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SB Pavhane
Ph.D., Scholar, Department of Horticulture, VNMVK, Parbhani, Maharashtra, India

GM Waghmare
Head, Department of Horticulture, VNMVK, Parbhani, Maharashtra, India

VN Shinde
Assistant Professor, Department of Horticulture, VNMVK, Parbhani, Maharashtra, India

VS Khandare
Research officer, Horticulture Research Scheme (Veg.) VNMKV, Parbhani, Maharashtra, India

Syed Ismail
Head, Department of Soil Science and Agriculture Chemistry, VNMKV, Parbhani, Maharashtra, India

SS More
Associate Professor, Department of Economics, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
SB Pavhane
Ph.D., Scholar, Department of Horticulture, VNMVK, Parbhani, Maharashtra, India

Effect of fertilizer and chelated micronutrient on chemical parameters of pomegranate fruit (*Punica granatum* L.) Cv. Bhagwa

SB Pavhane, GM Waghmare, VN Shinde, VS Khandare, Syed Ismail and SS More

Abstract
Experiment was carried out throughout two successive seasons of 2019-20 and 2020-21 on Bhagwa pomegranate trees grown under Mrig bahar season at the Department of Horticulture, VNMKV Parbhani. The selected trees were applied with organic and inorganic fertilizer though soil application *i.e.* F_1: 100% RDF; F_2: 80% RDF + 20% RDF though FYM and F_3: 60% RDF + 20% RDF though FYM + 20% RDF though neem cake and application of different concentration of chelated micronutrients though foliar application *i.e.* M_1: Chelated Mix formulation @ 3 gm/lit; M_2: Chelated Copper (Cu) @ 5 gm/lit; M_3: Chelated Manganese (Mn) @ 3 gm/lit; M_4: Chelated Zinc (Zn) @ 3 gm/lit; M_5: Liquid Boron (Bo) @ 5 gm/lit and M_6: Chelated Iron (Fe) @ 5 gm/lit. Based on recorded observations better chemical parameters of fruit *viz*., total soluble solid, reducing sugars, total sugars, non-reducing sugars, ascorbic acid and anthocyanin as well as minimum titratable acidity were recorded in F_3M_1 *i.e.* 60% RDF + 20% RDF though FYM + 20% RDF though neem cake + chelated mix formulation @ 3 gm/lit.

Keywords: Pomegranate**,** chelated micronutrients, fertilizer, neemcake, quality, production

Introduction
From an export point of view, pomegranate is one of the important crops of arid and semi-arid regions of India. The pomegranate (*Punica granatum* Linn) is one of the ancient fruit crop grown in tropical and subtropical regions of the world. It is claimed to have originated in the region extending from Iran to Northern India. Its domestication started 3000 - 4000 BC in the North of Iran and Turkey (Lye, 2008) [10] from where it spread to other regions *i.e.* Mediterranean countries, India and China, possibly through ancient trade routes. It was introduced in the Indian peninsula from Iran during the first century AD. In India commercial pomegranate orchards are found in rainfed areas, which characteristically have nutrient deficient soils, low in organic matter, irregular distribution of rainfall and generally experience water deficiency during plant growth period (Panwar and Tarafdar, 2006) [13]. Horticultural crops suffer widely by zinc deficiency followed by boron, manganese, copper, iron and molybdenum deficiencies. Cl, Cu, Fe and Mn are involved in various processes related to photosynthesis and Zn, Cu, Fe, and Mn are associated with various enzyme systems; Mo is specific for nitrate reductase only. B is the only micronutrient not specifically associated with either photosynthesis or enzyme function, but it is associated with the carbohydrate chemistry and reproductive system of the plant. The significance of micronutrients in growth as well as physiological functions of horticultural crops such as iron, zinc, boron, molybdenum, copper and manganese is essential for different biological functions that might be attributed to tree yield and fruit quality. It also increases resistance to disease, insect pests and improves drought tolerance. It is universally accepted that the use of chemical fertilizer is an integral part of package of practices for enhancing the agricultural production. Chemical fertilizer supplies NPK and other essential nutrients and micronutrients to plant for better growth and higher yields. The continuous use of high analysis chemical fertilizers leads to micronutrient deficiency in soil. Among the micronutrients, deficiency of Zn and Fe is wide spread in India and these soils are generally deficient in macronutrients like nitrogen and phosphorous. Among the foliar application of various level of nutrients *viz*. zinc, copper, magnesium and boron have been found more effective in improving the flowering, fruit set, fruit size, fruit yield and fruit quality in number of fruit. Micronutrients are used in smaller quantities,

but they are as important as macronutrients in respect of their functions in plants. Furthermore, they help to increase the use efficiency of macronutrients. They play an essential role in improving growth, yield and quality of many crops. Foliar application of micronutrients during crop growth was successfully used for correcting their deficits and improving the mineral status of plants as well as increasing the crop yield and quality (Kolota and Osinska, 2001) [8]

Materials and Methods

This experiment was executed through two successive seasons of seasons of 2019-20 and 2020-21 on six year old Bhagwa pomegranate plants grown on light soil having uniform growth and vigour were subjected to bahar treatment by withholding irrigation, so as to enable profuse flowering synchronously. All experimental plants were supplied with FYM @ 25 kg per plant after harvesting of previous crop and the dose of organic or inorganic fertilizers and micronutrient was given as per the treatment. The organic and inorganic fertilizers were given though soil application by ring method. Half dose of N was applied at the time of 1st irrigation after bahar treatment and remaining half dose of fertilizer applied after 4 week. Full dose of P & K was applied as single dose with 1st irrigation. Chelated micronutrients were applied through foliar application at flower initiation and fruit set with the fine sprayer. The required concentration of micronutrients solution was prepared by directly mixing them in required quantities of water and immediately used for spraying.The experiment consisted of eighteen treatment combinations and two replications laid out in Factorial Randomized Block Design (FRBD) and it consisted of two factor *i.e.* application of organic and inorganic fertilizer though soil application and application of different concentration of chelated micronutrients though foliar application. Three uniform and healthy trees were selected for each treatment combination. All the recommended cultural practices of pomegranate cultivation were undertaken as per the guidelines of Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

Treatments		Treatment Details
Factor A	(F)	Fertilizer levels
	F_1	100% RDF
	F_2	80% RDF + 20% RDF though FYM
	F_3	60% RDF + 20% RDF though FYM + 20% RDF though Neem cake
Factor B	(M)	Micronutrients levels
	M_1	Chelated Mix formulation @ 3 gm/lit
	M_2	Chelated Copper (Cu) @ 5 gm/lit
	M_3	Chelated Manganese (Mn) @ 3 gm/lit
	M_4	Chelated Zinc (Zn) @ 3 gm/lit
	M_5	Liquid Boron (Bo) @ 5 gm/lit
	M_6	Chelated Iron (Fe) @ 5 gm/lit

Observations recorded

The trees were given uniform cultural operations during the course of investigation. Observations on chemical parameter of fruit *viz.* total soluble solid (%), reducing sugars (%), total sugars (%), non-reducing sugars (%), ascorbic acid (mg/100 gm), anthocyanin (mg/100 gm) and titratable acidity (%) were recorded during experimentation.

Statistical analysis

The data were tabulated and statistical analysis was done by using method of analysis of variance (ANOVA) for Factorial Randomized Block Design (FRBD) as per the procedure given by Panse and Sukhatme (1989) [12].

Results and Discussion

Total soluble solid (TSS): The maximum total soluble solid (15.52%) was recorded in treatment F_3 *i.e.* soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake, while minimum in treatment F_1 *i.e.* 100% RDF (14.84%). The effect of foliar application of chelated micronutrient levels on total soluble solid was found to be non-significant. Further, interaction effect of F_3M_2 *i.e.* combination of soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake and foliar application of chelated copper (Cu) @ 5 gm/liter showed maximum total soluble solid (15.65%), while minimum (14.78%) in treatment F_1M_1 *i.e.* combination of soil application of 100% RDF and foliar application of chelated mix formulation @ 3 gm/liter (Table 1).

Table 1: Effect of fertilizer and chelated micronutrient on total soluble solid, reducing sugars, total sugars and non-reducing sugars of pomegranate fruit Cv. Bhagwa

Treatment	Total soluble solid (%)	Reducing sugars (%)	Total sugars (%)	Non-reducing sugars (%)
Factor A: Fertilizer levels (F)				
F_1	14.84	11.51	13.56	2.05
F_2	15.11	11.64	13.72	2.09
F_3	15.52	12.00	13.83	1.83
S.E. ±	0.06	0.03	0.05	0.06
C.D. at 5%	0.16	0.09	0.14	0.17
Factor B: Micronutrients levels (M)				
M_1	15.15	11.68	13.58	1.90
M_2	15.16	11.73	13.76	2.03
M_3	15.20	11.68	13.68	2.00
M_4	15.19	11.68	13.74	2.06
M_5	15.09	11.75	13.67	1.92
M_6	15.15	11.74	13.79	2.05

S.E ±	0.08	0.04	0.07	0.08
C.D. at 5%	NS	NS	NS	NS
Interaction A x B: Fertilizer levels x Micronutrients levels (F x M)				
F_1M_1	14.78	11.39	13.38	1.99
F_1M_2	14.79	11.50	13.67	2.18
F_1M_3	14.88	11.57	13.49	1.92
F_1M_4	14.95	11.50	13.56	2.06
F_1M_5	14.81	11.51	13.58	2.07
F_1M_6	14.84	11.57	13.68	2.11
F_2M_1	15.17	11.68	13.56	1.88
F_2M_2	15.04	11.64	13.83	2.19
F_2M_3	15.20	11.57	13.71	2.14
F_2M_4	15.11	11.53	13.67	2.14
F_2M_5	15.05	11.78	13.71	1.93
F_2M_6	15.11	11.62	13.86	2.25
F_3M_1	15.51	11.98	13.80	1.82
F_3M_2	15.65	12.04	13.77	1.72
F_3M_3	15.52	11.91	13.84	1.93
F_3M_4	15.52	12.03	14.00	1.97
F_3M_5	15.41	11.97	13.73	1.76
F_3M_6	15.50	12.05	13.85	1.80
S.E ±	0.13	0.07	0.11	0.14
C.D. at 5%	0.40	0.22	0.34	NS

The increase in total soluble solid might be attributed to rapid mobilization of sugars and other soluble solids to developing fruits due to borax application. The effect of boron on the amount of soluble solids might be due to its availability in foliar feeding of plants and the role of boron in photosynthesis 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 total soluble solids in pomegranate. Also foliar application of zinc helps in the enzymatic reactions like transformation of carbohydrates, activity of hexokinase and formation of cellulose and change in sugar are considered due to its action on zymohexose leads to increases in TSS content in fruit and boron helps in sugar transport which may be possible to improve TSS. This is in conformity with Sarkar *et al*. (1984) [14] in litchi, Arora and Singh (1972) [2] and Chaitanya *et al*. (1997) [6] in guava.

Reducing sugars (%)

The maximum reducing sugars (12.00%) was recorded in treatment F_3 *i.e.* soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake, while minimum in treatment F_1 *i.e.* 100% RDF (11.51%). The effect of foliar application of chelated micronutrient levels on reducing sugars was found to be non-significant. Further, interaction effect of F_3M_6 *i.e.* combination of soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake and foliar application of chelated iron (Fe) @ 5 gm/liter showed maximum reducing sugars (12.05%), while minimum (11.39%) in treatment F_1M_1 *i.e.* combination of soil application of 100% RDF and foliar application of chelated mix formulation @ 3 gm/liter (Table 1).

Total sugars (%)

The maximum total sugars (13.83%) was recorded in treatment F_3 *i.e.* soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake, while minimum in treatment F_1 *i.e.* 100% RDF (13.56%). The effect of foliar application of chelated micronutrient levels on total sugars was found to be non-significant. Further, interaction effect of F_2M_4 *i.e.* combination of soil application of 80% RDF + 20% RDF though FYM and foliar application of chelated zinc (Zn) @ 3 gm/liter showed maximum total sugars (14.00%), while minimum (11.38%) in treatment F_1M_1 *i.e.* combination of soil application of 100% RDF and foliar application of chelated mix formulation @ 3 gm/liter (Table 1).

Non-reducing sugars (%)

The maximum non reducing sugars (2.09%) was recorded in treatment F_2 *i.e.* soil application of 60% RDF + 20% RDF though FYM, while minimum in treatment F_3 *i.e.* soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake (1.83%). The effect of foliar application of chelated micronutrient levels on non reducing sugars was found to be non-significant. Further, interaction effect of soil application of organic and inorganic fertilizers and foliar application of chelated micronutrients levels on non reducing sugars was found to be non-significant. The changes in total and non-reducing sugar concentrations in the treated trees to the function of Zn, starch, nucleic acid and starch metabolism, as well as the activity of numerous enzymes involved in these biochemical processes. The combined application of Zn with B, Mn and Mg enhanced the proportion of total sugars in Pomegranate. Total sugars, reducing sugar and non-reducing sugar were all significantly affected by foliar sprays of micronutrients ($ZnSO_4$ 1% + Borax 0.5%) in sapota, according to Ghumare *et al*. (2014) [7]. Bhowmick *et al.* (2012) [4] reported highest total sugars and non-reducing sugar content with $ZnSO_4$ at 1.5 per cent. Similar results were reported by Anees *et al*. (2011) [1], Singh and Rajput (1976) [15] both in mango, Balakrishnan (2000) [3] in mango.

Ascorbic acid (mg/100 gm)

The maximum ascorbic acid (13.80 mg/100 gm) was recorded in treatment F_3 *i.e.* soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake, while minimum in treatment F_1 *i.e.* 100% RDF (13.41 mg/100 gm). The effect of foliar application of chelated micronutrient levels on ascorbic acid was found to be non-significant. Further, interaction effect of F_3M_5 *i.e.* combination of soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake and foliar application of Liquid Boron (Bo) @ 5 gm/liter showed maximum ascorbic acid (14.05 mg/100 gm), while minimum (12.97 mg/100 gm) in treatment F_2M_2 *i.e.* combination of soil application of 80% RDF + 20% RDF though FYM and foliar application of chelated copper (Cu) @ 5 gm/liter (Table 2).

Table 2: Effect of fertilizer and chelated micronutrient on ascorbic acid, anthocyanin and titratable acidity of pomegranate fruit Cv. Bhagwa

Treatment	Ascorbic acid (mg/100 gm)	Anthocyanin (mg/100 gm)	Titratable acidity (%)
Factor A: Fertilizer levels (F)			
F_1	13.41	15.42	0.38
F_2	13.50	15.82	0.39
F_3	13.80	16.25	0.41
S.E. ±	0.09	0.06	0.00
C.D. at 5%	0.27	0.18	0.00
Factor B: Micronutrients levels (M)			
M_1	13.23	15.74	0.39
M_2	13.77	15.79	0.39
M_3	13.54	15.72	0.39
M_4	13.72	15.97	0.40
M_5	13.60	15.89	0.40
M_6	13.55	15.90	0.40
S.E ±	0.13	0.09	0.00
C.D. at 5%	NS	NS	NS
Interaction A x B: Fertilizer levels x Micronutrients levels (F x M)			
F_1M_1	13.11	15.46	0.38
F_1M_2	13.70	15.42	0.37
F_1M_3	13.07	15.31	0.38
F_1M_4	13.64	15.28	0.39
F_1M_5	13.26	15.49	0.38
F_1M_6	13.70	15.58	0.38
F_2M_1	13.30	15.67	0.39
F_2M_2	13.64	15.61	0.39
F_2M_3	13.92	15.69	0.39
F_2M_4	13.67	16.02	0.40
F_2M_5	13.49	15.92	0.40
F_2M_6	12.97	16.05	0.40
F_3M_1	13.29	16.09	0.40
F_3M_2	13.98	16.33	0.41
F_3M_3	13.63	16.17	0.41
F_3M_4	13.86	16.60	0.42
F_3M_5	14.05	16.26	0.42
F_3M_6	13.97	16.07	0.44
S.E ±	0.22	0.15	0.00
C.D. at 5%	0.66	0.44	0.01

The ascorbic acid content was higher due to the increased in total sugars content due to the efficient translocation of available photosynthates to arils. While, an increase in ascorbic acid of pomegranate fruit might be due to high synthesis of nucleic acid on account of maximum availability of fruit metabolism. Treatments with combine application of inorganic and organic sources recorded highest ascorbic acid while inorganic fertilizers recorded lower ascorbic acid content; it is lowest with the application of RDF with spraying of Zn, Fe and B. The possible reason behind increase in content of ascorbic acid, because it is synthesized from sugar, particularly L-glucose, any increase in sugar content in fruits would be conductive to the higher synthesis of ascorbic acid in pomegranate fruits. It is also possible that boron reduced the activities of degrading enzymes. The results are in close proximity with the findings of Brahamachari *et al*. (1997) [5] in litchi and Singh and Rajput (1976) [15] in Chausa mango.

Anthocyanin (mg/100 gm)

The maximum anthocyanin (16.25 mg/100 gm) was recorded in treatment F_3 *i.e.* soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake, while minimum in treatment F_1 *i.e.* 100% RDF (15.42 mg/100 gm). The effect of foliar application of chelated micronutrient levels on anthocyanin content was found to be non-significant. Further, interaction effect of F_3M_4 *i.e.* combination of soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake and foliar application of chelated zinc (Zn) @ 3 gm/liter showed maximum anthocyanin (16.60 mg/100 gm), while minimum (15.28 mg/100 gm) in treatment F_1M_4 *i.e.* combination of soil application of 100% RDF and foliar application of zinc (Zn) @ 3 gm/liter (Table 2).

Titratable acidity (%)

The maximum titratable acidity (0.41%) was recorded in treatment F_3 *i.e.* soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake, while minimum in treatment F_1 *i.e.* 100% RDF (0.38%). The effect of chelated micronutrient levels on titratable acidity was found to be non-significant. Further, interaction effect of F_3M_6 *i.e.* combination of soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake and foliar application of chelated iron (Fe) @ 5 gm/liter showed maximum titratable acidity (0.44%), while minimum (0.37%) in treatment F_1M_2 *i.e.* combination of soil application of 100% RDF and foliar application of chelated copper (Cu) @ 5 gm/liter (Table 2). The acidity of fruits was recorded lowest in treatments involving individual application of organic manures compared to inorganic fertilizer treatments. The minimum acidity might due to either speedily conversion into sugars or their derivatives by reactions involving reverse glycolytic pathways or might have been used in respiration. The reduction in acid content might be due to the fact that mineral compounds reduced the acidity in fruits, since it is neutralized in parts during metabolic pathways and used in the respiratory process as a substrate. The results obtained in the present study are in agreement with that reported by Lal and Ahmed (2012) in pomegranate. Marathe (2005) [11] reported increase in acidity of fruit juice of sweet orange with increasing dose of N, P and K application reduced acidity.

Conclusion

Considering the above result it may be concluded that, soil application of 60% RDF + 20% RDF though FYM + 20% RDF though neem cake and foliar application of chelated mix formulation @ 3 gm/lit was recorded maximum total soluble solid, reducing sugars, total sugars, non-reducing sugars, ascorbic acid and anthocyanin as well as minimum titratable acidity.

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