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RESEARCH ARTICLE

Effect of calcium and boron on growth, yield and quality of pomegranate (*Punica granatum* L.)

■ **SUTANU MAJI, ANIRUDDHA YADAV AND K.R. MEENA**

SUMMARY

A field experiment was conducted to study the effect of foliar application of calcium and boron on vegetative growth, flowering, fruiting and fruit quality of young pomegranate plants cv. BHAGWA. The experiment was set under Randomized Block Design with application of calcium (3 and 5%), boron (0.25 and 0.5%) and their combinations with three replications. The experiment showed that combined application (T_6) of calcium (3%) and boron (0.25%) increased plant height at higher rate as compared to their sole application and control. It (T_6) also produced more number of secondary branches at early stage but, under T_7 (calcium 3% and boron 0.5%) at later stages of growth. Although, it was a young orchard, however, flower production was higher under T_6 followed by T_7 compared to others which was reflected on fruit yield and fruit yield was the highest (359.5 kg/ha) under T_6 followed by T_7. Fruit weight and fruit size was recorded maximum (77.0 g, 6.1 cm length, 6.00 cm diameter) under T_7. But, other quality parameters like fruit volume (70 ml), specific gravity (1.10 g/cc), TSS (12.57 ^{0}B) and sugars (6.66 % Total sugars, 4.73 % reducing sugar) were very good under T_6. It is concluded that the combined application of calcium (3%) and boron (0.25%) (T_6) could be practiced for good growth, yield and quality fruits of pomegranate.

Key Words : Pomegranate, Nutrients, Calcium, Boron, Growth, Flowering, Yield, Quality

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Pomegranate (*Punica granatum* L.) is one of the most nutritional fruit under family Punicaceae and is capable of growing in different agro-climatic condition ranging from tropical to sub-tropical (Levin, 2006) though originated from Iran. India is the largest producer of pomegranate in the world and commercially cultivated in Maharashtra, Karnatka and Andhra Pradesh. The most important cultivar in this belt is 'Bhagwa' which covers around 80 per cent area under pomegranate in Maharashtra. Other important pomegranate growing states are Gujarat, Rajasthan, Tamil Nadu and to a limited extent in Uttar Pradesh. Among various arid fruits pomegranate occupies second largest area after ber (Abubakkar *et al*., 2013). It can with stand a little frost

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and grows up to an altitude of 1600 meters from mean sea level (MSL), however, its quality is not good in humid areas. The tree is deciduous in cold winter area but, it is ever green in plains of India. It can tolerate alkaline and wet soil (Bal, 2013). Edible parts contain 52 per cent of the total fruit weight comprising 78 per cent juice and 22 per cent seeds. The fresh juice contains 85.4 per cent moisture, 10.6 per cent total sugars, 1.4 per cent pectin, 0.1 per cent total acidity (as citric acid), 19.6 mg/100 ml free amino nitrogen and 0.05 g/100 ml ash. The seeds are rich source of total lipids (27.2%), protein (13.2%), crude fibre (35%), ash (2%), pectin (6%) and total sugars (4.7%) (EI-Nemar and Nahapetian *et al*., 1990). Pomegranate seed contains about 15 per cent oil with a high refractive index iodine value along with 1.09 mg oestrone (El-Shaarawy and Nahapetian, 1983) and 0.036 mg coumestrol (anon steroid oestrogenl) (Moneam*et al*., 1988), polysaccharides (Normakhmatov *et al*., 1999), pectin substances. The fruit skin contains only the cyanidin and pelargnidin derivatives (Heber, 2011 and Gil *et al*., 2000). The fruits are mainly used for desert purpose especially for the patients for quick recovery. The fresh fruit is of exquisite quality while its processed products like bottled juice, syrup and jelly are highly appreciated. The juice is considered useful for patients suffering from leprosy, dysentery and diarrhea (Bal, 2013). So, pomegranate is considered as hardy as well as very good remunerative crop being rich in nutritional values. In Lucknow condition, the performance of pomegranate is not quite good, although, it has very good potential to pomegranate cultivation as the climate is drier subtropical climate. It needs good agricultural practices including mineral nutrition with micro nutrients. Mineral nutrition plays a vital role for its growth, yield and specially quality of fruits. It responses well to Ca, B, Zn to increase fruit yield, fruit weight and considerably decreases cracking which is one of the major disorders of pomegranate (Hoda and Hoda, 2013). In the Horticultural Research Farm in our university, the performance of newly planted pomegranate crop cv. BHAGWA is not good so far. Keeping these views, the present experiment has been conducted to study the response of application of calcium and boron on growth, yield and quality of pomegranate.

MATERIAL AND METHODS

The experiment was carried out at Horticulture Research Farm, Babasaheb Bhimrao Ambedkar University (A Central University), Vidaya Vihar, Rae Barely Road, Lucknow ($26^0 55^1$ North latitude and $80^0 59^1$ East longitudes and 123 meter from MSL), Uttar Pradesh, India during 2015-2016. It comes under subtropical climate with maximum temperature ranging from 22^0 - 45^0 C in summer, minimum temperature ranging from 3.5^0 - 15^0 C in winter and relative humidity ranging from 60-80. The soil of experimental field is sandy loam and slightly alkaline in nature with the soil pH of 8.2. The pomegranate plants cv. BHAGWA were three years old. The treatment comprised of application of calcium (3 and 5%), boron (0.25 and 0.5 %) and their combinations T_0-Control (water spray), T_1-Calcium @ 3%, T_2-Calcium @ 5%, T_3-Boron @ 0.25%, T_4-Boron @ 0.5%, T_5-Calcium @ 3% + boron @ 0.25%, T_6-Calcium @ 5% + boron @ 0.25%, T_7-Calcium @ 3% + Boron @ 0.5%, T_8-Calcium @ 5% + Boron @ 0.5% in three replications and were laid out in Randomised Block Design. Boron was applied as borax and calcium as calcium chloride form after proper calculation and solution was prepared with adjustment of pH at 6.5. Treatments were applied as foliar spray twice in August and 30 days after first application (*i.e.* September). Plants were pruned properly for getting uniformity in the treated crops before treatment application. Intercultural operations like irrigation, weeding etc. were done as per requirement. The observations were taken in respect of vegetative growth, fruit yield and fruit quality at various stages of growth *i.e.* 30, 60, 90, 120, 150, 180, 210 and 240 days after treatment (DAT). Fruit yield was calculated by multiplying number of plants per plant and average weight of fruit. Specific gravity was measured by following water displacement method and calculated by dividing fruit weight with its volume of displaced water. Among the fruit chemical characters, acidity was determined in term of citric acid by using 1 per cent phenolphthalein as indicator. Total sugars and reducing sugar percentage was determined by the method suggested by (AOAC, 2000) using Fehling's solution A and B. Statistical analysis of the data obtained in different set of experiments was calculated following the standard procedure as stated by Sahu and Das (2014) and treatments observation were compared with critical difference of mean at 5 per cent level of significance.

RESULTS AND DISCUSSION

Results of the present experiment (Table 1) showed that increase in plant height was maximum in treatment

T_6 (185 cm) and minimum was found under treatment T_0 (control water spray) at 30 days after treatment (DAT) application. At 30 to 60 DAT, maximum plant height was noted with treatment T_6 (187.33 cm) followed by treatment T_7 and minimum was under control and followed the similar pattern at 120 and 150 DAT. From 150 to 180 days it was seen again under treatment T_6 (Calcium @ 5% + Boron @ 0.25%). From 180 to 210 DAT, it was found that the plant height did not increase so much as compared to earlier stage of growth which might be due to the low temperature during winter months. But, overall increase in plant height was recorded in treatment T_6 (Calcium @ 3% + Boron @ 0.25%) followed by T_7 and minimum was recorded under treatment T_0 (control water spray). Singh *et al*. (2014) also found similar result of more vegetative growth due to micronutrient application.

Table 2 revealed that maximum (84.67) secondary branches were noted with treatment T_6 (Calcium @ 3% + Boron @ 0.25%) followed by treatment T_7 (Calcium @ 5% + Boron @ 0.5%) (80.00) and minimum was recorded under treatment T_1 (23.67) at 30 DAT which followed similar pattern upto 60 DAT. But, at 90 to 120 DAT, it was recorded maximum under treatment T_7 (Calcium @ 3% + Boron @ 0.5%). After 120 to 150 DAT maximum number of secondary branches were counted again under T_6 and other treatments showed low per cent of increase in secondary branches.

Number of flowers were counted at various stages and depicted in Fig. 1 which clearly showed that flower number increased upto 90 DAT from 30 DAT. This increase upto 90 DAT and decrease thereafter might be due to temperature which decreased after 90 DAT (treatments were applied in August first time and then in September). It was clear that treatment T_6 (Calcium @ 3% + Boron @ 0.25%) followed by T_7 increased flower production as compared to other treatments. Although, good number of flowers were counted at various days,

Table 1 : Effect of calcium and boron on plant height (cm)

Treatments	Height of plant (cm)							
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	210 DAT	240 DAT
T_0 – Control (water spray)	90.33	92.67	96.33	99.67	102.00	106.67	110.00	115.33
T_1- Ca @ 3%	114.50	119.33	125.67	127.33	129.33	133.67	136.67	138.33
T_2- Ca @ 5%	100.33	104.67	108.33	110.00	114.33	116.67	118.33	120.00
T_3- Boron @ 0.25%	136.00	138.00	140.00	142.33	144.33	147.00	149.00	151.33
T_4- Boron @ 0.5%	123.67	127.00	130.33	134.67	138.33	140.67	144.00	149.00
T_5- Ca @ 3% + Boron @ 0.25%	124.33	128.33	130.67	135.33	138.67	140.00	144.00	148.00
T_6- Ca@ 5% + Boron @ 0.25%	185.00	187.33	189.00	192.33	194.67	198.33	200.00	202.67
T_7- Ca @ 3%+ Boron @ 0.5%	157.33	159.00	161.33	163.67	165.33	167.00	169.00	171.00
T_8- Ca @ 5% + Boron @ 0.5%	108.33	111.00	114.67	117.33	119.67	122.00	126.00	129.67
S.E. ±	15.466	15.298	15.178	15.476	15.365	14.883	17.124	18.883
C.D. (P=0.05)	41.74	40.02	39.53	41.44	41.39	40.44	50.53	51.51

Table 2 : Effect of calcium and boron on secondary branch per plant

Treatments	Number of secondary branch per plant							
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	210 DAT	240 DAT
T_0 – Control (water spray)	28.67	43.67	57.33	77.00	79.33	83.33	48.33	52.67
T_1- Ca @ 3%	23.67	34.00	46.33	65.00	66.00	68.67	58.33	66.00
T_2- Ca @ 5%	36.67	47.00	59.00	75.00	78.67	83.67	57.67	64.00
T_3- Boron @ 0.25%	42.00	49.67	59.00	65.33	68.00	70.67	54.67	75.33
T_4- Boron @ 0.5%	35.33	49.00	65.00	74.67	78.00	83.00	65.00	74.00
T_5- Ca @ 3% + Boron @ 0.25%	32.67	45.33	60.00	73.33	77.33	82.33	62.33	76.00
T_6- Ca@ 5% + Boron @ 0.25%	84.67	99.33	130.67	138.33	148.33	154.33	168.00	183.00
T_7- Ca @ 3%+ Boron @ 0.5%	80.00	98.67	126.67	134.67	140.00	145.33	156.00	172.33
T_8- Ca @ 5% + Boron @ 0.5%	47.67	61.00	75.33	90.67	94.67	99.33	47.67	60.33
S.E. ±	30.465	32.056	30.066	40.145	30.781	21.025	18.145	15.62
C.D. (P=0.05)	NS	NS	NS	NS	55.23	48.12	40.05	40.21

NS=Non-significant

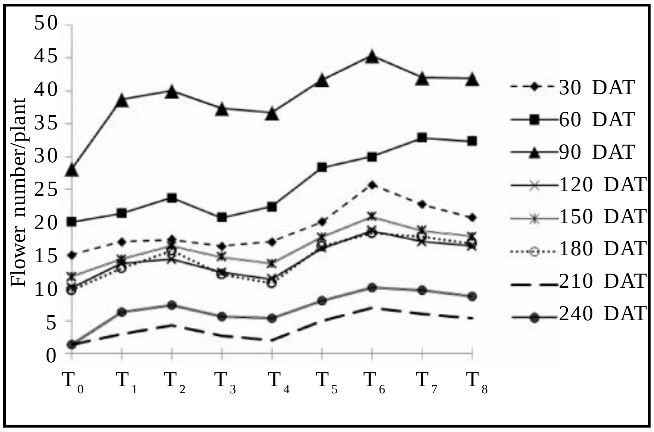

Fig. 1 : Effect of calcium and boron on flower number at various stages of growth

but it did not reflected on fruit yield due to less fruit set and high fruit drop. Estimated fruit yield (Table 3) was found very less due to early age of three years of old crop. However, maximum (539 g/plant) fruit yield was recorded under treatment T_6 (Calcium @ 3% + Boron @ 0.25%) followed by treatment T_7 and minimum was noted with treatment T_0 (control). Fruit yield was maximum (359.5 kg/ha) as recorded under treatment T_6 (Calcium @ 3% + Boron @ 0.25%) and minimum (68.0 kg/ha) was noted with control. Application of both Ca and B might have positive response on flowering and fruiting and thereby, showed higher yield as compared to other treatments.

The effect of calcium and boron on fruit characters is presented in Table 4 and 5. Fruit weight was recorded maximum under combined application of calcium (3%) and boron (0.25%) (T_6) followed by treatment T_7 and minimum was found under treatment T_0 (control water spray). Similarly, the maximum and minimum length (6.10 and 4.20 cm) and diameter (6.00 and 4.10 cm) of fruit was recorded under same treatment. The fruit volume and specific gravity of fruit were also maximum (70 ml and 1.10 g/cc) under treatment T_6 followed by treatment T_7. This type of result was also reported by Korkmaz and Aþkýn (2015) when experimented on pomegranate.

Table 3 : Effect of calcium and boron on fruit yield

Treatments	Fruit number/plant	Fruit yield (g)/ plant	Fruit yield (kg)/ hectare
T_0 – Control (water spray)	2.11	102	68.034
T_1- Ca @ 3%	4.15	240	160.08
T_2- Ca @ 5%	4.09	244	162.748
T_3- Boron @ 0.25%	3.05	183.99	122.7213
T_4- Boron @ 0.5%	5.20	330	220.11
T_5- Ca @ 3% + Boron @ 0.25%	5.01	306.65	204.5356
T_6- Ca@ 5% + Boron @ 0.25%	7.00	539	359.513
T_7- Ca @ 3%+ Boron @ 0.5%	6.05	369	246.123
T_8- Ca @ 5% + Boron @ 0.5%	4.05	240.4	160.3468
S.E. ±	2.561	220.561	150.303
C.D. (P=0.05)	0.58	449.606	300.020

Table 4 : Effect of calcium and boron on pomegranate physiochemical characters

Treatments	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (ml)	Specific gravity (g/ml)	Number of aril/fruit	Number of section and segments/fruit
T_0 – Control (water spray)	51.00	4.20	4.10	58.33	0.87	219.00	3.00
T_1- Ca @ 3%	60.00	5.20	5.15	60.00	1.00	205.00	4.00
T_2- Ca @ 5%	61.00	4.73	4.61	60.00	1.02	257.67	4.33
T_3- Boron @ 0.25%	61.33	5.10	5.00	59.00	1.04	230.00	4.00
T_4- Boron @ 0.5%	66.00	5.80	5.65	62.00	1.06	219.00	3.33
T_5- Ca @ 3% + Boron @ 0.25%	61.33	5.40	5.30	60.10	1.02	238.33	4.33
T_6- Ca@ 5% + Boron @ 0.25%	77.00	6.10	6.00	70.00	1.10	270.00	4.67
T_7- Ca @ 3%+ Boron @ 0.5%	61.50	5.80	5.60	60.67	1.01	323.33	5.00
T_8- Ca @ 5% + Boron @ 0.5%	60.10	5.00	4.95	59.33	1.01	262.33	4.33
S.E. ±	7.551	0.983	0.494	7.656	0.183	30.70	1.278
C.D. (P=0.05)	18.22	NS	2.16	18.20	NS	70.00	NS

NS=Non-significant

Table 5 : Effect of calcium and boron on physical characters of pomegranate

Treatments	Titrable acidity (%)	Vitimin C (mg/100g)	TSS (^{0}Brix)	TSS : Acid ratio	Total sugars (%)	Reducing sugar (%)	Non reducing sugar (%)
T_0 – Control (water spray)	0.33	8.00	8.60	26.06	4.90	3.87	1.03
T_1- Ca @ 3%	0.67	8.75	11.20	16.72	5.55	4.60	1.03
T_2- Ca @ 5%	0.37	9.00	11.70	31.62	5.83	4.00	1.83
T_3- Boron @ 0.25%	0.36	9.50	12.17	33.81	5.35	3.89	1.48
T_4- Boron @ 0.5%	0.42	9.20	11.80	28.10	5.20	3.83	1.37
T_5- Ca @ 3% + Boron @ 0.25%	0.37	9.30	11.45	30.95	5.07	3.90	1.17
T_6- Ca@ 5% + Boron @ 0.25%	0.41	9.65	12.57	30.66	5.43	4.17	1.26
T_7- Ca @ 3%+ Boron @ 0.5%	0.43	9.75	12.20	28.37	5.60	4.10	1.50
T_8- Ca @ 5% + Boron @ 0.5%	0.45	10.20	12.15	27.00	6.66	4.73	1.93
S.E. ±	0.055	0.461	0.966	4.965	0.561	0.461	0.452
C.D. (P=0.05)	0.117	1.090	2.461	10.452	1.23	NS	0.98

NS=Non-significant

They showed that application of boron and calcium improved physico-chemical quality of fruits. However, number of section and segments/ fruit was maximum (5.00) under T_7 (Calcium @ 3% + Boron @ 0.5%) followed by T_6 and minimum was found in T_0 (control).

The 'maximum (12.57 ^{0}B) total soluble solids (TSS) was recorded under treatment T_6 followed by T_7 and minimum (8.60 ^{0}B) was noted under control treatment T_0. Chavan *et al*. (2009) also found similar result in Sapota. The total sugars, reducing sugar and non-reducing sugar were estimated maximum (6.66 %, 4.73 %, 1.93 %, respectively) under treatment T_8 (Calcium @ 5% + Boron @ 0.5%) followed by treatment T_7 and minimum (4.90, 3.87 and 1.03) was recorded under treatment T_0 (control water spray), T_4 (Boron @ 0.5%) and T_1 (Calcium @ 3%). This result corroborates with the findings of Roa *et al*. (2015) who also found similar result in Salustiana oranges.

Use of calcium and boron as foliar application was found that acidity and vitamin C was maximum (0.43 and 9.75mg/100g) under treatment T_7 (Calcium @ 3%+ Boron @ 0.5%) followed by treatment T_6 (Ca @ 3% + Boron @ 0.25%) and minimum was recorded under treatment T_0 control. The maximum TSS: Acid ratio (33.81) was found under treatment T_3 (Boron @ 0.25%) followed by treatment T_2 and minimum (26.05) was recorded under treatment T_0 (control). Kishor *et al.* (2016) also found similar improvement in promegranate with bioregulators applications. Christaki *et al*. (2011) also stated the benefit of pomegranate and human intervention to produce good quality fruits of pomegranate with manuring.

Conclusion :

The present study clearly indicated that the use of calcium and boron improved the performance of pomegranate in general, compared to untreated control. Among the treatments under study, the combined application of calcium @ 5 % + boron @ 0.25 %could be considered as the best for good crop growth, better yield and superior fruit quality of pomegranate grown in Lucknow.

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