Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

JPP
Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 2006-2011
Received: 28-07-2018
Accepted: 29-08-2018

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Assessing leaf and soil micronutrient status in relation to pomegranate (CV*: Bhagwa*) productivity

Anusree T, Suma R and Nagaraja MS

Abstract
A survey was carried out in seven selected villages' *viz.*, Junnur, Seemikeri, Govinakoppa, Kaladagi, Sokanadagi, Chikkasamshi and Hiresamshi, located in and around Bagalkot Taluka, Bagalkot district, Karnataka during the *hasta bahar* season of 2017-18. The orchards were categorized based on their yield levels into low yielding (LYO) and high yielding (HYO) orchards considering Karnataka state average productivity of 11.71 t ha $^{-1}$. Twenty three orchards having mean yield of 9.91 t ha^{-1} (Range: 7.81-11.32 t ha^{-1}) were grouped under LYO and one hundred and twenty seven orchards were grouped under high yielding orchards with mean yield of 18.12 t ha^{-1}(Range: 12.32-25.63 t ha^{-1}).The average fruit yield (28.9 kg plant^{-1}), average fruit weight (389.7 g fruit^{-1}) and number of fruits (74) were significantly higher in HYO as compared to LYO. The soil status indicated significantly higher content of organic carbon, DTPA Zn and DTPA Fe in HYO as compared to LYO, while soil pH, EC, DTPA Cu and DTPA Mn were on par in both the categories. The HYO showed significantly higher content of Zn, Fe & Mn in pomegranate leaf, whereas Cu content was higher in low yielding orchards. The optimum leaf micro nutrient range was developed for obtaining higher pomegranate productivity and the values were in the range of 28-41, 20-43, 138-213 & 54-75 mg kg $^{-1}$ respectively for Zn, Cu, Fe and Mn. The correlation studies indicated negative relationship for pomegranate productivity with soil pH, EC, DTPA Cu and leaf Cu content while, soil OC, Zn, Fe and Mn content both in soil and leaf showed positive correlation.

Keywords: DTPA Fe, DTPA Zn, DTPA Mn, DTPA Cu, high yielding orchards

1. Introduction
Pomegranate (*Punica granatum*. L), popular crop, native from Iran, belongs to the family, lythraceae. It is highly valued for its delicious edible arils and health benefits. It is a good source of protein, carbohydrates, vitamin A, B, C and also used as preventive for several diseases. Pomegranate has wide adaptability and requires relatively low cost for its cultivation with drought tolerance and good economic returns with potential of export attributes. It is extensively grown in arid and semiarid region. In Karnataka, pomegranate is cultivated on an area of 28.09 thousand ha with an annual production of 328.92 thousand MT and productivity of 11.71 MT ha^{-1}(Ministry of Agriculture and Farmers Welfare, Government of India, 2017), in districts of Vijayapura, Koppal, Bagalkot, Belgaum, Dharwad, Chitrdurga and Bellary.
It has wide adaptability and requires relatively low cost for its cultivation with drought tolerance and good economic returns with potential of export attributes. Hence, its area is expanding in recent years. In this context, it is crucial to evolve strategies to sustain pomegranate productivity. Amongst the cultural practices, nutrient application and its availability, uptake and assimilation by pomegranate plays a key role in influencing productivity. For achieving higher and sustainable pomegranate productivity, balanced nutrient application is most important, which emphasize recommendation of nutrients based on soil and plant testing. It is fact that an intensive cropping, involving *bahar* treatment without proper nutrient management is the cause for deteriorating plant health. Further, continuous use of high analytical fertilizers with less organics has increased the incidence of nutrient deficiencies.
Mineral nutrition plays an important role in influencing the yield and quality of pomegranate. Among the essential nutrients, micronutrients are very important in determining pomegranate productivity and quality. It has been proved in several crops that soil and plant nutritional diagnosis is the basis for maximizing the yield and quality. This will simultaneously identify nutrient imbalances, deficiencies or excesses in both soil and crop, which helps in working out the strategies for optimizing nutrient application for higher yield and quality (Yao *et al.*, 2009) [21]. Soil analysis gives an idea about actual status of nutrient availability for the assimilation by the plant while, leaf analysis diagnoses the nutritional status of plant which ascertains the

nutrient requirement for a given crop. Hence, the present study aims at the systematic study on the availability of micro nutrients in soil, its uptake by plants and ultimately its effect on pomegranate productivity through survey study in Bagalkot, Karnataka.

2. Material and methods

2.1 Study area: The present survey was conducted in Bagalkot that comes under Northern Dry Zone of Karnataka. In Bagalkot district, it is majorly grown in talukas of Bagalkot and Mudhol, followed by Bilagi and Hunugund and in small area at Badami and Jamkandi. One hundred and fifty pomegranate orchards were selected randomly from seven villages *viz.*, Junnur, Seemikeri, Govinakoppa, Kaladagi, Sokanadagi, Chikkasamshi and Hiresamshi for the present survey. The details of the location and orchards are presented in table 1. The farmers of respective orchards were selected as contact farmers and the basic criteria used for selection of orchards were variety (Bhagwa), crop age (3-7yrs) and season (*hasta bahar* 2017-18).

2.2 Categorization of pomegranate Orchards: The survey orchards were categorized based on their yield levels by considering the Karnataka state average productivity *i.e*, 11.71 t ha^{-1}. The orchards with yield levels lesser than 11.71 t ha^{-1} were grouped as low yielding orchards (LYO) and with the yield levels greater than 11.71 t ha^{-1} were considered as high yielding orchards (HYO).

2.3 Collection of Pomegranate yield and yield parameters: Three healthy pomegranate plants from each orchard were selected randomly and labelled for recording the yield parameters. Weight of marketable fruit from all three labelled plants was recorded in each pickings (4-5) and cumulative weight computed to express fruit yield per plant in kilo gram. The total number of fruits was counted from all the three labelled plants and average was computed to indicate the number of fruits per plant. Then total weight of fruits harvested from three selected plants was measured and the fruit weight was calculated using following formula and expressed in gram per fruit.

$$\text{Fruit weight (gram/fruit)} = \frac{\text{Total weight of fruits}}{\text{Number of fruits}}$$

The information on marketed pomegranate fruit yield was collected from contact farmers through personal interview. Then, by considering the actual area of the orchard, the fruit yield was computed for one hectare area and expressed in tones per hectare.

2.4 Collection of soil and leaf sample: The soil samples were collected from the vicinity of the selected plants for 0-15 cm depth and appropriately 45 cm away from the dripper position using post hole auger and composite samples were prepared using quartering technique. The index tissue identified for pomegranate plant tissue analysis *i.e.* eight pair of leaf from non-bearing shoot (Raghupati and Bhargava 1998b), was collected from the labelled plants where, soil samples were collected from all orchards separately, at flowering stage to study their nutrient contents.

2.5 Preparation of samples: The collected soil samples were air dried, pounded using wooden pestle and mortar, sieved (2 mm) and stored in air tight polyethylene bags for further analysis. Similarly plant samples were powdered using stainless steel mixer jar and preserved in air tight plastic cover for further analysis.

2.6 Estimation of electrochemical properties of soil:
Soil pH was determined in 1:2.5, soil: water suspension by using digital pH meter having combined electrode as described by Jackson (1973). Electrical conductivity of the soil samples was measured in 1:2.5, soil: water extract using conductivity bridge and results were expressed in dS m^{-1} at 25^{0}C (Jackson, 1973). The organic carbon content of soil was determined using wet oxidation method (Walkley and Black, 1934). Approximately two grams of 2.0 mm sieved soil sample was fine powdered (0.2 mm) using agate pestle and mortar. A known weight (~0.5g) of finely powdered sample was treated with known and excess volume of standard $K_2Cr_2O_7$ in presence of concentrated H_2SO_4. The unused $K_2Cr_2O_7$ was quantified by back titrating with standard ferrous ammonium sulphate using ferroin as an indicator.

2.7 Estimation of micronutrients in soil: The method developed by Lindsay and Norvell (1978) [8]. using DTPA (Diethylene Triamine Penta Acetic Acid) was adopted for the estimation of Zn, Fe, Mn and Cu. The micronutrient cations were extracted with DTPA buffer at1:2 soil to extractant ratio and measured using Microwave plasma atomic emission spectrophotometer.

2.8 Estimation of micronutrients in pomegranate leaf: A known (0.5g) weight of dried leaf samples were digested using di-acid (HNO_3:$HClO_4$ -9:4) mixture on sand bath. The micronutrients (Zn, Fe, Cu and Mn) present in di-acid digested samples were determined by using Microwave plasma atomic emission spectrophotometer.

2.9 Statistical Analysis: The soil and leaf properties of pomegranate orchards were separated based on their yield levels falling into respective categories. Then one way ANOVA was studied to find the significance difference between the categories. Simple correlation between pomegranate yield and nutrient variables in leaf and soils were calculated using Pearson product moment correlation coefficient (r). The MS-office excel programme was used for calculating the simple correlation matrix. The perfect linear correlation was attained when r = ± 1 and r =0 implies that x and y tend to have no linear relationship. The table r values 0.361 @ p<0.05 and 0.467 @ p<0.01 were used to determine the significance of relationship between two variables (Snedecor and Cochran, 1981) [17].

2.10 Estimation of optimum leaf micronutrient concentration: The leaf nutrient concentration of high yielding orchards is considered as tissue nutrient parameter optima and was used to establish optimum concentration nutrient ranges in pomegranate index leaf by using the following formulae

Low concentration	**mean-4/3 SD to mean-8/3 SD**
Optimum concentration	mean - 4/3 SD to mean + 4/3 SD
High concentration	mean +4/3 SD to mean +8/3 SD

Where, mean is the average yield of high yield pomegranate orchards, SD refers to standard deviation

3. Results and discussion

3.1 Categorizing pomegranate orchards based on their yield levels

The orchards cultivating *Bhagwa* variety of 3-7 years old, fruiting season during *hasta bahar* 2017-18 were randomly selected and later categorized based on their yield levels by considering Karnataka state average productivity of 11.71 t ha^{-1}(Ministry of Agriculture and Farmers Welfare, Government of India, 2017). Accordingly amongst one hundred and fifty orchards surveyed, twenty three fell into low yielding category with average yield of 9.91 t ha^{-1} (Range; 7.81-11.32 t ha^{-1}) and one hundred and twenty seven orchards were grouped under high yielding orchards with mean yield of 18.12 t ha^{-1} (Range; 12.32-25.63 t ha^{-1}).

3.2 Pomegranate yield and yield parameters in low and high yielding orchards

Significant variation was found with respect to fruit yield (t ha^{-1} and kg $plant^{-1}$), fruit weight (g $fruit^{-1}$) and number of fruits between the two groups. Significantly higher fruit yield of 18.12 t ha^{-1} and 28.93 kg $plant^{-1}$ were observed in high yielding orchards as compared to 9.91 t ha^{-1} and 15.92 kg $plant^{-1}$ in lower yielding orchards (Table 2). Similarly fruit weight of 389.7 g $fruit^{-1}$ and fruit number 74 per plant was significantly higher in high yielding orchards as compared to low yielding orchards (264.3 g $fruit^{-1}$ and 60 respectively) (Table 2).

Number of fruits on each plant is one of the important factors that govern yield and quality of pomegranate. It is recommended to retain 60-80 fruits in fully grown up trees (NRCP, Solapur, 2014). However, depending on plant vigor and canopy, farmers regulate fruit number and this plays significant role in developing good size and quality of fruits. Fruit weight is also an important quality parameter used for grading and marketing.

Pomegranate fruit weight is governed by many factors *viz.*, number of fruits, fruit position, climatic condition and most importantly mineral nutrition (Sheikh and Rao, 2010) [16]. The mineral elements that are contributing for fruit yield are responsible for better fruit weight (Ray *et al.*, 2014) [15].

3.3 Electrochemical properties of soils in pomegranate orchards

The soil reaction of survey orchards were alkaline in nature recording average pH of 8.18 (range: 7.3-8.81) in high yielding orchards as compared to 8.34 (range: 8.22-8.71) in low yielding orchards however, the difference was insignificant (Table 3). The soil alkalinity may be attributed to parent material and climatic condition and the area. The soils of surveyed orchards are originated from lime stone and carbonates formed during weathering process tend to accumulate in soil due to semi-arid climatic condition and low rainfall. Thus the soils formed under these conditions possess alkaline pH with relatively more accumulation of calcium and magnesium carbonates /bicarbonates and lesser accumulation of transitional metal carbonates like Fe, Zn and Mn.

The variation in EC was insignificant in low and high yielding orchards. The soil EC was marginally higher in low yielding orchards (0.85 dS m^{-1}) and few orchards recorded EC (0.31-1.59 dS m^{-1}) (Table 3) greater than the critical level (1 dS m^{-1} for 1: 2.5 dilution ratio) (Tandon**,** 1992) [18]**.** The soil EC values were well within the safer limits in high yielding orchards (range: 0.24-0.85; Table 10). This might be Attributed to sparingly soluble nature of calcium carbonate which tend to occur in soil as filaments, nodules and seams as part of the colloidal complex rather in soil solution. Further good drainage condition due to dominance of gravels in most of the orchards might also suppress the adverse effect of soil salinity in these orchards. The organic carbon (OC) content in soil was significantly more in high yielding orchards (0.85 %; 0.39-1.32%) as compared to low yielding orchards (0.39%; 0.24-0.64%). This may be attributed to application of organic materials during *bahar* initiation. The surveyed data indicated higher amount of organic matter application in HYO (30.01 kg $plant^{-1}$) than LYO (13.30 kg $plant^{-1}$).

3.4 Micro nutrient status (Zn, Cu, Fe and Mn) in soils of pomegranate orchards in low and high yielding orchards

DTPA extractable micro nutrient content in soil recorded significant variation with Zn and Fe among orchards while variation in Cu and Mn content in soil was in significant (Table 3). Relatively higher DTPA Zn and Mn content of 2.67 and 17.26 mg kg^{-1} respectively was found in high yielding orchards as compared to 0.56 and 16.84 mg kg^{-1} respectively in low yielding orchards. (Table 3). Majority of the respondent farmers of high yielding orchards indicated application of $ZnSO_4$ (25-50 g plant $^{-1}$) to pomegranate plants during the *bahar* treatment while very few farmers of low yielding orchards indicated about its application. Hence, Zn content in soil was greater than critical level (0.6 mg kg^{-1} Tandon, 1992) [18]. even under alkaline condition in these soils beside the contribution from organic matter. Raghupati and Archana (2015) [3]. observed 1.119and 2.99 mg $kg^{-1}$of Zn in soils of pomegranate orchards of northern Karnataka. Similarly significantly higher DTPA-Fe content of 4.24 mg kg^{-1} was observed in high yielding orchards as compared to 2.92 mg kg^{-1} in low yielding orchards (Table 3). Relatively higher and consistent application of organic matter in HYO might have enhanced the availability of Fe in soil (Mir *et al.*, 2013) [10]. Low yielding orchards recorded a relatively higher mean copper content of 5.88 mg kg^{-1} as compared to high yielding orchards (5.33 mg kg^{-1}) (Table 6).

3.5 Pomegranate leaf micro nutrient concentration (Zn, Cu, Fe and Mn) in low and high yielding orchards

The micro nutrient content in pomegranate leaves showed significant variation among low yielding orchards and high yielding orchards (Table 3). Significantly higher amount of mean Zn, Fe and Mn content of 35.43, 175.0 and 64.65 mg kg^{-1} respectively was recorded in high yielding orchards as compared to 25.04, 134.0 and 44.08 mg kg^{-1} respectively in low yielding orchards. More deviation was recorded in Fe content followed by Mn and Zn in both the categories of orchards (Table 4). However, low yielding orchards recorded a relatively higher mean copper content of 38.5 mg kg^{-1} with a range of 21-46 mg kg^{-1} as compared to high yielding orchards (18- 45 mg kg^{-1}). Application of organic matter and $ZnSO_4$ during *bahar* initiation time might have contributed to higher Zn uptake in high yielding orchards (Khorsandi *et al.*, 2009) [6], Kumar *et al.*, 2009) [7], Hasani *et al.*, 2012) [5]. Similarly many farmers are using copper based pesticides *viz.*, copper oxy chloride, copper hydroxide and Bordeaux mixture as preventive and curative sprays for disease management. This might have influenced in accumulation of higher Cu content in pomegranate leaf.

3.6 Leaf nutrient concentration range in relation to pomegranate yield

Pomegranate leaf Zn content ranging from 28-41 mg kg^{-1} was found to be optimum while, 18-27 and 42-52 mg kg^{-1} was in low and high range (Table 4). The studies of Raghupati and and Deshmukh (2014) indicated the optimum nutrient range 14-72 mg kg^{-1} and 15-37 as optimum respectively for pomegranate

The nutrient range data indicate leaf Cu content of 20-43 mg kg^{-1} as optimum, 9-20 mg kg^{-1} and 44-55 mg kg^{-1} as low and high respectively (Table 4). The earlier studies indicate the leaf Cu content of 29-72 mg kg^{-1} (Raghupati and Bhargawa, 1998b), 21-35 mg kg^{-1} as optimum ranges for pomegranate crop however the studied variety and location were differing. Leaf Fe content of 138-213 mg kg^{-1} was recorded as optimum while 100-137 and 214-250 mg kg^{-1} was found to be in low and high ranges respectively (Table 4). The studies of Raghupati and Bhargawa, 1998b and Deshmukh, 2014 recorded the optimum Fe content for pomegranate as 71-214 and161.5-198.5 mg kg^{-1} respectively.

The nutrient concentration range data indicated leaf Mn content of 54-75 mg kg^{-1} as optimum, 42-53 mg kg^{-1} and 76-87 mg kg^{-1} as low and high respectively (Table 4). The earlier studies indicated leaf Mn content of 29-89 (Raghupati and Bhargawa, 1998b) and 40-60.4 mg kg^{-1} (Deshmukh, 2014) as optimum for pomegranate however their area of study for different. The leaf Zn content in LYO (25.04 mg kg-1) was less as compared to HYO (35.43 mg kg-1) and was in lower nutrient range. However Zn content in HYO was in optimum range. The leaf Cu content in HYO (18- 45 mg kg^{-1}) and in LYO (21-46 mg kg^{-1}) was in optimum range. The mean Fe content of 134 mg kg^{-1} in LYO was in lower nutrient range and 175 mg kg^{-1} in HYO was in optimum nutrient range. The leaf Mn content in HYO (64.65 mg kg^{-1}) and LYO (44.08 mg kg^{-1}) were falling in optimum and low nutrient range respectively.

3.7 Correlations among soil electrochemical properties, soil and leaf nutrient contents

The correlation index revealed significant positive relation Between OC (0.685) with pomegranate yield, whereas pH (-0.577) and EC (-0.202) showed a negative correlation Table 5). Pomegranate is relatively tolerant for alkalinity (Dagar *et al.*, 2001), yet the alkaline pH condition of soil had negative influence on pomegranate yield. The abundance of Ca at alkaline pH results in precipitation of P into unavailable forms *viz.*, di calcium phosphate, tri calcium phosphate, octacalcium phosphate and hydroxyl apatite (Shariatmadari *et al.*, 2007) and reduces the solubility of micro nutrients resulting in their decreased availability. These factors might have induced negative impact of pH over pomegranate yield.

Organic carbon had significant positive relation with pomegranate yield this could be due to increased availability and retention of nutrients in soil (Table 5). Besides, its effect on improving physical and biological condition of soil that helps for plant root activity, nutrient and water absorption, growth and ultimately yield (Mir *et al.*, 2013)[10].

At flowering stage, significant positive correlation was found between soil Zn (0.469), Fe (0.434) and Mn (0.476), with pomegranate yield. But Cu (-0.202) recorded a significant negative correlation with yield. In case of leaf micro nutrients, the correlation matrix signified a positive relationship with Zn (0.415), Fe (0.455) and Mn (0.444), with pomegranate yield (Table 5). This could be attributed to application of organic matter that influences on enhanced uptake of these micro nutrients that plays a key role in enzymatic activities and various metabolic processes in plants. (Yagodin, 1990, Mengel *et al.,* 2001, Bopath and Srivastava, 1982, Wiedenhoeft, 2006) [19, 20]. Copper (-0.240) was single micronutrient that had negative relationship with yield. Farmers use copper based pesticides for management of disease in pomegranate (Pangallo *et al*., 2017) [11]. This could have resulted in accumulation in higher amount in succulent leaves influencing negatively towards yield. However, the toxicity visual symptom was not expressed. The results of present study indicate cautious use of these chemicals to avoid its antagonistic effect on yield and uptake of other nutrients.

Table 1: Details of pomegranate orchards selected for the study

Sl. No.	Village Name	Longitude	Latitude	No of orchards	Age of orchards
1	Junnur	16.232s10^0 N	075.44176^0 E	12	3.5-6.5
2	Kaladagi	16.19493^0 N	075.50330^0 E	45	3-7
3	Sokanadagi	16.22876^0 N	075.57455^0 E	41	3.5-6
4	Chikkasamshi	16.23474^0 N	075.53139^0 E	23	3-5.5
5	Govinakoppa	16.20231^0 N	075.52857^0 E	14	3-6
6	Seemikeri	16.16227^0 N	075.57851^0 E	10	4-7
7	Hiresamshi	16.22532^0 N	075.52793^0 E	5	3-4.5

Table 2: Yield and yield parameters of low and high yielding pomegranate orchards

Yield Parameters	Low yielding (n=23)		High Yielding (n=127)	
	Range	Average	Range	Average
Fruit yield (tonnes ha^{-1})	7.81-11.32	9.91 ± 0.8^b	12.32-25.63	18.12 ± 3.3^a
Fruit yield (kg $plant^{-1}$)	12.43-18.0	15.92 ± 1.30^b	19.63-40.91	28.93 ± 5.2^a
Fruit weight (gram $fruit^{-1}$)	198.0-306.4	264.3 ± 27.3^b	245.8-587.5	389.7 ± 66.3^a
Number of fruits per plant	53-72	60 ± 3.6^b	61-86	74 ± 6.0^a

^{ns} non-significant, means of same parameter with different letters are statistically significant at $p < 0.05$ among low and high yielding orchards

Table 3: Electro chemical properties and nutrient content of low and high yielding pomegranate orchards

Soil electro chemical Properties	Low yielding (n=23)		High Yielding (n=127)	
	Range	Average	Range	Average
pH (1:2.5)	8.22-8.71	8.34 ± 0.16^{ns}	7.30-8.81	8.18 ± 0.29^{ns}

EC (dS m^{-1})	0.31-1.59	0.85 ± 0.30^{ns}	0.24-0.85	0.52 ± 0.25^{ns}
OC (%)	0.24-0.64	0.39 ± 0.14^{b}	0.39-1.32	0.85 ± 0.18^{a}
Soil micro nutrients	Range	Average	Range	Average
DTPA-Zinc (mg kg^{-1})	0.44-0.71	0.56 ± 0.07^{b}	1.72-3.62	2.67 ± 0.64^{a}
DTPA-Copper (mg kg^{-1})	3.78-7.98	5.88 ± 1.43^{ns}	2.17-8.49	5.33 ± 2.15^{ns}
DTPA-Iron (mg kg^{-1})	2.44-4.56	2.92 ± 0.58^{b}	2.54-5.94	4.24 ± 1.16^{a}
DTPA-Manganese (mg kg^{-1})	13.84-19.06	16.84 ± 1.49^{ns}	11.23-23.30	17.26 ± 4.12^{ns}
Leaf micro nutrient content	Range	Average	Range	Average
Zinc (mg kg^{-1})	20-34	25.04 ± 3.58^{b}	24-52	35.43 ± 6.29^{a}
Copper (mg kg^{-1})	21-46	38.50 ± 8.53^{a}	18-45	32.01 ± 8.69^{b}
Iron (mg kg^{-1})	72-196	134.0 ± 42.3^{b}	122-199	175.0 ± 28.2^{a}
Manganese (mg kg^{-1})	26-68	44.08 ± 12.62^{b}	51-79	64.65 ± 8.44^{a}

^{ns} non-significant, means of same parameter with different letters are statistically significant at $p < 0.05$ among low and high yielding orchards

Table 4: Micro nutrient concentration ranges developed considering nutrient content of high yielding orchards as nutrient optima

Micronutrient	Low	Optimum	High
Zn (mg kg^{-1})	18-27	28-41	42-52
Cu (mg kg^{-1})	9-20	20-43	44-55
Fe (mg kg^{-1})	100-137	138-213	214-250
Mn (mg kg^{-1})	42-53	54-75	76-87

Table 5: Correlation index (r) among pomegranate yield and soil micro nutrients at flowering stage

Yield and soil electrochemical properties	
pH	-0.577
EC	-0.202
OC	0.685
Yield and soil micro nutrients	
Zinc	0.469*
Copper	-0.202*
Iron	0.434*
Manganese	0.476*
Yield and leaf micro nutrient content	
Zinc	0.415*
Copper	-0.240*
Iron	0.455*
Manganese	0.444*

*p<0.05 **p<0.01,
EC in (dS m^{-1}) and OC in (%)
Soil Zn, Cu, Fe and Mn in (mg kg^{-1})
Leaf Zn, Cu, Fe and Mn in (%**)**

4 Conclusion

The present study indicated that the micronutrient management is crucial in obtaining higher pomegranate productivity. Application of organic matter, maintaining soil pH and EC are important for enhancing its availability in soil besides need based micronutrient fertilizer application. The leaf nutrient concentration should be maintained at optimum level for enhancing the pomegranate productivity.

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