REVIEW ARTICLE Agricultural Reviews, Volume 41 Issue 3: 297-302 (September 2020)

Influence of Foliar Sprays of Nutrients on Yield and Yield Accrediting Characters of Kinnow Mandarin: A Review

Reetika, G.S. Rana, Komal, Sanjay Kumar, Poonam Saini

10.18805/ag.R-2012

ABSTRACT

Plant nutrients both macro and micro plays a major productive and qualitative role in bringing stability and sustainability in the production system particularly in fruits crops like citrus and therefore, effective nutrient management is critical. The aim of our paper is to study the influence of foliar sprays of nutrients on yield and yield attributing characters such as fruit drop, final fruit retention, number of fruits per plant and fruit yield of Kinnow mandarin as appropriate rate, time and method of application of fertilizers in Kinnow are considered to be the major indices in deciding the desired level of productivity and quality of fruits. Therefore, many studies around the world, evaluating the yield and yield attributing characters of Kinnow mandarin with respect to foliar application of nutrients were studied and their results showed that the foliar application were economically viable and beneficial for both Kinnow productivity and environmental sustainability. Hence, for obtaining better fruit yield and minimizing fruit drop with aim to achieve desired level of productivity and improved fruit quality, foliar spray of macro and micronutrients could be used effectively.

Key words: Fertilizers, Fruit drop, Fruit size, Fruit yield, Kinnow mandarin.

Citrus is one of the major economically important fruit crop belonging to Rutaceae family and is grown worldwide and rich in vitamin C content. Citrus is grown widely in Indian and other parts of world and the area under this fruit crop in Haryana state is also appreciable with production of 323.92 thousand Metric Tons from 20.05 thousand hectares area and productivity 16.15 Metric Ton per hectare (Anonymous, 2017). Among different Citrus species, Kinnow has achieved a prime situation in north-western states of India, such as, Punjab, Haryana, Himachal Pradesh, Rajasthan and Uttar Pradesh. Further with the implementation of National Horticulture Mission, there has been a tremendous increase in area during the last decade. In India, the region under citrus is 1003 thousand hectares with 12546 thousand MT production and 12.5 $MTha^{-1}$ productivity (Saxena, 2018). Kinnow fruit is very refreshing, juicy, melting deep yellowish orange colour, rich and aromatic flavor with a fine sugar-acid blend, TSS 10-12%, acidity 0.75- 1.2%. Kinnow, a mandarin hybrid between King mandarin (*Citrus nobilis* Lour) x Willow Leaf Mandarin (*Citrus deliciosa* Tenora) is commercially cultivated due to its good yield, high processing quality, fresh consumption, aromatic flavor and better adaptation to agro-environmental conditions, however, fruit drop is one of the major reasons of low productivity of Kinnow in India (Sharma *et al.,* 2012).

With the changing climatic conditions, there arise various problems like erratic bearing, severe fruit drop, decline and poor fruit size, which results in huge economic losses to the farmers. However Kinnow industry of north-west India has also got a chronic tale of multiple nutrient deficiencies, primarily triggered by salinity induced high soil pH. Citrus is a generally high supplement requesting crop (Wang *et al*., 2006) and profoundly receptive to applied supplements as fertilizers. A deficient nutrition is one of the significant imperatives restricting the potential efficiency of a Kinnow plantation. The prudent use of fertilizers, along these lines, assumes a critical job in increasing the efficiency of Kinnow farmsteads (Srivastava and Bopaiah, 1977). The use of large scale supplements especially nitrogen (N), phosphorus (P), potassium (K) assume significant job in yield as well as fruit quality (Liu *et al.,* 2010). Be that as it may, nitrogen is the key part for Citrus producers as it has more effect on tree development, appearance and fruit quality than some other component (Obreza, 2001). Of numerous explanations behind creation of littler fruit size, the deficiency of potassium is the one of most noteworthy component that controls the size of fruit. It has been found that foliar application of K, two months after flowering, increases the fruit size of Valencia oranges (Miller and Hofman, 1988) and thus K fertilization is an important tool to optimize the yield of Citrus fruit. Generally, a modest quantity of micronutrient is required when contrasted with those of essential supplements, yet these are similarly significant for plant digestion (Katyal, 2004). Zinc helps in the creation of tryptophan, which is a precursor of auxin and thus helps in checking the fruit drop. Foliar utilization of micronutrients

Department of Horticulture, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India.

Corresponding Author: Reetika, Department of Horticulture, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India. Email: ritikapanwar18@gmail.com

How to cite this article: Reetika, Rana, G.S., Komal, Kumar, S. and Saini, P. (2020). Influence of Foliar Sprays of Nutrients on Yield and Yield Accrediting Characters of Kinnow Mandarin: A Review. Agricultural Reviews. 41(3): 297-302.

Submitted: 25-04-2020 **Accepted:** 09-06-2020 **Published:** 10-09-2020

like Zn, Cu, Mn, B and Fe was far superior to that of soil application since it was increasingly powerful, quickly accessible to the plants (Obreza *et al*., 2010). The effect of Zn and Fe the two critical nutrients, will make the effect of any amount of micronutrients application (Modise, 2009). Micronutrients play an active role in metabolism starting from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, hormone synthesis, nitrogen fixation and reduction (Singh *et al*., 2019).

Therefore, effective nutrient management of Citrus is required to get desired productivity and quality of fruits that involves finding of appropriate rate, time and method of application as well as selection of suitable combination of fertilizers. Therefore, present study was conducted with an objective to review the work done on estimation of influence of different combinations of nutrients in different doses and their interaction on fruit set, fruit drop patterns, yield and yield attributing characters of Kinnow mandarin.

Review of work done

In this section, attempts have been made to review the information available on the yield and yield attributing characters of Kinnow mandarin as influenced by foliar application of nutrients under various headings:

Flower count

Number of flowers per twig

Syamal *et al.* (2008) found that the spray of Urea 4% and zinc sulphate 0.4 % in February-march increased minimum duration of flowering and maximum number of flowers in Kagzi lime trees. Jat and Kacha (2014) observed the maximum number of flowers per shoot (5.33) with urea 1.5% in guava.

Initial fruit set (%)

Fruit setting per tree significantly improved with the foliar application of Zn 0.25% + K 0.25% + Salicylic acid 10 ppm in Kinnow mandarin (Ashraf *et al*., 2012). Nithin *et al*. (2017) reported that the foliar application of $ZnSO_4$ 0.2% + $FeSO_4$ 0.2% + H_3BO_4 0.2% + $MnSO_4$ 0.3% + $CuSO_4$ 0.4% significantly increased the fruit set percentage (52.49%) in six year old mandarin orange when sprayed thrice at monthly interval from July to October.

Fruit characters

Fruit drop percentage

Pre-harvest fruit abscission causes serious loss to the growers, especially during later part of harvest. Huchche (2001) found the application of two sprays of 2,4-D or GA_3 + Benlate + Urea effective in controlling fruit drop in citrus. Babu *et al.* (2001) observed least fruit drop (24.33%) in Khasi Mandarin with the application of 2, 4-D 20 ppm + carbendazim 0.1% + micronutrients 0.5%. Eman *et al.* (2007) noticed a decrease in fruit drop with foliar spray of zinc alone or in combination with gibberellic acid as compared to control in Washington Navel orange. Spraying boric acid or 2, 4-D alone at pea-stage decreased the pre-harvest fruit drop (63 to 100% compared to control) in Washington Orange (El-Kobbia *et al*., 2011). Fruit drop in Kinnow decreased significantly due to foliar spray of 2,4-D 10 ppm, Salicylic acid 10 ppm, Zn 0.25% + K 0.25% and their combinations in all selected citrus orchards (Saleem *et al*., 2013). The minimum fruit drop in Kinnow mandarin was observed with Urea 0.5% + $ZnSO_4$ 0.5% + 2,4-D 10 ppm (82.53%) treatment (Prasad *et al*., 2013). Gurjar and Rana (2014) recorded the minimum fruit drop (53.5%) in Kinnow mandarin with the application of $ZnSO_4$ 0.5% + 2, 4-D 10 ppm. Dixit *et al.* (1977) reported a significant increase in fruit retention in Kinnow by foliar application of zinc sulphate 1% twice in the month of April and September. Gupta *et al*. (1989) suggested that combined foliar application of Urea 1% and $ZnSO_4$ 0.4% twice a year in April and September would be most useful to substantially reduce both premature and pre-harvest drops in Kinnow and other citrus crops. Yadav *et al*. (2007) observed minimum fruit drop (64.26 %) with foliar application of zinc sulphate 0.75% in Sweet orange. Foliar application of mixture of micro nutrients ($FeSO_4$, $ZnSO_4$ and $MnSO_4$) along with urea (1%) also led to lesser fruit drop incidents as compared to the basal application of micro-nutrients in Kinnow mandarin plants (Vijaya *et al*., 2017). The most extreme capability of Kinnow mandarin plants in regard of June (39%) and pre-harvest (12%) fruit drop was abused to the least level with foliar utilization of Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2% (Reetika *et al*., 2018).

Number of fruits per plant

The expansion in various fruits because of potassium application could be ascribed to the enhancement in the vegetative development of plant (Singh *et al.*, 1979). Abd-Allah (2006) announced that the utilization of potassium in mix with other macro- and micronutrients at the full blossom stage essentially expanded the quantity of fruits per tree in Washington Navel orange. The maximum number of fruits per tree was asserted with the application of 2,4-D 20 ppm (1088), closely followed by urea 1% in Kinnow mandarin (Kaur *et al*., 2000). Gurjar and Rana (2014) obtained the highest number of fruits per tree with foliar application of $ZnSO_4$ 0.5% + 2,4-D 10 ppm (279.4) followed by 2,4-D 10 ppm (268.3 fruits/plant). Sangwan *et al.* (2008) observed maximum number of fruits per plant with foliar application of commercial grade KNO_3 1% in Kinnow mandarin. Omaima and El-Metwally (2007) revealed that applying Zn + K fundamentally expanded the fruit yield by 25.66%, nonetheless, applying Zn 0.4% and K 1% alone essentially expanded the yield by 10.93 and 16.26%, separately in Washington Navel orange. Sarrwy *et al*. (2012) found that the plants of Balady mandarin splashed with KNO_3 1.5% + chelated zinc 0.5% twice in May and July gave the most elevated number of fruits (436 and 441 fruits per plant in both the seasons, separately) when contrasted with different treatments. In Kinnow mandarin, Dixit *et al*. (1977) reported

increased number of fruits per plant with the spray of zinc sulphate 1% twice in the month of April and September. Babu *et al*. (2007) reported an improvement in the number of fruits of Kinnow mandarin with foliar spray of zinc sulphate 0.6%. Spraying K_2SO_4 1 % significantly improved the yield of grapes (Singh *et al.*, 1979). Application of GA_3 @ 15 ppm along with zinc (0.5%) and boron (0.1%) improved growth morphology, yield attributes of Kinnow mandarin fruits (Gurung *et al*., 2016).

Final fruit retention (%)

Fruit retention means the fruits that retain on the plant up to harvesting, which ultimately indicates the yield of plant. Eman *et al.* (2007) noticed a significant increase in fruit set and fruit retention and decrease in fruit drop and subsequently an improvement in yield as well as physical and chemical characteristics of Washington Navel orange with the spray of chelated zinc 0.4% alone or with GA_3, especially at 20 ppm. By spraying boric acid or 2,4-D alone at pea-stage of Washington orange, El-Kobbia *et al.* (2011) revealed 23-69% increase in final fruit retention over control. The maximum fruit retention (17.47%) was observed by Prasad *et al.* (2013) where the treatment Urea 0.5% + $ZnSO_4$ 0.5% + 2,4-D 10 ppm was given twice at one-month (Feb-march) intervals in Kinnow mandarin. Saleem *et al.* (2013) observed maximum fruit retention in plants sprayed with 2,4-D 10 ppm + Zn 0.25% + K 0.25% closely followed by Salicylic acid 10 ppm + Zn 0.25% + K 0.25%. Omaima and Metwally (2007) and Ashraf *et al*. (2011) also suggested that foliar application of K 0.25%, Zn 0.25% or Zn 0.25% + K 0.25% is effective in enhancing the fruit retention per tree.

Yield accrediting characters

Fruit size

Potassium assumes a crucial job in cell wall development, subsequently, the use of potassium improved the size of fruits (Boman and Hebb, 1998). Miller and Hofman (1988) found that foliar use of potassium two months subsequent to blooming expanded the fruit size of Valencia Oranges. Spray of zinc sulphate 0.7% after fruit set in last week of April had no significant effect on size fruit, *i.e.*, length and breadth but spraying 2,4-D 10 ppm and zinc sulphate 0.5% in combination increased the fruit size of Kinnow (Daulta *et al*., 1986). Rattanpal *et al*. (2005) concluded that KNO3 5.0% + 2, 4-D sprayed at 60 days after full bloom proved best with maximum increase in fruit size. Boman and Hebb (1998) revealed that the post-bloom utilization of potassium to Florida grapefruit expanded the normal size of both white and colored grapefruit. Saleh *et al.* (2001) revealed that potassium, phosphorus, or boron application improved fruit size in orange. Josan *et al.* (1995) revealed an expansion in fruit breadth of lemon fruit accepting foliar shower of K_2SO_4 10% at 15th and 30th May. Researchers have reported that plant growth regulator GA_3 @100 ppm applied along with micro-nutrients (Zn and potassium) markedly improved plant vegetative characters as well as yield characters (Singh *et al*., 2018).

Expanding the rate and recurrence of foliar use of potassium expanded the fruit size in citrus (Wei *et al.*, 2002; Obreza *et al.*, 2008). Gill *et al.* (2005) witnessed the impact of foliar utilization of potassium and nitrogen on Kinnow mandarin fruit quality. Prasad *et al*. (2013) recorded the maximum diameter of fruits taken from the plants sprayed with Urea + $ZnSO_4$ + 2,4-D (7.03 cm). Omaima and El-Metwally (2007) revealed an expansion in Washington Navel orange fruit width with foliar utilization of potassium and in mix with zinc showered thrice during mid-February, mid-March and last of April. Nithin *et al*. (2017) announced that the foliar utilization of $ZnSO_4$ 0.2% + $FeSO_4$ 0.2% + H_3BO_4 0.2% + $MnSO_4$ 0.3% + $CuSO_4$ 0.4% essentially expanded the fruit size *viz*., fruit height (6.24 cm) and fruit diameter (7.45 cm) in six year old mandarin orange when sprayed thrice at monthly interval from July to October.

Fruit weight (g)

Potassium assumes an imperative job in expanding the fruit weight, which may be upgraded the photosynthesis, which prompted the buildup of more starches (Harold and George, 1966). Lee and Chapman (1988) revealed a huge increment in the fruit weight of Ellendale Mandarin with an expanding pace of potassium fertilization. Wali and Sharma (1997) revealed that the Kinnow fruits had highest weight (123.00 g) with foliar application of $ZnSO_4$ 0.75% + 2,4-D 10 ppm. In orange, Saleh *et al.* (2001) detailed that potassium, phosphorus or boron application upgraded the average fruit weight. Gill *et al.* (2005) observed that three foliar sprays of potassium and nitrogen fertilizers on plant after attaining 2/3rd of their original leaf size fruit, fruitlets diameter of 2 cm and one month after second spray improved the quality of Kinnow mandarin. Babu *et al*. (2002) recorded maximum fruit weight (128.00 g) with the treatment of 2,4-D 20 ppm + carbendazim 0.1% + micronutrients 0.5% in Khasi mandarin. Josan *et al.* (1995) detected an expansion in the average fruit weight of lemon fruits accepting foliar shower of K_2SO_4 10% on the 15th and 30th of May. Rattanpal *et al*. (2005) observed the maximum fruit weight, peel percentage and rag percentage of Kinnow fruits harvested from the plants sprayed with KNO_3 5.0% + 2,4-D 20 ppm 60 days after full bloom. Prasad *et al.* (2013) documented the most elevated fruit weight with treatment Urea 0.5% + $ZnSO_4$ 0.5% + 2,4-D 10 ppm (159.83 g). Hamza *et al.* (2012) witnessed that a few foliar uses of KNO_3 8% best in improving the average fruit weight in Clementine citrus var. *Cadoux*. With foliar application of KNO*f* 2%, the maximum fruit weight (185.5 g) was obtained by Sangwan *et al.* (2008) in Kinnow mandarin. Comparable outcomes have been stated previously by Desai *et al.* (1986) in Coorg Mandarin, Bazelet *et al.* (1980) in Shamouti Oranges and Lee and Chapman (1988) in Ellendale Mandarin. Among the potassium compounds, Yadav *et al.* (2014) found significantly maximum increase in fruit weight of ber when K_2SO_4 2% was sprayed on plants during November, January and February. Dawood *et al*. (2001) observed that the fruit weight of Washington

Navel Orange, Valencia Orange and Balady mandarin increased with the application of zinc sulphate 0.4% as foliar spray. In mandarin orange, Nithin *et al*. (2017) reported highest yield (7.82 kg /plant) with foliar application of $ZnSO_4$ 0.2% + $FeSO_4$ 0.2% + H_3BO_4 0.2% + $MnSO_4$ 0.3% + $CuSO_4$ 0.4% thrice at monthly interval from July to October.

Fruit yield (kg/plant)

The use of supplements assumes a significant job in expanding the yield parameters. The maximum yield was recorded under the treatment Urea 0.5% + $ZnSO_4$ 0.5% + 2,4-D (81.31 kg), which might be due to an increase in fruit retention and decrease in fruit drop (Prasad *et al.*, 2013). Saleem *et al.* (2013) observed that the plants of Kinnow mandarin sprayed with 2,4-D 10 ppm + Zn 0.25% + K 0.25% produced significantly highest fruit yield (numbers) in all the selected orchards, followed by those with Salicylic acid 10 ppm + Zn 0.25% + K 0.25%. Gurjar and Rana (2014) recorded the maximum fruit yield per plant with foliar application of KNO_3 2% + $ZnSO_4$ 0.5% (43.7 kg), which was at par with the yield (42.9, 42.3 and 42.5 kg) recorded under foliar application of KNO_3 2% + 2,4-D 10 ppm, $ZnSO_4$ 0.5% + 2,4-D 10 ppm and KNO_3 2%. While considering the impact of foliar use of potassium on fruit yield and quality of Kinnow mandarin, Sangwan *et al*. (2008) obtained maximum yield (73.65 kg) with three foliar sprays of KNO_3 2%, first after attaining 2/3rd of original leaf size, second after 2 cm diameter of fruitlets and third one month after second spray. Malik *et al*. (2000) observed that the application of zinc sulphate 0.4% resulted in maximum yield (113.9 kg) of Kinnow mandarin. Hamza *et al*. (2012) presumed that raising the K concentration and the quantity of foliar application, results in expanding the tree fruit yield and quality of *Clementine citrus* var. Cadoux. Foliar spray of KNO_3 1.5% with chelated zinc 0.5% twice in the month of May and July raised the yield per plant and fruit quality of Balady mandarin significantly in both the seasons as compared to mono potassium phosphate and potassium thiosulphate (Sarrwy *et al*., 2012). Babu *et al*. (2007) reported highest productivity of Kinnow fruits (34.07 kg /tree) with two sprays of zinc sulphate 0.5% and manganese sulphate 0.5% in the month of May and September. In Khasi mandarin, Babu and Yadav (2005) observed maximum yield with spray of zinc sulphate 0.5%. In mandarin orange, Nithin *et al*. (2017) reported highest yield (7.82 kg /plant) with foliar application of $ZnSO_4$ 0.2% + $FeSO_4$ 0.2% + H_3BO_4 0.2% + $MnSO_4$ 0.3% + $CuSO_4$ 0.4% thrice at monthly interval from July to October. Foliar application of 1000 ppm Zn + 1000 ppm Mn at the end of April and mid of August gave maximum fruit yield (862 fruits/ tree) by correcting these micronutrient deficiencies in Kinnow mandarin (Kaur *et al*., 2015). Foliar application of mixture of micro nutrients ($FeSO_4$, $ZnSO_4$ and $MnSO_4$) along with urea (1%) produced significantly higher number of fruits and fruit yield (28.9 tha^{-1}) compared to other treatments (Vijaya *et al*., 2017). The most extreme capability of Kinnow mandarin plants in regard of number of fruits per plant (598.67), fruit maintenance (25.95%), fruit size (fruit length and diameter) (6.28 and 7.15 cm, separately), average fruit weight (163.67 g) and fruit yield per plant (97.83 kg /plant) was attained to a greatest level with foliar utilization of Urea 1.0% + K_2SO_4 1.0% + $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + H_3BO_3 0.2% (Reetika *et al*., 2018).

CONCLUSION

On the basis of the reviews of various studies, it can be concluded that foliar sprays of macro and micronutrients in Kinnow mandarin had positive impact on yield and yield attributing characters such as fruit drop, final fruit retention, number of fruits per plant and fruit yield. Therefore, for obtaining better fruit yield and minimizing fruit drop to get desired level of productivity and good quality fruits, foliar spray of macro and micronutrients can be used effectively.

REFERENCES

Abd-Allah, A.S.E. (2006). Effect of spraying some micro and macronutrients in fruit set, yield and fruit quality of Washington Navel orange tree. Applied Science Research.11: 1059 -1063.

Anonymous, (2017). Horticulture Department Report, Government of Haryana. www.hortharyana.gov.in.

Ashraf, M.Y., Hussain, F., Akhtar, J., Khan, M. and Ebert, G. (2011). Modulation in yield and juice quality characteristics of citrus fruit from trees supplied with zinc and potassium foliarly. Journal of Plant Nutrition. 34: 1996-2012.

Ashraf, M.Y., Yaqub, M., Akhtar, J., Khan, M., Khan, M.A. and Ebert, G. (2012). Control of excessive fruit drop and improvement in yield and juice quality of Kinnow (*Citrus deliciosa* x *Citrus nobilis*) through nutrient management. Pakistan Journal of Botany. 44: 259-265.

Babu, K.D. and Yadav, D.S. (2001). Effect of 2,4-Dichlorophenoxy acetic acid on yield and quality of Khasi mandarin (*Citrus reticulata* Blanco). South Indian Horticulture. 50(1-3): 31 -35.

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

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

Babu, K.D., Yadav, D.S., Prasad, M.S. and Sharma, Y.P. (2002). Pre-harvest fruit drop in Khasi Mandarin (*Citrus reticulata* Blanco). Crop Research, Hisar. 23(2): 308-312.

Bazelet, M., Feigenbaum, S. and Bar-Akiva, A. (1980). Potassium Fertilizer Experimenting Shamouti Orange Grove Pamph. Volcani Cen. No. 220-228.

Boman, B.J. and Hebb, J.W. (1998). Post bloom and summer foliar K effects on grapefruit size. In: Proceedings of Florida State Horticultural Society. 111: 128-135.

Daulta, B.S., Kumar, R. and Singh, D. (1986). Effect of zinc sulphate, cytozyme and 2,4-D on fruit retention and quality of Kinnow-a mandarin hybrid. Haryana Journal of Horticultureal Sciences. 15(2): 14-17.

Dawood, S.A., Meligy, M.S. and El-Hamady, M.M. (2001). Influence of zinc sulphate application on tree leaf and fruit characters

of three young citrus verities grown on slightly alkaline soil. Annals Agriculture Sciences Moshtohor. 39: 433-447.

Desai, U.T., Choudary, K.G. and Chaudary, S.M. (1986). Studies on the nutritional requirement of sweet orange. Journal of Maharashtra Agricultural University. 11: 145-147.

Dixit, C.K., Yamdagni, R. and Jindal, P.C. (1977). A note on the effect of micronutrients spray on quality of Kinnow. Haryana Journal of Horticultural Sciences. 6: 153-154.

El-Kobbia, A.M., Kassem, H.A., Marzouk, H.A. and Abo-Elmagd, M. (2011). Enhancing cropping of Navel orange by different agrochemicals foliar sprays. Emirates Journal of Food and Agriculture. 23(1): 95-102.

Eman, A.A.A.E., El-Migeed, M.M.M.A. and Omayma, M.M.I. (2007). GA_3 and zinc sprays for improving yield and fruit quality of Washington Navel orange trees grown under sandy soil conditions. Research Journal of Agriculture and Biological Sciences. 3(5): 498-503.

Gill, P.S., Singh, S.N. and Dhatt, A.S. (2005). Effect of foliar application of K and N fertilizers on fruit quality of Kinnow mandarin. Indian Journal of Horticulture. 62: 282-284.

Gupta, O.P., Jawanda, J.S. and Gupta, K.R. (1989). Foliar applications of urea and zinc sulphate for fruit drop control in Kinnow Mandarin. Current Science. 58(8): 456-457.

Gurjar, P.S. and Rana, G.S. (2014). 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. 71(1): 109-111.

Gurung, S., Mahato, S.K., Suresh, C.P. and Chetrri, B. (2016). Impact of foliar application of growth regulators and micronutrients on the performance of Darjeeling Mandarin. American Journal of Experimental Agriculture. 12(4): 1-7.

Hamza, A., Bamouh, A., Guilli, M.E.l. and Bouabid, R. (2012). Response of Clementine Citrus var. Cadoux to Foliar Potassium Fertilization: Effects on Fruit Production and Quality. *e-ifc* No. 31, pp. 8-15.

Harold, J.E. and George, J.S. (1966). Role of mineral elements with emphasis on the univalent cations. Annals of Plant Physiology. 11: 47-76.

Huchche, A.D. (2001). Nature and management of citrus fruit drop. In: *Citrus* [(Eds.) Singh, S. and Naqvi, S.A.M.H.)]. IBDC Publishers, Lucknow, UP. pp. 287-294.

Jat, G. and Kacha, H.L. (2014). Response of guava to foliar application of urea and zinc on fruit set, yield and quality. Journal of AgriSearch. 1(2): 86-91.

Josan, J.S., Sandhu, A.S., Singh, R. and Monga, P.K. (1995). Effect of various nutrient sprays on fruit quality of lemon. Indian Journal of Horticulture. 52: 288-290.

Katyal, J.C. (2004). Role of micronutrients in ensuring optimum use of macronutrients. In: Proceedings of International Symposium on Micronutrients, New Delhi, India. pp. 3-17.

Kaur, N., Monga, P.K., Arora, P.K. and Kumar, K. (2015). Effect of micronutrients on leaf composition, fruit quality and yield of Kinnow mandarin. Journal of Applied and Natural Science. 7(2): 639-643.

Kaur, N., Monga, P.K., Thatai, S.K. and Vij, V.K. (2000). Effect of growth regulators on periodical fruit drop in Kinnow mandarin. Haryana Journal of Horticultural Sciences. 29(1 and 2): 39-41.

Lee, L.S. and Chapman, J.C. (1988). Yield and fruit quality response of Ellendale mandarins to different nitrogen and potassium fertilizer rates. Australian Journal of Agriculture. 28: 143-148.

Liu, C.J., Wary, Y., Peng, S. and Lee, J. (2010). A review on effects of mineral nutrients on citrus. China Journal of Soil Science. 41: 2006-2045.

Malik, R.P., Ahlawat, V.P. and Nain, A.S. (2000). Effect of foliar spray of urea and zinc sulphate on yield and fruit quality of Kinnow-a mandarin hybrid. Haryana Journal of Horticultural Sciences. 29(1/2): 37-38.

Miller, J.E. and Hofman, P.J. (1988). Physiology and nutrition of citrus fruit, growth with special reference to the Valencia: A mini-review. In: Proceedings of 6th International Citrus Congress, Tel Aviv, Israel. pp. 503-510.

Modise, D.M., Likuku, A.S., Thuma, M. and Phuti, R. (2009). The influence of exogenously applied 2, 4- D acid on fruit drop and quality of Navel Oranges (*Citrus sinensis* L.). African Journal of Biotechnology. 8: 2131- 2137.

Nithin, K.C.J., Rajangam, J., Balakrishnan, K. and Sampath P.M. (2017). Influence of foliar application of micronutrients on yield and quality of mandarin orange (*Citrus reticulata* blanco.) under lower pulney hills. International Journal of Agriculture Sciences. 9(17): 4151-4153.

Obreza, T.A. (2001). Effect of P and K Fertilization on Young Citrus Growth. Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Florida. pp. 1-3.

Obreza, T.A., Morgan, K.T., Albrigo, L.G. and Boman, B.J. (2008). Recommended fertilizer rates and timing. In: Nutrition of Florida Citrus Trees, 2nd edn. [(Eds.) Thomas, A., Obreza and Kelly, Morgan, T.)], Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Florida. pp. 24-32.

Obreza, T.A., Zekri, M., Hanlon, E.A., Morgan, K., Schumann, A. and Rouse, R. (2010). Soil and Leaf Tissue Testing for Commercial Citrus Production. Cooperative Extension Service, University of Florida, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Florida. pp. 24-32.

Omaima, M.H. and El-Metwally, I.M. (2007). 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 Applies Sciences Research. 3(7): 613-621.

Prasad, H., Prasad, D., Bhan, C., Bairwa, S.K., Babu, S. and Pal, S. (2013). Effect of foliar application of urea, zinc sulphate and 2,4-D on Kinnow mandarin. Journal of Progressive Agriculture. 4(1): 148-153.

Rattanpal, H.S., Rani, S., Kumar, A. and Dhaliwal, H.S. (2005). Effect of potassium and 2,4-D sprays on physical parameters of Kinnow fruits. Haryana Journal of Horticultural Sciences. 34(3-4): 222-223.

Reetika, Rana, G.S, Rana, M.K., Prince and Kant, G. (2018). Effect of foliar application of macro and micronutrients on fruit drop and yield of Kinnow Mandarin. International Journal of Pure and Applied Bioscience. 6(2): 1163-1169.

Saleem, M., Ashraf, Y.M., Ashraf, M., Akhtar, M. and Mahmood, K. (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 Journal of Botany. 45: 433-440.

Saleh, M.M.S., Mostafa, E.A.M. and Abd-El-Migeed, M.M.M. (2001). Response of some orange cultivars to different rates of potassium fertilization under sandy soil conditions. Annals of Agricultural Sciences, Ain Shams University. 46: 861-873.

Sangwan, A.K., Rattanpal, H.S., Arora, N.K. and Dalal, R.S. (2008). Effect of foliar application of potassium on fruit yield and quality of Kinnow mandarin. Environment and Ecology. 26(4): 2315-2318.

Sarrwy, S.M.A., El-Sheikh, M.H., Sanna-Kabeil, S. and Shamseldin, A. (2012). Effect of foliar application of different potassium forms supported by zinc on leaf mineral contents, yield and fruit quality of 'Balady' mandarin trees. Middle-East Journal of Scientific Research. 12(4): 490-498.

Saxena, M. (2018). Horticultural Statistics at a Glance 2018. www.agricoop.nic.in.

Sharma, T., Khan, M.K., Misra, P. and Shukla, P.K. (2012). Micropropagation of Kinnow through nodal explants. The Bioscan. 7(2): 295-297.

Singh, A., Bakshi, M.A., Brar, S. and Singh, S.K. (2019). Effect of micro-nutrients in Kinnow mandarin production: A review. International Journal of Chemical studies. 7: 5161-5164.

Singh, P., Singh, D., Singh, M.C., Singh, S. and Singh, A. (2018). Impact of foliar application of growth regulators and micronutrients on fruit yield and quality of Kinnow. International Journal of Chemical Studies. 6(6): 2545-2549.

Singh, T.P., Yamdagni, R. and Jindal, P.C. (1979). A note on the effect of potassium sprays on quality of grapes cv. Perlette. Haryana Journal of Horticultural Science. 8(3-4): 207-208.

Srivastava, K.C. and Bopaiah, M.G. (1977). Further studies on influence of different levels and combinations of N, P and K on vigour, yield and quality of Coorg mandarin. In: Proceedings of International Citrus Symposium, IIHR, Bangalore, India. pp. 29-34.

Syamal, M.M., Singh, S.K., Lal, H. and Singh, B.P. (2008). Effect of urea and zinc on growth, flowering, fruiting and fruit quality of Kagzi lime (*Citrus aurantifolia* Swingle). Environment and Ecology. 26(3): 1036-1038.

Vijaya, H.M., Godara, R.K., Singh, S. and Sharma, N. (2017). Effect of exogenous application of micronutrients on growth and yield of Kinnow mandarin under semi-arid zone of Haryana. Journal of Pharmacognosy and Phytochemistry. 6(4):733-735.

Wali, P. and Sharma, D.N. (1997). Effect of soil and foliar application of zinc on yield and quality in Kinnow- A mandarin hybrid. Haryana Journal of Horticultural Sciences. 26(3-4): 213-215.

Wang, R., Xue-Gen, S., Zhang, W.Y., Xiao-E, Y. and Juhani, U. (2006). Yield and quality responses of citrus (*Citrus reticulata*) and tea (*Podocarpus fleuryi* Hickel.) to compound fertilizers. Journal of Zhejiang University, China. 7: 696-701.

Wei, L.J., Fang, C., Dongbi, L., Yun Fan, W., Chang Bing, Y. and Hua, W.Y. (2002). Effect of application of potassium sulphate and potassium chloride on growth of citrus tree, yield and quality of fruits. Soil and Fertilizers Beijing. 4: 34.

Yadav, D., Singh, S.P. and Singh, S. (2014). Effect of foliar application of potassium compounds on yield and quality of ber (*Zizyphus mauritiana*) cv. Banarasi Karaka. International Journal of Research in Applied, Natural and Social Sciences. 2: 89-92.

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 Journal of Horticultural Science. 36(3/4): 205-206.