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Beerappa
Department of Fruit Science, College of Horticulture, Bagalkot, UHS, Bagalkot, Udyanagiri, Karnataka, India

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

Suma R
Department of Soil Science, College of Horticulture, Bagalkot, UHS, Bagalkot, Udyanagiri, Karnataka, India

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

Correspondence
Beerappa
Department of Fruit Science, College of Horticulture, Bagalkot, UHS, Bagalkot, Udyanagiri, Karnataka, India

Effect of foliar application of gibberellic acid (GA_3) and nutrients on nutrient composition and organoleptic parameters of pomegranate fruit (*Punica granatum* L.) cv. Bhagwa

Beerappa, SN Patil, Suma R and DR Patil

Abstract
Present study was conducted in the farmer's field of Hire samshi village,in Bagalkot taluk of Bagalkot district during 2016-17 with an objective of to study the effect of foliar application of gibberellic acid and nutrients on nutrient composition of pomegranate cv. Bhagwa. The Experiment was consisted of nine treatments with three replications laid in Randomized block design. Treatment details include T_1- GA_3 @ 50 ppm, T_2- GA_3 @ 100 ppm, T_3- GA_3 @ 50 ppm + calcium nitrate (2%)+ borax (0.2%) + KNO_3 (2%), T_4- GA_3 @ 50ppm + calcium nitrate (2%) + borax (0.2%) + SOP (2%), T_5- GA_3 @ 100 ppm + calcium nitrate (2%) + borax (0.2%)+ KNO_3 (2%), T_6 - GA_3 @100 ppm + calcium nitrate (2%) + borax (0.2%)+ SOP (2%), T_7- Calcium nitrate (2%)+ borax (0.2%) + KNO_3 (2%), T_8- Calcium nitrate (2%)+ borax (0.2%) + SOP(2%), T_9- control(water spray). Analysis of nutrient content in juice and peel recorded highest nitrogen content in juice (5.43 g/L) was recorded in T_6 (GA_3 @ 100 ppm + calcium nitrate 2% +borax 0.2% + SOP 2%, potassium content in juice (18.70 g/L) and peel (0.81%) in T_4 (GA_3 @ 50 ppm + calcium nitrate 2% +borax 0.2% + SOP 2%.), phosphorus content in juice (4.13 g/L) and peel (0.28%)was recorded in T_5 (GA_3@ 100 ppm + calcium nitrate2% +borax 0.2% + KNO_3 2%, and maximum calcium and boron content of juice and peel were recorded in T_4 (GA_3 @ 50 ppm + calcium nitrate 2% + borax 0.2% + SOP 2%) whereas lowest were found in T_9 (Control). With respect to organoleptic parameters the maximum score for colour and appearance (9.17), taste and flavour (8.00) and overall acceptability (8.00) was noticed in T_4 (GA_3 50 ppm+ calcium nitrate 2% + borax 0.2% + SOP2%), while lower score in control.

Keywords: *Punica granatum* L., gibberellic acid, pomegranate

Introduction
Pomegranate (*Punica granatum* L.) belongs to family Lythraceae is being grown since ancient times for its fruits, ornamental and medicinal purposes. It is commonly known as 'Anar' in Hindi and 'Dalimbe' in Kannada. Pomegranate is a favourite table fruit of tropical and subtropical countries. India is the world leading country in pomegranate production. Total area under pomegranate in India is 1.93 lakh hectares, and total production in India is 21.98 lakh tonnes with a productivity of 11.39 tonnes/ha (Anon, 2017) [1]. Pomegranate production is governed by several factors like soil, climate, irrigation status, varieties, pest and disease situation and nutritional status of soil as well as the plant. Deficiency of various nutrients causes drastic reduction in growth, yield and quality of pomegranate. For every nutritional problem there is a horticultural solution". Hidden in this is the understanding of the dynamics of nutrients in horticulture. A due importance to nutrients is essential as they affect the productivity, quality and profitability. After achieving food security, it is being increasingly felt that India need to achieve nutritional security for betterment of its population. In achieving this cultivation of horticultural crops especially fruit crops plays a vital role. To accomplish nutritional security of our country 92 million metric tonnes of fruits will be required. Fruit and vegetable are an important source of essential elements (Tahvonen, 1993) [13]. Mineral nutrients and phenolics are natural component of many fruit and play an important role in maintaining fruit quality and determining nutritive value. Pomegranate fruit is an important source of potentially healthy bioactive compounds and mineral nutrients. The accumulation of all the macro- and microelement within the fruit also increased during fruit growth and development.

Sensory evaluation for any commodity decides its quality and the preference of the consumer towards that commodity. Experimental results indicate that there was variable impact of gibberellic acid and nutrients on organoleptic parameter of fruits.

Material and Methods

The field experiment was conducted in the farmer's field of Hiresamshi village of Bagalkot taluk of Bagalkot district. It is situated in the Northern Dry Zone (Zone-3) of Karnataka. The soil possessed slightly alkaline pH (7.70) with EC of 0.44 dS/m and having red soil. The major nutrients *viz.*, N, P_2O_5 and K_2O were 220.17 kg/ha, 43.90 kg/ha and 208.98 kg/ha, respectively. The average rainfall of 277.00 mm during crop growth period from September 2016 to March 2017. Mean relative humidity of morning and afternoon was 61.00 per cent and 40.43 per cent, respectively. The average maximum and minimum temperature was 30.00 and 17.29 °C, respectively. The experiment was laid out in a Randomized Block Design (RBD) with nine treatments, replicated thrice. Each treatment consisted of three plants in each replication were selected for recording biometric observations till harvest.

The treatments were imposed to pomegranate trees after fruit set. The foliar spray of gibberellic acid and nutrients (B, Ca) solutions were given in two intervals of time, 45 and 90 days after fruit set, KNO_3 and SOP at 15 days before harvest. Approximately 2 litre of spray solution per plant was used. Other cultural operations were attended regularly and timely in the experimental plot along with effective management of pest and disease during the experiment period. Gibberellic acid solution was prepared by dissolving 50 mg (50 ppm) and 100 mg (100 ppm) gibberellic acid (Pro Gibb) in approximately 25 ml absolute alcohol (95%) then it was diluted with water to make 1000 ml solution. The borax 0.2 percent solution was prepared by weighing 2 gram of borax and dissolved in 1000 ml of water (2 gram per litre of water).The calcium nitrate 2 percent solution was prepared by weighing 20 gram of calcium nitrate and dissolved in 1000 ml of water (20 gram per litre of water). The potassium nitrate 2 percent and sulphate of potash 2 percent solution were prepared by weighing 20 gram of Potassium nitrate and sulphate of potash dissolved in 1000 ml of water respectively.

Acid digestion of juice and peel samples: A known (25 ml) volume of fruit juice samples were digested using di-acid (HNO_3: $HClO_4$- 9:4) mixture on sand bath for analysis of mineral nutrients except nitrogen. The standard protocols as described below were used for determining the nutrient content of pomegranate juice.

A known weight (0.5g) of dried peel samples were digested using di-acid (HNO_3: $HClO_4$-9:4) mixture on sand bath for analysis of mineral nutrients except nitrogen. The standard protocols as described for juice were used for determining the nutrient content of pomegranate peel.

Nitrogen content in juice was estimated using 15 ml of the extracted juice sample by digesting with conc. H_2SO_4 in presence of digestion mixture ($CuSO_4$: K_2SO_4: Se 100:40:1). The concentration of phosphorus in digested sample was estimated by phospho-vanado-molybdate complex method. Intensity of yellow colour was read at 430 nm by using spectrophotometer. The phosphorus content was estimated using P-standard curve (Piper, 1966) [9]. The di-acid digested sample was fed to flame photometer directly, with proper dilution (if required). The reading was used along with the standard curve to estimate potassium contents (Piper, 1966) [9]. The Ca and Mg in digested samples were estimated by complex metric titration method. Calcium plus Magnesium (Ca + Mg) was determined by EDTA titration at 10.0 pH (maintained with buffer complex) in presence of EBT indicator. Calcium alone was estimated by EDTA titration at 12.0 pH (maintained with NaOH solution) using Patrons and Reader indicator reagent. (Jackson, 1973) [5]. Sulphur content in digested samples were determined by Turbidometry. The intensity of turbidity was measured at 420 nm using spectrophotometer and estimated by referring S- standard curve (Piper, 1966) [9]. For boron estimation the digested samples were directly fed to the Atomic Absorption Spectrometer and the intensity of absorption for particular micronutrients with a specific hallow cathode lamps was recorded (Lindsay and Norvell, 1978) [6] and estimated with respective standard curves. The data on nutrient content was tabulated and subjected to statistical analysis using method of analysis of variance (ANOVA) for randomized block design (RBD) by Fisher and Yates (1963) [4]. Whenever 'F' test was found significant for comparing the means of two treatments, critical difference (C.D. at 5%) were worked out.

Organoleptic evaluation was carried out by a panel of judges on the day of harvest. The fruit characters like colour & appearance, seed hardiness, taste and flavor and ovaerall acceptability was judged by following scores (Table -1).

Table 1: Range of scores and acceptability for quality parameters of pomegranate fruit (*Punica granatum* L.) cv. Bhagwa

Score	Fruit Colour and Appearance	Seed hardiness	Taste and Flavour	Overall acceptability
9-10	Bright red	Very soft	Excellent	Excellent
7-8	Red	Soft	Good	Good
5-6	Light red	Slightly hard	Fair	Fair
3-4	Reddish yellow	Hard	Acceptable	Acceptable
0-2	Yellow	Very hard	Unacceptable	Unacceptable

Results and Discussion

The mineral content in pomegranate juice showed significant variation due to various treatments with respect to N, P, K, Ca and B. While, the treatment effect was non-significant on Mg and S. In general, the concentration of nutrient content in juice were in the order of K>N>P>S>Ca>Mg>Fe>Mn>Zn>B (Raghupathi and Bhargava, 1996). Amongst the major nutrients, highest potassium content in juice (18.50 g/L) was recorded in T_4(GA_3 @ 50 ppm+ calcium nitrate 2% +borax 0.2% + SOP2%.), maximum nitrogen content in juice (5.43 g/L) was recorded in T_6 (GA_3 @ 100 ppm+ calcium nitrate 2% +borax 0.2% + SOP2%. Maximum Phosphorus content in juice (4.13 g/L) was recorded in T_5 (GA_3@ 100 ppm+ calcium nitrate 2% +borax 0.2% + KNO_3 2%) (Table-2). Among the secondary nutrients Ca alone showed significant variation in pomegranate juice (Table-3). The maximum calcium content in juice (1.83 g/L) was recorded in T_7 (calcium nitrate 2% +borax 0.2% + KNO_3 2%), which was statistically on par with T4 (1.62 g/L) while, the minimum T_9 (control). These results were in close conformity with findings of Dong *et al.*

(2009) [3]. Foliar application of Ca or Ca + B significantly increased the content of Ca in ‘Cara Cara’ fruit. In addition, only B alone could significantly influence the B content. This result showed that foliar application Ca or Ca + B could increase Ca mobility and concentration in the orange fruit.

Magnesium and Sulfur did not record significant variation. The maximum boron content in juice (1.40 mg/L) was recorded in T_4 (GA_3@ 50 ppm+ calcium nitrate 2% + borax 0.2% + SOP 2%).While, the minimum boron content (0.78 mg/L)in the juice was recorded in the T_9 (control). This could be attributed to the rate of application, availability in soil and assimilation in plant leaves further their translocation to fruits. Similar kinds of findings were observed by Merwad *et al*., 2016. The obtained results are in conformity with those reported on pomegranate where foliar spray with K significantly increased the content of K in peel and juice of pomegranate fruits (Tehranfar and Taber, 2009) [14].

Nitrogen content in peel did not record any significant variation among the treatments. The maximum potassium content in peel (0.81%) was recorded in T_4 (GA_3 @ 50 ppm+ calcium nitrate 2% + borax 0.2% + SOP2%) and phosphorus (0.28%) content in peel was recorded in T_5 (GA_3@ 100 ppm+ calcium nitrate 2% +borax 0.2% + KNO_3 2%. While, the minimum potassium content (0.57%) was recorded in T_9 (control) (Table-4). Among the secondary nutrients Calcium alone showed significant variation in pomegranate peel. The maximum calcium content in peel (0.45%) was recorded in T_4 (GA_3 @ 50 ppm + calcium nitrate 2% + borax 0.2% + SOP2%). While, the minimum calcium content (0.27%) was recorded in T_9 (control). The high concentration of Calcium in the peel and the low concentration in the pulp can be attributed to the low mobility of Calcium in phloem (Marschner, 1995). Magnesium and Sulfur did not record significant variation. Boron content in the peel varied significantly among different treatments with foliar spray of gibberellic acid and nutrients on pomegranate cv. Bhagwa (Table-5). The maximum boron content in peel (27.33 ppm) was recorded in T_3 (GA_3 @ 50 ppm + calcium nitrate 2% + borax 0.2% + KNO_3 2%), which was statistically on par with T_4 (25.67ppm) and the minimum boron content (13.00 ppm) in the peel was recorded in control (T_9).

Data pertaining to organoleptic evaluation of pomegranate fruits after harvesting was significantly influenced by application of gibberellic acid and nutrients (Table-6). The maximum score for colour and appearance was noticed in the T_4 (9.17) and it was statistically on par with the scores obtained by the treatment T_3 (8.50). Treatments like T_1, T_2, T_5 and T_6 were on par with each other. However, the minimum score (5.50) was noticed in T_9.The maximum score for taste and flavour was noticed in the T_4 (8.00) and it was statistically matching the scores obtained by the treatment T_3 & T_5. However, the minimum score was noticed in T_9 (5.50).

The overall acceptability was the highest (8.00) in the treatment T_4 (GA_3 @ 50 ppm+ calcium nitrate 2% + borax 0.2% + SOP2%), which was on par with treatment T_1& T_3. However, lowest was observed in T_9 (4.50). The score for seed hardiness was not varied significantly among the treatments (Table 7). These findings are closely similar to those observed by Singh *et al.* (1981) and Chandra *et al.* (1994) with regard to guava fruits. Spraying potassium dihydrogen orthophosphate (0.5%) or potassium nitrate 1% effectively improved rind colour from yellow to red or red yellow. This might be due to involvement of potassium in triggering the synthesis of anthocyanin (Sheikh, 2015) [11]. With respect to taste and flavor the higher rating could be mainly due to proper blend of total soluble solids, sugar and acid content of fruits under the applications of these treatments as observed in the present investigations.

Table 2: Effect of foliar application of gibberellic acid and nutrients on primary nutrients content of juice of pomegranate cv. Bhagwa

Treatment	Nitrogen (g/L)	Phosphorus (g/L)	Potassium (g/L)
T_1- GA_3 @ 50 ppm	4.47	3.53	16.07
T_2- GA_3 @ 100 ppm	5.07	3.23	15.87
T_3- GA_3 @ 50ppm+calcium nitrate(2%)+borax(0.2%) + KNO_3 (2%)	5.23	3.77	17.92
T_4- GA_3 @ 50 ppm+ calcium nitrate(2%)+borax (0.2%) + SOP(2%)	5.13	3.60	18.50
T_5- GA_3 @100 ppm+ calcium nitrate(2%)+ borax(0.2%) + KNO_3 (2%)	5.00	4.13	17.14
T_6- GA_3 @ 100 ppm+ calcium nitrate(2%)+borax(0.2%) + SOP(2%)	5.43	3.57	17.53
T_7- Calcium nitrate(2%)+borax(0.2%) +KNO_3(2%)	5.20	3.50	17.33
T_8- Calcium nitrate(2%)+borax(0.2%) +SOP(2%)	4.50	3.30	16.12
T_9- Control(water spray)	4.43	3.17	14.32
S. Em.±	0.05	0.11	0.24
C.D. at 5% 0.5% + Molybdenum 0.1%	0.16	0.32	0.71

SOP – Sulphate of potash; KNO_3– Potassium nitrate

Table 3: Effect of foliar application of gibberellic acid and nutrients on secondary nutrients content of juice of pomegranate cv.Bhagwa

Treatment	Calcium(g/L)	Magnesium (g/L)	Sulphur (g/L)	Boron(mg/L)
T_1- GA_3 @ 50 ppm	1.47	1.30	2.00	0.85
T_2- GA_3 @ 100 ppm	1.37	1.07	2.37	0.83
T_3- GA_3 @ 50ppm+calcium nitrate(2%)+ borax (0.2%) + KNO_3 (2%)	1.37	1.07	2.60	1.02
T_4- GA_3 @ 50 ppm+ calcium nitrate(2%)+ borax (0.2%) + SOP(2%)	1.62	1.37	2.47	1.40
T_5- GA_3 @100 ppm+ calcium nitrate(2%)+ borax (0.2%) + KNO_3 (2%)	1.37	1.50	2.53	1.16
T_6- GA_3 @ 100 ppm+ calcium nitrate(2%)+ borax (0.2%) + SOP(2%)	1.53	1.17	2.33	1.33
T_7- Calcium nitrate(2%)+ borax (0.2%) +KNO_3(2%)	1.83	1.07	2.23	1.29
T_8- Calcium nitrate(2%)+ borax (0.2%) +SOP(2%)	1.53	1.17	2.40	1.04
T_9- Control(water spray)	1.47	1.07	2.00	0.78
S. Em.±	0.08	0.12	0.16	0.03
C.D. at 5% 0.5% + Molybdenum 0.1%	0.25	NS	NS	0.09

SOP – Sulphate of potash; KNO_3– Potassium nitrate

Table 4: Effect of foliar application of gibberellic acid and nutrients on primary nutrients content of peel of pomegranate cv. Bhagwa

Treatment	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1- GA_3 @ 50 ppm	0.36	0.22	0.66
T_2- GA_3 @ 100 ppm	0.32	0.19	0.59
T_3- GA_3 @ 50ppm+calcium nitrate(2%)+borax(0.2%) + KNO_3 (2%)	0.40	0.22	0.74
T_4- GA_3 @ 50 ppm+ calcium nitrate(2%)+borax (0.2%) + SOP(2%)	0.38	0.23	0.81
T_5- GA_3 @100 ppm+ calcium nitrate(2%)+ borax(0.2%) + KNO_3 (2%)	0.36	0.28	0.71
T_6- GA_3 @ 100 ppm+ calcium nitrate(2%)+borax(0.2%) + SOP(2%)	0.36	0.22	0.71
T_7- Calcium nitrate(2%)+borax(0.2%) +KNO_3(2%)	0.41	0.24	0.72
T_8- Calcium nitrate(2%)+borax(0.2%) +SOP(2%)	0.35	0.20	0.67
T_9- Control(water spray)	0.33	0.18	0.57
S. Em.±	0.04	0.01	0.02
C.D. at 5% 0.5% + Molybdenum 0.1%	NS	0.03	0.07

SOP – Sulphate of potash; KNO_3– Potassium nitrate

Table 5: Effect of foliar application of gibberellic acid and nutrients on secondary nutrients content of peel of pomegranate cv. Bhagwa

Treatment	Calcium (%)	Magnesium (%)	Sulphur (%)	Boron (ppm)
T_1- GA_3 @ 50 ppm	0.30	0.06	0.17	22.67
T_2- GA_3 @ 100 ppm	0.33	0.07	0.16	20.00
T_3- GA_3 @ 50ppm+calcium nitrate(2%)+ borax (0.2%) + KNO_3 (2%)	0.35	0.07	0.20	27.33
T_4- GA_3 @ 50 ppm+ calcium nitrate(2%)+ borax (0.2%) + SOP(2%)	0.45	0.10	0.17	25.67
T_5- GA_3 @100 ppm+ calcium nitrate(2%)+ borax (0.2%) + KNO_3 (2%)	0.40	0.13	0.17	22.00
T_6- GA_3 @ 100 ppm+ calcium nitrate(2%)+ borax (0.2%) + SOP(2%)	0.42	0.08	0.18	22.33
T_7- Calcium nitrate(2%)+ borax (0.2%) +KNO_3(2%)	0.33	0.07	0.15	21.00
T_8- Calcium nitrate(2%)+ borax (0.2%) +SOP(2%)	0.39	0.08	0.13	18.00
T_9- Control(water spray)	0.27	0.07	0.12	13.00
S. Em.±	0.01	0.03	0.03	1.47
C.D. at 5% 0.5% + Molybdenum 0.1%	0.03	NS	NS	4.41

SOP – Sulphate of potash; KNO_3– Potassium nitrate

Table 6: Effect of foliar application of gibberellic acid and nutrients on organoleptic evaluation of pomegranate cv. Bhagwa

Treatment	Colour and appearance	Seed hardiness	Taste and flavor	Overall acceptability
T_1- GA_3 @ 50 ppm	7.50	5.67	7.17	7.50
T_2- GA_3 @ 100 ppm	7.33	5.50	6.83	6.83
T_3- GA_3 @ 50ppm+calcium nitrate(2%)+borax(0.2%) + KNO_3 (2%)	8.50	5.67	7.67	7.67
T_4- GA_3 @ 50 ppm+ calcium nitrate(2%)+borax (0.2%) + SOP(2%)	9.17	6.33	8.00	8.00
T_5- GA_3 @100 ppm+ calcium nitrate(2%)+ borax(0.2%) + KNO_3 (2%)	7.50	5.33	7.33	7.00
T_6- GA_3 @ 100 ppm+ calcium nitrate(2%)+borax(0.2%) + SOP(2%)	7.17	5.00	7.00	7.00
T_7- Calcium nitrate(2%)+borax(0.2%) +KNO_3(2%)	6.67	5.00	6.67	6.50
T_8- Calcium nitrate(2%)+borax(0.2%) +SOP(2%)	7.00	5.50	6.00	5.67
T_9- Control(water spray)	5.50	5.67	5.50	4.50
S. Em.±	0.28	0.45	0.26	0.31
C.D. at 5% 0.5% + Molybdenum 0.1%	0.84	NS	0.79	0.94

SOP – Sulphate of potash; KNO_3– Potassium nitrate

Table 7: Effect of foliar application of gibberellic acid and nutrients on physiological loss in weight (%) and shelf life (days) of pomegranate cv. Bhagwa

Treatments	Physiological loss in weight (%)					Mean	Shelf life(days)
	4 days	8 days	12 days	16 days	20 days		
T_1- GA_3@ 50 ppm	6.03	10.77	12.93	20.77	30.03	16.11	22.39
T_2- GA_3@ 100 ppm	6.20	10.93	13.10	20.93	30.27	16.29	22.50
T_3- GA_3@ 50ppm+calcium nitrate(2%)+ borax (0.2%) + KNO_3 (2%)	5.19	10.66	12.35	20.89	29.35	15.69	25.30
T_4- GA_3@ 50 ppm+ calcium nitrate(2%)+borax (0.2%) + SOP(2%)	4.32	8.99	11.16	18.87	28.04	14.28	27.02
T_5- GA_3@ 100 ppm+ calcium nitrate(2%)+borax (0.2%) + KNO_3 (2%)	5.96	10.18	13.06	20.18	30.06	15.89	23.97
T_6- GA_3@ 100 ppm+ calcium nitrate(2%)+ borax (0.2%) + SOP(2%)	5.93	10.89	12.83	20.66	30.00	16.06	24.17
T_7- Calcium nitrate(2%)+ borax (0.2%) +KNO_3(2%)	6.47	11.12	13.29	21.13	30.29	16.46	23.00
T_8- Calcium nitrate(2%)+ borax (0.2%) +SOP(2%)	6.91	11.21	13.38	21.10	31.27	16.77	22.05
T_9- Control(water spray)	8.29	12.62	15.09	23.26	33.27	18.51	20.19
S. Em.±	0.37	0.49	0.44	0.34	0.46		0.44
C.D. at 5%	1.10	1.46	1.32	1.01	1.38		1.31

SOP – Sulphate of potash; KNO_3 – Potassium nitrate

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