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Effect of foliar application of chemicals on yield of pomegranate cv. Bhagwa

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Abstract
An investigation on "Effect of foliar application of chemicals on yield and quality of pomegranate (*Punica granatum* L.) cv. Bhagwa." was undertaken with objective, To enhance the yield and quality of pomegranate by foliar application of various chemicals. The field study was carried out on the field of Horticulture (pomology) VNMKV, Parbhani. The experiment was laid out in Randomized Block Design (RBD) with Ten treatments *viz*., T_1 NAA (40 ppm) + Boron (0.3%), T2 NAA (40 ppm) + $CaCl_2$ (1.5%), T_3 NAA (40 ppm) + $ZnSO_4$ (0.2%), T_4 GA_3 (75 ppm) + Boron (0.3%), T_5 GA_3 (75 ppm) + $CaCl_2$(1.5%), T_6 GA_3 (75 ppm) + $ZnSO_4$ (0.2%), T_7 2,4-D (20 ppm) + Boron (0.3%), T_8 2,4-D (20 ppm) + $CaCl_2$ (1.5%),T_9 2,4-D (20 ppm) + $ZnSO_4$ (0.2%), T_{10} control with three replications. Observations on yield attributes of individual treatments were recorded.
The results obtained for yield parameters and quality parameters had significant and non-significant influence due to foliar application of various chemicals in given treatments.
Among these treatments fruit attributes such as length of fruit (8.71 cm), diameter of fruit (9.40 cm), and volume of fruit (334.40 ml), were found maximum in treatment T_4 i.e. spraying of GA_3 (75 ppm) + Boron (0.3%) which were respectively 14.16 per cent, 18.98 per cent, 47.80 per cent more as compared to control. Aril attributes such as number of aril in 100 g (416.00), aril percentage (76.74%), aril to rind ratio (2.40) and number of aril per fruit (864.00). The rind attributes i.e. rind thickness and rind percentage was increase treatment T_{10} i.e. control (1.84 mm), (38.15%) respectively. Given treatments also enhanced the yield attributes i.e. average weight (310.11 g), number of fruit per plant (111.25), weight of fruit per plant (34.49 kg) and yield mt/ha (19.14 mt/ha) in the treatment T_4 i.e. spraying of GA_3 (75 ppm) + Boron (0.3%) which were respectively 28.03 per cent, 63.60 per cent, 109.53 per cent and 109.40 per cent more as compared to control.
Close analysis of the present investigation revealed that the foliar application of alone or in combination with plant growth regulators and chemicals were able to increase the yield and quality characters of pomegranate cv. Bhagwa. Among the ten different treatments of sprays with superior treatment T_4 i.e. spraying of GA_3 (75 ppm) + Boron (0.3%) was found to be more effective in increasing the yield attributing characters respectively.

Keywords: pomegranate, yield, foliar, chemicals, plant growth regulator

1. Introduction
Pomegranate (*Punica granatum* L.), commonly known by the name "Anar", belongs to the plant family Punicaceae. It is an ancient tree native to the Middle East, probably Iran. It is reported to have been cultivated some 5000 to 6000 or more years ago. It is economically important plant and had been used by mankind since the dawn of civilization. There are many myths, legends and folklore associated with this unique, delicious and fascinating fruit as it has seeds. It is documented in Greek mythology, Egyptian papyrus, Biblisold Testament, Roman history, *Koran* and Indian *Sanskrit* scriptures. Pomegranate is one of the favorite table fruit of tropical and subtropical regions. It is now extensively cultivated in the Mediterranean countries (Spain, Morocco, Turkey, Tunisia), Egypt, Iran, Afghanistan, Balochistan (Pakistan) and India.
In India major pomegranate producing states are Maharashtra, Karnataka, Gujrat, Andhra Pradesh, Madhya Pradesh, Tamil Nadu and Rajasthan. Maharashtra is in the leading state with 136.75 thousand ha area with annual production of 1578 Mt and productivity of 11.54 Mt/ha. Maharashtra state accounts for 78 per cent of the total area in India and 84 per cent of the total production in the country. The prominent pockets where pomegranate cultivated area are concentrated are Solapur, Nashik, Sangli, Satara and ahemednagar districts of Western region of Maharashtra.

In recent years, the important cultural practices such as manuring, training, spacing etc. have been standardized. The plant growth substances and micronutrients have been used for various beneficial effects such as promoting root growth, number of flowers, increasing the fruit set, fruit size and quality for inducing early uniform fruit ripening.

Although a lot of work regarding beneficial effects of PGRs namely GA_3, 6-BA, CPPU, Brassionsteroid, NAA, 2,4-D and foliar application micro-nutrients i.e. boron, zinc and calcium chloride etc. have been reported on many fruit crops and proved beneficial for improving quality and yield of fruit crop like grape, strawberry, apple. The plant growth regulators has role in metabolic activities which enhance the mobility of micronutrient in various functions in cell, which is resulted in growth, yield and quality of plants. It is therefore, felt necessary to layout a trial find out the various effects of above growth substances on pomegranate applied through foliar sprays at different intervals after *bahar* treatment. However, such systematic works on use of plant growth regulators and chemical are inadequate and inconclusive in pomegranate for Marathwada region. Hence by considering the need for producing export oriented production technology in pomegranate the present investigation was planned.

2. Material and Method

The experiment was carried out during *Ambe bahar* 2017-18 under the agroclimatic conditions of Parbhani at Horticulture Research Scheme (Pomoloy), Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, Maharashtra.

The experimental site falls under Parbhani conditions and categorized as semi-arid tropics and black soils which are formed from basaltic material originating through volcanic eruptions. Soils are alkaline in reaction.

Table 1: Time of application of chemicals

Sr. No.	Chemicals	Time of application Days after flowering (DAF)		
1	NAA	45	90	-
2	GA_3	45	90	-
3	2-4-D	45	90	-
4	Boron	90	105	135
5	$CaCl_2$	90	105	135
6	$ZnSo_4$	90	105	135

The plant growth regulators were applied by foliar spray with the fine sprayer. Care was also taken to avoid spray of one solution over other treatments. The spray was washed with the clean water after the application of every solution of plant growth regulator.

3. Result and Discussion

The uneven yield characters i.e. weight, number of fruit per plant and aril characters of the fruit resulted in the reduction of final outcome to the pomegranate growers. Therefore it was necessary to develop techniques or measures, which would ensure maximum yield with quality of pomegranate fruit. This could be achieved with proper cultural practices or with the aids of various combinations of plant growth regulators and micronutrients.

3.1 Fruit Character

3.1.1 Length of fruit (cm)

The data presented in Table 3 revealed the results obtained for length of fruit had significant influence due to foliar application of various micronutrients and plant growth regulators. Treatment T_4 i.e. foliar spraying of GA_3 (75 ppm) + Boron (0.5%) recorded significant maximum length of fruit (8.71 cm), which was 14.16 per cent more as compared to control. However, it was at par with treatment T_6 and T_1. The minimum length of fruit (7.60 cm) was observed in treatment T_{10} i.e. control.

This seems to be the involvement of gibberellins in cell division and elongation in longitudinal direction and also might be reduced or suppress the radial growth which might influenced the fruit size Hoda and Hoda (2013) [10]. The results of present study are in accordance with Reddy (2010) [17] and Pawar (2005) [16] in pomegranate, Ansari *et al.* (2008) [2] in Nagpur mandarins, Nath and Baruah (2001) [13] and Arora and Singh (2014) [13] in ber.

3.2 Diameter of Fruit (cm)

The maximum diameter of fruit (9.40 cm) was recorded in treatment T_4 i.e. spraying of GA_3 (75 ppm) + Boron (0.5%) which was 18.98 per cent increase over control. However, It was at par with treatment T_6, T_1, T_5 and T_7, the lowest diameter of fruit (7.90 cm) was recorded in treatment T_{10} i.e. control.

It seems that foliar sprays of boron improved the diameter of fruit which might have brought beneficial effects on fast growing meristematic tissues. It might also affect cell division, development and carbohydrate metabolism. Similar results were obtained by Bambal (1991) [6] in pomegranate who reported that application of boron helps in increasing diameter of fruit which confirms present findings.

3.3 Volume of fruit (ml)

The treatment T_4 recorded significant maximum volume of fruit (554.40 ml), which was 47.80 per cent more as compared to control. However, it was at par with treatment T_6 and T_1. The minimum volume of fruit (7.60 cm) was observed in treatment T_{10} i.e. control.

This might be due to influence of GA_3 which increased the cell wall plasticity thus creating water diffusion pressure deficit, which might resulted in increased water uptake, thereby causing cell elongation.

The increase in volume of fruits could be due to nature of gibberlic acid which is to promote the growth by increasing plasticity of the cell wall followed by the hydrolysis of starch into sugars which reduces the cell water potential, resulting in the entry of water into the cell and causing the elongation (Richard 2006). The result of present study are in line with those of Gajarmal (2014) [8], Abubakar *et al.* (2013) [1], Hoda and Hoda (2013) [10], Lal and Ahmed (2013), Reddy (2010) [17] and Pawar (2005) [16] in pomegranate. Jagtap *et al.* (2013) [11] in acid lime which confirms present investigation.

4. Aril attributes

4.1 Number of aril in 100g

The data presented in Table 4 revealed the results obtained for number of aril in 100g had non- significant influence due to foliar application of various micronutrients and plant growth regulators. Treatment T_4 recorded significant maximum number of aril (416.00) which was 40.59 per cent more as compared to control. However, it was at par with treatment T_6 andT_1. The minimum volume of fruit (295.88 ml) was observed in treatment T_{10} i.e. control. Because it could be attributed that GA_3 play the role in multiplication and elongation of cells in the fruits. The similar results were obtained by Gajarmal (2014) [8] and Devkare (2004) [7] in pomegranate.

4.2 Aril percentage

The aril percentage had significant influence due to foliar application of various micronutrients and plant growth regulators. Treatment T_4 recorded significant maximum number of aril (76.74%) which was 26.07 per cent more as compared to control. However, it was at par with treatment T_6, T_1 and T_5. The minimum aril percentage (60.87) was observed in treatment T_{10} i.e. control.

4.3 Aril to Rind ratio

The data presented in Table 4 which revealed the results obtained for number of aril to rind ratio had non-significantly influence due to foliar application of various micronutrients and plant growth regulators. Treatment T_4 recorded maximum ratio (2.40) which was 42.85 per cent more as compared to control. The minimum ratio (1.68) was observed in treatment T_{10} i.e. control.

4.4 No. of arils per fruit

The data presented in Table 4 which revealed the results obtained for number of aril per fruit had non-significantly influence due to foliar application of various micronutrients and plant growth regulators. Treatment T_4 recorded maximum number of aril per fruit (864.00) and the minimum number of aril per fruit (694.00) was observed in treatment T_{10} i.e. control. It could be attributed to GA_3 play the role in multiplication and elongation of cells in the fruits.

5. Rind attributes

5.1 Rind thickness (mm)

The minimum rind thickness (0.78mm) was recorded in treatment T_4 i.e. spraying of GA_3 (75 ppm) + Boron (0.5%). The maximum rind thickness were found in T_{10} i.e. control (1.84mm). Similar results is also conform by Gajarmal (2014) [8], Devkare (2004) [7], and Vandana (2017) [19],

5.2 Rind percentage (%)

The results obtained for rind percentage had significant influence due to foliar application of various micronutrients and plant growth regulators. Treatment T_4 recorded minimum rind percentage (24.09%). However, maximum rind percent was found in T_{10} (58.15%) i.e. control. Similar result was obtained by Gajarmal (2014) [8] and Pawar (2001) [15] in pomegranate.

6. Yield attributes

6.1 Average weight of fruit (g)

The treatment T_4 recorded significantly maximum weight of fruit (510.11 g) which was (28.02%) more as compared to control. However, it was at par with treatment T_6, T_1, T_5, T_3 and T_2. The minimum weight of fruit (128.25 g) was recorded in treatment T_{10} control.

The beneficial effects of GA_3 in increasing weight of fruit seems to be through enhanced rapid mobilization of food reserves from the plant during the vegetative growth by gibberllic acid. This might also be due to more accumulation of food material and increase in size of fruit as well as fruit weight which was positively correlated with fruit size. The present results obtained through spraying of GA_3 are in accordance with Gajarmal (2014) [8], Reddy (2010) [17], Lal and Ahmed (2013).

Application of 2, 4-D at full bloom might stage have induced cell division and elongation in fruits of pomegranate (Rahemi and Atahosseini (2009). Diversion of metabolites and acessation of growth of shoot might have resulted in higher average weight of fruit in 2, 4-D.

The beneficial effects of boron in increasing yield parameters appears to be due to application of boron (0.5%) which might have played important role in photosynthesis, translocation and therefore the accumulation of photosynthate in fruit might have been increased resulting in increase in weight of pomegranate fruit. Similar observations were find by Bambal (1991) [6] who reported application of boron increased fruit yield in pomegranate.

6.2 No. of fruits per plant

Number of fruit per plant had significantly influence due to foliar application of various micronutrients and plant growth regulators. Treatment T_4 i.e. spraying of GA_3 (75 ppm) + Boron (0.5%) recorded maximum number of fruit per plant (111.25) which was 65.60 per cent more as compared to control treatment, which was at par with treatment T_6 and T_1. The minimum number of fruit per plant was recorded in treatment T_{10} i.e. control (68.00).

The beneficial effects of GA_3 in increasing number of fruits per plant seems to be through enhanced rapid mobilization of food reserves from the plant during the vegetative growth by gibberllic acid. The present results obtained through spraying of GA_3 are in accordance with Gajarmal (2014) [8], Reddy (2010) [17], Lal and Ahmed (2012) [12].

6.3 Weight of fruit per plant (kg)

Weight of fruit per plant had significantly influenced due to foliar application of various micronutrients and plant growth regulators. Treatment T_4 recorded maximum weight of fruit per plant (54.49 kg) which was 109.55 per cent more as compared to control treatment, however, it was at par with treatment T_6 and T_1. The lowest weight of fruit per plant was recorded in treatment T_{10} i.e. control (16.46kg). It could be effect of combination of different concentrations of plant growth regulators and micronutrients on fruit component *viz*, weight of fruit it should be positively correlated with weight of fruit per plant.

Micronutrients play more important roles in photosynthesis, development of reproductive stage, aids in regulating plant growth hormones and reaction involving cell division and growth of banana, which helps increasing in the yield of banana in term of increasing the weight of bunch. Similar type of study was done by Haripriya (1996) and Pathak *et al.* (2011) [9] recorded maximum weight of bunch (16.50 kg) in banana.

6.4 Yield (Mt/ha)

The data presented in Table 5 which revealed the results obtained for weight of fruit per plant had significantly influenced due to foliar application of various micronutrients and plant growth regulators. Treatment T_4 i.e. spraying of GA_3 (75 ppm) + Boron (0.5%) recorded maximum yield per hector (19.14 mt/ha) which was 109.40 per cent more as compared to control. However, it was at par with treatment T_6 i.e. spraying of GA_3 (75 ppm) + $ZnSO_4$ (0.2%) (18.52 mt/ha) and T_1 i.e. NAA (40 ppm) + Boron (0.5) (16.85 mt/ha).The lowest yield per hectare was recorded in treatment T_{10} i.e. control (9.14mt/ha).

The suppressive effect of 2, 4-D at optimal concentration might have increased weight and yield. Auxin causes cell elongation by loosening of cell wall. The rigid cell wall becomes softened and its plasticity (irreversible capacity to stretch) increases. The loosening of cell wall begins due to

dissolution of cell wall material, breaking of chemical bonds between cellulose and other cell wall materials, and fresh synthesis of new cell wall material and its incorporation into existing cell wall. The loosening of cell wall decreases the wall pressure (WP) which is equal to turgor pressure (TP). This action causes greater uptake of water and increase in the size of vacuole; and cell stretches resulting in increasing the yield contributing characters. Our findings are in agreement with those of Reddy (2010) [17] and Venkatesan and Kader (1994) [20] in pomegranate, Babu and Yadav (2000) [4] in ber and Ratna Babu *et al.* (1985) in citrus.

Increase in yield parameters of interaction effect might be due to cumulative effect of increased performance of yield characters contributed by application of GA_3 and boron foliar application of essential growth regulators and micronutrients might provide required nutrition for resulting in rapid fruit development and increasing number of fruits ultimately increasing weight, yield per plant and yield per hectare. Present results are in proximity with earlier findings of Shukla *et al.* (2011) [18] in phalsa.

Table 2: Effect of plant growth regulators and micronutrients on fruit attributes of pomegranate Cv. Bhagwa.

Tr. No.	Treatment Details				Length of fruit (cm)	Diameter of fruit (cm)	Volume of fruit (ml)
	PGR	PPM	Chemicals	%			
T_1	NAA	40	Boron	0.3	8.16 (7.36)	8.88 (12.40)	317.20 (40.19)
T_2	NAA	40	$CaCl_2$	1.5	7.96 (4.73)	8.30 (5.06)	295.20 (30.47)
T_3	NAA	40	$ZnSO_4$	0.2	8.15 (7.23)	8.53 (7.97)	302.50 (33.70)
T_4	GA_3	75	Boron	0.3	8.71 (14.16)	9.40 (18.98)	334.40 (47.80)
T_5	GA_3	75	$CaCl_2$	1.5	7.98 (5.00)	8.53 (7.97)	297.50 (31.49)
T_6	GA_3	75	$ZnSO_4$	0.2	8.39 (10.39)	9.25 (17.08)	325.40 (43.82)
T_7	2,4-D	20	Boron	0.3	7.93 (4.34)	8.55 (8.22)	283.10 (25.12)
T_8	2,4-D	20	$CaCl_2$	1.5	7.78 (2.36)	8.28 (4.81)	265.80 (17.48)
T_9	2,4-D	20	$ZnSO_4$	0.2	7.81 (2.76)	8.35 (5.69)	275.10 (21.59)
T_{10}	Control	-	-	-	7.60	7.90	226.25
	S.E ±				0.53	0.56	19.52
	C.D@ 5%				N.S	N.S	57.90

(Figures in parenthesis indicates the values of respective characters in percentage increased as compared to control)

Table 3: Effect of plant growth regulators and micronutrients on aril attributes of pomegranate Cv. Bhagwa.

Tr. No.	Treatment Details				Number of aril in 100g	Aril (%)	Aril to Rind ratio	No. of aril Per fruit
	PGR	PPM	Chemicals	%				
T_1	NAA	40	Boron	0.3	384.20 (29.84)	67.79 (11.36)	2.09 (15.29)	823.00 (18.58)
T_2	NAA	40	$CaCl_2$	1.5	315.10 (6.49)	65.93 (8.31)	1.93 (14.88)	775.00 (11.67)
T_3	NAA	40	$ZnSO_4$	0.2	359.21 (21.40)	67.86 (11.48)	2.08 (23.80)	815.00 (17.43)
T_4	GA_3	75	Boron	0.3	416.00 (40.59)	76.74 (26.07)	2.40 (42.85)	864.00 (24.49)
T_5	GA_3	75	$CaCl_2$	1.5	337.21 (13.96)	66.12 8.62	1.95 (16.07)	797.00 (14.84)
T_6	GA_3	75	$ZnSO_4$	0.2	397.24 (34.25)	70.65 (16.06)	2.10 (25.00)	831.00 (19.74)
T_7	2,4-D	20	Boron	0.3	307.17 (3.81)	63.87 (4.92)	1.86 (10.71)	751.00 (8.21)
T_8	2,4-D	20	$CaCl_2$	1.5	302.23 (2.14)	61.93 (1.74)	1.74 (3.57)	704.00 (1.44)
T_9	2,4-D	20	$ZnSO_4$	0.2	305.27 (3.17)	62.81 (3.18)	1.78 (5.95)	730.00 (5.18)
T_{10}	Control	-	-	-	295.88	60.87	1.68	694.00
	S.E ±				23.22	4.42	0.13	51.93
	C.D@ 5%				68.90	N.S	0.39	N.S

(Figures in parenthesis indicates the values of respective characters in percentage increased as compared to control)

Table 4: Effect of plant growth regulators and micronutrients on rind attributes of pomegranate Cv. Bhagwa.

Tr. No.	Treatment Details				Rind thickness (mm)	Rind (%)
	PGR	PPM	Chemicals	%		
T_1	NAA	40	Boron	0.3	1.05 (-42.93)	32.19 (-15.55)
T_2	NAA	40	$CaCl_2$	1.5	1.51 (-17.93)	34.10 (-10.61)
T_3	NAA	40	$ZnSO_4$	0.2	1.40 (-23.91)	32.26 (-15.43)
T_4	GA_3	75	Boron	0.3	0.78 (-57.60)	24.09 (-36.85)
T_5	GA_3	75	$CaCl_2$	1.5	1.41 (-23.36)	33.80 (-11.40)
T_6	GA_3	75	$ZnSO_4$	0.2	0.96 (-47.82)	29.18 (-23.51)
T_7	2,4-D	20	Boron	0.3	1.56 (-15.21)	35.80 (-6.16)
T_8	2,4-D	20	$CaCl_2$	1.5	1.60 (-13.04)	36.25 (-4.98)
T_9	2,4-D	20	$ZnSO_4$	0.2	1.78 (-32.60)	37.25 (-2.35)
T_{10}	Control	-	-	-	1.84	38.15
	S.E ±				0.09	2.16
	C.D@ 5%				0.26	6.41

(Figures in parenthesis indicates the values of respective characters in percentage decreased as compared to control).

Table 5: Effect of plant growth regulators and micronutrients on yield attributes of pomegranate Cv. Bhagwa.

Tr. No.	Treatment Details				Average weight (g)	No of fruit /plant	weight of fruit/plant (kg)	Yield Mt/ha
	PGR	PPM	Chemicals	%				
T_1	NAA	40	Boron	0.3	300.20 (23.94)	101.10 (48.67)	30.35 (84.38)	16.83 (84.13)
T_2	NAA	40	$CaCl_2$	1.5	278.20 (14.86)	84.09 (23.66)	23.39 (42.10)	12.97 (41.90)
T_3	NAA	40	$ZnSO_4$	0.2	294.00 (21.38)	96.50 (41.91)	28.37 (72.35)	15.74 (72.21)
T_4	GA_3	75	Boron	0.3	310.11 (28.03)	111.25 (63.60)	34.49 (109.53)	19.14 (109.40)
T_5	GA_3	75	$CaCl_2$	1.5	288.10 (18.95)	90.10 (32.50)	25.95 (57.65)	14.40 (57.54)
T_6	GA_3	75	$ZnSO_4$	0.2	305.00 (25.92)	108.26 (59.20)	33.01 (100.54)	18.32 (100.43)
T_7	2,4-D	20	Boron	0.3	266.66 (10.09)	82.80 (21.76)	21.54 (30.86)	12.25 (34.02)
T_8	2,4-D	20	$CaCl_2$	1.5	254.40 (5.03)	74.00 (8.82)	18.82 (14.33)	10.44 (14.22)
T_9	2,4-D	20	$ZnSO_4$	0.2	261.50 (7.96)	77.77 (14.36)	20.33 (23.51)	11.28 (23.41)
T_{10}	Control	-	-	-	242.20	68.00	16.46	9.14
	S.E ±				18.70	6.11	1.77	0.98
	C.D @ 5%				N.S	18.31	5.31	2.95

(Figures in parenthesis indicates the values of respective characters in percentage increased as compared to control)

7. Conclusions

In summing up the present investigation based on obtained results, the combination of all plant growth regulators and micronutrients application positively influenced on fruit attributes and yield of pomegranate fruits as compared to control. The all treatment combination, among that GA_3 @ 75 PPM and Boron 0.3% produced higher yield and quality of pomegranate fruits.

In nut shell, it can be concluded that foliar application of GA_3 @ 75 PPM and Boron 0.3% at 90, 105 and 135 days after flowering was beneficially in producing higher yield and yield attributing characters.

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