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Review

Foliar Spray of Micro-nutrients in Mandarin Orange (Citrus reticulata Blanco); An Efficient Technique of Nutrient Management

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Abstract: *Foliar application of micronutrients is a new concept in citriculture, foliar fertilizer application is practiced for treatment of deficiency symptoms like zinc, manganese, boron, copper and magnesium deficiencies. Properly nourished crops can tolerate insects, pest sand diseases. Direct soil application of micronutrients was practiced traditionally which cannot fulfill the deficiency symptoms. Foliar fertilization has been a key factor to stimulate the natural defense mechanisms of trees, pest and disease resistance and further improve the fruit quality and yield and a new alternative for treatment of nutritional deficiencies. Boron, copper, zinc, iron, manganese, molybdenum are the most essential micro nutrients that can be sprayed as foliar application. Several research findings concluded that foliar application is not only a cost effective method but also improve yield up to 45%.*

Keywords*: Foliar fertilization, micronutrients, citrus, quality, yield*

INTRODUCTION

The mandarin orange (*Citrus reticulata* Blanco) also called the mandarin, is a small citrus tree with fruit resembling other oranges. Mandarins are usually eaten plain or in fruit salads. .Mandarins are smaller and oblate, rather than spherical like the common oranges (which are a mandarin hybrid). The taste is considered less sour, as well as sweeter and stronger. A ripe mandarin is firm to slightly soft, heavy for its size, and pebbly-skinned.

The height of tree reaches up to 25 feet (7.5 meter) with greater spreading. The tree is usually thorny, with slender twigs, broad-or slender-lanceolate leaves having minute, rounded teeth, and narrowly-winged petioles. The flowers are borne singly or a few together in the leaf axils. The fruit is oblate, the peel bright-orange or red-orange when ripe, loose, separating easily from the segments. Seeds are small, pointed at one end, green inside.

Citrus fruits are indigenous to Nepal, since they are cultivated from ancient time. In some citrus pocket areas of Nepal, still more than 100 years old citrus trees are found in fruiting condition. The mid hills from eastern part to western part of Nepal, have the suitable climate and soil for citrus fruit production. The citrus fruits include mandarin orange, sweet orange, lime, lemon, pumelo, grape fruits etc. Citrus fruits play the vital role to uplift the economic condition mid hills people. (NCDP, 2016)

The major producing countries of mandarin orange are China, Spain, Brazil and Japan. Mandarin grows successfully in all frost-free tropical and subtropical regions. It is grown in the mid hills at an altitude range of 650-1700 masl but it thrives well between 800-1400 masl.

There is wide difference in productivity level from one type of soil to another types of soils even under similar management. The yield and quality variation occurs due to differences in soil condition. Chemical environments such as sufficiency of nutrients, excess of nutrients or harmful materials in the soil influence the citrus growth and production. These problems should be properly managed to obtain the higher yields and quality (Baral, 2008).

Water or other liquid moving in a mass of dispersed droplets, as from a wave is called the practices of spraying. Several micro nutrients and hormones are sprayed in Mandarin orange after fruiting. The macro nutrients nitrogen and potassium are also sprayed in commercial orchard of developed countries. Foliar spray of nitrogen and potassium is more effective than basal application. Many researches resulted, mandarin shows good response to the foliar spray (split dose) to some macro nutrients and most of the micro nutrients. Boron, copper, zinc, iron, manganese, molybdenum are the most essential micro nutrients that can be sprayed as foliar application.

Most of research of soils science related to nutrient conducted in hills of Nepal show that there lack of many essential nutrients including macro and micro nutrients due to bedrock with low nutrient content, high erosion rates, subsistence agriculture, increasing cropping intensity, and inconsistence use of fertilizers. Most studies have recorded the severe deficiencies of micro

nutrients throughout the country. 80 to 90% of soil samples were deficient in boron (B), 20 to 50% in zinc (Zn), and 10 to 15% in molybdenum (Mo) (Anderson, 2007). These important micronutrient deficiencies limit agricultural production and also affect human nutrition directly or indirectly

The research conducted in citrus growing areas of Dhankuta District in eastern hills of Nepal analyzed, for its content of Nitrogen, Potassium, Phosphorous, Magnesium, Manganese, Copper, Zinc and Boron resulted, Zinc deficiency was wide spread, followed by Boron, Nitrogen, Magnesium, and copper Whereas phosphorous, Potassium and Manganese were sufficient. (Gupta,1996)

Similarly, Research conducted in Western Hills of Nepal by Tripathi (1999) found that 87% of samples were deficient (< 1 mg/kg) in B, and 10–20% of samples were low in Zn (< 0.5 mg/kg), Mn (< 10 mg/kg) and Cu (< 0.5 mg/kg).

Being a rich source of vitamin C, the fruit has a great nutritional role in our daily fruit requirements (Gregory, 1993). Nutritional survey, soil and leaf analysis and visual symptoms of different orchards showed certain micronutrient shortages specially Zn, Mn, and Boron (Rehman, 1990; Khattak,1991). These deficiencies have resulted in unproductive orchards causing the drastic losses of yield with poor quality fruits. Citrus is a nutrient loving plant, but farmers in the country are not using the micronutrient fertilizers resulting in the serious nutritional disorders in citrus (Catara, 1987). Soil application of micronutrients is not effective as citrus is deep rooted crop. Since, Micronutrient applied to soil may be of little value, the alternative way is to supply micronutrient fertilizer through foliar spray. Chiu and chang (1986) reported the foliar application of boric acid resulted good effects in curing Boron deficiency in Citrus.

It is clear that the foliar application of bio-regulators and nutrients is very important not only for increasing yield but also to improve the quality of fruits.

MATERIALS AND METHODS

This paper was prepared by the detailed review of different research articles published in the national and international journals. An intensive and critical analysis was done by the team of experts on the related field.

LITERATURE REVIEW

Foliar application of magnesium sulphate two times a year (April- may) and (September to October) at 0.5 percent significantly increased the growth parameters like height, plant spread and stem girth on *Poncitrus trifoliate* root stock Nanaya et al. (1985). Foliar application of $ZnSo_4$ @ 0.5% and Phosphoric acid (0.1%) either single or in combination with Mg and Cu resulted an effective increase in plant height and spread. The significant highest increase in plant height and spread was found with combined application of Mg, Cu and Zn. Haque et al. (2000).

Gendiah and Hagagy, 2000 reported the vegetative growth of C. volkameriana and Citrus reticulata Blanco increased significantly with foliar spray of 1% urea and 50 ppm GA singly or in combination. A drastic change on plant height was reported with foliar application of 1% urea, 50 ppm GA, and 0.2% zinc sulphate Gendiah and Hagagy, 2000. The combined application of Boric acid (0.2%) + Zinc sulphate (0.5%) at fruit set and peach size stage of fruit through foliar spray showed significant influence on plant height, tree spread and shoot length Guriar et al. (2015).

Foliar application of zinc sulphate (0.75%) increased plant height over control in sweet orange as reported by Babu et. al. (2007). Maximum fruit yield (34.07 kg per tree) was found on treatment with combined application of $ZnSO_4$ (0.5%) + $MnSO_4$ (0.5%) over control in Kinnow Mandarin. Similarly, 34.07 kg per tree was recorded with foliar spray of 0.5% Zn and minimum yield compared to control in Khasi mandarin. A significant increase on the plant height, tree spread and stem girth was reported by Ahmad et al. (2012) with foliar application of foliar application of $ZnSO_4$ (0.5%) and Boric acid (0.3%) at fruit set stage. Application of 0.75 per cent zinc sulphate (2nd week of May, last week of June and second week of August)) resulted in better growth of plant height and spread of sweet orange Yadav et al. (2007). Foliar application of $MgSO_4$ (2%) has recorded maximum fruit weight (107.17 g/fruit) in mandarin orange as reported by Ram and Bose (2000) in mandarin orange. A maximum fruit weight (111.60 g/fruit) was found when $ZnSO_4$ sprayed with 0.5% and the minimum fruit weight was found as compared to control in Khasi mandarin Babu and Yadav (2005). Babu et al. (2007) reported that the maximum fruit weight (140 g/fruit) was recorded in treatment consisting of $ZnSO_4$ (0.5%) + $MnSO_4$ (0.5%) + $MgSO_4$ (0.5%) over the control in Kinnow mandarin. The highest yield of 105.3 kg per tree and 49.79% increases over control was obtained in sweet orange with foliar

application of zinc in contrast with trees not sprayed with zinc Perveen and Rehman 2000. Similarly, foliar application of Zn and Mn on sweet orange trees increased the yield significantly as compared to control. Zn and Mn alone depicted a yield increase of 49.79% and 30.87% respectively Rahman and Haq (2006).

Foliar application of plant growth regulators (NAA 200 ppm) and micronutrient spray (1 %) recorded a significant increase in fruit length and volume in Kagzi Lime. Similarly, increase in fruit size (L/B-7.73/7.65) with foliar spray of $MnSO_4$ (60 g) + $CuSO_4$ (60 g) + $FeSO_4$ (60 g) + $ZnSO_4$ (100 g) as reported by Kachave and Bhosale (2007) .

Foliar application of Mn alone was significantly reduced the percentage of peel thickness in Sweet orange. Tariq et al. (2007). Similarly lowest rind thickness of fruits (0.43 mm) was recorded with foliar application of $MnSO_4$ (60 g) + $CuSO_4$ (60 g) + FeS_{O4} (60 g) + $ZnSO_4$ (75g) respectively in Kinnow Mandarin, Javaid et al. (2008).

The application of boric acid at 0.4% increase the peel thickness compare to control in Kinnow mandrain Razzaq et al. (2013). In an addition, foliar application of Zn + 20 ppm GA_3 were significantly increase the rind thickness in Washington Novel orange compare to control Eman et al. 2007. Application of micronutrient Mg (2%) + Cu (0.4%) + Zn (0.5%) + B (0.1%) + Fe (0.25%) revealed significant increase of pulp weight as reported by Ram and Bose 2000. Similarly, foliar spray of 0.3% Boric Acid at fruit set stage showed pulp weight increase in Citrus reticulata Blanco.

Foliar application of Zinc (0.6%) influence leaf mineral status, vegetative and reproductive growth,yield and fruit quality of Kinnow Mandarian. The application of zinc (0.2%, 0.4%, 0.6%, 0.8%) at different concentration increased pulp weight compare to control in Kinnow mandrain, Razzaq et al. (2013). Foliar spray of Ferrous sulphate @ 750ppm gave significant increase on the pulp weight percentage compared to control in Kinnow Mandrian Nirmaljit et al. (2015).

The effect of foliar spray of plant growth regulators NAA 200 ppm and micronutrient 0.5 % a mixture of Zn, Mn, Fe and Cu on Kagzi lime trees were treated and the results revealed the significant increase on fruit juice content percent over all treatments. Foliar spray of zinc sulphate @ 0.5% significantly increased the fruit juice content (47.6%) in Khasi mandarin as reported by Dhinesh and Yadav (2005).

A research conducted by Aishailyas et al. (2015) as the effect of micronutrient (Zn,Cu, and B) on photosynthetic and fruit yield characters on Citrus reticulata Blanco, Kinnow mandarin found that the treatment combination of $ZnSO_4$ (0.3%) + $CuSO_4$ (0.1%) + Borax (0.2%) significantly increased the fruit juice content in Kinnow mandarin. Foliar application of 0.8 % zinc sulphate exhibited 25.86 % higher juice weight percentage as compared to control in Kinnow mandarin Razzaq et al. (2013). Foliar application of Zn (5 ppm) and Fe (5ppm) applied twice a year alone or in combination on Washington Orange increased fruit set and increased the yield as compared to control. Similarly, foliar application of Zinc and B significantly affected days to flowering. In contrast percentage of fruit set and fruit drop were not significantly influenced by foliar application of Zn and B. Muhammad Sajid et al. (2010). Khan et al. (2012) observed application of 0.3% boric acid + 0.5% zinc sulphate at fruit set stage effectively increase fruit set of Feutrell's Early mandarin. Spraying of Zinc sulphate alone or in combination with calcium chelates, biozem and gibberellic acid increased the fruit set and reduced June and pre-harvest fruit drop, Heerendra et al. (2013). Foliar application of combination of $MgSO_4$ (2%) + CuSO4 (0.4%) + $ZnSO_4$ (0.5%) + Boric acid (0.1%) + $FeSO_4$ (0.25%) resulted more number of fruits (442/tree) in mandarin orange (Ram and Bose, 2000). Similarly, highest number of fruits (1406 fruits/ tree) with foliar application of $MnSO_4$ (60 g) + $CuSO_4$ (60 g) + $FeSO_4$ (60 g) + $ZnSO_4$ (100 g) were reported in Kinnow mandarin Javaid et al. (2008)

The highest number of fruits per plant (124.6) was recorded when sprayed with 0.5% of $ZnSo_4$ followed by magnesium sulphate in Khasi mandarin Babu and Yadav (2005). Similar results have been discussed by Dhinesh and Yadav;2005 as maximum numbers of fruits per plant were observed (380 plant^{-1}) with zinc and manganese, whereas minimum (335 plant^{-1}) was recorded in control followed by the highest productivity was also recorded with zinc and manganese.

Babu et al. (2007), Dhinesh et al. (2007) recorded a more number of fruits per tree (246) with treatment consisting $ZnSO_4$ (0.5%) + $MnSO_4$ (0.5%) over the control. Foliar application of 2, 4-D (10 mg/lit), salicylic acid (10 mg/lit), potassium (0.25%) and zinc (0.25%) significantly increase the number of fruits per plant and reducing the fruit drop as reported by Ashraf et al. (2013).

Foliar application of 2, 4-D (10 mg/lit), salicylic acid (10 mg/lit), potassium (0.25%) and zinc (0.25%) significantly increase the number of fruits per plant and reducing the fruit drop as reported by Ashraf et al. (2013).

Maximum fruit yield (34.07 kg per tree) was found on treatment with combined application of $ZnSO_4$ (0.5%) + $MnSO_4$ (0.5%) over control in Kinnow Mandarin. Similarly, 34.07 kg per tree was recorded with foliar spray of 0.5% Zn and minimum yield compared to control in Khasi mandarin.Foliar spray of GA_3 (20ppm) resulted the maximum fruit length of 5.55cm followed by Borax spray (0.3%) with 5.42cm of fruit length compared to minimum fruit length of 4.62 cm (Bharat Bhusan Bhatt, 2017).The foliar application of NAA (200 ppm) after 30 days of full bloom on Unshiu Orange trees significantly increased fruit size and proportion of larger fruits (Nakajima et al., 1969). A research conducted by Babu and Lavania (1985) stated maximum length of lemon fruits were found with spray of 10 ppm NAA followed by 5 ppm and 20 ppm 2,4-D.The highest yield of 105.3 kg per tree and 49.79% increases over control was obtained in sweet orange with foliar application of zinc in contrast with trees not sprayed with zinc, Perveen and Rehman (2000). Similarly, foliar application of Zn and Mn on sweet orange trees increased the yield significantly as compared to control. Zn and Mn alone depicted a yield increase of 49.79% and 30.87% respectively Rahman and Haq (2006).

The highest yield of 105.3 kg per tree and 49.79% increases over control was obtained in sweet orange with foliar application of zinc in contrast with trees not sprayed with zinc. Perveen and Rehman (2000). Similarly, foliar application of Zn and Mn on sweet orange trees increased the yield significantly as compared to control. Zn and Mn alone depicted a yield increase of 49.79% and 30.87% respectively Rahman and Haq (2006). Foliar application of $ZnSO_4$ @ 0.5% showed a highest percentage of Total Soluble Solid(TSS) as compared to control in Citrus reticulata Blanco as reported by Dinesh babu and Yadav (2005). In the same manner, foliar application of magnesium, zinc and manganese resulted in higher TSS content with respect to control Babu et al. (2007). The fruit sprayed with (0.5%) zinc sulphate + 20 ppm GA_3 had 12.0% TSS compared to control in Washington Navel orange trees, Eman et al. (2007). Exogenous application of Boron and Zinc on influence of leaf nutrient status, tree growth and fruit quality of Citrus reticulata Blanco. Results revealed the application of 0.3 % Boric acid at fruit set stage increases seed weight per fruit. Ahmed et al. (2012). Maximum fruit yield (34.07 kg per tree) was found

on treatment with combined application of $ZnSO_4$ (0.5%) + $MnSO_4$ (0.5%) over control in Kinnow Mandarin. Similarly, 34.07 kg per tree was recorded with foliar spray of 0.5% Zn and minimum yield compared to control in Khasi mandarin.The fruit sprayed with (0.5%) zinc sulphate + 20 ppm GA_3 had 12.0% TSS compared to control in Washington Navel orange trees, Eman et al. (2007). Foliar spray of $FeSo_4$ @ 0.5 % increased sugar and total sugar in fruit juice in Kinnow mandarin Siddapa et al. (2014).

CONCLUSION

Foliar spray of micronutrients along with urea significantly improved the quality of fruits and the productive life of citrus trees. Foliar spray is the best alternative way to supply the micro nutrients in citrus trees. With the good view of unfavorable physiochemical conditions in the soils, it become conditional to supply micronutrients in balanced amount for better yield and quality of fruits. The foliar application also provides a more timely and immediate method for supply of specific nutrients at the critical stages of plant growth. Micronutrients (Zn, Cu, Fe and Mn) spray on the leaves of Mandarin oranges increased the concentration of the respective nutrient in the leaves. Thus, foliar application of micronutrients provides a valuable supplement to soil applications.

REFERENCES

Ahmad S.K., Ullah W., Aman U.M., Ahmad R., Saleem B.A., and Rajwana I.A., 2012, Exogenous application of boron and zinc influence leaf nutrient status, tree growth and fruit quality of Feutrell's Early (Citrus reticulate Blanco), Pak. J. Agri. Sci., 49(2):113-119

Ashraf Y.M., Akthar M., Mahmood K., and Saleem M., 2013, Improvement in yield, quality and reduction in fruit drop in kinnow (Citrus reticulata Blanco) by exogenous application of plant growth regulators, potassium and zinc, Pakistan. J. Bot., 45(1): 433-440

Babu K.D, and Yadav D.S., 2005, Foliar spray of micronutrients for yield and quality improvement in Khasi mandarin (Citrus reticulata Blanco.), Indian J. Hort., 62: 280-281

Babu K.D., Dobey A.K.,and Yadav D.S.,2007. Effect of micronutrients on enhancing the productivity and quality of Kinnow mandarin, Indian J. Hort., 64(3):353-356

Babu, G.H.V.R. and Lavania, M.L. 1985. Effect of plant growth regulators on fruit set and fruit drop of Pant Lemon-1. *Indian J. Hort*., 42 (2): 237-240.

Baral, Dilliram. (2008). Performance of Mandarin trees (Citrus reticulate Blanco.) at different altitude and nutrient management in mid hills of Nepal. Tribhuwan University, Nepal.

Dhinesh B.K, and Yadav D.S., 2005. Foliar spray of micronutrients for yield and quality improvement in Khasi mandarin (Citrus reticulata Blanco), Indian J. Hort., 62(3): 280-281

Dhinesh B.K., Dubey A.K., and Yadav D.S., 2007. Effect of micronutrients on enhancing the productivity and quality of Kinnow mandarin, Indian J. Hort., 64(3): 353-356

Eman A.A., El-moneim A., El-Migeed M.M.M.A., Omayma A., and Ismail M.M., 2007, Ga3 and Zinc sprays for Improving Yield and Fruit Quality of Washington Naval Orange trees grown under sandy soil conditions, Research J. of Agri. and Biological Sci., 3(5): 498-503

Gendiah H.M., and Hagagy N.A.,2000, Physiological studies on the effect of some micronutrients foliar fertilization treatments on nutritional status, growth and fruiting of Washington Navel orange trees, Annals of Agricultural Science Moshtohor., 38(2): 1181-1194

Gurjar M.K., Kaushik R.A., and Baraily P., 2015, Effect of Zinc and Boron on the growth and yield of kinnow mandarin, International J. of Scientific Res., 4(1): 207-208

Haque R.,Roy A., and Pramanic M., 2000. Response of foliar application of Mg, Zn, Cu and B on improvement of growth, yield and trial quality of Mandarin orange in Darjeeling Hills of West Bengal, Hortic. J., 13(2):15-20.https://doi.org/10.1080/01904167.2013.785567

Influence of Foliar Application of Bio-Regulators and Nutrients on the Fruit Quality of Lemon (*Citrus limon* Burma.) Cv. Pant Lemon-1. *Int.J.Curr.Microbiol.App.Sci.* 6(4): 2451-2458. doi: https://doi.org/10.20546/ijcmas.2017.604.286

Kachave D.B, and Bhosale A.M., 2007. Effect of plant growth regulator and micronutrient on fruiting and yield parameters of Kagzi lime (Citrus aurantifolia swingle) fruits, Asian J. of Hort., 2(2): 75-79.

Khan A.S., Ullah W., Malik A.U., Ahmad R., Saleem B.A., and Rajwana I. A., 2012, Exogenous application of boron and zinc influence leaf nutrient status, tree growth and fruit quality of Feutrell's Early (Citrus reticulata Blanco.), Pakistan J. Agric. Sci., 49(2): 113-119

Nakajima, T., Wanago, M. and Ogaki, C. 1969. Practical studies on the use of naphthalene acetic acid for thinning the fruits of Unshiu orange trees. *Bull. Kangawa. Hort. Exp. Sta*., 17: 9-17.

Nanaya K.A., Anjaneylu K., and Kotur S. C.,1985, Effect of foliar applied Zn, Mn, Cu and Mg on growth parameters, chlorosis and interrelationships of micronutrients in leaf tissue of coorg mandarin, Prog. Hort., 17: 309-314

Perveen S, and Rehman H.,2000. Effect of foliar application of zinc, manganese and boron in combination with urea on the yield of sweet orange, Pakistan J. Agric. Res., 16(2) :135-141

Rahman H., and Haq I., 2006, Diagnostic criteria of micronutrient for sweet orange, Soil and Environ., 25(2): 119-127

Ram R.A., and Bose T. K., 2000, Effect of foliar application magnesium and micronutrients on growth, yield and fruit quality of mandarin orange (Citrus reticulate Blanco), Indian J. Hort., 61 (4): 302-304

Razzaq K., Khan A.S., Malik A.U., Shahid M., and Ullah S., 2013, Foliar application of zinc influence leaf mineral status, vegetative and reproductive growth, yield and fruit quality of Kinnow mandarin, J. Plant Nutrition, 36: 1479-1495

Yadav R.K., Rana G.S., Ahlawat V.P., Dahiya D.S., and Kumar S., 2007, Effect of zinc application on growth and fruit drop of sweet orange (Citrus sinensis Osbeck) cv, Jaffa, Haryana J. of Hortic. Sci., 36(3/4): 205-20Bharat Bhushan Bhatt, Krishan Kumar Singh and Rawat, S.S. 2017.

Conflicts of Interest

There are no conflicts to declare.