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Deepa MG
Department of Fruit Science, College of Horticulture Bagalkot, Karnataka, India

SN Patil
Department of Fruit Science, College of Horticulture Bagalkot, Karnataka, India

SG Gollagi
Dept. of Crop Physiology, UHS Bagalkot, Karnataka, India

DR Patil
Department of Fruit Science, College of Horticulture Bagalkot, Karnataka, India

Suma R
Department of Fruit Science, College of Horticulture Bagalkot, Karnataka, India

Raghavendra KM
Department of Fruit Science, College of Horticulture Bagalkot, Karnataka, India

Correspondence
SG Gollagi
Dept. of Crop Physiology, UHS Bagalkot, Karnataka, India

Economics and yield of pomegranate (*Punica granatum* L.) cv. Bhagwa as influenced by gibberellic acid and nutrients under Northern Dry Zone of Karnataka

Deepa MG, SN Patil, SG Gollagi, DR Patil, Suma R and Raghavendra KM

Abstract
The investigation was conducted in the farmer's field of Tulasigiri village, in Bagalkot taluk Bagalkot district during 2017-18 with an objective to study the effect of foliar application of gibberellic acid and nutrients on yield and economics of pomegranate cv. Bhagwa. Among the different treatments, foliar application of GA_3 @ 100 ppm + $CaCl_2$ 2% + borax 0.2% + $MgSO_4$ 0.5% has recorded the highest fruit length (93.74 mm), fruit diameter (92.38 mm), fruit volume (387.63 ml), number of arils (594.60), total aril weight (232.98 g), peel weight (136.02 g), fruit weight (363.55 g), yield per plant (28.90 kg) and yield per hectare (21.38 t/ha) compared to control which recorded lowest yield (16.57 t/ha) and yield attributes. Highest B:C was obtained in T_{13} (3.23) and T_{15} (3.22). Among the different treatments, the plants treated with GA_3 @ 100 ppm + $CaCl_2$ 2% + borax 0.2% + $MgSO_4$ 0.5% influenced the improved fruit growth, increased yield and better B:C as compared to other treatments.

Keywords: Gibberellic acid, nutrients, yield, economics, pomegranate, Bhagwa

Introduction
Pomegranate (*Punica granatum* L., 2n=16) belongs to the family Lythraceae and the genus *Punica* has two species *viz.*, *Punica granatum* widely accepted and cultivated species throughout the world and *Punica protopunica* a wild type. The word 'pomegranate' comes from French language which means 'seeded apple'. In recent years, the area under pomegranate has been increasing substantially, mainly because of the versatility, adaptability, drought resistance and low maintenance cost and steady and high yields of the crop, excellent shelf life and export potential.

India is the leading country in world pomegranate production. In India, pomegranate is commercially grown in the states of Maharashtra, Karnataka, Gujarat etc. Total area under pomegranate in India is 2.20 lakh hectares with production of 2795 MT. Production of pomegranate in Karnataka is around 328.92 MT from an area of 28.09 thousand hectares.

The fruits of pomegranate are known to possess pharmaceutical and therapeutic properties and has great demand for domestic market as well as for export in the international market. Export quality of fruits are assessed by fruit size, shape, attractive red external fruit colour, red coloured and fully developed arils, high TSS and sugar acid blend *etc.*

In semi arid regions, the soils are light, having low organic matter and nutrient deficiencies usually occur during growing season under low rainfall. Soil application nutrients usually cause phytotoxicity, but its foliar applications are more effective than soil application (Wojcik and Lewandowski, 2003). Hence, the present investigation was carried out.

Material and Methods
This study was carried out during 2017-2018 on four year old uniform pomegranate trees grown in private orchard situated at tulasigiri village, Bagalkot district, Karnataka. The trees are planted in red sandy loam at 4.5 m x 3 m apart and were subjected to cultural practices which usually done in this orchard. The experiment was designed as a Randomized block design with 16 treatments include 3 replicates.

The applied treatments were arranged as follows
1. GA_3 @ 100 ppm
2. $CaCl_2$ (2%)
3. Borax (0.2%)

4. $MgSO_4$ (0.5%)
5. GA_3 @ 100 ppm + $CaCl_2$ (2%)
6. GA_3 @ 100 ppm + borax (0.2%)
7. GA_3 @ 100 ppm + $MgSO_4$ (0.5%)
8. $CaCl_2$ (2%) + borax (0.2%)
9. $CaCl_2$ (2%) + $MgSO_4$ (0.5%)
10. Borax (0.2%) + $MgSO_4$ (0.5%)
11. GA_3 @ 100 ppm + $CaCl_2$ (2%) + borax (0.2%)
12. GA_3 @ 100 ppm + $CaCl_2$ (2%) + $MgSO_4$ (0.5%)
13. GA_3 @ 100 ppm + borax (0.2%) + $MgSO_4$ (0.5%)
14. Borax (0.2%) + $CaCl_2$ (2%) + $MgSO_4$ (0.5%)
15. GA_3 @ 100 ppm + $CaCl_2$ (2%) + borax (0.2%) + $MgSO_4$ (0.5%)
16. Control

Treatments were imposed at 45, 90, 103, 135 days after fruit set. During harvesting stage 5 fruits from each treatment were taken for quality determination. Average fruit length (mm), fruit diameter (mm), fruit weight (g), aril weight (g), peel weight (g) were measured and they estimated cost of cultivation.

Results and Discussion

Table 1: Effect of foliar application of gibberellic acid and nutrients on fruit growth, yield and yield attributes of pomegranate cv. Bhagwa

Treatment	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Fruit volume (ml)	No. of arils per fruit	Aril weight (g)	Peel weight (g)
T_1 - GA_3 @ 100 ppm	350.25	91.27	88.42	366.93	571.33	223.94	126.30
T_2 - $CaCl_2$ (2%)	336.75	88.02	85.85	364.01	498.53	209.81	126.94
T_3 - Borax (0.2%)	328.03	86.41	83.87	356.13	535.40	216.34	111.68
T_4 - $MgSO_4$ (0.5%)	322.44	84.50	83.25	349.58	524.40	213.22	109.213
T_5 - GA_3 @ 100 ppm + $CaCl_2$ (2%)	357.33	92.53	90.51	381.09	578.00	230.73	126.59
T_6 - GA_3 @ 100 ppm + borax (0.2%)	354.94	92.26	89.79	374.42	577.33	228.44	126.50
T_7 - GA_3 @ 100 ppm + $MgSO_4$ (0.5%)	348.42	89.53	88.07	366.70	568.60	218.74	129.67
T_8 - $CaCl_2$ (2%) + borax (0.2%)	343.41	88.46	86.56	364.38	563.66	218.42	124.99
T_9 - $CaCl_2$ (2%) + $MgSO_4$ (0.5%)	353.82	91.68	89.61	372.71	546.00	217.80	136.02
T_{10} - Borax (0.2%) + $MgSO_4$ (0.5%)	343.68	89.49	87.76	366.67	555.93	218.05	125.63
T_{11} - GA_3 @ 100 ppm + $CaCl_2$ (2%) + borax (0.2%)	356.76	92.28	90.49	378.76	576.80	227.40	129.36
T_{12} - GA_3 @ 100 ppm + $CaCl_2$ (2%) + $MgSO_4$ (0.5%)	361.62	93.20	91.52	382.04	578.66	231.65	129.97
T_{13} - GA_3 @ 100 ppm + borax (0.2%) + $MgSO_4$ (0.5%)	359.90	92.61	90.66	381.38	592.00	232.33	127.56
T_{14} - Borax (0.2%) + $CaCl_2$ (2%) + $MgSO_4$ (0.5%)	352.92	91.33	89.53	367.81	569.93	223.63	129.29
T_{15} - GA_3 @ 100 ppm + $CaCl_2$ (2%) + borax (0.2%) + $MgSO_4$ (0.5%)	363.55	93.73	92.38	387.63	594.60	232.98	130.56
T_{16} - Control	303.72	80.22	78.37	308.54	492.00	201.03	102.69
S. Em.±	1.95	0.60	0.84	4.44	3.04	1.75	0.25
C.D. at 5%	5.64	1.75	2.42	12.98	8.77	4.84	7.27

Fruit length (mm), fruit diameter (mm) and fruit volume (ml): The maximum length, diameter and volume of the fruit was recorded with the application of GA_3 and nutrients in combination as compared to application of only GA_3 and only nutrients. Among the treatments, the maximum fruit length (93.74 mm), fruit diameter (92.38 mm) and fruit volume (387.63 ml) were recorded in treatment T_{15} (GA_3 @ 100 ppm + $CaCl_2$ 2% + borax 0.2% + $MgSO_4$ 0.5%). However, the minimum fruit length (80.22 mm), diameter (78.37 mm) and volume of the fruit (308.34 ml) was recorded in T_{16} (Control).These results might be due to stimulation of cell elongation and membrane permeability by GA_3 which resulted in higher water uptake (Chaudhary *et al.,* 2006) [1]. They recorded the highest fruit diameter and volume when they treated with GA_3 @ 75 ppm + borax 0.3 per cent in pomegranate cv. Bhagwa. The highest fruit length and diameter obtained by GA_3 @ 50 or 100 ppm and $CaCl_2$ 2 or 4% treatment in pomegranate was observed by Hegazi *et al.* (2014) [3]. Gibberellic acid is reported to promote 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 elongation (Richard, 2006) [6].

Number of arils and total aril weight (g): The number of arils per fruit and total aril weight was significantly influenced by various treatments. Highest number of arils per fruit (594.60) and total aril weight (232.98 g) was observed in T_{15} (GA_3 @ 100 ppm + $CaCl_2$ 2% + borax 0.2% + $MgSO_4$ 0.5%) while, lowest values were found in T_{16} (Control). These results were in conformity with the findings of Digrase, *et al.* (2016) [2] they reported that combined application of plant growth regulators and micronutrient such as gibberellic acid and boric acid increases pulp weight of pomegranate fruit. The increased values may be due to enhanced synthesis of metabolites, increased absorption of water and mobilization of sugar and minerals in the expanded cells and intercellular space.

Weight of fruit (g): Present findings revealed that the maximum fruit weight (363.55 g) was obtained in T_{15} (GA_3 @ 100 ppm + $CaCl_2$ 2% + borax 0.2% + $MgSO_4$ 0.5%), which was statistically on par with T_{12} (361.63 g), T_{13} (359.90 g), While the lowest fruit weight (303.72 g) was recorded in T_{16} (Control). Findings are in conformity with reports of Digrase *et al.* (2016) [2]. The interaction combination of treatment consisting of GA_3 @ 75 ppm + borax 0.3 per cent recorded significantly maximum average weight of fruits. Increase in yield parameters due to interaction effect might be due to cumulative effect of increased performance of yield characters contributed by application of GA_3 and boron attributed to the initial rapid mobilization of the food reserves from the plants during the rapid extension. Similar result was also obtained by Lal and Ahmed (2012) [4] in pomegranate.

Table 2: Effect of foliar application of gibberellic acid and nutrients on number of fruits per plant and fruit yield of pomegranate cv. Bhagwa

Treatment	Number of fruits per plant	Yield per plant (kg)	Yield per ha (t/ha)
T_1 - GA_3 @ 100 ppm	82.00	26.72	19.77
T_2 - $CaCl_2$ (2%)	79.00	23.91	17.69
T_3 - Borax (0.2%)	80.33	25.05	18.53
T_4 - $MgSO_4$ (0.5%)	80.33	23.9	17.68
T_5 - GA_3 @ 100 ppm + $CaCl_2$ (2%)	84.33	27.93	20.67
T_6 - GA_3 @ 100 ppm + borax (0.2%)	84.66	28.21	20.87
T_7 - GA_3 @ 100 ppm + $MgSO_4$ (0.5%)	84.00	27.65	20.46
T_8 - $CaCl_2$ (2%) + borax (0.2%)	82.00	26.15	19.35
T_9 - $CaCl_2$ (2%) + $MgSO_4$ (0.5%)	85.00	27.18	20.12
T_{10} - Borax (0.2%) + $MgSO_4$ (0.5%)	83.33	26.64	19.71
T_{11} - GA_3 @ 100 ppm + $CaCl_2$ (2%) + borax (0.2%)	82.33	27.77	20.55
T_{12} - GA_3 @ 100 ppm + $CaCl_2$ (2%) + $MgSO_4$ (0.5%)	84.66	28.25	20.90
T_{13} - GA_3 @ 100 ppm + borax (0.2%) + $MgSO_4$ (0.5%)	85.66	28.82	21.33
T_{14} - Borax (0.2%) + $CaCl_2$ (2%) + $MgSO_4$ (0.5%)	84.00	27.69	20.49
T_{15} - GA_3 @ 100 ppm + $CaCl_2$ (2%) + borax (0.2%) + $MgSO_4$ (0.5%)	85.00	28.90	21.38
T_{16} - Control	80.33	22.40	16.57
S. Em.±	3.73	1.33	0.98
C.D. at 5%	NS	3.85	2.85

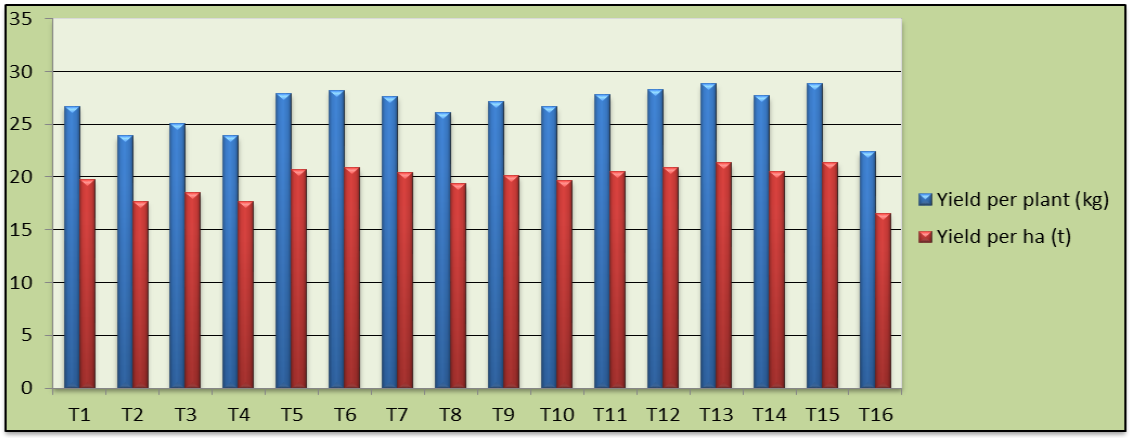

Fig 1: Fruit yield of pomegranate cv. Bhagwa as influenced by foliar application of gibberellic acid and nutrients

Yield per plant (kg) and yield per hectare (tonnes): As observed in the present study, the yield per plant (28.90 kg in four year old pomegranate plants) and per hectare (21.38 tonnes/ha) were maximum in the treatment with the application GA_3 @ 100 ppm + $CaCl_2$ 2% + borax 0.2% + $MgSO_4$ 0.5% (Table 2 & Fig 1). These results indicated that growth and physiological parameters were favorably influenced by these growth promoters and nutrients with consequent increase in yield. Similar to the present findings, the influence of GA_3 (75 ppm) on increasing the yield of pomegranate cv. Ganesh was reported by Pawar *et al.* (2005) [5]. The increase in yield with GA_3 treatment is evident and that can be attributed to better fruit size, better vegetative growth and more leaf area for photosynthetic activity. Similar results were also observed in ber fruits by Singh *et al.* (1982) [7].

Table 3: Effect of foliar application of gibberellic acid and nutrients on economic parameters of pomegranate production (lakhs/ha) cv. Bhagwa

Treatment	Gross income (Rs/ha)	Total Cost (Rs/ha)	Net income (Rs/ha)	Benefit Cost ratio
T_1 - GA_3 @ 100 ppm	790942	200960.8	589981.2	2.94
T_2 - $CaCl_2$ (2%)	707866.3	201077.2	506789	2.52
T_3 - Borax (0.2%)	741589.9	200316.7	541273.2	2.70
T_4 - $MgSO_4$ (0.5%)	707514.5	200450.6	507063.9	2.53
T_5 - GA_3 @ 100 ppm + $CaCl_2$ (2%)	826878.3	202025.8	624852.5	3.09
T_6 - GA_3 @ 100 ppm + borax (0.2%)	835120.1	201272.5	633847.6	3.15
T_7 - GA_3 @ 100 ppm + $MgSO_4$ (0.5%)	818449.9	201406.4	617043.5	3.06
T_8 - $CaCl_2$ (2%) + borax (0.2%)	774317.5	201288.7	573028.8	2.85
T_9 - $CaCl_2$ (2%) + $MgSO_4$ (0.5%)	804811.5	201422.6	603388.9	3.00
T_{10} - Borax (0.2%) + $MgSO_4$ (0.5%)	788693.5	200662.3	588031.2	2.93
T_{11} - GA_3 @ 100 ppm + $CaCl_2$ (2%) + borax (0.2%)	822106	202244.5	619861.5	3.06
T_{12} - GA_3 @ 100 ppm + $CaCl_2$ (2%) + $MgSO_4$ (0.5%)	836235.5	202378.4	633857.1	3.13
T_{13} - GA_3 @ 100 ppm + borax (0.2%) + $MgSO_4$ (0.5%)	853348.3	201618.1	651730.2	3.23
T_{14} - Borax (0.2%) + $CaCl_2$ (2%) + $MgSO_4$ (0.5%)	819714.8	201634.3	618080.5	3.07
T_{15} - GA_3 @ 100 ppm + $CaCl_2$ (2%) + borax (0.2%) + $MgSO_4$ (0.5%)	855498.5	202590.1	652908.4	3.22
T_{16} - Control	663125.2	200105	463020.2	2.31

* Rate of fruits 40 Rs/kg respectively.

Economics: The treatment T_{13} (foliar spray of GA_3 @ 100 ppm + borax - 0.2% + $MgSO_4$ - 0.5%) had a maximum benefit: cost (3.23) which was followed by T_{15} (3.22). While the minimum benefit cost (2.31) was recorded in T_{16} (Control). This might be due to higher quality parameters such as colour and appearance, size have fetched the higher price and higher gross returns compared to control. Similar results were observed by Digrase *et al.* (2016) [2] who reported that application of GA_3 75 ppm + boron 0.3 per cent recorded the highest benefit cost ratio (2.86) in pomegranate.

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