carbon dioxide evolution and utilization, carbohydrate and phosphorous metabolism and synthesis of proteins.

NAA is a most important growth regulator of auxin group, which reduces the fruit drop and improve fruit set and quality specially TSS and also helps in soil nutrient absorption because auxin increase the mobility of nutrients. It also helps to induce heavy fruiting and promotes flowering (Sharma and Tiwari, 2015)<sup>[17]</sup>.

NAA and zinc sulphate are reported to be effective in nutrients absorption by plant roots from soil which helps in fruit drop control and quality improvement in several fruit crops, however limited information is available in the present agro climate conditions of Haryana with respect to mulberry.

### Materials and Methods

This experiment was conducted during 2018-19, on uniform thirty-two years old plants of Local cultivar of mulberry

(*Morus alba* L.) trees planted at the spacing of 10X10 m. Experiment was carried out at Experimental orchard, Laboratory of the Department of Horticulture and Laboratory of Department of Soil Science, CCS Haryana Agricultural University, Hisar, (Haryana). Experimental orchard is situated at 215.2 m above mean sea level at 29° 10' N latitude and 75° 46' E longitudes. A large variation occurs for total annual rainfall and its distribution throughout the year. The average rainfall of this area is around 450 mm, 75-80 per cent of which is received during rainy season, i.e., July to September, while a few occasional rainfalls also occur during the months from December to February due to western disturbances. During summer months of May and June, the temperature reaches maximum up to 48°C while during winter months of December and January, the minimum temperature comes down to the freezing point. The physico-chemical properties of the soil of experimental field are presented below in Table.

Physico-chemical properties of soil of the experimental field

S. No.	Parameters	Observed value	Method of determination
1	Soil texture	Sandy loam	
2	Organic carbon (%)	0.46	Wet digestion method (Walkley and Black, 1965) <sup>[20]</sup>
3	pH	8.10	Glass electrode pH meter (Jackson, 1973) <sup>[7]</sup>
4	EC (ds/m)	0.38	1:2 soil water suspension. USDA Handbook No. 60 (Richards, 1954) <sup>[15]</sup>
5	Available nitrogen (kg/ha)	140.50	Alkaline potassium permanganate method (Subhaiah and Asija, 1956) <sup>[18]</sup>
6	Available phosphorus (kg/ha)	32.00	Olsen's method (Olsen <i>et al.</i> , 1954) <sup>[12]</sup>
7	Available potassium (kg/ha)	554.00	Flame photometer method (Richards, 1954) <sup>[15]</sup>

The field selected for conducting the research experiment was uniform in fertility gradient. A composite soil sample from 0 to 30 cm of soil depth was taken randomly in zigzag pattern from ten different places of the field before preparing layout of the experiment. The soil samples so collected were mixed properly, dried and subjected to mechanical and chemical analysis. The soil analysis data indicates that the soil of the experimental field was sandy loam in texture, medium in organic carbon, non-saline, low in available nitrogen, high in available phosphorus and very high in available potassium.

The experiment was laid out in a Factorial Randomized Block Design with two replication and sixteen treatments these are of comprises combining foliar sprays of Naphthalene acetic acid (NAA) at 20 ppm, 40 ppm and 60 ppm along with micronutrients ZnSO<sub>4</sub> at 0.20%, 0.40% and 0.60 % and control. The plant growth regulator and micronutrients were combine sprayed at two times. First combine spraying of plant growth regulator (NAA) and micronutrients (ZnSO<sub>4</sub>) was carried in the first week of March and second spraying in last week of March after first spray.

### Sampling and Measurements for Nutrient analysis of leaf and fruit

Composite leaf samples comprising of coarse, medium and tender leaves were collected from all the four sides and centre shoot of the plant as described by Nakashima (1931)<sup>[11]</sup>. Similarly composite fruit samples comprising of immature, mature and over mature fruit were collected from all the four sides and centre shoot of the plant as described by Nakashima (1931)<sup>[11]</sup>. Collected leaf and fruit samples were washed with tap water and then dipped in 0.1% HCl. The samples were then washed with single and double distilled water. These samples were then air dried on filter papers and then oven dried at 65°C (Chapman, 1964)<sup>[4]</sup> till constant weight was found. The samples were grinded in stainless steel blender and sieved through 0.2 mm mesh and were sealed in labelled

airtight polythene bags for subsequent analysis. For determination of nitrogen, a grinded leaf and fruit sample of 0.5 g was taken in a 50 ml conical flask and 15 ml of di-acid mixture (H<sub>2</sub>SO<sub>4</sub>: HClO<sub>4</sub> in 4:1 ratio) was added for digestion on a hot plate till the solution became clear as described by Jackson (1973)<sup>[7]</sup>.

For determination of phosphorus, potassium and zinc content, the samples were digested in di-acid (HNO<sub>3</sub>: HClO<sub>4</sub> in 4:1 ratio). The digestion was carried out in 50 ml conical flasks on hot plate till the solution became clear following the procedure given by Jackson (1973). The digested solutions were used for the determination of N using Nessler's reagent method, P by Vanado-molybdo phosphoric acid yellow colour method, and K by flame photometer as described by Jackson (1973)<sup>[7]</sup>. Metal element (Zn) was estimated on Atomic absorption spectrophotometer as outlined by Lindsay and Norvell (1978)<sup>[10]</sup>.

### Results and Discussion

#### Leaf nutrients analysis

The result exhibited in table-1 that there was significant increases in the nitrogen content in leaves with the foliar sprays of ZnSO<sub>4</sub> and NAA. Maximum nitrogen content was observed from the leaves of plants receiving ZnSO<sub>4</sub> @ 0.4 per cent (1.20%) and NAA @ 60 ppm (1.13%) which was at par with NAA @ 40 ppm (1.10%). The interaction results was found significantly maximum with the combination of ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 20 ppm as well as ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 60 ppm (1.26%) followed by ZnSO<sub>4</sub> @ 0.6 per cent + NAA @ 60 ppm (1.24%). Zinc reported as a precursor for tryptophan and which was synthesis of auxin and auxin (NAA) was work as a nutrient mobilization in plant system, so this was the reason for improving nitrogen content in the leaves. These outcomes are in close agreement with the results of Kumari *et al.* (2009)<sup>[9]</sup> who observed highest leaf concentrations of nitrogen was found from leaves of trees

sprayed with zinc sulphate (0.5%) in Kinnow mandarin. Similar results were observed by Ashraf *et al.* (2013) [1] in pecan nut, Razzaq *et al.* (2013) [14] and Prasad *et al.* (2017) [13] in Kinnow mandarin and Sau *et al.* (2018) [19] in guava.

**Table 1:** Effect of NAA and zinc sulphate on nitrogen content in leaves (%) in mulberry

Micro-nutrient spray	Nitrogen in leaf (%)				
	Growth regulator spray (NAA)				
	0 ppm	20 ppm	40 ppm	60 ppm	Mean
Zinc sulphate 0%	0.85	0.94	1.00	0.95	0.93
Zinc sulphate 0.2%	0.91	0.91	1.11	1.08	1.00
Zinc sulphate 0.4%	1.15	1.26	1.15	1.26	1.20
Zinc sulphate 0.6%	1.14	1.13	1.14	1.24	1.16
Mean	1.01	1.06	1.10	1.13	
CD at 5%	Zn = 0.04, NAA = 0.04, Zn x NAA = 0.08				

An appraisal of data recorded in table-2 exhibited that there was significant improvement in the phosphorus content in leaves with the foliar application of ZnSO<sub>4</sub> and NAA. Maximum phosphorus content was observed with ZnSO<sub>4</sub> @ 0.4 per cent (0.49%) followed by ZnSO<sub>4</sub> @ 0.6 per cent (0.47%) and NAA @ 60 ppm (0.50%). The interaction was found maximum with the foliar spray of ZnSO<sub>4</sub> @ 0.6 per cent + NAA @ 60 ppm (0.54%) followed by ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 20 ppm as well as ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 60 ppm (0.53%). This was mainly due to increase in nutrient concentration of plant system leads to increased phosphorus content in leaves. The increase in growth parameters and dry matter production of plants favours plant uptake of more nutrients. These outcomes are in close agreement with the results of Kumari *et al.* (2009) [9] who observed highest leaf concentrations of phosphorus was found from leaves of trees spray with zinc sulphate (0.5%) in Kinnow mandarin. Similar results were observed by Ashraf *et al.* (2013) [1] in pecan nut, Razzaq *et al.* (2013) [14] and Prasad *et al.* (2017) [13] in Kinnow mandarin.

**Table 2:** Effect of NAA and zinc sulphate on phosphorus content in leaves (%) in mulberry

Micro-nutrient spray	Phosphorus in leaf (%)				
	Growth regulator spray (NAA)				
	0 ppm	20 ppm	40 ppm	60 ppm	Mean
Zinc sulphate 0%	0.28	0.44	0.40	0.45	0.39
Zinc sulphate 0.2%	0.41	0.40	0.44	0.46	0.43
Zinc sulphate 0.4%	0.46	0.53	0.46	0.53	0.49
Zinc sulphate 0.6%	0.44	0.46	0.46	0.54	0.47
Mean	0.40	0.46	0.44	0.50	
CD at 5%	Zn = 0.03, NAA = 0.03, Zn x NAA = 0.05				

A perusal of observations recorded in table-3 showed that potassium content was observed maximum with ZnSO<sub>4</sub> @ 0.4 per cent (4.93%) treatment which was at par with ZnSO<sub>4</sub> @ 0.6 per cent (4.89%) and NAA @ 60 ppm treatment. The interaction was found significantly maximum with the combination of ZnSO<sub>4</sub> @ 0.6 per cent + NAA @ 60 ppm (5.26%) followed by ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 60 ppm (5.15%) and ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 20 ppm (5.14%). It may be due to the fact that increases absorption of zinc and growth regulator that act as a mobilizer leads to increasing potassium content in leaves. These outcomes are in close agreement with the results of Khan *et al.* (2012) [8] who recorded highest increase of K in leaf was observed in the trees treated with ZnSO<sub>4</sub> @ 0.5 per cent in mandarin (*Citrus reticulata* Blanco.) cv. Feutrell's Early. Similar results were

observed by Razzaq *et al.* (2013) [14] in and Prasad *et al.* (2017) [13] in Kinnow mandarin and Sau *et al.* (2018) [19] in guava.

**Table 3:** Effect of NAA and zinc sulphate on potassium content in leaves (%) in mulberry

Micro-nutrient spray	Potassium in leaf (%)				
	Growth regulator spray (NAA)				
	0 ppm	20 ppm	40 ppm	60 ppm	Mean
Zinc sulphate 0%	3.18	4.19	4.22	4.25	3.96
Zinc sulphate 0.2%	4.71	4.70	4.66	4.82	4.72
Zinc sulphate 0.4%	4.62	5.14	4.81	5.15	4.93
Zinc sulphate 0.6%	4.71	4.82	4.78	5.26	4.89
Mean	4.30	4.71	4.62	4.87	
CD at 5%	Zn = 0.15, NAA = 0.15, Zn x NAA = 0.30				

The findings of the present study exhibited in table 4 that there was significant improvement in the zinc content was observed with the foliar spray of ZnSO<sub>4</sub> @ 0.6 per cent (111.71ppm) followed by ZnSO<sub>4</sub> @ 0.4 per cent (110.78ppm) and NAA @ 60 ppm (110.18ppm). The interaction was found significantly maximum with the combined application of ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 60 ppm (114.95ppm) followed by ZnSO<sub>4</sub> @ 0.6 per cent + NAA @ 60 ppm (113.70ppm) and ZnSO<sub>4</sub> @ 0.6 per cent + NAA @ 40 ppm (113.15ppm). This may be due to zinc uptake rate was faster in mulberry trees when ZnSO<sub>4</sub> was foliar application as compared with its soil applied (Bahadur *et al.*, 1998). These outcomes are in close agreement with the results of Kumari *et al.* (2009) [9] who observed highest zinc concentrations when Kinnow mandarins were foliar spray with ZnSO<sub>4</sub> @ 0.5 per cent. Similar results were observed by Hasani *et al.* (2012) [6] in guava, Khan *et al.* (2012) [8], Razzaq *et al.* (2013) [14] and Prasad *et al.* (2017) [13] in Kinnow mandarin, Ashraf *et al.* (2013) [1] in pecan nut and Sau *et al.* (2018) [19] in guava. This might be due to the fact that application of zinc improves the concentration of zinc in plant tissue.

**Table 4:** Effect of NAA and zinc sulphate on zinc content in leaves (ppm) in mulberry

Micro-nutrient spray	Zinc in leaf (ppm)				
	Growth regulator spray (NAA)				
	0 ppm	20 ppm	40 ppm	60 ppm	Mean
Zinc sulphate 0%	91.60	110.60	100.15	107.25	102.40
Zinc sulphate 0.2%	101.50	103.95	107.75	104.80	104.50
Zinc sulphate 0.4%	110.35	109.15	108.65	114.95	110.78
Zinc sulphate 0.6%	109.45	110.55	113.15	113.70	111.71
Mean	103.23	108.56	107.43	110.18	
CD at 5%	Zn = 1.22, NAA = 1.22, Zn x NAA = 2.45				

### Fruit nutrients analysis

A perusal of data recorded on per cent fruit nitrogen shown in table-5 reveals that there was a significant improvement in nitrogen content in fruits was observed with the foliar application of zinc sulphate and NAA. Maximum nitrogen content was observed from the fruits of tree receiving ZnSO<sub>4</sub> @ 0.4 per cent (1.18%) followed by ZnSO<sub>4</sub> @ 0.6 per cent (1.16%) and NAA @ 60 ppm (1.12%) followed by NAA @ 40 ppm (1.11%). Significant interaction was found with the combined spray of ZnSO<sub>4</sub> @ 0.6 per cent + NAA @ 60 ppm (1.24%) followed by ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 60 ppm (1.23%) and ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 40 ppm (1.22%). Reasons have been describe above in nitrogen content in leaves.

**Table 5:** Effect of NAA and zinc sulphate on nitrogen content in fruits (%) in mulberry

Micro-nutrient spray	Nitrogen in fruit (%)				
	Growth regulator spray (NAA)				
	0 ppm	20 ppm	40 ppm	60 ppm	Mean
Zinc sulphate 0%	0.82	0.91	0.97	0.95	0.91
Zinc sulphate 0.2%	0.91	0.93	1.11	1.08	1.01
Zinc sulphate 0.4%	1.12	1.15	1.22	1.23	1.18
Zinc sulphate 0.6%	1.14	1.13	1.14	1.24	1.16
Mean	1.00	1.03	1.11	1.12	
CD at 5%	Zn = 0.03, NAA = 0.03, Zn x NAA = 0.06				

Analysis of data clearly indicates in table-6 showed that phosphorus content in fruits was influenced by the foliar spray of NAA and zinc sulphate at different concentrations on mulberry trees. Maximum phosphorus content was observed with ZnSO<sub>4</sub> @ 0.4 per cent (0.53%) followed by ZnSO<sub>4</sub> @ 0.6 per cent (0.51%) and NAA @ 40 ppm treatment (0.52%).

**Table 6:** Effect of NAA and zinc sulphate on phosphorus content in fruits (%) in mulberry

Micro-nutrient spray	Phosphorus in fruit (%)				
	Growth regulator spray (NAA)				
	0 ppm	20 ppm	40 ppm	60 ppm	Mean
Zinc sulphate 0%	0.46	0.47	0.49	0.48	0.47
Zinc sulphate 0.2%	0.48	0.49	0.51	0.52	0.50
Zinc sulphate 0.4%	0.50	0.53	0.55	0.54	0.53
Zinc sulphate 0.6%	0.51	0.52	0.54	0.50	0.51
Mean	0.49	0.50	0.52	0.51	
CD at 5%	Zn = 0.03, NAA = NS, Zn x NAA = NS				

**Table 7:** Effect of NAA and zinc sulphate on potassium content in fruits (%) in mulberry

Micro-nutrient spray	Potassium in fruit (%)				
	Growth regulator spray (NAA)				
	0 ppm	20 ppm	40 ppm	60 ppm	Mean
Zinc sulphate 0%	2.53	2.61	2.69	2.88	2.68
Zinc sulphate 0.2%	2.79	2.81	2.83	2.87	2.82
Zinc sulphate 0.4%	2.76	3.03	3.01	3.06	2.97
Zinc sulphate 0.6%	2.88	2.84	3.07	2.83	2.91
Mean	2.74	2.82	2.90	2.91	
CD at 5%	Zn = 0.06, NAA = 0.06, Zn x NAA = 0.12				

It is quite evident from table-7 showed that potassium content in fruit samples was significantly affected due to foliar sprays of zinc sulphate and NAA. Potassium content was observed maximum with foliar spray of ZnSO<sub>4</sub> @ 0.4 per cent (2.97%) treatment and NAA @ 60 ppm (2.91%) followed by NAA @ 40 ppm (2.90%). The interaction was found significantly maximum with the combined application of ZnSO<sub>4</sub> @ 0.6 per cent + NAA @ 40 ppm (3.07%) followed by ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 60 ppm (3.06%) and ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 20 ppm (3.03%) and ZnSO<sub>4</sub> @ 0.4 per cent + NAA @ 40 ppm (3.01%).

**Table 8:** Effect of NAA and zinc sulphate on zinc content in fruits (ppm) in mulberry

Micro-nutrient spray	Zinc in fruit (ppm)				
	Growth regulator spray (NAA)				
	0 ppm	20 ppm	40 ppm	60 ppm	Mean
Zinc sulphate 0%	46.20	53.70	49.30	59.75	52.24
Zinc sulphate 0.2%	50.74	56.20	57.95	64.90	57.45
Zinc sulphate 0.4%	91.30	84.05	85.90	90.15	87.85
Zinc sulphate 0.6%	85.65	87.20	88.15	92.65	88.41
Mean	68.47	70.29	70.33	76.86	
CD at 5%	Zn = 6.16, NAA = 6.16, Zn x NAA = NS				

The results obtained in present investigation revealed from table-8 exhibited that zinc content in fruits was significantly affected due to foliar spray of zinc sulphate and NAA. Maximum zinc content was observed with the foliar spray of ZnSO<sub>4</sub> @ 0.6 per cent (88.41 ppm) followed by ZnSO<sub>4</sub> @ 0.4 per cent (88.41 ppm) and NAA @ 60 ppm (52.24 ppm). Interaction effect between different levels of NAA and ZnSO<sub>4</sub> was found to be non-significant for zinc content in fruits.

### Conclusions

On the basis of results obtained in the present study we can conclude that there was significant improvement in the nutrient status with the foliar applications of NAA and zinc sulphate on mulberry fruit crop. Nutrient status in mulberry leaves and fruits was significantly higher with foliar applications of ZnSO<sub>4</sub> @ 0.4 per cent and 0.6 per cent as well as NAA @ 40 ppm and 60 ppm. Therefore, it may be concluded that foliar spray of these treatment can be recommended to the mulberry growers for obtaining better yield and quality attributes of mulberry fruits.

### Literature cited

- Ashraf N, Ashraf M, Hassan GH, Rehman MU, Dar NA, Khan IM *et al.* Effect of foliar application of nutrients and biostimulant on nut quality and leaf nutrient status of pecan nut cv. Western Schley. African Journal of Agricultural Research. 2013; 8(6):559-563.
- Bahadur L, Malhi CS, Singh Z. Effect of foliar and soil applications of zinc sulphate on zincuptake, tree size, yield, and fruit quality of mango. J. Plant Nutr. 1998; 21(3):589-600.
- Chapman HD. Suggested foliar sampling and handling techniques for determining the nutritional status of some field, horticultural and plantation crops. Indian Journal of Horticulture. 1964; 21:97-119.
- Chattopadhyay TK. Mulberry. In: A text book on pomology (temperate fruits). 1997; 4:293-308.
- Datta RK. Mulberry cultivation and utilization in India. Central Sericultural Research & Training Institute, Central Silk Board, Srirampura, Mysore, 1999.
- Hasani M, Zamani Z, Savaghebi G, Fatahi R. Effects of zinc and manganese as foliar spray on pomegranate yield, fruit quality and leaf minerals. Journal of Soil Science and Plant Nutrition. 2012; 12(3):471-480.
- Jackson ML. Soil Chemical Analysis. Prentice Hall of India Private Ltd., New Delhi, 1973.
- Khan AS, Ullah W, Malik AU, Ahmad R, Saleem BA, Rajwana IA. 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.
- Kumari N, Yadav PK, Sinch RS, Sharma BD. Effect of foliar sprays of micronutrients on nutrients status, yield and fruit quality of Kinnow mandarin. Haryana J. hort. Sci. 2009; 38(3 & 4):204-206.
- Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America Journal. 1978; 42:421-428.
- Nakashima. In: Moriculture: Science of mulberry cultivation. (Ed. K. Minamizawa, 1997). Oxford and IBH Publishing Company Pvt. Ltd., New Delhi, 1931, 431p.
- Olsen SR, Cole CV, Watanable FS, Dean LA. Estimation of available phosphorous in soil by extraction with sodium bicarbonate, USDA, Circ., 1954, 939.

13. Prasad H, Tomar CS, Kumari M, Sajwan P, Solanki SPS. Effect of 2, 4-D, Urea, Zinc Sulphate and Combinations on Growth and Nutrient Status of the Kinnow Mandarin. *International Journal of Chemical Studies*. 2017; 5(1):167-170.
14. Razzaq K, Khan AS, Malik AU, Shahid M, Ullah S. Foliar application of zinc influences the leaf mineral status, vegetative and reproductive growth, yield and fruit quality of Kinnow mandarin. *Journal of Plant Nutrition*. 2013; 36(10):1479-1495.
15. Richards LA. Diagnosis and improvement of saline and alkaline soils. USDA Hand Book No. 60, 1954.
16. Saroj PL, Awasthi OP. Mulberry. *Advances in Arid Horticulture: Production Technology of Arid and Semiarid Fruits*. International Book Distributing Co, Lucknow. 2006; 2:333-358.
17. Sharma R, Tiwari R. Effect of growth regulator sprays on growth, yield and quality of guava under Malwa plateau conditions. *Ann. Plant and Soil Res*. 2015; 17(3):287-291.
18. Subaiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. *Current Science*. 1956; 25:259-260.
19. Sau S, Sarkar S, Ghosh B, Ray K, Deb P, Ghosh D. Effect of foliar application of B, Zn and Cu on yield, quality and economics of rainy season guava cultivation. *Current Journal of Applied Science and Technology*. 2018; 28(1):1-10.
20. Walkey A, Black CA. An estimation of different methods for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*. 1965; 37:29-38.