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

**ABSTRACT**

Plant nutrients both macro and micro play 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 India 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), phosphorous (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

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**Corresponding Author:** Reetika, Department of Horticulture, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India.  
**Email:** ritikapanwar18@gmail.com
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 ZnSO4 0.2% + FeSO4 0.2% + H2BO3 0.2% + MnSO4 0.3% + CuSO4 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. Huchce (2001) found the application of two sprays of 2,4-D or GA3 + 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% + ZnSO4 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 ZnSO4 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 ZnSO4 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 (FeSO4, ZnSO4 and MnSO4) 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% + K2SO4 1.0% + ZnSO4 0.5% + FeSO4 0.5% + H2BO3 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 ZnSO4 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 KNO3 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. Sarwry et al. (2012) found that the plants of Balady mandarin splashed with KNO3 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$_2$SO$_4$ 1% significantly improved the yield of grapes (Singh et al., 1979). Application of GA$_4$ @ 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$_4$, 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 KNO$_3$ 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$_2$SO$_4$ 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$_3$ 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 Shomouti 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$_2$SO$_4$ 2% was sprayed on plants during November, January and February. Dawood et al. (2001) observed that the fruit weight of Washington

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$_2$BO$_3$ 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$_2$SO$_4$ 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$_3$ 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 Shomouti 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$_2$SO$_4$ 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 ZnSO₄ 0.2% + FeSO₄ 0.2% + H₂BO₃ 0.2% + MnSO₄ 0.3% + CuSO₄ 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% + ZnSO₄ 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 KNO₃ 2% + ZnSO₄ 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 KNO₃ 2%, 2,4-D 10 ppm, ZnSO₄ 0.5% + 2,4-D 10 ppm and KNO₃ 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 KNO₃ 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 citron* var. Cadoux. Foliar spray of KNO₃ 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 (Sarwry 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 Khadi 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 ZnSO₄ 0.2% + FeSO₄ 0.2% + H₂BO₃ 0.2% + MnSO₄ 0.3% + CuSO₄ 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 (FeSO₄, ZnSO₄ and MnSO₄) 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% + K₂SO₄ 1.0% + ZnSO₄ 0.5% + FeSO₄ 0.5% + H₂BO₃ 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.

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