E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(9): 488-497
Received: 03-07-2024
Accepted: 10-08-2024

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Studies on foliar application of chemicals on flowering, yield and quality of pomegranate (*Punica granatum* L.) in *hasta* bahar

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i9Sg.1525

Abstract
An investigation on "Studies on foliar application of chemicals on flowering, yield and quality of pomegranate (*Punica granatum* L.) in *hasta* bahar" was carried out at farmers field during the year 2020-21. The field experiment was laid out in Randomized Block Design with eleven treatments and three replications. The experiment consisted of eleven treatment combinations *viz.*,T_1-Cycocel1500ppm + 0.2% $ZnSO_4$ + 0.2% boric acid,T_2-Cycocel 2000 ppm + 0.2% $ZnSO_4$ + 0.2% boric acid, T_3- Nitrobenzene 5ml/lit + 0.2% $ZnSO_4$ + 0.2% boric acid, T_4-Nitrobenzene 7.5ml/lit + 0.2% $ZnSO_4$ + 0.2% boric acid, T_5-Salicylic acid 100 ppm + 0.2% $ZnSO_4$ + 0.2% boric acid, T_6- Salicylic acid 200 ppm + 0.2% $ZnSO_4$ + 0.2% boric acid, T_7-Ethrel 2% + 0.2% $ZnSO_4$ + 0.2% boric acid, T_8-Ethrel 3% + 0.2% $ZnSO_4$ + 0.2% boric acid, T_9-Potassium nitrate 2% + 0.2% $ZnSO_4$ + 0.2% boric acid,T_{10}-Potassium nitrate 3% + 0.2%$ZnSO_4$ + 0.2% boric acid,T_{11}- control.
The result obtained for flowering, yield and quality attributes had significantly influenced due to foliar application of different chemicals over control. Flowering parameters *viz.* less number of male flowers (45.1) was recorded in treatment T_8 while maximum number of hermaphrodite flower (185.20), total number of flower (234.89), more fruit set% (51.53) was recorded in treatment consisting of Salicylic acid 200 ppm + 0.2% $ZnSO_4$ + 0.2% boric acid. maximum fruit length (10.37 cm), fruit diameter (8.76 cm), fruit volume (316.16 ml), fruit weight (295.90 g), number of arils per fruit (597.62), aril weight per fruit (225.01 g) was recorded in treatment Potassium nitrate 3% + 0.2% $ZnSO_4$ + 0.2% Boric acid, maximum yield per plant (19.28 kg), yield per hectare (9.64 t/ha), was obtained in the treatment applied with Salicylic acid 200 ppm + 0.2% $ZnSO_4$ + 0.2% Boric acid. Total soluble solids (15.8%), reducing sugar (10.71%), non-reducing sugar (2.57%), total sugar (13.28%), total soluble solids (14.21%) and minimum titrable acidity (0.29%), of pomegranate fruit were recorded by treatment Potassium nitrate 3% + 0.2% $ZnSO_4$ + 0.2% Boric acid. B: C ratio (3.48) was recorded higher in treatment T_6 (Salicylic acid 200 ppm + 0.2% $ZnSO_4$ + 0.2% Boric acid) among treatments in present study.

Keywords: Flowering, yield, quality, chemicals, pomegranate

Introduction
Pomegranate (*Punica granatum* L.) fruit can be considered as old as human life. Pomegranate is native to Iran and the Himalayas and is the most historic fruit tree domesticated for its innumerable health benefits. Folk medicines have been using this tree for a long time and its use in modern-day medicine continues. All parts of this miracle tree-roots, stems, leaves, bark, flowers, fruits, seeds, rind, etc. are being exploited in pharmacy, the leather or dye industry or for decorative value.
The total area under cultivation of pomegranate in India is (246000 ha) and production is around (2865000 MT) (Anon. 2018-19). In India, pomegranate is commercially cultivated in Maharashtra followed by Andhra Pradesh, Karnataka, Gujarat, Rajasthan, Madhya Pradesh, Uttar Pradesh, Tamil Nadu, Punjab and Haryana. The prominent pomegranate producing districts in Maharashtra are Solapur, Nashik, Sangli, Ahmednagar, Pune, Dhule, Aurangabad, Satara, Osmanabad and Latur.
The pomegranate plant flower and provide fruit throughout the year in central and southern India however, it needs to be thrown into rest period so as to enable prolific harvest at a given time.

Looking to the pattern of precipitation, flowering can be induced during January-February (*ambia* bahar), June- July (*mrig* bahar) and September-October (*hast* bahar). Water stress induces flowering in a stipulated period which ultimately leads to proper management and thereby receiving good quality of yield. (Durgude, *et al*. 2019) [9]. The flowering habit of pomegranate is influenced by the prevailing climatic conditions of the geographical region where it is being grown (Pareek and Sharma, 1993) [20].

Material and Methods

The present investigation entitled "Studies on foliar application of chemicals on yield and quality of pomegranate (*Punica granatum* L.) in *hasta* bahar" was conducted on farmer's (Shri Dhananjay Hajgude) field at village Kini Taluka and District-Osmanabad during the year 2020-21. Geographically Osmanabad district lies in the southern part of state. It lies on the Deccan plateau, about 600 m above sea level. The district located on the east side of the Marathwada region between latitude 17^0 35' to 18^0 40' north and latitude 75^0 16' to $76^0$40' east with geographical area 7569 km^2.

The data obtained in respect of various observations were subjected to the statistical analysis as per procedure given by Panse and Sukhatme (1985) [19] for completely randomized design and critical difference has been calculated at 5 percent level of significance.

Methodology

The experiment was carried out during *hasta* bahar of 2020-21. The pomegranate plants were grown on light soil of the five years age having uniform growth and vigour were subjected to bahar treatment by giving water stress from September month. The foliar spray of different chemical treatments on tagged tree was done in three stages: first spray was given one month prior to bud break stage, second spray at full bloom stage and third spray one month after second spray. First flow of light irrigation was given to break the bahar treatment then irrigations were given as per the need through drip to all the experimental plants particularly during fruit development stage to harvest of the crop.

Treatment details

Treatment No.	Treatment details
T_1	Cycocel 1500 ppm + 0.2% ZnSO4 + 0.2% boric acid
T_2	Cycocel 2000 ppm + 0.2% ZnSO4 + 0.2% boric acid
T_3	Nitrobenzene 5ml/lit + 0.2% ZnSO4 + 0.2% boric acid
T_4	Nitrobenzene 7.5m/lit + 0.2% ZnSO4 + 0.2% boric acid
T_5	Salicylic acid 100 ppm + 0.2% ZnSO4 + 0.2% boric acid
T_6	Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% boric acid
T_7	Ethrel 2% + 0.2% ZnSO4 + 0.2% boric acid
T_8	Etherl 3% + 0.2% ZnSO4 + 0.2% boric acid
T_9	Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% boric acid
T_{10}	Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% boric acid
T_{11}	Control (no spray)

Flowering parameters

Male flower

The total number of male flowers which were bell shape flower structure and contains pollen grains and no pistil or infertile ovary were counted and expressed in numbers.

Perfect (Hermaphrodite) flower

The total number of perfect flowers which were vase shape structure and fertile with normal ovary and capable of developing fruit while stigma was covered with functional anthers were counted and expressed in numbers.

Total number of flowers

Total sum of male flower and hermaphrodite (perfect) flower on experimental tree were counted and summed up to obtain total number of flower and expressed in numbers.

Fruit set (%)

The percentage of fruit set was calculated and expressed in per cent (%).

$$\text{Percentage of fruit set} = \frac{\text{Total number of fruits per plant}}{\text{Total number of hermaphrodite flowers}} \text{ x100}$$

Fruit characters

Fruit length (cm)

The length of the fruit represented the distance between the distal end of the fruit. This was measured in cm with the help of vernier caliper and average length was worked out.

Fruit diameter (cm)

Diameter of selected fruits was measured with the help of vernier caliper at the middle portion with maximum thickness and averages were worked out and recorded as fruit diameter in centimeter.

Fruit volume (ml)

The volume of each fruit was obtained in ml through water displacement technique (Archimedes principle) by measuring with the help of volumetric beaker. The mean volume of the five fruits for each treatment was calculated separately.

Number of arils per fruit

All the arils from five fruits per treatment were separated and the average number of arils per fruit was calculated and expressed in numbers.

Aril weight per fruit (g)

Arils of selected five fruits were weighted with the help of electronic weight balance and average were calculate in grams (g).

Peel weight (g)

The peel weight of five uniform fruits per treatments were recorded and the average peel weight was calculated in gram (g).

Yield parameters

Average fruit weight (g)

Five matured fruits from each of the treatment combinations were randomly selected at field level and each fruit was weighed

on electronic balance and average weight of the fruit per treatment was computed in gram (g).

Fruit yield per plant (kg/plant)
Yield per plant was arrived at by harvesting the total number of fruits produced from selected plants individually and expressed in kilogram (kg/plant).

Yield per ha (t/ha)
The fruit yield per hectare was computed by multiplying the yield per plant with the number of plants in one hectare and was expressed in tones per hectare.

Quality parameters
Total soluble solids (%)
The total soluble solid was recorded by Erma hand refractometer (0-32%) by taking three to four drops juice of arils on prism of the refractometer and observing against the light. The refractometer calibrated with distilled water before use.

Reducing sugars (%)
Reducing sugars of juice were determined by method and given by Ranganna (1986). The percentage of reducing sugar was calculated according to following formula.

$$\text{Reducing sugars (\%)} = \frac{\text{Glucose equivalent x Total volume made up}}{\text{Titrate value x weight of sample}} \text{x100}$$

Non-reducing sugars (%)
The quantity of non-reducing sugars was calculated by the subtracting the reducing sugar from the total sugars and multiplying the difference by a factor 0.95 as given in A.O.A.C. (1975) [1].

Non reducing sugars = Total sugars- reducing sugars) x 0.95

Total sugars (%)
Total sugars of juice were estimated by method given by Ranganna (1986).

$$\text{Total sugars (\%)} = \frac{\text{Glucose equivalent x Total volume made up x Volume made up after inversion}}{\text{Titrate x wt. of sample x Aliquot taken for inversion}} \text{x100}$$

Titrable acidity (%)
The titrable acidity of the juice extract was determined according to A.O.A.C. (1975) [1] method by titrating the extract against 0.1 N NaOH using Phenolphthalein as indicator. Ten ml of juice was taken in conical flask and volume was made to up 100 ml with distilled water. 10 ml of aliquot was titrated against standard 0.1 N sodium hydroxide solution using phenolphthalein as an indicator until permanent faint pink colour developed. The titrable acidity was calculated and expressed in terms of anhydrous citric acid as percent.

$$\text{Titrable acidity (\%)} = \frac{\text{Titrate x Normality of alkaline (0.1 N) x Vol. made up x Eq. wt. of citric acid}}{\text{Wt. of sample taken x Aliquot taken for estimation x 1000}} \text{ x 100}$$

Benefit: cost ratio (B: C)
Treatment-wise cost of cultivation was worked out. The total expenditure on cultivation and management of crop was recorded in terms of rupees and per hectare cost of cultivation was calculated. The gross monetary returns per hectare was worked out considering the average prevailing price. The net returns were calculated by subtracting the cost of cultivation from gross returns and B: C ratio was worked out by using following formula:

$$\text{Benefit: cost ratio} = \frac{\text{Gross income}}{\text{Total expenditure}}$$

Results and Discussion
Flowering parameters
Number of male flowers
The number of male flowers of pomegranate cv. Bhagwa as influenced by foliar spray of different chemicals is presented in Table 1. The number of male flowers ranged from 45.15 to 57.33 in different treatments under study. Significantly less number of male flowers were recorded in the treatment applied with Ethrel 3% + 0.2% ZnSO4 + 0.2% Boric acid (45.1), however was found at par with the treatment T7 (47.34) and T2 (49.67). Less number of male flowers were treatment T2 (49.67) and T1 (50.1) and were at par with each other. The treatment control recorded more number of male flowers in pomegranate (57.83). The results are in conformity with those reported by Chaudhari and Desai (1993) that application of Ethrel (250 ppm) on pomegranate cv. Ganesh one month before expected flowering reduces percentage of male flower

Number of hermaphrodite flowers
The number of hermaphrodite flowers increased with treatments applied with different chemicals as compared to control. The number of hermaphrodite flowers ranged from 155.34 to 185.20 in different treatments under present study. The treatment application of Cycocel 2000 ppm + 0.2% ZnSO4 + 0.2% Boric acid resulted in significantly maximum number of hermaphrodite flower (185.2) as compared with rest of the treatments in present study. It was followed by the treatment T1, T3, T4, T8, T7, T6, and T5 however, were found at par with each other. The minimum number of hermaphrodite flower (155.34) was recorded in treatment control. Similar findings were observed by Ngullie *et al.* (2014) [17] in mango and Ashraf *et al.* (2013) in kinnow

Total number of flowers
Total number of flowers increased with treatments applied with different chemicals as compared to control. The total number of flowers ranged from 212.67 to 234.89 in different treatments under present study. The treatment application of Cycocel 2000 ppm + 0.2% ZnSO4 + 0.2% Boric acid resulted in significantly a greater number of total flower (234.89) as compared with rest of the treatments in present study however, was found at par with the treatment T1, T3, T4, and T6. It was followed by the treatment T5, T7 and T5 which showed intermediate results and were at par with each other. The treatment control recorded less number of total flowers (212.67). Similar findings were observed by Dhurve *et al.* (2018) in pomegranate, Ngullie *et al.* (2014) [17] in mango and Ashraf *et al.* (2013) in kinnow

Table 1: Effect of foliar application of different chemicals on number of male flowers, number of hermaphrodite flowers and total number of flowers in pomegranate

Treatment No.	Treatment details	Number of male flowers	Number of hermaphrodite flower	Total number of flowers
T_1	Cycocel 1500 ppm + 0.2% ZnSO4 + 0.2% Boric acid	50.10	180.70	235.8
T_2	Cycocel 2000 ppm + 0.2% ZnSO4 + 0.2% Boric acid	49.67	185.20	234.89
T_3	Nitrobenzene 5ml/lit + 0.2% ZnSO4 + 0.2% Boric acid	53.67	179.70	233.37
T_4	Nitrobenzene 7.5m/lit 0.2% ZnSO4 + 0.2% Boric acid	52.33	179.40	231.73
T_5	Salicylic acid 100 ppm + 0.2% ZnSO4 + 0.2% Boric acid	55.67	173.20	228.87
T_6	Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid	56.07	175.3	231.37
T_7	Ethrel 2% + 0.2% ZnSO4 + 0.2% Boric acid	47.34	177.60	224.94
T_8	Ethrel 3% + 0.2% ZnSO4 + 0.2% Boric acid	45.15	178.7	223.85
T_9	Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid	55.33	157.3	212.63
T_{10}	Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid	54.33	161.3	215.63
T_{11}	Control (no spray)	57.33	155.34	212.67
S.E. (m)±		1.07	3.06	3.94
C.D. at 5%		3.17	9.18	11.84

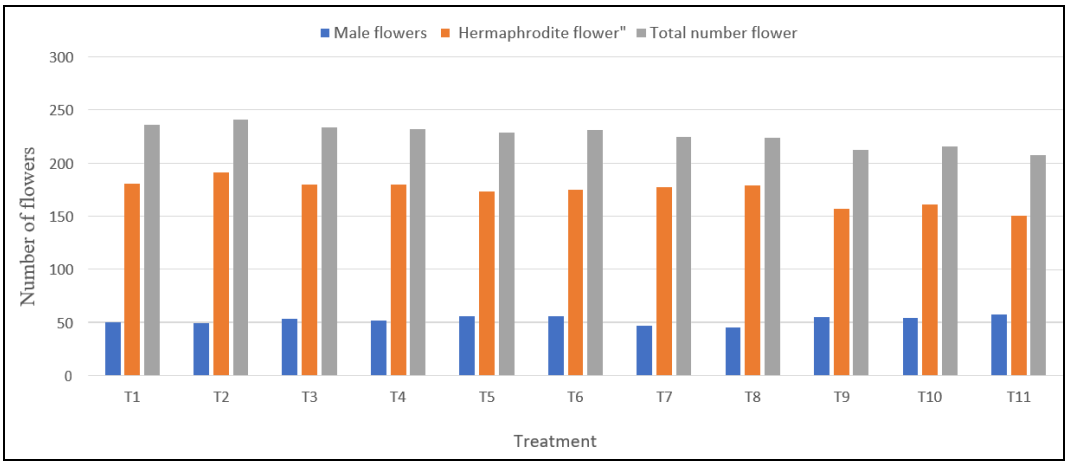

Fig 1: Effect of foliar application of chemicals on number of male flowers, number of hermaphrodite flowers and total number of flowers in of pomegranate

Fruit set (%)

The fruit set (%) ranged from 42.82 to 52.48 in different treatments under present study. The treatment application of Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid resulted in significantly maximum fruit set (%) of pomegranate (52.48) as compared with rest of the treatments and found at par with the treatment T10 (51.53) and T6 (51.12). more fruit set (%) was found in T9 (49.29), The treatments T2, T1 and T4 revealed intermediate results and were at par with each other. The minimum fruit set (%) of pomegranate (42.82) was recorded in treatment control. Similar findings were observed by Shinde *et al*. (2010), Ngullie *et al*. (2014) [17] in mango and Ashraf *et al*. (2013) in kinnow.

Table 2: Effect of foliar application of different chemicals on fruit set (%) in pomegranate

Treatment No.	Treatment details	Fruit set (%)
T1	Cycocel 1500 ppm + 0.2% ZnSO4 + 0.2% Boric acid	46.60
T2	Cycocel 2000 ppm + 0.2% ZnSO4 + 0.2% Boric acid	46.65
T3	Nitrobenzene 5ml/lit + 0.2% ZnSO4 + 0.2% Boric acid	44.35
T4	Nitrobenzene 7.5m/lit 0.2% ZnSO4 + 0.2% Boric acid	45.69
T5	Salicylic acid 100 ppm + 0.2% ZnSO4 + 0.2% Boric acid	51.12
T6	Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid	52.48
T7	Ethrel 2% + 0.2% ZnSO4 + 0.2% Boric acid	43.58
T8	Ethrel 3% + 0.2% ZnSO4 + 0.2% Boric acid	43.10
T9	Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid	49.29
T10	Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid	51.53
T11	Control (no spray)	42.82
S.E. (m)±		0.70
C.D. at 5%		2.12

Fruit characters

Fruit length (cm)

The fruit length ranged from 8.68 cm to 10.37 cm in different treatments. Significantly maximum fruit length of pomegranate was recorded in the treatment applied with Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid (10.37 cm) over rest of the treatments under study. It was followed by the treatment T9 (10.01 cm). The next best treatments were T2 (9.53 cm), T1 (9.39 cm) and T6 (9.37 cm) and were found at par with each other. The remaining treatment showed intermediate results and

were at par with each other. The minimum fruit weight of control (8.68 cm) was recorded in treatment control. The results are in line with the findings of Gill and Bal (2009) [12], Burondkar *et al*. (2009), Manju (2016) and Sharma *et al*. (2016) [28].

Fruit diameter (cm)

The fruit diameter of pomegranate ranged from 7.22 cm to 8.76 cm in different treatments in present study. Significantly maximum fruit diameter of pomegranate was recorded in the treatment applied with Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid (8.76 cm), over rest of the treatments under study, except the treatments T9 (8.54 cm), T2 (8.26 cm), T1 (8.20 cm), T6 (8.17 cm), T5 (8.10 cm) and T4 (8.09 cm),which were at par with each other. The treatments T3, T7, T11, and T8 showed intermediate results and were at par with each other. The treatment control recorded minimum fruit diameter of pomegranate (7.22 cm). The results are in line with the findings of Chaitanya *et al*. (1997) and Sarrwy (2012) [27]. These findings are also in conformity with the work of Gill *et al*. (2012) [13] in pear and Ramesh *et al*. (2016) [24] in custard apple.

Fruit volume (ml)

The fruit volume of pomegranate ranged from 225.30 ml to 316.16 ml in different treatments under present study. The treatment application of Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid resulted in significantly maximum fruit volume of pomegranate fruit (316.16 ml) as compared with rest of the treatments in present study. It was followed by the treatment T9 (310.07 ml) and T2 (303.63 ml). The next best treatments in these regards were T1 and T6, however were found at par with each other. The treatment T4, T3, T8, and T7 revealed intermediate results and were at par with each other. The minimum fruit volume of pomegranate (225.3 ml) was recorded in treatment control. Similar results were also obtained by Digrase *et al*. (2016) [8], Pandey *et al*. (1988) [18] and Sarrwy (2012) [27].

Peel weight (g)

The peel weight of fruit ranged from 68.40 g to 85.85 g in different treatments in present study. Significantly less peel weight of fruit was recorded in the treatment T9 (68.40 g) over rest of the treatments under study, however was found at par with the treatment T10. The next best treatments which showed less peel weight were treatment T3, T5 and T6 and were found at par with each other. The treatments T6, T4, T2 and T7 showed intermediate results and were at par with each other. The maximum peel weight of pomegranate fruit (85.85 g) was recorded in treatment control. The experimental findings are similar to Ramesh *et al*. (2016) [24] and Pippal *et al*. (2019) [22].

Table 3: Effect of foliar application of different chemicals on fruit parameters such as fruit length (cm), fruit diameter (cm) and fruit volume (ml) of pomegranate

Treatment No.	Treatment details	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (ml)
T1	Cycocel 1500 ppm + 0.2% ZnSO4 + 0.2% Boric acid	9.39	8.20	298.23
T2	Cycocel 2000 ppm + 0.2% ZnSO4 + 0.2% Boric acid	9.53	8.26	303.63
T3	Nitrobenzene 5ml/lit + 0.2% ZnSO4 + 0.2% Boric acid	9.25	8.05	276.87
T4	Nitrobenzene 7.5m/lit 0.2% ZnSO4 + 0.2% Boric acid	9.21	8.09	277.47
T5	Salicylic acid 100 ppm + 0.2% ZnSO4 + 0.2% Boric acid	9.29	8.10	280.53
T6	Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid	9.37	8.17	287.50
T7	Ethrel 2% + 0.2% ZnSO4 + 0.2% Boric acid	9.17	7.86	272.67
T8	Ethrel 3% + 0.2% ZnSO4 + 0.2% Boric acid	9.21	7.94	273.20
T9	Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid	10.01	8.54	310.07
T10	Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid	10.37	8.76	316.16
T11	Control (no spray)	8.68	7.22	225.30
S.E. (m)±		0.05	0.06	1.81
C.D. at 5%		0.16	0.20	5.44

3.2.5 Number of arils per fruit

The number of arils per fruit ranged from 496.57 to 597.57 in different treatments in present study. Significantly maximum number of arils per fruit of pomegranate var. Bhagwa was recorded in the treatment T10 (597.62) over rest of the treatments under study, however was found at par with the treatment T9, T2 and T1. It was followed by the treatment T4 (567.8) and T3 (560.2) and were found at par with each other. The treatment T8 and T7 showed intermediate results and were at par with each other. The minimum number of arils per fruit of pomegranate (496.57) was recorded in treatment control. Similar results were obtained by Digrase *et al.* (2016)9 [8] and Gaikwad *et al.* (2019) [10] in pomegranate which supports present findings.

3.2.6 Arils weight per fruit (g)

The treatment application of Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid recorded significantly maximum aril weight per fruit of pomegranate (225.01 g) as compared with rest of the treatments in present study, however was found at par with the treatment T9. It was followed by the treatment T2 (204.87 g) and T1 (197.03 g) and found at par with each other. The treatment T5, T4, T3 and T8 revealed intermediate results and were at par with each other. The minimum aril weight per fruit of pomegranate (144.4 g) was recorded in treatment control. The experimental findings are similar to Sharma *et al.* (2016), Digrase *et al.* (2016) [8] and Waskela *et al.* (2013) [34].

Table 4: Effect of foliar application of different chemicals on peel weight (g), number of arils per fruit and arils weight per fruit (g) in pomegranate

Treatment No.	Treatment details	Peel weight (g)	Number of arils per fruit	Arils weight per fruit (g)
T_1	Cycocel 1500 ppm + 0.2% ZnSO4 + 0.2% Boric acid	77.4	580.4	197.03
T_2	Cycocel 2000 ppm + 0.2% ZnSO4 + 0.2% Boric acid	80.26	596.58	204.87
T_3	Nitrobenzene 5ml/lit + 0.2% ZnSO4 + 0.2% Boric acid	76.58	560.2	177.09
T_4	Nitrobenzene 7.5m/lit 0.2% ZnSO4 + 0.2% Boric acid	80.10	567.8	181.7
T_5	Salicylic acid 100 ppm + 0.2% ZnSO4 + 0.2% Boric acid	74.23	570.2	187.5

T_6	Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid	76.47	578.56	197.01
T_7	Ethrel 2% + 0.2% ZnSO4 + 0.2% Boric acid	80.92	501.64	169.21
T_8	Ethrel 3% + 0.2% ZnSO4 + 0.2% Boric acid	85.16	508.24	175.21
T_9	Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid	68.40	590.82	213.17
T_{10}	Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid	70.89	597.62	225.01
T_{11}	Control (no spray)	85.85	496.57	144.40
S.E. (m)±		1.04	9.55	4.14
C.D. at 5%		3.12	28.67	12.44

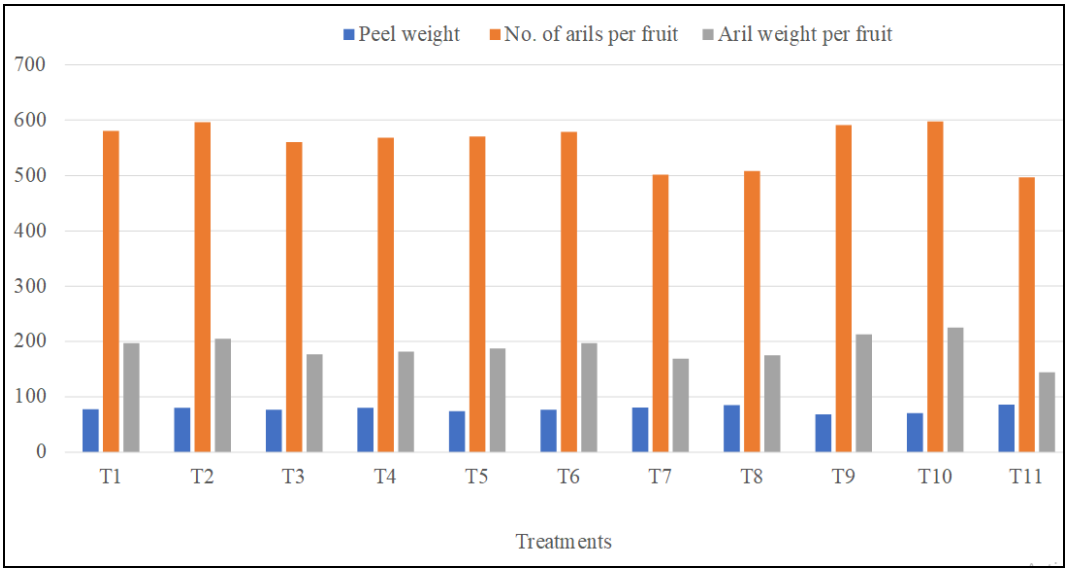

Fig 2: Effect of foliar application of different chemicals on peel weight (g), number of arils per fruit and arils weight per fruit (g) in pomegranate

Yield parameters

Average weight of fruit (g)

The average weight of fruit ranged from 230.25 g to 295.9 g in different treatments under study. Significantly maximum average weight of fruit (295.9 g) of pomegranate was recorded in the treatment Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid over rest of the treatments under study, however was found at par with the treatment T9 (285.57 g). The next best treatment in that regards were T2 and T1. The remaining treatment showed intermediate results and were at par with each other. The treatment control recorded minimum average weight of fruit of pomegranate (230.25 g) in present study. The increased fruit weight due to zinc appears to have indirect role in hastening the processing of cell division and cell elongation due to which weight of fruit would have improved. Zinc regulates the semi permeability of cell of fruit resulting more water mobilized into the cell. Yadav *et al.* (2011) [35] also reported similar findings of Gajarmal (2014) [11] and Reddy (2010) [26].

Fruit yield per plant (kg)

The yield per plant ranged from 10.09 kg to 19.28 kg in different treatments. Significantly maximum yield per plant (19.28 kg) of pomegranate was recorded in the treatment Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid over rest of the treatments under study, however was found at par with the treatment T5 (18.14 kg), T2 (17.93 kg) and T1 (17.82 kg). The next best treatments were T10 and T9 and were at par with each other. The remaining treatment showed intermediate results and were at par with each other. The treatment control recorded minimum yield per plant of pomegranate (10.09 kg) in present study. Similar findings were also represented by Singh *et al.* (2011) [31] in mango which corroborate present findings.

Fruit yield per hectare (t/ha)

The yield per hectare ranged from 5.04 t/ha to 9.64 t/ha in different treatments of present study. Significantly maximum yield per hectare (9.64 t/ha) of pomegranate was recorded in the treatment Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid over rest of the treatments under study, however was found at par with the treatment T5 (9.07 t/ha), T2 (8.96 t/ha) and T1 (8.91 t/ha). The next best treatment was T10 (8.82 t/ha). The treatment T9 and T4 showed intermediate results and were at par with each other. The treatment control recorded minimum yield per hectare of pomegranate (5.04 t/ha) in present study.

Table 5: Effect of foliar application of different chemicals on average weight of fruit (g) and yield per plant (kg) and yield per hectare (t/ha) of pomegranate

Treatment No.	Treatment details	Average weight of fruit (g)	Fruit yield per plant (kg)	Yield per hectare (t/ha)
T_1	Cycocel 1500 ppm + 0.2% ZnSO4 + 0.2% Boric acid	275.43	17.82	8.91
T_2	Cycocel 2000 ppm + 0.2% ZnSO4 + 0.2% Boric acid	280.13	17.93	8.96
T_3	Nitrobenzene 5ml/lit + 0.2% ZnSO4 + 0.2% Boric acid	258.67	13.85	6.92
T_4	Nitrobenzene 7.5m/lit 0.2% ZnSO4 + 0.2% Boric acid	261.80	14.22	7.11
T_5	Salicylic acid 100 ppm + 0.2% ZnSO4 + 0.2% Boric acid	269.83	18.14	9.07
T_6	Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid	270.37	19.28	9.64
T_7	Ethrel 2% + 0.2% ZnSO4 + 0.2% Boric acid	237.13	11.76	5.88
T_8	Ethrel 3% + 0.2% ZnSO4 + 0.2% Boric acid	250.37	12.17	6.08

T_9	Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid	285.57	16.03	8.01
T_{10}	Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid	295.90	17.64	8.82
T_{11}	Control (no spray)	230.25	10.09	5.04
S.E. (m)±		4.13	1.64	0.26
C.D. at 5%		12.42	9.93	0.77

Quality parameters

Total soluble solids (%)

The findings of the present study revealed that there was significant increase in the total soluble solids with the treatments applied with foliar sprays of different chemicals in comparison with control treatment. Total soluble solids ranged from 13.71% to 15.8% in different treatments under present study. Significantly maximum total soluble solids were recorded in the treatment applied with Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid (15.8%) over rest of the treatments under study. It was followed by the treatment T9 (15.67%), T6 (15.61%), T5 (15.39%), T2 (15.37%), and T1 (15.33%) and were found at par with each other. The remaining all treatments showed intermediate results and were at par with each other. The treatment control recorded minimum total soluble solids (13.71%) in present study. Similar findings have been reported by Prasad *et al.* (2015) [23], Sarrwy (2012) [27], Gill and Bal (2009) [12].

Titrable acidity (%)

The titrable acidity of fruits ranged from 0.29% to 0.48% in different treatments of present investigation. Significantly minimum acidity of pomegranate fruits was recorded in the treatment applied with Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid (0.29%), however was found at par with the treatment applied with Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid (0.31%) and Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid (0.32%). The next best treatments were treatment T5 (0.34%) and T2 (0.37%). The remaining treatment showed intermediate results and were at par with each other. The treatment control recorded maximum acidity of pomegranate fruits (0.48%) in present study. Similar findings have been reported by Jawandhar *et al.* (2017), Yadav *et al.* (2011) [35] and Prasad *et al.* (2015) [23].

Table 6: Effect of foliar application of different chemicals on Total Soluble Solids (%) and Titrable acidity (%) in -pomegranate

Treatment No.	Treatment details	T.S.S. (%)	Titrable acidity (%)
T_1	Cycocel 1500 ppm + 0.2% ZnSO4 + 0.2 % Boric acid	15.33	0.37
T_2	Cycocel 2000 ppm + 0.2% ZnSO4 + 0.2% Boric acid	15.37	0.39
T_3	Nitrobenzene 5ml/lit + 0.2% ZnSO4 + 0.2% Boric acid	14.80	0.43
T_4	Nitrobenzene 7.5m/lit 0.2% ZnSO4 + 0.2% Boric acid	14.94	0.42
T_5	Salicylic acid 100 ppm + 0.2% ZnSO4 + 0.2% Boric acid	15.39	0.34
T_6	Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid	15.61	0.32
T_7	Ethrel 2% + 0.2% ZnSO4 + 0.2% Boric acid	14.10	0.45
T_8	Ethrel 3% + 0.2% ZnSO4 + 0.2% Boric acid	14.48	0.43
T_9	Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid	15.67	0.31
T_{10}	Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid	15.80	0.29
T_{11}	Control (no spray)	13.71	0.48
S.E. (m)±		0.11	0.001
C.D. at 5%		0.38	0.03

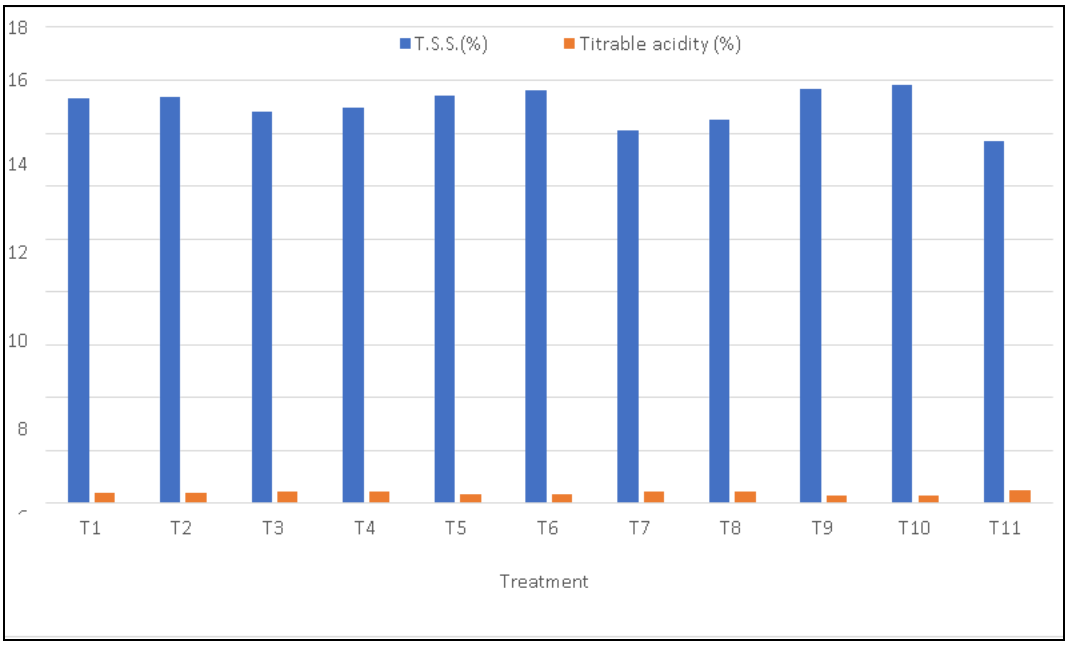

Fig 3: Effect of foliar application of different chemicals on Total Soluble Solids (%) and Titrable acidity (%) of pomegranate

Reducing Sugar (%)

Reducing sugar of fruits ranged from 9.20% to 10.71% in different treatments of present study. Significantly maximum reducing sugar of pomegranate fruits was recorded in the treatment Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid (10.71%), however was found at par with the treatment Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid (10.64%). The next best treatments in this regard were treatment T6 (9.57%) and T5 (9.52%). The treatments T1, T2, T3, T4, T8, and T7 showed intermediate results and were at par with each other. The treatment control recorded minimum reducing sugar of pomegranate fruits (9.20%) in present study. Singh and Chhonkar (1983) [30] recorded significant increase in reducing sugar in guava pulp with foliar spray of zinc sulphate @ 0.40% Waskela *et al*. (2013) [34] which supports present findings.

Non-Reducing Sugar (%)

Non reducing sugar of fruits ranged from 1.11% to 2.57% in different treatments of present study. Significantly maximum non reducing sugar of pomegranate fruits was recorded in the treatment applied with Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid (2.57%). It was followed by the treatment Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid (2.21%). The next best treatments in this regard were treatment T6 (1.59%), T2 (1.56%), T5 (1.55%) and T1 (1.55%) and were at par with each other. The treatment control recorded minimum non reducing sugar of pomegranate fruits (1.11%) in present study. These results corroborate the earlier records of Prasad *et al*. (2015) [23] and Patoliya *et al*. (2017) [21].

Total Sugar (%)

Total sugar of fruits ranged from 10.31% to 13.28% in different treatments of present study. Significantly maximum total sugar of pomegranate fruits was recorded in the treatment applied Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid (13.28%). The next best treatment in this regard was Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid (12.85%). It was followed by the treatment T6 (11.16%) and T5 (11.07%). The treatments T1, and T2 showed intermediate results and were at par with each other. The treatment control recorded minimum total sugar of pomegranate fruits (10.31%) in present study. The results are in confirmation with the findings of Manivannan *et al*. (2015) [15].

Benefit: cost ratio (B: C)

B: C ratio as influenced by the foliar sprays of different chemicals revealed differences. The treatment applied with Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid gave the maximum (3.48) B:C ratio during the investigation proved superior over rest of the treatments. The treatment control (2.00) recorded minimum B: C during the experimentation. The results are in confirmation with findings of Vishwakarma (2015) [33] and Sonkariya *et al*. (2016) in guava.

Table 7: Effect of foliar application of different chemicals on reducing sugars (%) and Non-reducing sugars (%) and Total sugars (%) in pomegranate

Treatment No.	Treatment details	Reducing sugars (%)	Non - reducing sugar (%)	Total sugars (%)
T_1	Cycocel 1500 ppm + 0.2% ZnSO4 + 0.2% Boric acid	9.35	1.55	10.90
T_2	Cycocel 2000 ppm + 0.2% ZnSO4 + 0.2% Boric acid	9.42	1.56	10.98
T_3	Nitrobenzene 5ml/lit + 0.2% ZnSO4 + 0.2% Boric acid	9.31	1.39	10.70
T_4	Nitrobenzene 7.5m/lit 0.2% ZnSO4 + 0.2% Boric acid	9.34	1.41	10.75
T_5	Salicylic acid 100 ppm + 0.2% ZnSO4 + 0.2% Boric acid	9.52	1.55	11.07
T_6	Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid	9.57	1.59	11.16
T_7	Ethrel 2% + 0.2% ZnSO4 + 0.2% Boric acid	9.24	1.18	10.42
T_8	Ethrel 3% + 0.2% ZnSO4 + 0.2% Boric acid	9.27	1.27	10.54
T_9	Potassium nitrate 2% + 0.2% ZnSO4 + 0.2% Boric acid	10.64	2.21	12.85
T_{10}	Potassium nitrate 3% + 0.2% ZnSO4 + 0.2% Boric acid	10.71	2.57	13.28
T_{11}	Control (no spray)	9.20	1.11	10.31
S.E. (m)±		0.05	0.03	0.06
C.D. at 5%		0.14	0.10	0.17

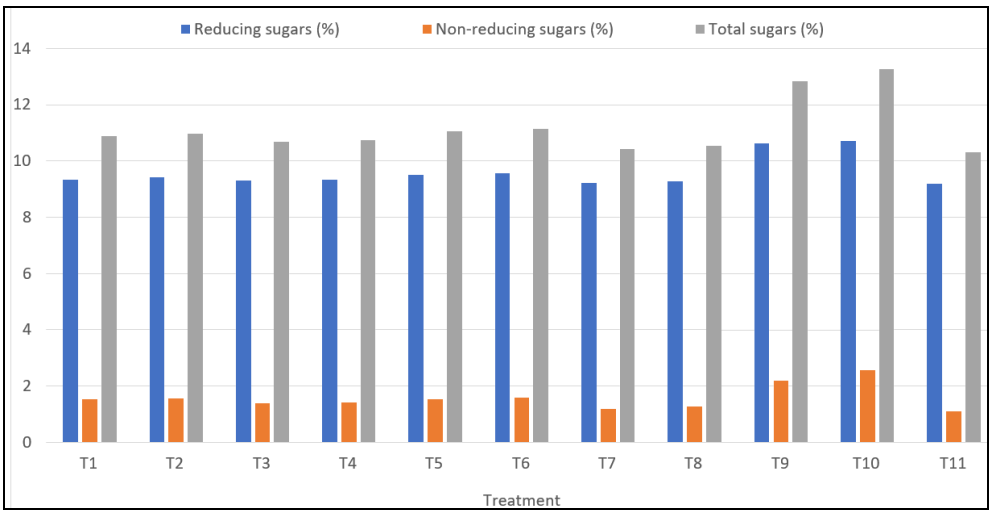

Fig 4: Effect of foliar application of different chemicals on reducing sugars (%) and Non-reducing sugars (%) and Total sugars (%) in pomegranate

Table 8: Economics of pomegranate fruits as influenced by foliar sprays of chemicals

Treatments	Total Expenditure/ha	Gross income/ha	Net return/ha	B:C ratio
T1	1,72,090	5,34,600	3,62,510	3.10
T2	1,74,355	5,37600	3,63,245	3.08
T3	1,79,080	4,15,200	2,36,120	2.31
T4	1,85,980	4,26,600	2,40,620	2.29
T5	1,66,645	5,44,200	3,77,555	3.26
T6	1,65,850	5,78,400	4,12,550	3.48
T7	1,86,764	3,52,800	1,66,036	1.88
T8	2,02,264	3,64,800	1,62,536	1.80
T9	1,78,884	4,80,600	3,01,716	2.68
T10	1,90,444	5,29,200	3,38,756	2.77
T11	1,51,000	3,02,400	1,51,400	2.00

Conclusion

Among combination treatment of different forms of potassium and micronutrients, the treatment consisting of Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid applied as foliar spray in pomegranate resulted in improving yield and quality parameters of pomegranate fruits. In nut shell, it can be concluded that three foliar sprays: first spray one month before bud break stage, second spray at full bloom stage and third spray one month after second spray with Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid in pomegranate var. Bhagwa was highly effective in producing more yield, improving post-qualities and achieving higher B: C ratio among the treatments applied. Thus, arriving to conclusion to advice for large scale use of Salicylic acid 200 ppm + 0.2% ZnSO4 + 0.2% Boric acid in pomegranate orchards of Marathwada region.

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