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EFFECT OF FOLIAR APPLICATION OF CALCIUM, ZINC AND BORON ON BIOCHEMICAL CHARACTERS OF AONLA (*EMBLICA OFFICINALIS* GAERTN) CV. NA-7

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ABSTRACT

The present investigation entitled "Effect of foliar application of calcium, zinc and boron on biochemical characters of Aonla (*Emblica officinalis* Gaertn) cv. NA-7" was carried out during 2021-22 at Experimental Farm, Department of Fruit Science, Faculty of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in Randomized Block Design (RBD) with nine treatments and three replications. The different treatments viz., T_1 - (Calcium chloride 1 %), T_2 - (Calcium chloride 1.5 %), T_3 - (Zinc sulphate 0.4 %), T_4 - (Zinc sulphate 0.6 %), T_5 - (Borax 0.4 %), T_6 - (Borax 0.6 %) T_7 - (Calcium chloride 1.0 % + Zinc sulphate 0.4 % + Borax 0.4 %), T_8 - (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %), T_9 - (Control), were used in research programme. Two sprays of each treatment were given at pea stage and at thirty days interval after first spray. The results of present investigation indicated that, treatment T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %) was found to be the best among all as it gives the maximum TSS (11.24 ^{0}B), vitamin C (590 mg/100 gm pulp), total sugar (5.76 %), reducing sugars (3.40 %) and non-reducing sugars (2.36 %) with minimum titratable acidity (1.42 %), while minimum TSS (9.03 ^{0}B), vitamin C (524.33 mg/100gm pulp), total sugar (4.72 %), reducing sugars (2.63 %) and non-reducing sugars (2.09 %) with maximum titratable acidity (1.84 %) were recorded with control.
***Keywords*:** Aonla, Foliar application, Calcium, Zinc, Boron, Calcium

Introduction

Aonla (*Emblica officinalis* Gaertn syn. *Phyllanthus emblica* L.) is a commercially important fruit crop. It is quite hardy, prolific bearer and remunerative even without much care. It belongs to the family Euphorbiaceae. Aonla is an important fruit of future due to its high medicinal and nutritional value. Aonla is the richest source of vitamin "C" among all fruits after Barbados cherry. The aonla fruit contains about three times more protein and 160 times more vitamin "C" as compared to apple (Meena *et al.,* 2014). Its fruit is valued as an anti-ascorbic, diuretic, laxative, antibiotic and cooling refrigerant. It is well-known that calcium plays a significant role in preserving the quality of fruits and vegetables. Calcium treatment aids in preserving fruit firmness, increasing vitamin C content, reducing storage breakdown and rotting, and also reducing fruit browning. Boron is required for ovule development, pollen tube growth, and fruit set. Boron is a component of cell membranes and is required for cell division. It regulates the potassium-calcium ratio in the plant and aids in nitrogen absorption and sugar translocation. Boron increases the availability of nitrogen in plants. Zinc is an essential trace element for plants, being involved in many enzymatic reactions and is necessary for good growth and development. Zinc is also involved in regulating the protein and carbohydrate metabolism. Foliar application is based on the principle that nutrients are quickly absorbed by leaves and transported to various parts of the plant to fulfil the functional requirement of nutrition. Obviously, it is an excellent method of avoiding nutrient availability issues. This method is extremely beneficial for the correction of element deficiencies, restoring disrupted nutrient supply, overcoming stress factors limiting their availability, and it plays a critical role in fruit productivity and quality, as well as the recovery of nutritional and physiological disorders in fruit trees. Various experiments have been conducted earlier on the foliar spray of micro-nutrients in different fruit crops and have shown significant responses to improve the yield and quality of fruits. Keeping in view the above aspects, the present experiment was initiated to study the effect of foliar application of calcium, zinc and boron on the biochemical characters of aonla.

Materials and Methods

The experiment was conducted on twenty-four years old healthy plants of aonla cv. NA-7 at Experimental Farm, Department of Fruit Science, Faculty of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in Randomized Block Design (RBD) with nine treatments and three replications. The different treatments viz., T_1 - (Calcium chloride 1 %), T_2 - (Calcium chloride 1.5 %), T_3 - (Zinc sulphate 0.4 %), T_4 - (Zinc sulphate 0.6 %), T_5 - (Borax 0.4 %), T6 - (Borax 0.6 %) T_7 - (Calcium chloride 1.0 % + Zinc sulphate 0.4 % + Borax 0.4 %), T_8 - (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %), T_9 - (Control), were used in research programme. Two sprays of each treatment were given at the pea stage and thirty days intervals after the first spray. The standard cultural operations and basal application of manures and fertilizers were applied as per the recommended schedule for aonla cultivation.

Chemical observation of fruit

1. TSS (^{0}B)

Total Soluble Solids (TSS) of fruit was recorded by using a hand refractometer. A drop of extracted aonla juice was put on the hand refractometer prism (Atago India instrument Pvt. Ltd, Mumbai) and the reading was recorded and expressed in terms of degree ^{0}B. Five readings were taken in each replication of treatment and their average value was calculated.

2. Titratable acidity (%)

Titratable acidity of the extracted juice was determined by titrating it against 0.1 N NaOH solution using phenolphthalein as an indicator and expressed as a percentage in terms of citric acid (AOAC, 1990).

$$\text{Titratable acidity (\%)} = \frac{\text{Titre value} \times \text{Equivalent weight of Citric acid} \times 100}{\text{Volume of sample} \times 1000}$$

3. Vitamin C (mg/100g)

The ascorbic acid content in the juice was determined titrametrically using 2, 6- dichlorophenol indophenol dye described by Ranganna (1986). The dye solution was standardized against vitamin C content.

Sample preparation:

It involved transferring 10 g of homogenized sample into a 100 ml volumetric flask. The volume was increased to 100 ml by adding 3 % oxalic acid solution. A known volume aliquot (10 ml) was drawn and utilized for titration. The freshly synthesized dye (2,6-dichlorophenol indophenol) was standardized by titration against fresh Vitamin C, and the dye factor was calculated. A known volume (10 ml) of aliquot was transferred to a 100 ml conical flask and titrated against the standardized dye solution. Titration was continued until the light pink colour persists. The vitamin C content was calculated by using the following formula.

$$\text{Ascorbic Acid} = \frac{\text{Titrate value} \times \text{Dye factor} \times \text{volume made up}}{\text{Aliquot taken for estimation} \times \text{Weight of sample taken}}$$

4. Total sugars (%)

Total sugars were determined by Dubois method (Dubois *et.al.*, 1951). In this method, 5% phenol and 96% concentrated H_2SO_4 were used to carry out the analysis. The absorbance of the sample was noted at 490 nm and graph values were put in the following formula to estimate the final value of total sugar.

$$\text{Total sugar (\%)} = (\text{reading of graph}) \times \frac{1}{1000000} \times \frac{100}{1} \times \frac{50}{1} \times \frac{100}{\text{weight of sample}}$$

5. Reducing sugars (%)

Reducing sugars content were estimated by the Spectrophotometric method as described by Somogyi (1952). One gram of the mature fruit was weighed and macerated with 5 ml of hot 80 % ethanol and supernatant was collected. Then it was evaporated in a water bath at 80^{0}C. The residue was dissolved in 5 ml distilled water to make extract in different volumes, the absorbance was recorded at 620 nm in the spectrophotometer and compared against standard glucose solution. Reducing sugars was calculated by using the following formula.

$$\text{Reducing sugars (\%)} = (\text{reading of graph}) \times \frac{1}{1000000} \times \frac{100}{1} \times \frac{100}{1} \times \frac{1}{\text{weight of sample}}$$

6. Non-reducing sugars (%)

The content of non-reducing sugars was calculated using the following formula (Ranganna, 1986).

Non reducing sugars (%) = Total sugars (%) – Reducing sugars (%)

Result and Discussion

1. TSS (^{0}B)

The TSS in aonla fruit was found to be significantly influenced by the foliar application of calcium, zinc and boron (Table 1). The results on TSS revealed that, the foliar application of , zinc and boron significantly increases TSS (Fig.1). The highest TSS (11.24 ^{0}B) was recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %). Whereas, the lowest TSS (9.03 ^{0}B) was recorded in T_9 (control). The increase in TSS might be due to zinc increasing the synthesis of tryptophan which is a precursor of auxin. It plays a key role in protein synthesis, sugar metabolism and maintains the integral structure. On the other hand, boron may be associated with the cell membrane where it could be complex with sugar molecules and facilitate its passage across the membrane which might be the reason for increased Total Soluble Solids. Similar results were found by Chandra and Singh (2015), Mishra *et al.* (2017) and Dadheech *et al.* (2021) in aonla, Deepa *et al.* (2008) in ber, Nehete *et al.* (2011) in mango and Rajkumar *et al.* (2014) in guava.

Table 1 : Effect of foliar application of calcium, zinc and boron on TSS, titratable acidity and vitamin C in aonla fruit

Treatments	TSS (^{0}B)	Titratable acidity (%)	Vitamin C (mg/100mg pulp)
T_1 $CaCl_2$ 1.0 %	9.20	1.75	570.33
T_2 $CaCl_2$ 1.5 %	9.47	1.70	575.00
T_3 $ZnSO_4$ 0.4 %	9.90	1.65	524.33
T_4 $ZnSO_4$ 0.6 %	10.57	1.53	578.33
T_5 Borax 0.4 %	9.78	1.63	527.67
T_6 Borax 0.6 %	10.03	1.62	575.00
T_7 $CaCl_2$ 1.0 % + $ZnSO_4$ 0.4 % + Borax 0.4 %	10.78	1.46	588.33
T_8 $CaCl_2$ 1.5 % + $ZnSO_4$ 0.6 % + Borax 0.6 %	11.24	1.42	590.00
T_9 Control	9.03	1.84	524.33
SE(m) ±	0.08	0.012	5.6
CD at 5%	0.23	0.035	16.7

2. Titratable acidity (%)

The titratable acidity in aonla fruit was found to be significantly influenced by the foliar application of calcium, zinc and boron (Table 1). The results on titratable acidity revealed that, the foliar application of zinc and boron significantly decreases titratable acidity (Fig.2). The lowest titratable acidity (1.42 %) was recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %) which was at par with T_7 (Calcium chloride 1.0 % + Zinc sulphate 0.4 % + Borax 0.4 %). Whereas, the highest titratable acidity (1.84 %) was recorded in T_9 (control). The decrease in acidity content of fruits might be due to an increase in TSS and total sugars. Under the influence of chemicals, the acids may have either been utilized as a substratum in respiration or transformed into sugars and their derivatives through reactions involving the reversal of the glycolytic pathway. on the other hand, zinc is a component of the dehydrogenase enzyme, a respiratory enzyme whose substrate is organic acid. Thus, this enzyme oxidizes the organic acid and lowers down the acidity of the fruit. Similar results were found by Meena *et al.* (2014), Chandra and Singh (2015), Verma *et al.* (2016), Tiwari *et al.* (2017) and Kumar *et al.* (2017) in aonla and Gurung *et al.* (2016) in citrus.

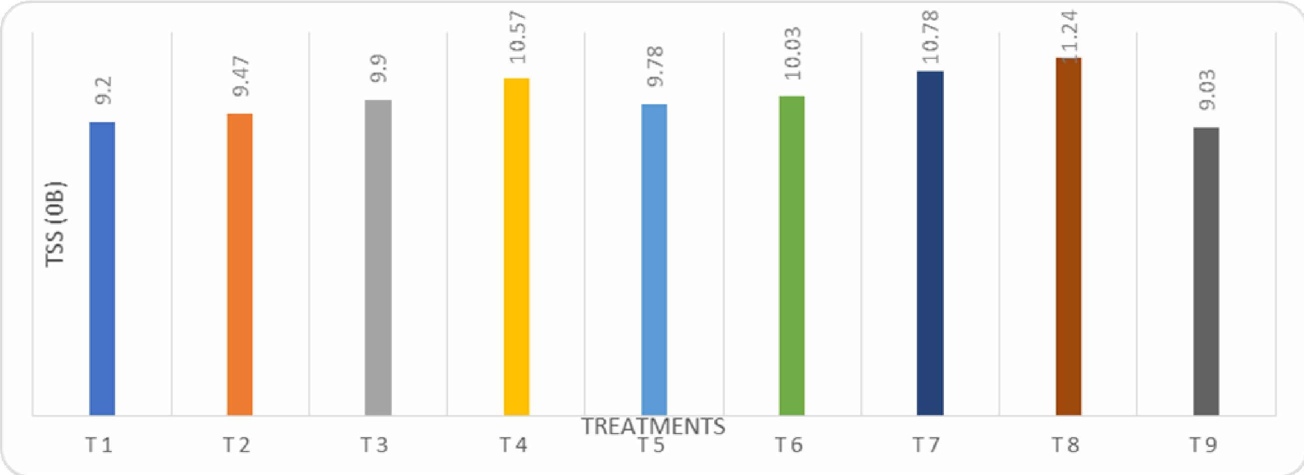

Fig. 1 : Effect of foliar application of calcium, zinc and boron on TSS (^{0}B)

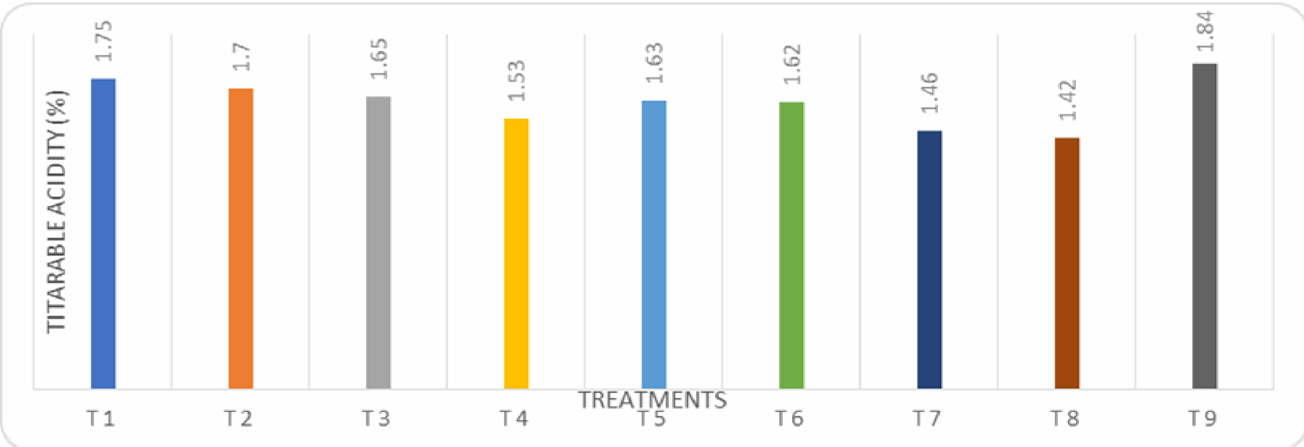

Fig. 2 : Effect of foliar application of calcium, zinc and boron on titarable acidity (%)

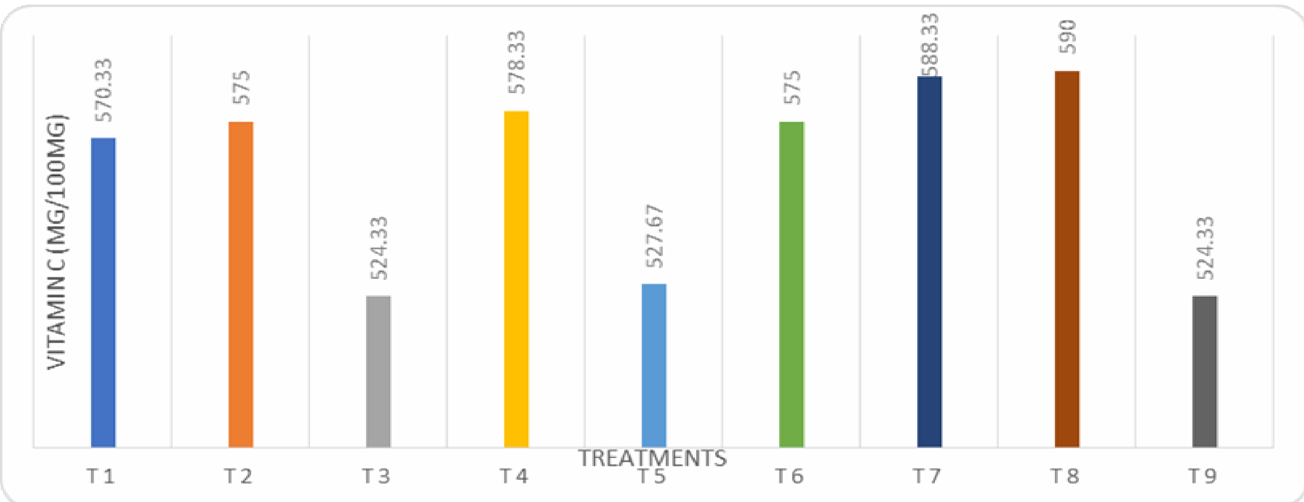

Fig. 3 : Effect of foliar application of calcium, zinc and boron on vitamin C (mg/100mg)

3. Vitamin C (mg/100 g)

The vitamin C in aonla fruit was found to be significantly influenced by the foliar application of calcium, zinc and boron (Table 1). The results on vitamin C revealed that, the foliar application of zinc and boron significantly increases vitamin C (Fig. 3). The highest Vitamin C (590.00 mg/100gm pulp) was recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %) which was at par with T_2 (Calcium chloride 1.5 %), T_4 (Zinc sulphate 0.6 %), T_6 (Borax 0.6 %) and T_7 (Calcium chloride 1.0 % + Zinc sulphate 0.4 % + Borax 0.4 %). Whereas, the lowest vitamin C (524.33 mg/100gm pulp) was recorded in T_9 (control). The increase in ascorbic acid might be due to the combined effect of zinc and calcium. Zinc and calcium have a catalytic effect on the biosynthesis of its precursors, such as glucose-6-phosphate, during the conversion of starch into different sugars, as well as inhibiting its conversion to dehydroxy ascorbic acid by the enzyme ascorbic acid oxidase. The finding follows the results of Tripathi and Shukla (2011), Meena *et al.* (2014), Chandra and Singh (2015) Tripathi *et al.* (2018) in aonla, Rajkumar *et al.* (2014) in guava and Gurung *et al.* (2016) in citrus.

4. Total sugars (%)

The total sugars in aonla fruit were found to be significantly influenced by the foliar application of calcium, zinc and boron (Table 2). The results on total sugars revealed that the foliar application of zinc and boron significantly increases total sugars (Fig. 4). The highest total sugar (5.76 %) was recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %). Whereas, the lowest Total sugar (4.72 %) was recorded in T_9 (control). The increase in total sugars of fruit may be due to the significant action of calcium, zinc and boron on the translocation of carbohydrates and photosynthates. The increase in sugars fraction by the foliar feeding of zinc and boron might be due to their involvement in the photosynthesis of metabolites and quick translocation of sugars from other parts of the plants to developing fruits. Similar results were found by Chandra and Singh (2015), Mishra *et al.* (2017) and Dadheech *et al.* (2021) in aonla, Deepa *et al.* (2008) in ber and Nehete *et al.* (2011) in mango.

Table 2 : Effect of foliar application of calcium, zinc and boron on total sugars, reducing sugars and non-reducing sugars in aonla fruit

Treatments	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)
T_1 $CaCl_2$ 1.0 %	4.98	2.77	2.21
T_2 $CaCl_2$ 1.5 %	5.15	2.84	2.31
T_3 $ZnSO_4$ 0.4 %	5.33	3.01	2.32
T_4 $ZnSO_4$ 0.6 %	5.52	3.17	2.35
T_5 Borax 0.4 %	5.22	2.97	2.25
T_6 Borax 0.6 %	5.45	3.11	2.34
T_7 $CaCl_2$ 1.0 % + $ZnSO_4$ 0.4 % + Borax 0.4 %	5.65	3.30	2.35
T_8 $CaCl_2$ 1.5 % + $ZnSO_4$ 0.6 % + Borax 0.6 %	5.76	3.40	2.36
T_9 Control	4.72	2.63	2.09
SE(m) ±	0.015	0.013	0.012
CD at 5%	0.044	0.039	0.036

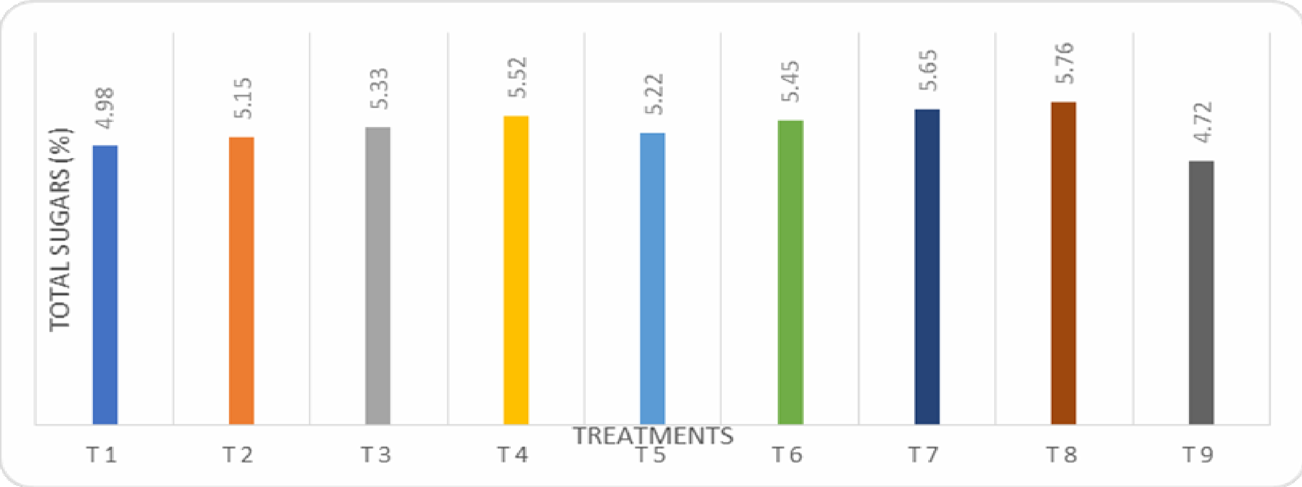

Fig. 4 : Effect of foliar application of calcium, zinc and boron on total sugars (%)

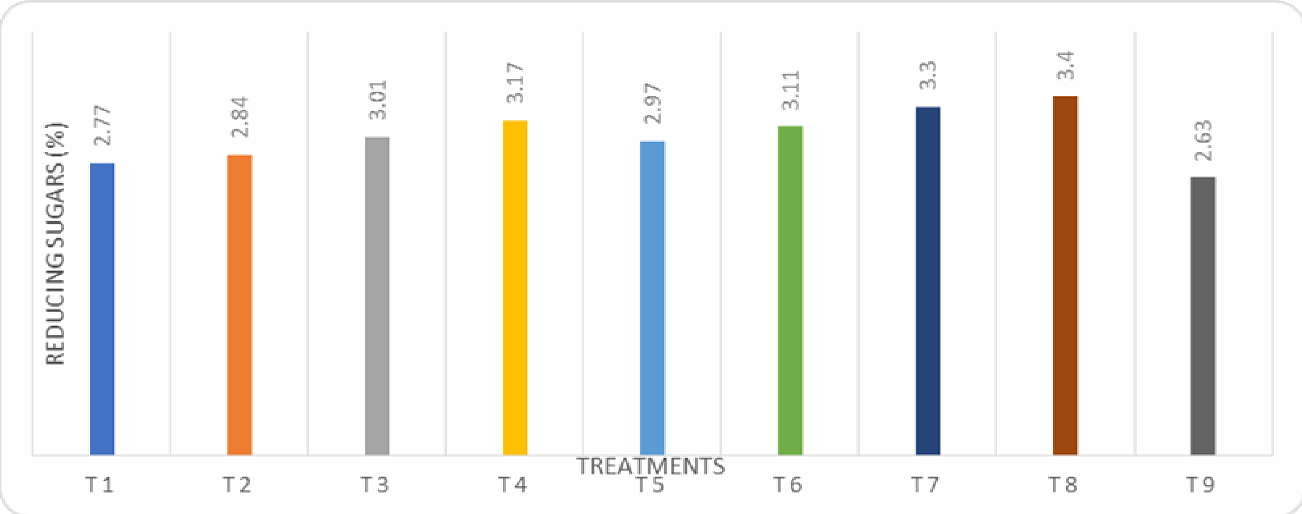

Fig. 5 : Effect of foliar application of calcium, zinc and boron on reducing sugars (%)

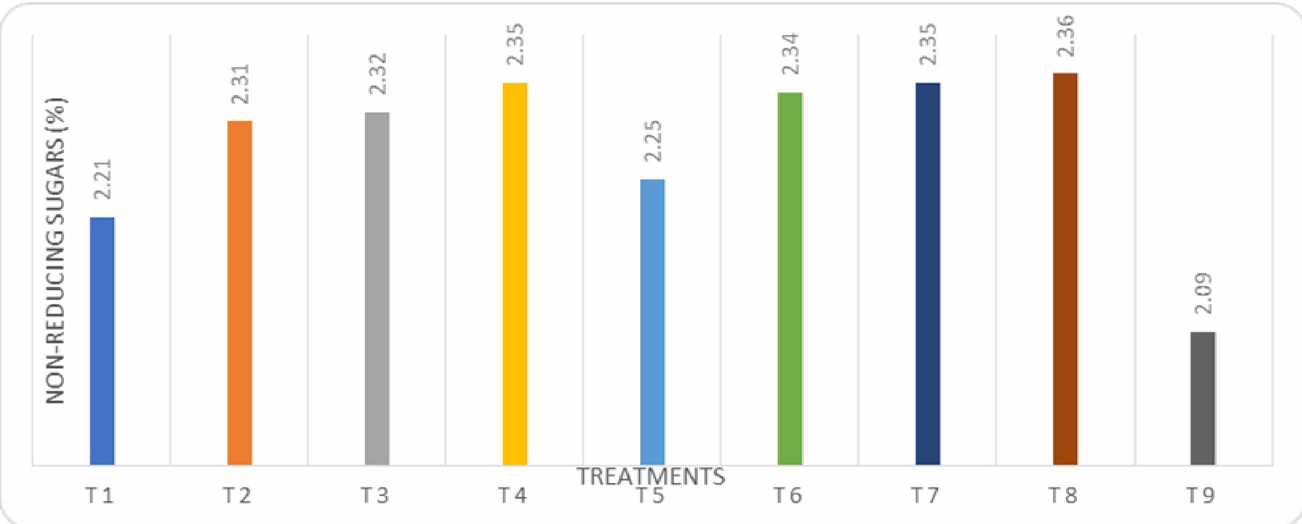

Fig. 6 : Effect of foliar application of calcium, zinc and boron on non-reducing sugars (%)

5. Reducing sugars (%)

The reducing sugars in aonla fruit were found to be significantly influenced by the foliar application of calcium, zinc and boron (Table 2). The results on reducing sugars revealed that, the foliar application of zinc and boron significantly increases the reducing sugars (Fig.5). The highest reducing sugars (3.40 %) were recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %). Whereas, the lowest reducing sugars (2.63 %) was recorded in T_9 (control). The Increase in reducing sugars content (e.g., glucose, maltose) has direct link with the beneficial effect of micronutrients. Zinc and boron are associated with the conversion of complex polysaccharides into simple sugars (disaccharides and monosaccharides). The similar results were also found in the experiments of Chandra and Singh (2015), Mishra *et al.* (2017) and Kumar *et al.* (2017) in aonla, Rajkumar *et al.* (2014) in guava and Gurung *et al.* (2016) in citrus.

6. Non-reducing sugars (%)

The non-reducing sugars in aonla fruit were found to be significantly influenced by the foliar application of calcium, zinc and boron (Table 2). The results on non-reducing sugars revealed that, the foliar application of zinc and boron significantly increases non-reducing sugars (Fig.6). The highest non-reducing sugars (2.36 %) were recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %) which was at par with T_3 (Zinc sulphate 0.4 %), T_4 (Zinc sulphate 0.6 %), T_6 (Borax 0.6 %) and T_7 (Calcium chloride 1.0 % + Zinc sulphate 0.4 % + Borax 0.4 %). Whereas, the lowest non-reducing sugars (2.09 %) were recorded in T_9 (control). The increase in non-reducing sugars is due to the beneficial effect of micronutrients. Boron and zinc are primarily responsible for the enhanced translocation of polysaccharides in mature fruits, resulting in an increase in non-reducing sugars. These results are in close conformity with the findings of Chandra and Singh (2015), Mishra *et al.* (2017), Kumar *et al.* (2017) in Aonla, Anees *et al.* (2011) in mango and Rajkumar *et al.* (2014) in guava.

Conclusions

The study's findings highlight the efficacy of combined nutrient treatments over singular applications, with treatment T_8 (Calcium chloride 1.5% + Zinc sulphate 0.6% + Borax 0.6%) demonstrating superior results in enhancing the biochemical properties of aonla fruits. This treatment notably increased the total soluble solids (TSS), vitamin C, total sugars, reducing sugars and non-reducing sugars content, while simultaneously reducing titratable acidity. The outcomes of this investigation not only provide a practical approach to optimizing Aonla fruit quality but also offer a foundation for future research on the synergistic effects of nutrients in horticulture. The success of treatment T_8 underscores the potential of integrated nutrient management strategies in achieving higher quality produce, which is vital for meeting the increasing demands for nutritious and high-quality fruits in the market. Overall, the research underscores the importance of precise nutrient management in horticulture and its role in improving crop quality and yield, thereby contributing to the sustainability and profitability of aonla cultivation.

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