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Effect of foliar application of calcium and boron on growth, productivity and quality of Indian gooseberry *(Emblica officinalis*)

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ABSTRACT

An experiment was conducted in 'NA7' cultivar of Indian gooseberry *(Emblica officinalis* Gaertn) to assess whether pre-harvest foliar application of Ca (as calcium carbonate), B (as borax) individually or their combination influences physiological problems (poor fruit set, blossom and fruit drop, deformation of fruits etc.), fruit yield and quality or not. Treatments consisted of Ca as $CaCO_3$ at 0.2%, 0.4%, 0.6%, boron as borax at 0.2%, 0.4% 0.6%, Ca+B (mixed) 0.2%, 0.4%, 0.6% and plants sprayed with water served as the control. Treatments were applied five times on full grown tree of Indian gooseberry cultivar 'NA7' at pre bloom, full bloom, at fruit set initiation, pea stage (fruit development stage) and pre-harvest stage (one month before harvest). Results indicated that fruit harvested from plants which were sprayed with Ca+B 0.4% had significantly lesser incidence of fruit deformation (0.8**%**), blossom and fruit drop (32.6%) than in the plants kept under control (2.8% and 79.2%, respectively). The maximum yield (158.6 kg/tree) was recorded with the application of calcium carbonate + borax 0.4%, while minimum was recorded under control (105.2 kg/tree). In totality all the treatments have increased the fruit weight, fruit size, number of fruit/shoot, and quality of fruits as compared to control. The maximum dry matter (20.2%), juice content (78.5%), vitamin C (626.49 mg/100 g) was recorded with calcium carbonate + borax 0.4%. Similarly, it was also observed that such fruit (sprayed with Ca+B 0.4%) were bold, had slightly higher TSS (16.5%) at harvest than those in control (15.1%). Studies indicated that pre-harvest foliar application of Ca+B is quite useful for reducing the incidence of physiological problems and getting higher marketable yield in 'NA7' Indian gooseberry. Ca+B 0.4% significantly increased fruit size, fruit length and breadth. Calcium carbonate at concentration of 0.4% significantly reduced the fruit drop and increased the retention of blossom and deformed fruit.

Key word: Boron, Calcium, Fruit set, Indian gooseberry, Quality, Yield

Indian gooseberry *(Emblica officinalis* Gaertn) is an under-utilized fruit tree with medicinal and herbal qualities. It is the richest source of vitamin C (500 mg/100 g) among the fruits except Barbados cherry and rich in pectin, iron, calcium and phosphorus. It is also known as *amritphal*. It is indigenous to tropical south-eastern Asia, particularly in central and southern India and belongs to family Euphorbiaceae. It can be grown under wider edapho-climatic situations. However, well-drained fertile loamy soil is the best. It can also do well even in moderately alkaline soils. Aonla is drought hardy fruit crop which is characterized by deep root system and exhibits deciduous nature due to abscission and shedding of determinate shoots during February–March. Fruit pulp of Indian gooseberry is an important ingredient of *chavanprash* and *triphala* powder which is used for curing different abnormalities. The fruit contains a chemical substance gallic acid and leucoanthocyanin which have antioxidant property. Crop production under arid environment faces several constraints such as scanty water resources, poor soil condition, extremes of temperature (high and low), desiccated wind, less precipitation which leads to low productivity. The success of aonla cultivation under arid ecosystem is largely based on efficient management of available natural resources (Shukla *et al*. 2004).

The foliar application of macro and micro-nutrients have very important role in improving fruit set, productivity and quality of fruits. It has also beneficial role in recovery of nutritional and physiological disorders in fruit trees. Various experiments have been conducted earlier on foliar spray of micro-nutrient in different fruit crops and shown significant response to improve yield and quality of fruits (Kumar *et al*.2004, Singh *et al*. 2001). It is well known that calcium play an important role in maintaining quality of fruits and

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vegetable and calcium treatment helps to retain fruit firmness, increase vitamin C content, decreased storage breakdown and rotting and also decrease browning in apple. It also protects from disorganization of membrane and prevents the increase of apparent-free space in the tissue generally associated with senescence and maintains the protein synthesizing ability of cell. Foliar application is based on the principle that the nutrients are quickly absorbed by leaves and transported to different parts of the plant to fulfill the functional requirement of nutrition. Foliar application of the nutrients is obviously an ideal way of evading the problems of nutrient availability. This method is highly helpful for the correction of trace element deficiencies to restore disrupted nutrient supply and to overcome stress factors limiting their availability. This method has been commercialized in a number of fruits, like *Citrus*, pineapple, guava etc (Sharma 2000). Boron is most effective when applied as a foliar spray. Boron is important for ovule development, pollen tube growth and fruit set. Indian gooseberry being minor fruit crop no systematic research work has been carried out for improving fruit set, yield and quality of aonla fruit by foliar spray of micro and macro nutrients, therefore keeping in view this experiment was carried out.

MATERIALS AND METHODS

A field experiment was conducted on five-year old 'NA7' Indian gooseberry tree at Central Institute for Arid Horticulture, Bikaner (28° N latitude, 73° 18' longitude at an altitude of 234.84 m above mean sea level) from 2001 to 2005. The treatment consisted 10 application rates (foliar) of calcium as calcium carbonate and boron as borax, viz (i) Ca as CaCO3 at 0.2%, (ii) 0.4%, (iii) 0.6%, (iv) boron as borax at 0.2%, (v) 0.4%, (vi) 0.6%, (vii) Ca+B (mixed) 0.2%, (vii) 0.4%, (viii) 0.6%, and (ix) control (water spray). The treatment were imposed at five different stages, i e pre bloom, full bloom, fruit set initiation, pea stage and one month before harvest. The different nutrients solutions were prepared separately by dissolving the required amount of salts in light hot water and neutralized by adding slack lime in borax. In each solution a surfactant (Teepol) was added @ 0.1%. The uniform management practices with respect to nutrition and irrigation were adopted for experimental trees kept for observation. Observation on fruit set, fruit drop, yield-attributing parameters, like fruit length, breadth, weight and number of fruit/branchlet and fruit yield /tree were recorded during final harvesting from 2001 to 2005. The fruit quality parameters like fruit shape, fruit and flesh colour, pulp content, stone size, weight, seed weight acidity, TSS and ascorbic acid were analyzed based on pooled data of five year. The data on fruit drop was recorded from five randomly pre-tagged branches, data on misshapen fruits were recorded by taking the weight of such fruits after harvesting of fruits of all the treatments under investigation separately. Size of fruit and stone was recorded with the help of vernier callipers. TSS was determined with the help of hand refractometer. The acidity was estimated by titrating known volume of juice against 0.1N NaOH using phenolphthalein as an indicator and the ascorbic acid (vitamin C) was determined by volumetric method through standard dye solution (Sadasivam and Thymoli 1987). The agroecological region comes under hot arid ecosystem where experimentation was done. The soil was sandy with low fertility status and poor water-holding capacity. Meteorological parameters like temperature, rainfall and relative humidity were recorded during study period for interpretation of experimental results. The data on various parameters were analyzed by INDOSTAT statistical package in randomized block design having three replications.

RESULTS AND DISCUSSION

Vegetative growth, fruit set and fruit drop

Observation on effect of different treatments were recorded to assess the growth behaviour under uniform management situation. Data pertaining to plant height (Table 1) revealed

Table 1 Effect of calcium and boron on growth, flowering and fruit set behaviour in Indian gooseberry

Treatment	Plant height (m)	Canopy spread (m)		Length of determinate shoot (cm)	female flower/ shoot (%)	productive shoot/ branch (%)	Fruit set (%)	Fruit drop (%)	Fruit retention (%)	Colour of fruit
		EW	NS							
T_1 Calcium carbonate 0.2%	3.41	3.65	3.80	18.1	5.5	61.2	51.90	75.30	24.70	Yellowish green
T_2 Borax 0.2%	3.90	3.75	3.95	18.5	5.8	68.8	56.50	78.80	21.20	Yellowish green
T_3 Calcium carbonate +borax 0.2%	4.00	3.90	4.05	18.7	6.0	67.8	63.20	69.40	30.60	Yellowish green
T_4 Calcium carbonate 0.4%	3.36	4.00	4.10	17.9	6.4	63.3	56.60	74.70	25.30	Yellowish green
T_5 Borax 0.4%	3.68	4.10	4.25	18.3	6.2	75.6	65.20	64.40	35.60	Yellowish green
T_6 Calcium carbonate +borax 0.4%	4.12	4.25	4.40	19.8	9.8	817	78.70	32.60	67.40	Bright yellowish
T_7 Calcium carbonate 0.6%	3.35	4.00	4.20	18.0	6.1	63.4	50.10	61.40	38.60	Yellowish green
T_8 Borax 0.6%	3.52	4.15	4.25	17.9	6.5	71.5	51.50	60.30	39.70	Yellowish green
T_9 Calcium carbonate +borax 0.6%	3.85	4.10	4.35	18.1	5.9	68.1	62.60	51.10	48.90	Yellowish green
T_{10} Control (water spray)	3.20	3.50	3.70	17.7	5.0	56.3	49.70	79.20	20.80	Dull yellowish
CD (*P*=0.05)	0.95	NS	NS	NS	3.21	13.71	21.6	16.58	21.62	

that it was maximum in T_6 (4.12 m), followed by T_3 (4.0 m), T_2 (3.90 m) with minimum under control (3.20 m), while plant height of other treatments were in between. Canopy spread in east-west direction vary from 3.50 m to 4.25 m with the maximum in T6 (4.25 m), followed by in T_8 (4.15 m), T_5 and T_9 (4.10 m) and minimum was recorded in control (3.50 m). Canopy spread in north-south direction was also maximum in T_6 (4.40 m), followed by T_9 (4.35 m), T_5 and T_8 (4.25 m) with the minimum in control (3.70 m). The length of branchlet (determinate shoot) was found highest in T_6 (19.8 cm) and minimum was recorded under control (17.7 cm), difference among the treatments were at par with T_6. In general longer the determinate shoot more the fruiting areas which resulted more number of fruit/branchlet. The maximum female flower was observed in T_6 (9.8%) with minimum under control (5.0%). Pre-flowering foliar application of calcium and boron have significantly affected productive shoot/branch percentage and highest (81.7%) was recorded in T_6 and minimum in control (56.3%). It may be due to the fact that boron has significant role in mobilization of food material from source to sink. Data presented in Table 1 elucidated that fruit set was recorded maximum with T_6 (78.70%), followed by T_5 (65.20%), T_3 (63.20%) and minimum was recorded under control (49.70%). The beneficial effect of calcium and borax in increasing fruit set might be due to the higher availability of photosynthates and these chemicals are also associated with hormone metabolism which promotes synthesis of auxin, essential for fruit set and growth. Data pertaining to fruit drop (Table 1) indicated that foliar spray of borax and calcium reduced fruit drop significantly. The maximum fruit retention and minimum fruit drop was recorded in T_6 (67.40% and 32.60%), followed by T_9 (48.90% and 51.10%), T_8 (39.7% and 60.3%) and minimum fruit retention was recorded with control (20.80%) however, fruit drop was highest in control (79.2%). It also might be due the reason that calcium and borax being main constituent of cell wall (middle lamella) of plant cell in the form of calcium pectate which play important role in strengthening of pedicel attached to proximal end of fruit resulted less fruit drop, similarly reduction in fruit drop by spray of borax can be due to the indirect action of boron in auxin synthesis that delayed the formation of abscission layer during early stages of fruit development (Skoog 1940, Guardiola and Garcia 2000). Fruit retention is an important criteria for prolific bearing of tree. The brightness of colour was also affected by application of calcium and boron and bright yellowish green colour was observed in T_6 (calcium carbonate + borax 0.4%) and brightness of fruits in rest of the treatments were in between yellowish green to dull yellowish.

Fruit dormancy, fruit maturity and yield parameters

Data presented in Table 2 on dormancy, fruit maturity and yield parameters of Indian gooseberry. In general after fruit set in aonla pin heads (fruitlets) remain dormant for 3–4 month, these pin heads starts growing with onset of rainfall during July–August. Foliar application of calcium and boron influenced the dormancy of fruitslets, which is varied from 84 to 91 days with minimum in T_6 (84 days) and maximum in control (91 days). Days taken in fruit maturity was recorded lowest in T_6 (178 days), followed by T_3 (188 days), T_2 (194 days) with maximum under control (206 days) (CIAH 2004 6 05). Although deformity of fruit is not a very serious problem but under hot arid ecosystem, fruit deformity in aonla was observed in different varieties. Similarly, in 'NA7' the per centage deformed fruit was influenced by application of calcium and borax and it was recorded minimum in T_6 (0.8%) with maximum under control (2.8%) rest were in between. The highest fruit weight was recorded with T_6 (39.80 g), closely followed by T_1 (37.10 g), T_7 (36.90 g) and minimum under control (33.9 g). High fruit weight has direct correlation with accumulation of more photosynthates for which boron play key role. Stone and seed weight was not significantly affected by treatment application and there was no definite

Table 2 Effect of calcium and boron on fruit dormancy, fruit maturity and yield parameters in Indian gooseberry

Treatment	Dormancy period (days)	Days taken in fruit maturity	Deformed fruits (%)	Fruit weight (g)	Stone weight (g)	Seed weight (g)	Average no. of fruits/shoot	Harvesting period (days)	Yield/ tree (kg)
T_1 Calcium carbonate 0.2%	88	200	1.2	37.10	1.60	0.025	15.7	102	109.7
T_2 Borax 0.2%	89	194	1.4	35.40	1.50	0.028	16.8	98	112.7
T_3 Calcium carbonate + Borax 0.2%	89	188	1.0	34.80	1.59	0.036	17.4	112	135.6
T_4 Calcium carbonate 0.4%	90	204	1.1	34.50	1.46	0.030	15.9	110	108.7
T_5 Borax 0.4%	88	196	1.7	35.10	1.40	0.031	16.8	96	109.8
T_6 Calcium carbonate + Borax 0.4%	84	178	0.8	39.80	1.60	0.038	20.3	115	158.6
T_7 Calcium carbonate 0.6%	90	202	1.2	36.90	1.70	0.031	17.8	102	124.5
T_8 Borax 0.6%	91	198	2.3	34.60	1.80	0.037	18.2	99	118.6
T_9 Calcium carbonate + Borax 0.6%	90	201	1.8	35.80	1.70	0.037	18.6	101	110.7
T_{10} Control (water spray)	91	206	2.8	33.90	1.60	0.030	15.5	91	105.2
CD (*P*=0.05)	NS	19.7	NS	4.32	NS	NS	4.25	11.6	26.72

Table3 Effect of calcium and boron on fruit characters and quality attributes in Indian gooseberry

Treatment	Fruit size (cm)		Stone size (cm)		Pulp weight (g)	Pulp/ stone ratio	TSS (%)	Dry matter (%)	Juice content (%)	Acidity (%)	Vitamin C (mg/100g)
	L	B	L	B							
T_1 Calcium carbonate 0.2%	3.20	3.40	2.10	2.00	35.5	22.15	15.9	16.9	76.10	1.98	614.2
T_2 Borax 0.2%	3.30	3.60	1.80	1.90	33.9	22.58	15.8	17.5	75.90	1.75	618.3
T_3 Calcium carbonate + Borax 0.2%	3.50	3.60	1.90	1.71	33.21	20.88	15.7	18.2	75.41	1.93	615.76
T_4 Calcium carbonate 0.4%	3.40	3.70	1.90	1.85	33.04	22.64	15.0	17.8	76.40	2.1	611.7
T_5 Borax 0.4%	3.70	3.80	1.85	1.75	33.70	24.06	14.6	17.3	77.10	2.31	613.5
T_6 Calcium carbonate + Borax 0.4%	3.90	4.10	1.70	1.65	38.20	23.81	16.2	20.2	78.50	2.31	626.49
T_7 Calcium carbonate 0.6%	3.40	3.80	1.75	1.8	35.20	20.69	15.7	16.9	76.40	2.15	611.9
T_8 Borax 0.6%	3.20	3.70	1.80	1.85	32.80	20.19	15.1	16.8	75.90	2.4	612.1
T_9 Calcium carbonate + Borax 0.6%	3.40	3.80	2.00	1.70	34.10	20.05	14.8	18.1	75.38	1.85	615.6
T_{10} Control (water spray)	3.10	3.20	2.2	2.15	32.30	18.23	14.5	16.5	74.20	2.47	610.7
CD (*P*=0.05)	0.72	0.85	NS	NS	5.21	NS	NS	2.36	NS	NS	12.31

trend and correlation among the treatments however, it was varied from 1.4 to 1.8 g and 0.025 to 0.038 g in defferent treatments. The average number of fruit/branchlet, which is an important contributing trait of aonla, was varied 15.5–20.3 with maximum in T_6 (20.3) and minimum under control (15.5). More number of fruit/branchlet is attributed to higher fruit retention and lower fruit drop in aonla and ultimately resulted into higher fruit yield. Harvesting period was recorded maximum in T_6 (115 days) without deterioration in quality of fruit, followed by T_3 (112 days), T_4 (110 days), whereas minimum harvesting period was found under control (91 days). The enhancement in harvesting period in aonla signifies the storage of matured fruits on the tree itself without quality deterioration. The maximum fruit yield (158.6 kg) / tree (Table 2) was recorded with mixed application of Ca + B 0.4% (T_6), followed by T_3 (135.6 kg), T_7 (124.5 kg) with minimum under control (105.2 kg). Singh *et al*. (2001), Kumar and Shukla (2010) have also reported increased trend of fruit yield through micronutrient application. This may be the reason that in present investigations there was highest fruit retention, lowest fruit drop and maximum number of fruit/cluster which resulted into highest yield/tree.

Fruit characters and quality attributes

Data with respect to fruit length was presented in Table 3 indicated that highest fruit length was recorded with T_6 (3.9 cm), closely followed by T_5 (3.7 cm), T_3 (3.5 cm) with minimum under control (3.1 cm). Fruit breadth was recorded maximum in T_6 (4.1 cm) with minimum under control (3.2 cm) rest were in between. Stone length varied from 1.7–2.1 cm with maximum in T_1 (2.1 cm) and minimum under T_6 (1.7 cm). Similarly, stone breadth was varied from 1.65 to 2.15 cm with maximum under control (2.15 cm) and minimum with T_6 (1.65 cm). Small stone size is desirable quality character of aonla fruit. Pulp weight was recorded maximum in T_6 (38.2 g), followed by T_1 (35.5 g), T_7 (35.2 g) and minimum recorded with control (32.3 g). Pulp/stone ratio was recorded maximum in T_5 (24.06), closely followed by T_6 (23.81) and minimum with control (18.23). Preference of consumers depend on pulp/stone ratio of aonla, more the pulp content more is acceptability by the consumer (Hazarika *et al*. 2009). The total soluble solids (TSS) was varied from 14.5 to 16.2% with maximum in T6 (16.2%) and minimum under control (14.5%). In general, TSS is an important quality factor which influences the palatability and acceptability of fruit. Dry matter content was significantly influenced by different treatments and it was recorded maximum in T_6 (20.2%), followed by T_3 (18.2%), T9 (18.1%), T4 (17.8%) and minimum in control (16.5%). High dry matter content in different treatment may be due to enhanced accumulation of photosynthates through foliar feeding of Ca and B. Juice content in fruit pulp was varied from 74.2 to 78.5% with maximum in T6 (78.5%), followed by T5 (77.1%), T4 and T7 (76.4%) and minimum was recorded in control (74.2%). Acidity content in Indian gooseberry was varied from 1.75 (T2) to 2.47% (control) in different treatments. The highest vitamin C in fruit pulp was recorded in T6 (626.49 mg/100 g) with minimum in control (610.7 mg/100 g) rest were in between. Improvement in quality of Indian gooseberry fruit may be due to the fact that boron is associated with carbohydrate transportation within the plants. Similar findings were reported by Samant *et al*. (2008). It may also be due to micro-nutrients which are known to impart direct and indirect effects on fruit yield and quality. Similarly, Kumar and Shukla (2005) also reported that fruit quality of litchi increased by spray of Borax and Zinc Sulphate 0.3–0.5%.

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