International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(5): 35-39

Received: 07-08-2020
Accepted: 21-09-2020

# Effect of foliar application of zinc and boron from different sources on growth, yield and quality of custard apple (*Annona squamosa* L.) cv. Arka Sahan

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**DOI:** https://doi.org/10.22271/chemi.2020.v8.i5a.10989

## Abstract
A field experiment was conducted at Regional Horticultural Research and Extension Centre, GKVK campus, Bengaluru-65, Karnataka during 2019-20 to study the effect of foliar application of zinc and boron from different sources on growth, yield and quality of custard apple (*Annona squamosa* L.**)** cv. Arka Sahan. The experiment was laid out in Randomized Complete Block Design with twelve treatments replicated thrice. The treatments consisted of foliar application of 0.5% Zinc sulphate, 0.5% Zinc chloride, 0.5% Zinc oxide, 0.3% Boric acid and 0.3% Borax either alone or in combination, along with water spray as control. Each treatment was imposed thrice to the existing custard apple trees, one at the time of flowering, second at fruit set stage and third at pre-harvest stage. The results revealed that foliar application of 0.5% Zinc sulphate plus 0.3% borax significantly enhanced the growth attributes of custard apple in terms of shoot length (50.60 cm), number of leaves per branch (130.72) and leaf area (130.35 $cm^2$) along with improved yield parameters like number of flowers per tree (564.17), percentage of fruit set (93.33), number of fruits per tree (22.83) and fruit yield per tree (11.09 kg). The same treatment combination yielded the fruits having superior physical quality in terms of highest fruit diameter (9.65 cm), fruit volume (174.59 mL), fruit weight (485.98 g) and pulp weight (353.64 g). The quality parameters of fruit such as reducing sugars (22.03%), total sugars (23.85%), TSS (32.25 $^0$Brix) and ascorbic acid (38.61%) contents of fruit significantly improved along with minimum physiological weight loss during keeping time of 1$^{st}$ day (1.00 %), 3$^{rd}$ day (3.42 %), 5$^{th}$ day (6.27 %) and 7$^{th}$ day (11.01 %) after ripening were recorded with the same treatment combination. Among different treatments, the combined foliar application of 0.5% Zinc sulphate and 0.3% Borax showed best results with regard to growth, yield and quality of custard apple cv. Arka Sahan.

**Keywords:** Zinc sulphate, zinc chloride, zinc oxide, borax, boric acid, custard apple, growth, yield and quality

## Introduction
Custard apple (*Annona squamosa* L.) belongs to the family Annonaceae. This family has 46 genera and about 500 to 600 species and most of which found in tropics. Arka Sahan is one of the popular variety of custard apple as it fetches higher price than other varieties because of its exquisite quality and taste. Arka Sahan requires artificial pollination, because of difficulty involved in natural pollination due to the protogynous dichogamy phenomenon. Although custard apple trees have hermaphrodite flowers, self-pollination is nearly impossible because stigma becomes receptive or viable long before the pollen is released (Campbell and Phillips, 1994) [5].

Micronutrients play a catalytic role in nutrient absorption and balancing of other nutrients. Role of micronutrients is important in custard apple not only for high productivity but also to get better quality fruits and to maintain post- harvest life of fruit. Although they need a small quantities, they largely affects the growth and development of custard apple. Mainly, Zn and B which are immobile in plants are majorly deficient. The deficiency of micronutrients in soil may be due to intensive cropping, loss of top soil by erosion, loss of micronutrients by leaching, liming of soils, *etc*. Micronutrients play an important role in metabolic processes, thereby influence the yield.

Micronutrients are involved in cell wall development to respiration, photosynthesis, chlorophyll development, enzyme activity, nitrogen fixation, *etc*. They stimulate more vegetative growth and boost the fruit set and ultimately increases yield.
Zinc activates the synthesis of tryptophan, a precursor of growth hormone IAA. It is involved in protein synthesis mediated through RNA and activation of several enzymes such as carbonic anhydrase, alcohol dehydrogenase, glutamic dehydrogenase, malic dehydrogenase, lactic dehydrogenase, *etc*. While, boron plays an importance role in flowering and fruiting processes. Boron has a specific role in pollen tube growth by forming pectin–borate complex which encourages the premature rupture of pollen tubes and thus, promotes growth of pollen tube and whole process of pollination in addition to stimulating effect on oxygen uptake and on sugar absorption by the germinating pollen. The major role of boron in fruit trees involve fruit setting and seed formation by influencing either cell division or nucleic acid synthesis in the developing fruits. It helps in translocation of sugars through cellular membrane by formation of ionizable sugar-borate complex and thus, prevents polymerization of sugars. It also poses dehydrating properties and thus, prevents hydration of root tips and thereby strengthens the plant roots against the unfavourable and harmful influences of the hydroxyl ions. It enhances rooting by influencing oxidative processes. It is involved in carbohydrate metabolism and synthesis of cell wall components mainly leucocyanin and thus, gives resistant for pest and disease infection. With all the intension of improving productivity and boosting quality of custard apple fruit, it is necessary to make the availability of micronutrients to crop. Hence, the present study was conducted to evaluate the different sources of Zn and B for foliar application on growth, yield and quality of custard apple.

**Material and Methods**

A field experiment was conducted at Fruit Research Block of Regional Horticultural Research and Extension Centre (RHREC), College of Horticulture, GKVK Campus, Bengaluru-560 065 during 2019-2020 to study the effect of foliar application of zinc and boron from different sources on growth, yield and quality of custard apple cv. Arka Sahan. The experiment was laid out in Randomized Complete Block Design (RCBD) with twelve treatments replicated thrice. The treatments consisted of foliar application of 0.5% Zinc sulphate, 0.5% Zinc chloride, 0.5% Zinc oxide, 0.3% Boric acid and 0.3% Borax either alone or in combination, along with water spray as control. Each treatment was imposed thrice to existing custard apple trees, one at the time of flowering, second at fruit set stage and third at pre-harvest stage. The zinc and boron at required concentration was dissolved in the water and sprayed on to custard apple tree. The growth attributes *viz*., shoot length, number of leaves per branch and leaf area as well as yield attributes *viz*., number of flowers per tree, percentage of fruit set, number of fruits per tree and fruit yield per tree were recorded. The physical quality of fruit in terms of fruit diameter, fruit weight, fruit volume, pulp weight and number of seeds per fruit were evaluated. The chemical quality of fruit with regard to titratable acidity, ascorbic acid and sugar contents were determined using methods suggested by Ranganna (1986) [13] and total soluble solids content of fruit was determined using laboratory scale refractometer. The keeping quality of fruit was evaluated based on physiological Loss in Weight (PLW). For this, initial weight of fruit before ripening and the weights at 1$^{st}$, 3$^{rd}$, 5$^{th}$ and 7$^{th}$ day after ripening were recorded. The difference in weights before and after ripening were expressed in per cent as PLW.
The data on various parameters during the course of investigation were statistically analyzed by applying the technique of analysis of variance as suggested by Panse and Sukhatme (1985) [11]. Wherever, the treatment differences were found significant, critical difference was worked out at five per cent probability level.

**Results and Discussion**

*Growth and yield attributes of custard apple*

The data on growth and yield attributes of custard apple as influenced by foliar application of Zn an B from different sources presented in Table 1 revealed that tress sprayed with 0.5% Zinc sulphate + 0.3% Borax recorded significantly longest shoot length (50.60 cm), more number of leaves per branch (130.72) and maximum leaf area (130.35 cm$^2$). The superior vegetative growth in this treatment combination might be due to enhanced metabolic activity by increased supply of nutrients and high photosynthesis rate. These outcomes are similar to the findings of Bagali *et al.* (1993) [2] and Trivedi *et al*. (2012) [16].
With regard to yield attributes, significantly more number of flowers per tree (564.17) and maximum fruit set (93.33%) were noticed in trees sprayed with 0.5% $ZnSO_4$ + 0.3% Borax. The increased number of flowers and more fruit set were attributed to boron spray that play a major role in the activated salt absorption, flowering and fruiting processes and cytokine synthesis. These outcomes are in conventionality with findings of Kumar *et al.* (2009) [10] in litchi and Banik *et al.* (1997) [3] in mango.
The significantly more number of fruits per tree (22.83) and maximum fruit yield per tree (11.09 kg) were recorded in tree sprayed with 0.5% Zinc sulphate + 0.3% Borax. Raise in fruit yield per tree might be due to promotion of starch formation followed by rapid transportation of carbohydrates in plants as activated by Zn and B. The observed results are in line with the findings of Kumar *et al.* (2009) [10] in litchi.

*Physical quality of fruit*

The data on physical quality of fruit as influenced by foliar application of Zn and B from different sources presented in Table 2 indicated that tree sprayed with 0.5% Zinc sulphate + 0.3% Borax recorded significantly maximum fruit diameter (9.65 cm), fruit volume (174.59 mL) and fruit weight (485.98 g) during the harvesting stage. The improved physical attributes might be due to the combined effect of zinc and boron, wherein boron as a constituent of cell membrane is essential for cell division and elongation (Bhatia *et al.*, 200 [4] and Trivedi *et al*., 2012 [16]).
The number of seeds per fruit in custard apple was not affected by foliar application of zinc and boron from different sources. But significantly maximum pulp weight (353 g) was recorded in the fruits sprayed with 0.5% Zinc sulphate + 0.3% Borax. The possible reasons for enhancement in fruit pulp with these nutrients might be due to higher synthesis of metabolites and enhanced mobilization of food and minerals from other parts of the plants towards the developing fruits as it is a well-established fact that the fruit acts as extremely active metabolic sink. These results are in line with the findings of Ramesh *et al.* (2016) [12].

*Chemical quality of fruit*

A cursory glance of data presented in Table 3 on chemical quality of fruit as influenced by foliar application of Zn an B from different sources revealed that fruits obtained from trees sprayed with 0.5% Zinc sulphate + 0.3% Borax contained significantly highest reducing sugars (22.03%) and total sugars (23.85%). This may be due to the fact that zinc and boron may increase the activity of amylase enzyme, which hydrolyze the complex polysaccharides into simple sugars. The same reports were given by Ghosh *et al*. (2000) [8] in sweet orange and Babu and Yadav (2005) [1] in Khasi mandarin. Whereas, fruits obtained from trees sprayed with 0.3% Borax contained significantly highest non-reducing sugars (4.16%). The same reports were given by Hemavathi *et al*. (2019) [9] in Jamun (*Syzygium cumini* Skeels).

The fruits obtained from trees sprayed with 0.5% Zinc sulphate + 0.3% Borax contained significantly highest TSS ($32.25^0$ Brix). The increased TSS might be due to increment in the fruit mass or may be due to the reason that boron helps in transport of sugars thereby triggering the accumulation of more sugars in fruit. These findings are supported by results obtained by Chaitanya *et al*. (1997) [5]. The fruits obtained from the same treatment combination contained significantly lowest titratable acidity (0.40%). The decrease of acid content in fruit with borax application might be due to speeding up process of ripening at which acid degradation might have occurred and helped in preventing polymerization of sugars and accumulation of more sugars in the cells of the plant. Related trend was observed by Singh and Brahmachari (1999) [14]. Similarly, the fruits obtained from the same treatment combination recorded significantly maximum ascorbic acid content (38.61%). This may be due to catalytic activity of boron and zinc. Zinc plays an active role in the production of auxin which increases ascorbic acid content. These findings are supported by results obtained by Subedi *et al*. (2019) [15] in papaya.

*Keeping quality of fruit*

The physiological loss in weight of the fruit is the major quality attribute where the lowest losses in fruit weight during keeping time of 1st day (1.00%), 3rd day (3.42%), 5th day (6.27%) and 7th day (11.01%) after ripening were observed in fruits obtained from trees which received foliar application of 0.5% Zinc sulphate + 0.3% Borax (Tables 4). The lowest weight loss by treatment combination of zinc and boron might be due to its role in the maintenance of fruit firmness, retardation of respiratory rates as well as transpiration and delayed senescence. Related trend was observed by Gaya (2008) [7] and Subedi *et al*. (2019) [15] in papaya.

**Table 1:** Growth and yield attributes of custard apple cv. Arka Sahan as influenced by foliar application of zinc and boron from different sources

| Treatments | Growth attributes | | | Yield attributes | | | |
|---|---|---|---|---|---|---|---|
| | Shoot length (cm) | Number of leaves per branch | Leaf area ($cm^2$) | Number of flowers per tree | Fruit set (%) | Number of fruits per tree | Yield per tree (kg) |
| $T_1$: Water spray (Control) | 26.30 | 74.26 | 83.47 | 297.33 | 46.67 | 9.33 | 2.58 |
| $T_2$: 0.5% Zinc sulphate foliar application | 38.88 | 97.27 | 111.85 | 407.83 | 68.00 | 16.00 | 6.51 |
| $T_3$: 0.5% Zinc chloride foliar application | 36.33 | 97.84 | 109.28 | 385.83 | 62.67 | 13.50 | 5.29 |
| $T_4$: 0.5% Zinc oxide foliar application | 37.03 | 100.45 | 109.55 | 402.50 | 60.00 | 13.17 | 5.08 |
| $T_5$: 0.3% Boric acid foliar application | 34.43 | 104.50 | 101.93 | 395.83 | 58.67 | 14.00 | 5.63 |
| $T_6$: 0.3% Borax foliar application | 37.73 | 99.16 | 104.98 | 398.83 | 67.33 | 15.67 | 6.34 |
| $T_7$: 0.5% Zinc sulphate + 0.3% Boric acid foliar application | 44.92 | 113.94 | 122.02 | 420.83 | 82.00 | 19.17 | 8.20 |
| $T_8$: 0.5% Zinc sulphate + 0.3% Borax foliar application | 50.60 | 130.72 | 130.35 | 564.17 | 93.33 | 22.83 | 11.09 |
| $T_9$: 0.5% Zinc chloride + 0.3% Boric acid foliar application | 37.35 | 109.89 | 110.91 | 399.67 | 72.00 | 16.17 | 6.65 |
| $T_{10}$: 0.5% Zinc chloride + 0.3% Borax foliar application | 40.17 | 111.01 | 111.27 | 409.00 | 62.67 | 15.00 | 6.22 |
| $T_{11}$: 0.5% Zinc Oxide + 0.3% Boric acid foliar application | 38.47 | 103.76 | 110.67 | 407.00 | 69.33 | 14.33 | 5.78 |
| $T_{12}$: 0.5% Zinc Oxide + 0.3% Borax foliar application | 39.50 | 103.51 | 111.13 | 406.33 | 64.67 | 14.67 | 5.81 |
| S. Em ± | 1.96 | 2.74 | 6.44 | 12.85 | 4.74 | 0.93 | 0.50 |
| C.D. at 5% | 4.06 | 8.03 | 13.35 | 37.68 | 13.91 | 2.73 | 1.47 |

**Table 2:** Physical parameters of custard apple cv. Arka Sahan as influenced by foliar application of zinc and boron different sources

| Treatments | Fruit diameter (cm) | Fruit volume (mL) | Fruit weight (g) | Number of seeds per fruit | Fruit pulp weight (g) |
|---|---|---|---|---|---|
| $T_1$: Water spray (Control) | 7.38 | 133.54 | 276.53 | 34.17 | 171.35 |
| $T_2$: 0.5% Zinc sulphate foliar application | 8.65 | 156.38 | 408.45 | 31.67 | 268.43 |
| $T_3$: 0.5% Zinc chloride foliar application | 8.27 | 149.54 | 390.80 | 31.83 | 255.58 |
| $T_4$: 0.5% Zinc oxide foliar application | 7.55 | 136.51 | 382.33 | 31.50 | 253.09 |
| $T_5$: 0.3% Boric acid foliar application | 8.28 | 149.72 | 399.65 | 32.33 | 261.71 |
| $T_6$: 0.3% Borax foliar application | 7.96 | 144.02 | 404.25 | 30.33 | 264.86 |
| $T_7$: 0.5% Zinc sulphate + 0.3% Boric acid foliar application | 8.94 | 161.69 | 429.25 | 30.00 | 290.81 |
| $T_8$: 0.5% Zinc sulphate + 0.3% Borax foliar application | 9.65 | 174.59 | 485.98 | 28.50 | 353.64 |
| $T_9$: 0.5% Zinc chloride +0.3% Boric acid foliar application | 8.73 | 157.86 | 411.91 | 30.17 | 256.58 |
| $T_{10}$: 0.5% Zinc chloride + 0.3% Borax foliar application | 8.93 | 161.57 | 415.02 | 30.83 | 273.90 |
| $T_{11}$: 0.5% Zinc Oxide + 0.3% Boric acid foliar application | 8.35 | 151.10 | 403.19 | 31.00 | 263.01 |
| $T_{12}$: 0.5% Zinc Oxide + 0.3% Borax foliar application | 8.80 | 159.25 | 394.55 | 30.67 | 272.38 |
| S. Em ± | 0.21 | 3.78 | 14.74 | 1.60 | 13.11 |
| C.D. at 5% | 0.61 | 11.09 | 43.22 | NS | 38.44 |

**Table 3:** Fruit quality of custard apple cv. Arka Sahan as influenced by foliar application of zinc and boron from different sources

| Treatments | Reducing sugars (%) | Non-Reducing sugars (%) | Total sugars (%) | Total Soluble Solids ($^0$Brix) | Titratable acidity (%) | Ascorbic acid (mg 100g$^{-1}$) |
|---|---|---|---|---|---|---|
| $T_1$: Water spray (Control) | 16.10 | 4.14 | 20.23 | 29.40 | 0.46 | 31.61 |
| $T_2$: 0.5% Zinc sulphate foliar application | 18.36 | 4.16 | 22.51 | 30.53 | 0.44 | 33.08 |
| $T_3$: 0.5% Zinc chloride foliar application | 18.06 | 3.50 | 21.55 | 30.33 | 0.45 | 32.14 |
| $T_4$: 0.5% Zinc oxide foliar application | 18.24 | 3.91 | 22.15 | 30.43 | 0.45 | 33.76 |
| $T_5$: 0.3% Boric acid foliar application | 18.38 | 3.95 | 22.33 | 30.45 | 0.44 | 33.18 |
| $T_6$: 0.3% Borax foliar application | 19.23 | 3.06 | 22.28 | 30.48 | 0.43 | 34.16 |
| $T_7$: 0.5% Zinc sulphate + 0.3% Boric acid foliar application | 20.76 | 2.13 | 22.89 | 30.38 | 0.41 | 36.52 |
| $T_8$: 0.5% Zinc sulphate + 0.3% Borax foliar application | 22.03 | 1.82 | 23.85 | 32.25 | 0.40 | 38.61 |
| $T_9$: 0.5% Zinc chloride + 0.3% Boric acid foliar application | 18.27 | 3.43 | 21.69 | 30.70 | 0.42 | 36.35 |
| $T_{10}$: 0.5% Zinc chloride + 0.3% Borax foliar application | 19.14 | 3.60 | 22.74 | 30.58 | 0.42 | 35.61 |
| $T_{11}$: 0.5% Zinc Oxide + 0.3% Boric acid foliar application | 19.43 | 3.46 | 22.88 | 31.25 | 0.43 | 33.79 |
| $T_{12}$: 0.5% Zinc Oxide + 0.3% Borax foliar application | 18.55 | 3.22 | 21.77 | 30.65 | 0.43 | 35.05 |
| S. Em ± | 0.12 | 0.20 | 0.18 | 0.30 | 0.01 | 0.32 |
| C.D. at 5% | 0.38 | 0.62 | 0.59 | 0.95 | 0.02 | 0.99 |

**Table 4:** Physiological loss in weight (%) of custard apple fruit c. Arka Sahan as influenced by foliar application of zinc and boron from different sources

| Treatments | 1$^{st}$ Day (%) | 3$^{rd}$ Day (%) | 5$^{th}$ Day (%) | 7$^{th}$ Day (%) |
|---|---|---|---|---|
| $T_1$: Water spray (Control) | 1.95 | 6.46 | 11.89 | 22.59 |
| $T_2$: 0.5% Zinc sulphate foliar application | 1.41 | 4.63 | 7.47 | 17.80 |
| $T_3$: 0.5% Zinc chloride foliar application | 1.46 | 4.59 | 8.70 | 18.87 |
| $T_4$: 0.5% Zinc oxide foliar application | 1.42 | 4.26 | 7.71 | 17.52 |
| $T_5$: 0.3% Boric acid foliar application | 1.37 | 4.28 | 7.63 | 17.56 |
| $T_6$: 0.3% Borax foliar application | 1.35 | 4.19 | 8.07 | 17.39 |
| $T_7$: 0.5% Zinc sulphate + 0.3% Boric acid foliar application | 1.28 | 4.08 | 7.29 | 16.13 |
| $T_8$: 0.5% Zinc sulphate + 0.3% Borax foliar application | 1.00 | 3.42 | 6.27 | 11.01 |
| $T_9$: 0.5% Zinc chloride + 0.3% Boric acid foliar application | 1.33 | 4.38 | 8.39 | 17.83 |
| $T_{10}$: 0.5% Zinc chloride + 0.3% Borax foliar application | 1.40 | 4.62 | 8.72 | 16.87 |
| $T_{11}$: 0.5% Zinc Oxide + 0.3% Boric acid foliar application | 1.21 | 4.31 | 7.55 | 16.64 |
| $T_{12}$: 0.5% Zinc Oxide + 0.3% Borax foliar application | 1.37 | 4.56 | 7.67 | 17.53 |
| S. Em ± | 0.11 | 0.37 | 0.54 | 0.91 |
| C.D. at 5% | 0.32 | 1.09 | 1.57 | 2.67 |

## Conclusion

From the above findings, it can be inferred that zinc sulphate is a better source of zinc than zinc chloride and zinc oxide while, borax is a better sources of boron than boric acid. It can be concluded that foliar application of 0.5% zinc sulphate and 0.3% borax are better choices in enhancing productivity and boosting quality of custard apple.

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