Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(2): 1290-1292
Received: 02-01-2019
Accepted: 05-02-2019

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Response of zinc and boron sprays on growth and yield of Aonla (*Emblica officinalis* Gaertn) cv. Chakiya

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Abstract
An experiment was conducted during 2016-17 at Department of Horticulture and Post Harvest technology, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal on eight years old aonla trees, to study the effect of foliar application of Zn and B singly and in combinations on the growth and yield of aonla cv. Chakiya, revealed that fruit retention, fruit size (length and breadth), fruit weight, pulp weight, stone weight, pulp thickness and yield were maximized when foliar spray was done with Borax 0.50% + $ZnSO_4$ 0.60%.

Keywords: Aonla, boron, zinc, growth, yield

Introduction
Aonla or Indian gooseberry *(Emblica officinalis* Gaertn) belongs to the family Euphorbiaceae. It is one of the most important non-traditional fruits indigenous to India. It is hardy prolific bearer and highly remunerative even without much care and can be successfully grown in variable agro-climatic and soil conditions. Though aonla is a subtropical fruit but its cultivation in tropical climate is quite successfully. It responds well to the conditions of dry weather, moderately cool temperature during winter followed by high temperature of summer. It can tolerate freezing temperature as well as temperature as high as 46°c. The fruits are highly nutritive and one of the richest sources of vitamin-C. Out of 100 gram edible portion of aonla, it contain 0.5 gm protein, 0.1 gm fat, 0.7 gm minerals, 1.9-3.4 gm fibers, 14.1-21.8 gm carbohydrates, 0.05 gm calcium, 0.02 gm phosphorus, 1.2 gm iron and 200-750 mg vitamin-C (Mehta *et al.* 2002) [7]. The fruits contain a chemical substance called `leucoanthocyanins' which retards oxidation of vitamin-C. Aonla probably the only fruits to fill the gap of astringent food recommended by the ayurvedic system of medicine for a balanced diet and sound health. It is acidic, cooling, refrigerant, diuretic and laxative. Micronutrients are required by plants in minute quantities, although these are very effective in regulating plant growth as they form a part of the enzyme system and thus, regulating plant life. To obtain the higher yields, micronutrients are becoming necessary in fruit crop nutrition. Keeping this in view, the present investigation was undertaken to study the effect of foliar application of Zn and B singly and in combinations on the growth and yield of aonla cv. Chakiya.

Materials and Methods
The study was conducted at Department of Horticulture and Post Harvest technology, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal. Eight years old, 27 uniform healthy trees of aonla cultivar 'chakiya' were selected. The experiment was laid out in randomized block design with nine treatments replicated three times. The trees were sprayed twice at flowering and pea stage.

The details of the treatment composition were as
T_1 –Borax (0.25%)
T_2–Borax (0.50%)
T_3 – Zinc Sulphate (0.40%)
T_4 –Zinc Sulphate (0.60%)
T_5 – Borax (0.25%) + Zinc Sulphate (0.40%)
T_6 – Borax (0.25%) + Zinc Sulphate (0.60%)
T_7 – Borax (0.50%) + Zinc Sulphate (0.40%)
T_8 – Borax (0.50%) + Zinc Sulphate (0.60%)
T_9 – Control (water spray)

Results and Discussion

The data presented in the tables showed that all the parameters were influenced by the foliar spray of micronutrients. Among all the treatments maximum percentage of fruit retention (59.00%) was recorded under foliar spray of Borax 0.50% + Zinc Sulphate 0.60%. It is well known that boron play a significant role in carbohydrate transport and various physiological processes like nitrogen metabolism, active salt absorption, hormone metabolism, fat metabolism, etc. within the plant (Nason and McElroy, 1963) [8]. Wright (1956) suggested that primitive effect of growth substances in greater retention of fruit may be attributed to reduction in fruit drop. There is correlation between fruit drop and endogenous hormonal status, and existence of high level of internal auxin is useful for preventing fruit drop. Since high level of endogenous hormones might help in building up endogenous hormone at appropriate level that might be potent enough to reduce the fruit drop. The increased fruit retention due to zinc spray might be due to prevention in fruit drop owing to increased auxin concentration to distal end of fruits.

The fruit weight of aonla differed significantly with the sprays of zinc and boron alone or in combination. The maximum fruit weight (28.33 g) was recorded when Borax 0.50% + Zinc Sulphate 0.60% was sprayed followed by Borax 0.25% + Zinc Sulphate 0.60% (27.63g) while the minimum fruit weight (21.72 g) was measured under control. The findings are similar to those reported by Ghosh *et al.* (2009) [2], Khan *et al.* (2010) [4] and Verma *et al*. (2008) [11]. Beneficial effect of zinc in improving fruit weight was also observed by Wali and Sharma (1997) [12] in Kinnow mandarin and Ghosh and Besra (2000) [3] in Sweet orange. Increase in fruit weight may be attributed to the strengthening of middle lamella and consequently cell wall, which later may have increased the free passage of solutes to the fruits. Zinc is essential for auxin and protein synthesis, seed production and proper maturity of fruits, while Boron has a key role in cell division and elongation and there by increases fruit weight. The higher fruit weight due to combined application of higher concentrations of zinc and boron may be attributed to their stimulatory effect on plant metabolism. Volume of fruit under different levels of zinc and boron ranged from 23.53ml - 30.27ml. It was not significant. However, the maximum fruit volume was recorded with the application of Borax 0.50% + Zinc Sulphate 0.60%. The minimum (35.39) number of fruits per kg was recorded with Borax 0.50% + Zinc Sulphate 0.60% followed by (36.29) in Borax 0.25% + Zinc Sulphate 0.60%.

Maximum length of aonla fruit (28.52 mm) were obtained under foliar spray of Borax 0.50% + Zinc Sulphate 0.60% followed by (24.86mm) in Borax 0.25% + Zinc Sulphate 0.60% and minimum length of fruit(21.20mm) was noted in control. The present findings have been also confirmed by Ghosh *et al.* (2009) [2], Khan *et al.* (2012) [4], and Verma *et al.* (2008) [11]. Increasing fruit length may be due to fact that mineral nutrients (Boron and Zinc) appear to have direct role in hastening the process of cell division and cell elongation due to which length might have improved. Similar to fruit length, the character fruit breadth was influenced significantly with the application of borax and zinc. It is noted from table 1, that the breadth of fruit shown increasing trend with all the treatments as compared to control. The maximum (35.72 mm) breadth of fruit was recorded with Borax 0.50% + Zinc Sulphate 0.60% followed by (33.22mm) in Borax 0.25% + Zinc Sulphate 0.60%. The minimum (27.59 mm) breadth of fruit was noted in control.

The maximum pulp weight (27.20 g) and pulp thickness (10.48 mm) was recorded with Borax 0.50% + Zinc Sulphate 0.60%. The minimum pulp weight (20.65 g) and pulp thickness (8.86 mm) of fruit was noted in control. These results are further supported by Bhatia *et al.* (2001) [1] and Trivedi *et al.* (2012) [10]. They also reported that increase in fruit yield might be due to positive effect of micronutrients on fruit setting. Increased vegetative growth due to residual effect of higher concentration of auxins in plant which resulted in high leaf to fruit ratio there by contribution accumulation of higher amount of photosynthates which increased finally pulp weight and pulp thickness. The lowest stone weight (1.06 g) was recorded with Borax 0.50% + Zinc Sulphate 0.60% and the highest stone weight (1.57 g) were noted in control. The reduced stone weight might be due to the nutrients role in accumulation of more flesh in the fruit which decreased finally stone weight.

The highest yield per tree (12.20 kg) was recorded with the spray of Borax 0.50% + Zinc Sulphate 0.60% followed by (12.10 kg) in Borax 0.50% + Zinc Sulphate 0.40%. which was found significantly superior over control. The minimum fruit yield (7.60 kg) was noted in control. These results are in conformity with the findings of Singh *et al.* (2004) [9], Kumar *et al.* (2010), Khan *et al.* (2012) [4] and Trivedi *et al.* (2012) [10]. The results revealed that the combination of boron and zinc produced an additive effect on the yield. Increased fruit yield was obtained due to combined application of higher concentration of both the nutrients (Zn and B). This is due to fact that spraying of borax provides boron to the plant. It is believed that boron brings about inactivation of superfluous growth hormone by formation of complex compound. The importance of this element in improving the physiological activities of plant is well established but it is not clear whether it influences directly or indirectly. The significant effect of zinc in increasing fruit yield might be due to the synthesis of tryptophan which serves as precursor for auxin synthesis.

Table 1: Influence of foliar application of zinc and boron on fruit retention, fruit weight, no. of fruits, fruit length, fruit breadth and fruit volume of aonla cv. chakiya

Treatments	Fruit Retention (%)	Fruit weight (g)	No. of fruits (per kg)	Fruit length (mm)	Fruit breadth (mm)	Fruit volume (ml)
T_1-Borax (0.25%)	42.93	22.18	45.10	21.32	28.67	23.80
T_2-Borax (0.50%)	47.70	22.30	44.90	23.44	28.91	24.90
T_3-Zinc Sulphate (0.40%)	36.80	23.62	42.44	24.10	29.17	25.92
T_4-Zinc Sulphate (0.60%)	37.40	23.67	42.15	24.16	29.58	26.53
T_5- Borax (0.25%) + Zinc Sulphate (0.40%)	48.50	24.13	41.67	24.75	29.74	26.73
T_6-Borax (0.25%) + Zinc Sulphate (0.60%)	49.20	27.63	36.29	24.86	33.22	24.96
T_7- Borax (0.50%) + Zinc Sulphate (0.40%)	54.00	24.47	40.88	24.75	30.10	26.67
T_8-Borax (0.50%) + Zinc Sulphate (0.60%)	59.00	28.33	35.39	28.52	35.72	30.27
T_9 -Control (water spray)	33.00	21.72	46.05	21.20	27.59	23.53
CD (P=0.05)	6.75	2.29	3.58	2.57	4.24	NS

Table 2: Influence of foliar application of zinc and boron on pulp weight, stone weight, pulp thickness and yield of aonla cv. chakiya

Treatments	Pulp weight (g)	Stone weight (g)	Pulp thickness (mm)	Yield (kg/tree)
T_1-Borax (0.25%)	21.04	1.27	8.99	8.90
T_2-Borax (0.50%)	21.12	1.23	9.16	9.50
T_3-Zinc Sulphate (0.40%)	22.53	1.17	9.31	9.70
T_4-Zinc Sulphate (0.60%)	22.87	1.13	9.92	10.40
T_5- Borax (0.25%) + Zinc Sulphate (0.40%)	23.20	1.13	10.13	11.50
T_6-Borax (0.25%) + Zinc Sulphate (0.60%)	26.06	1.07	10.40	12.00
T_7- Borax (0.50%) + Zinc Sulphate (0.40%)	23.34	1.09	10.28	12.10
T_8-Borax (0.50%) + Zinc Sulphate (0.60%)	27.20	1.06	10.48	12.20
T_9 -Control (water spray)	20.65	1.57	8.86	7.60
CD (P=0.05)	1.86	0.11	0.91	1.18

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