Indian Journal of Agricultural Sciences **88** (11): 1784–8, November 2018/Article

Influence of foliar application of gibberellic acid, calcium and boron on fruit drop, yield and quality attributes of aonla (*Emblica officinalis*) cv. NA 7

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Received: 23 October 2017 ; Accepted: 11 July 2018

ABSTRACT

A study was undertaken to examine the influence of foliar application of gibberellic acid (GA_3), calcium and boron on fruit drop, yield and quality attributes of aonla (*Emblica Officinalis* Gaertn.) cv. NA 7 during two successive years, i.e. 2014-15 and 2015-16 on 15 year old plant of aonla cv. NA 7 at CSAUA&T, Kanpur (Uttar Pradesh), India. The experiment was laid out in randomized block design with three replications and 10 treatments, viz. GA_3 (25, 50 and 100 ppm), calcium chloride (0.5, 1.0 and 1.5 %) and borax (0.2, 0.4 and 0.6 %) including a control. Significantly reduced fruit drop (66.2 %) with increased fruit retention (29.85%) and specific gravity (1.06 g/cm^3) was observed in plants treated with borax at 0.6%. Maximum fruit length (3.78 cm), width (3.89 cm), weight (30.90 g), volume (29.46 cc), pulp weight (29.16 g), total sugars (12.92 %), TSS (14.90 ^{0}Brix), fruit yield (80.50 kg/plant) with more moisture contents (94.04 %) was recorded in fruits produced from GA_3 50 ppm treated plants, whereas, GA_3 @ 100 ppm treatment reduces the titratable acidity (1.56 %) and stone weight (1.45 g) but increases the pulp: stone ratio (18.44%). Fruits with maximum ascorbic acid (608 mg/100g pulp) contents were produced from the plants treated with calcium chloride 1.5 % in the month of August in northern plains of India.

Key words: Aonla, Boron, Calcium chloride, Fruit drop, Gibberellic acid, Yield, Quality

The Indian gooseberry or aonla (*Emblica officinalis* Gaertn.), a native of tropical South – East Asia, particularly central and south India, is grown in India since the ancient times. The plants are also found common in mixed deciduous forest of India ascending to 1300 m on hills and also naturally occurring in other tropical countries of the world. However, the traditional cultivation of aonla is predominantly occupied in Uttar Pradesh particularly in Pratapgarh and its surrounding districts, and rapidly spreading in the semi-arid regions of the country.

Aonla fruit is valued for its high nutritive and medicinal properties, processing into various value added products and herbal drugs. Due to its importance and various medicinal uses, it is also known as 'Amrit Phal' and 'Wonder drug'. It is an important ingredient of Triphala, Chavanprash, Amritkalash, Trilax, Amlaplex, Neutrale and Tylophora plus. Fruits are commonly used for making preserve (murabba), pickle, candy, jelly, sauce, dried chips, etc.

Foliar application of plant bio-regulators, macro and micronutrients have immense important role in improving fruits set, productivity and quality of fruits. It also has beneficial role in the recovery of nutritional and physiological disorder in fruit trees. Numerous effects of gibberellins on different aspect of plant life suggests that this hormone can be used commercially for the benefit of human welfare. Gibberellins have found great use in increasing stalk length and fruit production, including uniform crop emergence, increasing fruit size by cell division and cell elongation, improving fruit quality and storage life, delaying maturity period, controlling cracking of fruits and fruit drop problem, improve fruit retention, producing seedless-ness and increasing sugar content in different fruit crops at different concentrations (Pandey and Sinha 1995).

Calcium plays an important role in maintaining quality of fruits and calcium treatments helps to retain fruit firmness, increase vitamin-C content, decreased storage break down and rotting. It also protects from disorganization of membrane and prevents increase in apparent free space of the tissues. This is generally associated with senescence and maintains the protein synthesizing ability of cell.

Aonla is facing a serious problem of internal fruit necrosis and some of the varieties are susceptible to the tune of 60-80%. The symptoms of the malady start with the browning of mesocarp in the fruit extending towards the upper surface in the 2nd and 3rd week of October. The disorder is non-pathogenic in nature and the application

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of trace elements particularly boron has given some clue towards the control. Boron also plays an important role in ovule development, pollen tube growth and fruit set. The intensity of damage caused by fruit dropping can also be minimized by the foliar application of PBR's and nutrients, which also helps in improving yield and fruit quality of aonla. Keeping these in view, the present investigation was carried out to study the influence of gibberellic acid, calcium and boron on aonla fruits.

MATERIALS AND METHODS

Experiment was made during two successive years, i.e. 2014-15 and 2015-16 on the 15 year old plants of aonla cv. NA 7, in the Department of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh), India.

The 30 trees having uniform growth were selected randomly for foliar application. The experiment was laid out in randomized block design with three replications and ten treatments, viz. GA_3 (25, 50 and 100 ppm), calcium chloride (0.5, 1.0 and 1.5 %) and borax (0.2, 0.4 and 0.6 %) including a control. The foliar application of GA_3, macro and micronutrients was done at fruit developmental stage during August in both years. The standard cultural operations, plant protection measures and basal application of manures and fertilizers were done as per recommended schedule for aonla plantation in all treatments. The observations were recorded on fruit drop, fruit retention and yield with various other physico-chemical parameters of fruits. Data of both years were analyzed and mean data of two years is presented here. Hand refractometer was used for determination of TSS and represented in ^{0}Brix. Other chemical parameters, viz. total sugars, ascorbic acid and acidity was determined by the standard method as described in AOAC (1980).

RESULTS AND DISCUSSION

Fruit drop and retention per cent

Significantly reduced fruit drop per cent with increased fruit retention per cent was recorded with the spray of plant bio-regulator and nutrients as compared to control (Table 1). The lowest fruit drop (66.21 %) and higher fruit retention per cent (29.85 %) were recorded in plants treated with borax @ 0.6 % followed by calcium chloride @ 1.5 % (70.15 and 29.80 % respectively), whereas maximum fruit drop (81.33 %) and minimum fruit retention (18.67 %) per cent was observed under control (water spray). This reduction in fruit drop per cent and increase in fruit retention per cent in aonla fruits might be due to the reason that boron and calcium being main constituent of cell wall (middle lamella) of plant cell in the form of calcium pectate plays an important role in the strengthening of pedicel attached to the proximal end of fruits resulted less fruit drop. Similarly reduction in fruit drop by spray of borax may also be due to indirect action of boron in auxin synthesis that delayed the formation of abscission layer during early stages of fruit development which ultimately increases fruit retention per cent. The present findings are in accordance with the findings of Singh and Singh (2015), Verma *et al.* (2016) and Singh *et al.* (2016) in aonla.

Table 1 Effect of foliar application of GA_3, calcium and boron on fruit drops and fruit retention in aonla cv. NA-7 (mean of two years)

Treatment	Fruit drop (%)	Fruit retention (%)
GA_3 @ 25 ppm	74.80	25.20
GA_3 @ 50 ppm	70.80	29.20
GA_3 @ 100ppm	72.67	27.33
Calcium chloride @ 0.5 %	76.07	23.93
Calcium chloride @ 1.0 %	73.53	26.47
Calcium chloride @ 1.5 %	70.15	29.80
Borax @ 0.2 %	76.67	23.33
Borax @ 0.4 %	71.50	25.46
Borax @ 0.6 %	66.21	29.85
Control (water spray)	81.33	18.67
SE (diff.)±	1.05	0.65
CD (P=0.05)	2.33	1.38

Fruit yield

The application of plant bio-regulator and nutrients significantly increased the fruit yield/plant as compared to control (Fig 1). Maximum fruit yield/plant (80.50 kg) was found in 50 ppm GA_3 treated plants followed by borax @ 0.6% (79.15 kg), whereas the lowest fruit yield of 69.80 kg/ plant was recorded in control, where no plant bio-regulator and nutrients were applied. These findings are in conformity with the results of Tripathi and Shukla (2006) in strawberry cv. Chandler, Singh and Tripathi (2010) in strawberry cv. Chandler, Chandra *et al.* (2015) and Verma *et al.* (2016) in aonla. This significant increase in fruit yield in GA_3 treated plants might be due to their direct role in photosynthesis in the plants which results an increase in fruit size, weight, volume and ultimately yield of fruits.

Fruit size (Length and width)

Fruit size was significantly influenced by the foliar application of plant bio-regulator and nutrients (Table 2). Plants treated with GA_3 @ 50 ppm as foliar application produced significantly higher length and width of fruit (3.78 and 3.89 cm, respectively), whereas the plants under control produced significantly smaller size of fruits (3.18 and 3.38 cm, respectively). All other treatments of GA_3, borax and calcium chloride has also produced significantly increased size of fruits as compared to control. With the reduction in plant bio-regulator and nutrients concentration, fruits size gets reduced in comparison to their higher concentration but remains significantly higher as compared to untreated one. This increase in size of fruits with the application of gibberellic acid might be due to the significantly increase in cell division and cell elongation. These results have got

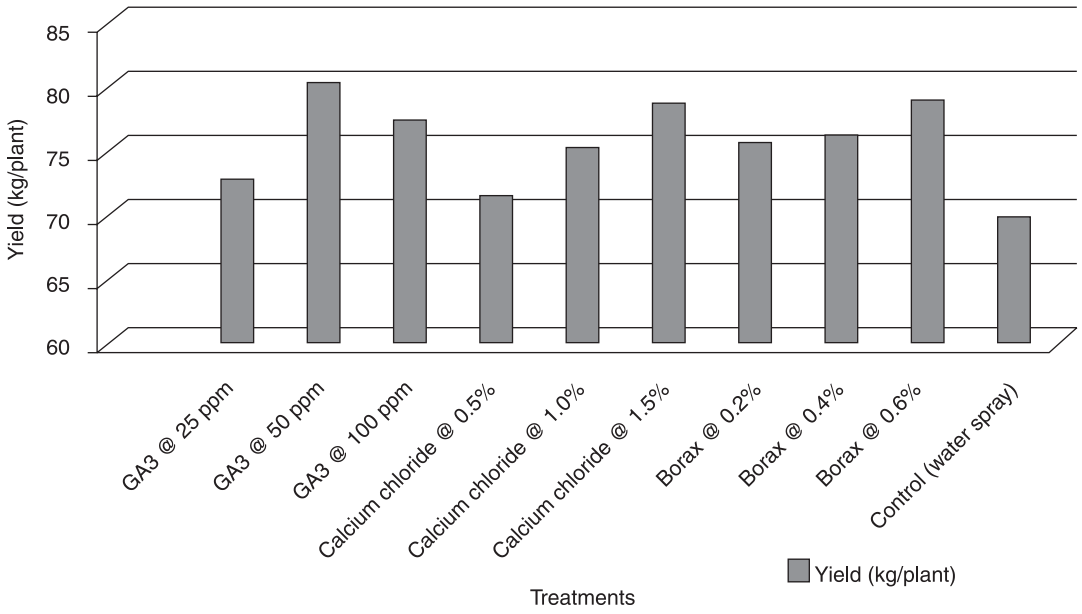

Fig 1 Effect of foliar application of GA_3, calcium and boron on yield of fruits in aonla cv. NA-7

the support with the findings of Shukla *et al.* (2011), Singh and Singh (2015), Chandra *et al.* (2015), Verma *et al.* (2016) and Singh *et al.* (2016) in aonla.

Weight, volume and specific gravity of fruits were significantly influenced by the foliar application of plant bio-regulator and nutrients. Significantly maximum weight, volume and specific gravity of fruit was recorded with the application of GA_3 @ 50 ppm (30.90 g, 29.46 cc and 1.08 g/cm^3, respectively) followed by calcium chloride @ 1.5 % treatment (29.20 g, 27.68 cc and 1.08 g/cm^3, respectively), while minimum weight, volume and specific gravity of fruit was produced in untreated control plants (25.37 g, 24.29 cc and 1.04 g/cm^3, respectively). It is also recorded that with the reduction in dose of nutrients and plant bio-regulator weight, volume and specific gravity of fruits also get reduced but remains significantly higher as compared to control (Table 2). Gibberellic acid and nutrients are directly or indirectly associated with the photosynthesis in the plants and then they were translocated to the fruits during their growth and development, which increase the reserved food material in the fruits and ultimately increases weight and volume of fruits. This increase in weight and size, results an increase in specific gravity of fruits. These results have got the support of Shukla *et al.* (2011) in aonla cv. Banarasi, Singh and Singh (2015), Chandra *et al.* (2015), Singh *et al.* (2016) and Verma *et al.* (2016) in aonla.

Fruit pulp weight

Fruit pulp weight was significantly increased by the foliar application of plant bio-regulator, macro and micronutrients (Table 2). Significantly more weight of pulp was recorded in fruits, which were harvested from the plants treated with the GA_3 @ 50 ppm (29.16 g) closely followed by calcium chloride @ 1.5 % (27.32 g), GA_3 @ 100 ppm (26. 60 g) and borax @ 0.6 % (26.52 g), whereas fruits with minimum pulp weight were harvested from untreated (control) plant (23.44 g). Remaining all other treatments also significantly increased pulp content in the fruits as compared to control. These findings are in conformity with the findings of Chandra *et al.* (2015) and Verma *et al.* (2016) in aonla.

Table 2 Effect of foliar application of GA_3, calcium and boron on physical characters of fruits in aonla cv. NA 7 (mean of two years)

Treatment	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Fruit volume (cc)	Specific gravity (g/cm3)	Pulp weight (g)	Stone weight (g)	Pulp: stone ratio (%)
GA_3 @ 25 ppm	3.34	3.63	27.27	25.72	1.06	25.61	1.66	16.36
GA_3 @ 50 ppm	3.78	3.89	30.90	29.46	1.08	29.16	1.74	17.72
GA_3 @ 100 ppm	3.48	3.69	28.20	26.35	1.07	26.68	1.52	18.44
Calcium chloride @ 0.5%	3.39	3.41	26.77	25.01	1.07	25.18	1.59	16.80
Calcium chloride @ 1.0%	3.41	3.46	28.13	26.28	1.07	26.31	1.82	15.45
Calcium chloride @ 1.5%	3.58	3.71	29.20	27.68	1.08	27.32	1.88	15.47
Borax @ 0.2%	3.41	3.51	26.18	24.69	1.07	24.54	1.64	15.95
Borax @ 0.4%	3.60	3.60	27.80	25.98	1.06	26.26	1.54	18.02
Borax @ 0.6%	3.68	3.72	28.13	26.75	1.06	26.52	1.61	17.45
Control (water spray)	3.18	3.38	25.37	24.29	1.04	23.44	1.93	13.12
S E (diff.)±	0.11	0.20	1.04	0.51	0.11	0.26	0.05	0.35
CD (P = 0.05)	0.19	N.S.	2.18	1.08	N.S.	0.55	0.11	0.74

Fruit stone weight and pulp : stone ratio

Reduction in stone weight with increased pulp : stone ratio was recorded with the use of plant bio-regulator, macro and micronutrients as compared to control (Table 2). Minimum weight of stone (1.52 g) and higher pulp: stone ratio (18.44 %) was recorded in the fruits produced from the plants treated with GA_3 @ 100 ppm followed by borax @ 0.4 % (1.54 g and 18.02%, respectively), whereas maximum weight of stone and minimum pulp: stone ratio was recorded under control (1.93 g and 13.12%, respectively). These results have got the support with the findings of Chandra *et al.* (2015), Verma *et al.* (2016) and Singh *et al.* (2016) in aonla. This improvement in pulp: stone ratio might be due to more accumulation of food substances in elongated cell and intercellular space of mesocarp.

Fruit moisture per cent

Significantly more fruit moisture content (94.04 %) was recorded in the fruits produced from GA_3 @ 50 ppm treated plants closely followed by calcium chloride @ 1.5 % (93.81%) treated plants, whereas minimum moisture per cent were recorded in control (90.10 %). Pre-harvest treatments of GA_3, borax and calcium chloride have many functions in plant life. They also directly or indirectly influence many enzyme systems in plants, out of these roles of GA_3 and calcium chloride in activation of amylase enzyme is well known which are responsible for the conversion of starch into sugar. There is no report are available yet, thus warrants further studies.

TSS and total sugars

The maximum TSS and total sugars content were recorded in the fruits produced from the plants treated with the foliar application of GA_3 @ 50 ppm (14.90 ^{o}Brix and 12.92 %, respectively) followed by borax @ 0.6 % (14.72 ^{o}Brix and 12.61 %, respectively), whereas the minimum contents (13.90 ^{o}Brix and 11.05 %, respectively) were recorded under untreated fruit plants (Table 3). This increase in TSS and total sugars with GA_3 and boron application might be due to the facts that these plant bio-regulator and nutrients are helpful in the process of photosynthesis which leads to the accumulation of oligosaccharides and polysaccharides in higher amount besides this they also regulate the enzymatic activity and metabolize the carbohydrates into simple sugars. These results are in conformity with the findings of Shukla *et al.* (2011) in aonla cv. Banarasi, Singh and Singh (2015), Singh *et al.* (2016) and Verma *et al.* (2016) in aonla.

Titratable acidity

Titratable acidity content in fresh fruits was decreased by the application of plant bio-regulator, macro and micronutrients. The minimum titratable acidity per cent was found in the fruits produced from the plants treated with GA_3 @ 100 ppm (1.56 %), closely followed by calcium chloride @ 1.5 % (1.63 %) and borax @ 0.6 % (1.66%), whereas the maximum content (1.98 %) was recorded in fruits produced from untreated control plants (Table 3). This decrease in acidity content of fruits might be due to an increase in TSS and total sugars. The acids under the influence of chemicals might have either been converted into sugars and their derivatives by the reactions involving reversal of glycolytic pathway or may be used as a substratum in the respiration or both. The results have got the support of the findings of Shukla *et al.* (2011) in aonla cv. Banarasi, Singh and Singh (2015), Chandra *et al.* (2015), Verma *et al.* (2016) and Singh *et al.* (2016) in aonla.

Ascorbic acid

The maximum ascorbic acid content (620.00 mg/100g) was recorded in the fruits produced from the plants treated with calcium chloride @ 1.5 % closely followed by GA_3 @ 50 ppm (608.00 mg/100g) treated plants, whereas the minimum ascorbic acid content (575.33 mg/100g) was obtained in untreated control plants (Table 3). This increase

Table 3 Effect of foliar application of GA3, calcium and boron on chemical composition of fruits in aonla cv. NA-7 (mean of two years)

Treatment	Fruit moisture (%)	T.S.S. (^{o}Brix)	Total sugars (%)	Titratable acidity (%)	Ascorbic acid (mg/100g)
GA3 @ 25 ppm	93.10	14.10	11.96	1.86	590.00
GA3 @ 50 ppm	94.04	14.90	12.92	1.73	608.00
GA3 @ 100ppm	93.50	14.33	12.44	1.56	603.00
Calcium chloride @ 0.5%	92.80	14.10	11.92	1.82	590.00
Calcium chloride @ 1.0%	93.05	14.27	12.12	1.73	606.00
Calcium chloride @ 1.5%	93.81	14.57	12.37	1.63	620.00
Borax @ 0.2%	92.40	14.48	11.86	1.80	589.00
Borax @ 0.4%	92.73	14.70	12.29	1.70	600.00
Borax @ 0.6%	93.01	14.72	12.61	1.66	602.00
Control (water spray)	90.10	13.90	11.05	1.98	575.33
SE (diff.)±	0.34	0.27	0.09	0.12	2.23
CD at (P = 0.05)	0.71	0.56	0.18	0.21	4.69

in ascorbic acid content with calcium nitrate application may be due to uninterrupted synthesis of its precursor like glucose-6-phosphate during conversion of starch into various sugars and low rate of oxidation. The finding is in accordance with the results of Shukla *et al.* (2011) in aonla cv. Banarasi, Tripathi and Shukla (2011), Singh and Singh (2015), Chandra *et al.* (2015), Verma *et al.* (2016) and Singh *et al.* (2016) in aonla.

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