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Effect of Foliar Application of Micronutrients on Yield and Quality of Pomegranate

Dinesh K. Yadav[1], Yogendra K. Meena[2], Parvati Deewan[3] and Deepak Gupta[4]

[1]Dept. of Horticulture, S K N College of Agriculture, Jobner, Rajasthan (303 329), India
[2]SMS of Horticulture Krishi Vigyan Kendra, Gonera, Kotputli, Jaipur, Rajasthan (303 108), India
[3]Dept. of Agronomy, ARSS- Gonera, Kotputli, Jaipur. Rajasthan (303 108), India
[4]Dept. of PBG, SKNCOA, Jobner, Jaipur, Rajasthan (303 329), India

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Corresponding dkyadav.arss.gonera@sknau.ac.in

0000-0002-3585-9654

ABSTRACT

An experiment was conducted to evaluate the response to the foliar application of micro nutrient viz. iron, zinc and boron in single or in different combination on pomegranate in randomized block design with nine treatments and four replications during the mrig bhahar season *kharif* (June–July flowering time, 2016, 2017 and 2018) at Agriculture Research sub–Station Gonera Kotputli, Jaipur. Rajasthan, India. A perusal pooled data indicated that the different treatments of micronutrients application in pomegranate had significant effect on growth, yield and quality of pomegranate. The micronutrients spraying resulted in higher yield due to increased growth, better flowering and higher fruit set. The early initiation of flowering (44.8 Days), highest fruit set (52.66%), highest number of fruits plant^{-1} (87.37 fruit plant^{-1}), yield of fruit (20.37 kg plant^{-1}), B:C ratio (2.99), less fruit cracking (3.82%), high TSS (14.83%), low acidity (0.91 %), high TSS/ acid ratio (16.39) and low fruit drop (0.56 %) were observed under spray of ferrous sulphate @ 0.5%+zinc sulphate @ 0.5%+borax @ 0.4% (T_8). Whereas control condition T_1 late initiation of flowering (49 days), lowest fruit set (42.61%), lowest number of fruits plant^{-1} (69.75 fruit plant^{-1}), yield of fruit (14.33 kg plant^{-1}), B:C ratio (2.13), high fruit cracking (15.36 %), low TSS (13.45 %), higher acidity (1.48 %), low TSS/ acid ratio (9.09) and higher fruit drop (2.04 %) was recorded.

KEYWORDS: Pomegranate, micro nutrient, spraying, fruit cracking, yield

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Pomegranate (*Punica granatum* L.) belonging to Punicaceae family, is most important commercial fruit is eaten fresh and also processed for jams, jellies, syrups, pomegranate juice products and is used for medical purposes (Marina et al., 2020). Pomegranate fruit is highly appreciated for beneficial health effects in the form of decreasing cardiovascular and other chronic diseases (Al-Maiman and Ahmad, 2002). Pomegranate fruit is increasingly recognized as a highly beneficial fruit with a unique combination of appealing appearance, good taste and high content of healthy metabolites (Seeram et al., 2006). Pomegranate juice was indeed shown recently to possess impressive antioxidative properties due to its polyphenolics, tannins and anthocyanins (Gil et al., 2000) and it is reported that these polyphenol compounds may lower risk of heart disease (Aviram et al., 2000). It covers 271 thousand ha area with an annual production of 3088 thousand tonnes and a productivity of 11.39 t ha^{-1} in India (Anonymous., 2022). The area under pomegranate cultivation in India is increasing at faster rate owing to its high demand, hardy nature, better storage quality and nutritional values (Saroj and Kumar, 2019). Due to its hardy nature, high yield and low input requirements it has emerged as a potential fruit crop for the resource poor farmers under harsh conditions (Rajkumar et al., 2017). The micronutrients are required in small amounts, but play a great role in plant metabolism (Katyal., 2004). (Kishor et al., 2016) reported that bio regulators and chemicals have a positive influence on yield and fruit quality characters of pomegranate fruit. (Kaur et.al., 2015) reported that application of this dose of micronutrient combination will improve yield and fruit quality in Kinnow mandarin by correcting the deficiencies of these micronutrients. Iron is an essential micronutrient required for normal growth and plant function. It plays an important role in the activation of chlorophyll and in the synthesis of many proteins such as different cytochrome, which participate in different functions in the plant metabolism (Al-Bamarny et al., 2010). Iron have enzyme activating functions and play structural role in stabilizing proteins (Hansch and Mendel., 2009). Iron increases the chlorophyll content of leaves, reflecting the colour of leaves (Bakshi et al., 2013). The number and quality of pomegranates are greatly enhanced by zinc and iron. It may significantly enhance the colourless aril disorder as well as its other commercial characteristics, such as flavour and look (Asadi et al., 2019). (Haneef et al., 2014) reported that number of fruits with the fertigation treatment in pomegranate. In pomegranate crop regulation, plant growth regulators, nutrient and plant are major horticultural innovations which influence flowering induction, alter sex ratio and improve fruit quality (Kumar et al., 2019). Foliar spray of zinc sulphate improved the general condition of the Kinnow plants and decreases the die-back of twigs and leaf chlorosis (Gurjar et al., 2014). Auxin and protein synthesis, seed development and appropriate maturation all depend on zinc. In addition, it boosts yield and fruit size (Ashis et al., 2021). (Shivanandam et al., 2007) reported that the Zn improvement of the fruit's quality of sweet orange. Ashraf et al., 2013 and Razzaq et al., 2013 found that the Zn foliar sprays enhanced fruit productivity with better fruit quality. (Ullah, et al., 2012) reported that boron influences the leaf mineral status, vegetative and reproductive growth, yield and fruit quality of Kinnow Manadarin. Pomegranate growth, fruit yield, quality and leaf nutritional content all increase with the use of boric acid (Kumar et al., 2020). (Ashraf et al., 2012) reported that micronutrients foliar spray increased the fruit numbers/tree, juice volume and ascorbic acid contents of sweet orange and Kinnow mandarin fruits. B foliar spray increases fruit set per cent and yield in several fruit trees species, such as almond, prune, olive and sour cherry (Slavko et al., 2001). Therefore, considering all the given points, the present investigation was conducted to evaluate the response to the foliar application of micro nutrient viz. iron, zinc and boron in single or in different combination on pomegranate.

2. MATERIALS AND METHODS

A present field experiment was carried out during mrig bhahar season *kharif* (June–July flowering time, 2016, 2017 and 2018) at Agriculture Research Sub Station, Kotputli, Jaipur, Rajasthan, India which is located at an altitude of 439 meters above sea level and located at 27°42'16.4" N latitude and 76°12'4.66" E longitude. The soil of the zone is light textured sandy loam soil, the mean annual temperature between 40-43°C in the month of May and June while mean winter temperature about 10-12°C during the months of December and January. The experiment was conducted on well-established orchard of 8 years old Sindhuri trees which are planted at 5.0×5.0 m^2 spacing. The experiment was laid out in Randomized Block Design (RBD) with nine treatments and four replications. The treatments comprised of control condition (T_1), ferrous sulphate @ 0.5% (T_2), zinc sulphate @ 0.5% (T_3), borax @ 0.4% (T_4), ferrous sulphate @ 0.5%+zinc sulphate @ 0.5% (T_5), ferrous sulphate @ 0.5%+borax @ 0.4% (T_6), zinc sulphate @ 0.5%+borax @ 0.4% (T_7), ferrous sulphate @ 0.5%+zinc sulphate @ 0.5%+borax @ 0.4% (T_8) and soil application @ ferrous sulphate 25 g+zinc sulphate 20 g and borax 15 g (T_9). The two foliar applications of micro nutrient viz. iron, zinc and boron in single or in different combination on pomegranate before flowering and after flowering. First spray during last fortnight of June and second spray on last fortnight of August. The pooled data were statistically evaluated by analysis of variance procedures, using SAS software (SAS, 1989). Duncan's multiple range test at 5% level of probability was used for comparison of means.

3. RESULTS AND DISCUSSION

3.1. Effect of Fe, Zn and B on yield of pomegranate

The data presented (Table 1) shows that lowest initiation of flowering (44.8)), highest yield per tree (20.37 kg), highest B:C ratio (2.99) were recorded in the treatment of ferrous sulphate @ 0.5%+zinc sulphate @ 0.5%+borax @ 0.4% (T_8) while lowest fruits per tree (69.75), yield tree^{-1} (14.33 kg) and B:C ratio (2.13) were recorded in the treatment control (T_1). In pomegranate crop regulation, plant growth regulators, nutrient and plant are major horticultural innovations which influence flowering induction, alter sex ratio and improve fruit quality (Kumar et al., 2019). Hence, the impact of micronutrients was accessed on pomegranate. Iron is an essential micronutrient required for normal growth and plant function (Al-Bamarny et al., 2010). (Davarpanah et al., 2020) reported that early season Fe foliar sprays, applied at full bloom and one month thereafter, led to significant increases in the number of fruits tree^{-1} and fruit yield. Fe depletion causes specific effects on the chloroplast Fe proteome, with strong and early down-regulation of SufB and ferredoxin, followed by the cytochrome-b_6f complex. These changes affect photosynthesis (Laura, 2018). In most of the plant system, it is located in chloroplast and help in the production of chlorophyll responsible for more production of photosynthates. It is also essential for cell division and cell enlargement resulting in increasing the fruit size and fruit weight which ultimately leads to the increase in yield of plants (Balk and Pilon, 2011), and it is also the site for the synthesis of heme precursors (Moulin and Smith, 2005).

Table 1: Effect of micronutrients on yield of pomegranate

Sl. No.	Treatment details	Initiation of flowering (Days)	Fruit set %	No. of fruits tree^{-1}	Yield kg plant^{-1}	B:C Ratio
1.	T_1	49.00	42.61	69.75	14.33	2.13
2.	T_2	47.94	45.18	72.83	16.37	2.43
3.	T_3	48.22	46.88	72.15	15.63	2.32
4.	T_4	48.03	45.38	75.74	16.94	2.51
5.	T_5	46.69	51.04	80.70	18.03	2.65
6.	T_6	46.65	49.79	83.77	18.47	2.71
7.	T_7	46.00	51.77	84.93	18.79	2.76
8.	T_8	44.80	52.66	87.37	20.37	2.99
9.	T_9	47.05	49.88	77.43	17.75	2.62
	SEm±	0.28	0.18	0.41	0.34	0.05
	CD (p=0.05)	0.80	0.52	1.15	0.967	0.14

It also involved in regulating the protein and carbohydrate metabolism (Swietlik, 1999). Zn facilitates in the synthesis of tryptophan which is the precursor of auxin synthesis and consequently the auxin level in the fruit increases. It not only helps in the production of proteins, seeds but also essential for proper maturity of fruits. (Khorsandi et al., 2009, Kumar et al., 2017) showed that the foliar spray of Zn increased the yield and quality of pomegranate fruits. (Sau et al., 2018) reported that that combined application of Boron (B) and Zinc (Zn) recorded the highest fruits number/tree (133) and fruit yield (12.63 kg tree^{-1}) amongst different micronutrient combinations in guava crop. (Ashis et al., 2021) reported that foliar sprays of zinc or boron could enhance the economic yield. It increases pollen grain germination, pollen tube elongation, consequently fruit set percentage and finally the yield (Qinli, 2003). Boron spray increased plant height, secondary branches, flower production and fruit yield (Maji et al., 2017).

Data also indicating that the number of fruits/trees reached to the maximum in treatment combination of micro nutrient spray (T_8) with an average (87.37), while the minimum number of fruits (69.75) were obtained from control. Foliar sprays of zinc sulfate significantly increased the fruit diameter, yield ha^{-1} and Zn concentration in leaves (Hasani et al., 2012). Boron and copper help to increase the growth rate by stimulating enzymatic action in the peripheral tissue which otherwise could not be due to their inherent deficiency in the area. Boron application may probably help in translocation of sugars and synthesis of cell wall and increasing the yield (Sheikh and Manjula, 2012).

The increase in yield of pomegranate fruits by application of micronutrient treatments may be due to its leads to improvement in yield contributing characters like size and weight of fruits, fruit set percent, fruit retention per cent as evident by the present study which finally increased the yield. Increased fruit set and reduced fruit drop as a result of zinc, boron and iron spray could give higher number of fruits and consequently the yield.

3.2. Effect of Fe, Zn and B on quality of pomegranate

It is evident from the results that application of micronutrients on pomegranate had significantly improved the nutritional quality of fruits in terms of low cracking %, high TSS %, low acidity %, high TSS /acidity % and low fruit drop % fruit as compared to control. A significant decrease in fruit drop percentage were obtained as compared to control. Pooled data (Table 2) based on three years indicating that low fruit drop (0.56%) and low cracking (3.82%) was observed with the treatment of ferrous sulphate @ 0.5%+zinc sulphate @ 0.5%+borax @ 0.4% (T_8) and high fruit drop and cracking were observed in control treatment. (Maji et al., 2017) reported that the use of calcium and boron improved the performance of pomegranate in general, compared to untreated control. (Mirzapour and Khoshgoftarmanesh, 2013) stated that soil and foliar application of Fe and Zn in pomegranate decreased the fruit juice pH significantly. The highest percentage of fruit drop was observed from untreated trees at all the stages of fruit growth (Gawade et al., 2018). The foliar fertilizers, which may include Zn, B, N and Fe, to improve the quality and yield of pomegranate orchards grown in poor soils (Davarpanah et al., 2018). Nutritional deficiency, especially boron, calcium, zinc, and potash are directly associated with fruit cracking in pomegranate (Saei et al., 2014). Nutrients like potassium, calcium, zinc, copper, molybdenum, and manganese are involved in some physiological processes during the fruit growth period, and their deficiency results in fruit cracking. (Sheikh and Manjula, 2012, Pal et al., 2017) reported that increased N, and imbalance between K and Ca also lead to fruit cracking. The reducing effect on fruit cracking % in response to application of boron was mainly attributed to its important role in the extension of plant cell walls through building of pectin as well as enhancing indole-3-acetic acid (IAA) and water uptake (Yagoden, 1990). (Singh et al., 2017) reported that foliar application of borax (0.4%), zinc sulfate (0.5%), and kaolin (4%) with mulching of tree basin (black polythene sheet 150 μ) is more effective in minimizing fruit cracking rather than sprays alone. Combined application of KNO_3 (1%), $CaCl_2$ (1%) and H_3BO_3 (0.4%) resulted significant improvement in growth, yield, fruit quality and leaf nutrient content of pomegranate (Kumar et al., 2020). Application of Mg, Cu, Zn, Fe and B in combination, increased the juice content, whereas effect of these nutrients on TSS, total sugar, reducing sugars and acidity of fruits was non-significant (Ram and Bose, 2000).

Table 2: Effect of micronutrients on quality of pomegranate

Sl. No.	Treatment details	Cracking %	TSS %	Acidity %	TSS / acid ratio	Fruit droop %
1.	T_1	15.36	13.45	1.48	9.09	2.04
2.	T_2	9.03	13.51	1.37	9.86	1.64
3.	T_3	8.71	13.51	1.16	11.74	1.76
4.	T_4	5.26	13.76	1.35	10.30	1.46
5.	T_5	8.10	13.92	1.06	13.18	1.23
6.	T_6	5.53	14.03	1.15	12.26	1.10
7.	T_7	4.55	14.39	1.07	13.56	0.72
8.	T_8	3.82	14.83	0.91	16.39	0.56
9.	T_9	5.75	14.14	1.07	13.22	1.45
	SEm±	0.182	0.11	0.03	0.23	0.024
	CD (p=0.05)	0.513	0.30	0.07	0.66	0.067

The effect of application of different micronutrient treatment on TSS is presented in Table 2. A significant increase in TSS in comparison to the control were obtained in T_8 (14.83) followed by T_7 (14.39), T_9 (14.14) and T_6 (14.03). Further data indicating that low acidity % (0.91%) was observed with treatment T_8. These results agreed with those obtained by (Ramezanian et al., 2009). (Korkmaz et al., 2015) who found that foliar micronutrient increased TSS (Brix) in pomegranate. (Hasani et al., 2012) conducted an experiment on effects of foliar sprays of zinc on the fruit yield and quality in pomegranate. Increases in TSS might be observed because of the fact that micronutrients directly perform a vital role in the plant metabolic process. Zinc is required in enzymatic reactions namely hexokinase, carbohydrate and protein synthesis. The increase in fruit juice might be because of the fact that Zn controls the semi-permeability of cell wall through which the movement of water into fruits increases, that results in obtaining the highest juice content as reported (Trivedi et al., 2012). The improvement in quality of fruit might be due to the fact that micronutrients directly play an important role in plant metabolism as zinc is needed in enzymatic reaction like hexokinase, formation of carbohydrate and protein synthesis. Further, boron facilitated sugar transport through boron-sugar complex and it also increase hydrolysis of saccharides into simple sugar and iron play an important role in photosynthetic efficiency that cause higher photosynthetic rate. Given that the main product of photosynthesis is sugar, so increasing the photosynthesis, lead to increase the sugar compounds and cause more soluble solids in fruit juice. The reduction in acidity might be due to accumulation of reducing and non-reducing sugars. Thus, the quality of fruit in term of TSS, total sugar, reducing sugar was improved by zinc, boron and iron.

4. CONCLUSION

The response to the foliar application of micronutrient viz. iron, zinc and boron in single or in different combination on pomegranate had significant effect over the no use of micro nutrient. The combination uses of ferrous sulphate @ 0.5%+zinc sulphate @ 0.5%+borax @ 0.4% gave the more yield, more number of fruit per plant, high B:C ratio, low fruit cracking as well as low fruit drop as comparison to rest of treatments.

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