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EFFECT OF FOLIAR APPLICATION OF CALCIUM, ZINC AND BORON ON PHYSICAL 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 physical 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 %), T4 - (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 the pea stage and a thirty-day interval after the first spray. The results of the 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 fruit weight (34.96 g), fruit width (4.15 cm), fruit length (3.91 cm), fruit volume (33.09 cc), specific gravity (1.10 gm/cm^3), pulp weight (33.41 g), pulp stone ratio (21.74) with less stone weight (1.54 g) compared with control.

Keywords: Aonla, Foliar application, Calcium, Zinc, Boron, physical characters.

Introduction

Aonla (*Emblica officinalis* Gaertn syn. *Phyllanthus emblica* L.) is a commercially important fruit crop. It is a prolific bearer, quite hardy and remunerative even without much care. It belongs to the family Euphorbiaceae. Aonla is an important fruit of the 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 the apple (Meena *et al*., 2014). Its fruit is valued as an anti-ascorbic, diuretic, laxative, antibiotic and cooling refrigerant. Calcium is well known to play an important function in maintaining the quality of fruits and vegetables. Calcium treatment aids in increasing vitamin C content, preserving fruit firmness, 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 necessary for cell division. It regulates the plant's potassium-calcium ratio and helps with nitrogen absorption and sugar translocation. Boron increases the availability of nitrogen in plants. Zinc is a crucial trace element for plants, as it participates in numerous enzymatic activities and is required for proper growth and development. Zinc also helps regulate protein and carbohydrate metabolism. Foliar application is based on the idea that nutrients are rapidly absorbed by leaves and delivered to various parts of the plant to meet the functional requirements 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 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 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 %), 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 the pea stage and a thirty-day interval after the first spray. Standard cultural operations, as well as the basal application of manures and fertilizers, were carried out by the recommended aonla cultivation schedule.

Physical observation of fruit

1. Fruit weight (gm)

The fruit weight of five randomly collected individual fruits from each tree was recorded using weighing balance and their average weight was expressed in grams.

2. Fruit width (cm)

Fruit width of five randomly collected individual fruits from each tree was measured at the broadest portion using vernier callipers and their average width was expressed in centimetres.

3. Fruit length (cm)

The fruit length of five randomly collected individual fruits from each tree was measured from base to tip portion using a vernier callipers and their average length was expressed in centimetres.

4. Fruit volume (cc)

The fruit volumes of five randomly collected individual fruits from each tree were measured at harvest (maturity stage) by the water displacement method. Fruit was placed in a measuring cylinder filled with full of 1 litre water. The fruit was placed in a cylinder, the replaced water was measured in milli litre (ml) and after conversion in cubic centimetre (cc) and their average fruit volume was recorded in cubic centimetre (cc).

5. Specific gravity (gm/cm^3)

The specific gravity of five randomly collected individual fruits from each tree was measured by dividing the weight of the fruit by the volume of the fruit and their average specific gravity was recorded in grams per cubic centimetre (gm/cm^3).

$$\text{Specific gravity (gm/cm3)} = \frac{\text{weight of the fruit (gm)}}{\text{volume of the fruit (cc)}}$$

6. Stone weight (gm)

Five fruits were randomly collected from each tree and the stones were separated from the fruit. stone weight was taken using a weighing balance and their average weight was recorded in grams.

7. Pulp stone ratio

Five fruits were randomly collected from each tree and the pulp content of the fruit was separated from each stone and both the weight of the pulp and stone were individually taken. It tells the proportion of pulp and stone content in a fruit.

$$\text{Pulp stone ratio} = \frac{\text{weight of the pulp (gm)}}{\text{weight of the stone (gm)}}$$

Result and Discussion

1. Fruit weight (gm)

The results on fruit weight revealed that, the foliar application of calcium, zinc and boron significantly increases fruit weight (Fig.1). The highest fruit weight (34.96 g) was recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %). Whereas, the lowest fruit weight (26.76 g) was recorded in T_9 (control). This increase in fruit weight may be the result of plants treated with foliar applications of zinc and boron having a better supply of nutrients and photosynthates, which may have facilitated the rapid synthesis of metabolites, especially carbohydrates, and their translocation to the fruits, resulting in a relatively higher pulp content. Similar results have been reported by Meena *et al.* (2014), Mayura *et al.* (2016), Kumar *et al.* (2017) in aonla and Venu *et al.* (2014) in citrus.

Table 1 : Effect of foliar application of calcium, zinc and boron on fruit weight, fruit width and fruit length in aonla fruit

Treatments	Fruit weight (gm)	Fruit width (cm)	Fruit length (cm)
T_1 $CaCl_2$ 1.0 %	29.16	3.48	3.33
T_2 $CaCl_2$ 1.5 %	29.53	3.64	3.39
T_3 $ZnSO_4$ 0.4 %	31.08	3.45	3.42
T_4 $ZnSO_4$ 0.6 %	31.85	3.64	3.56
T_5 Borax 0.4 %	31.73	3.74	3.60
T_6 Borax 0.6 %	33.62	3.68	3.54
T_7 $CaCl_2$ 1.0 % + $ZnSO_4$ 0.4 % + Borax 0.4 %	34.11	3.86	3.80
T_8 $CaCl_2$ 1.5 % + $ZnSO_4$ 0.6 % + Borax 0.6 %	34.96	4.15	3.91
T_9 Control	26.76	3.26	3.21
SE(m) ±	0.19	0.06	0.006
CD at 5%	0.58	0.17	0.017

2. Fruit width (cm)

The results on fruit width revealed that the foliar application of calcium, zinc and boron significantly increases fruit width (Fig. 2). The highest fruit width (4.15 cm) was recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %). Whereas, the lowest fruit width (3.26 cm) was recorded in T_9 (control) with the reduction in nutrient concentration, fruit size was reduced significantly.

This significant increment in fruit width must probably be due to the resultant growth-stimulating effect of boron and zinc. Besides, zinc is a vital component of enzymes such as proteinase and dehydrogenase. It acts as a catalyst in chlorophyll formation and this will lead to an increase in the photosynthetic activity of plants and hence greater accumulation of photosynthates and metabolites. It also promotes starch formation in plants while boron plays an important role in cell growth, cell division, cell enlargement and elongation and also the transport of sugar and photosynthates from source to sink within the plant system. This ultimately resulted in the increased fruit width. Similar results have been reported by Meena *et al.* (2014), Chandra and Singh (2015), Mayura *et al.* (2016), Kumar *et al.* (2017), Mishra *et al.* (2017), in aonla, Yadav *et al.* (2011) and Waskela *et al.* (2013) in guava.

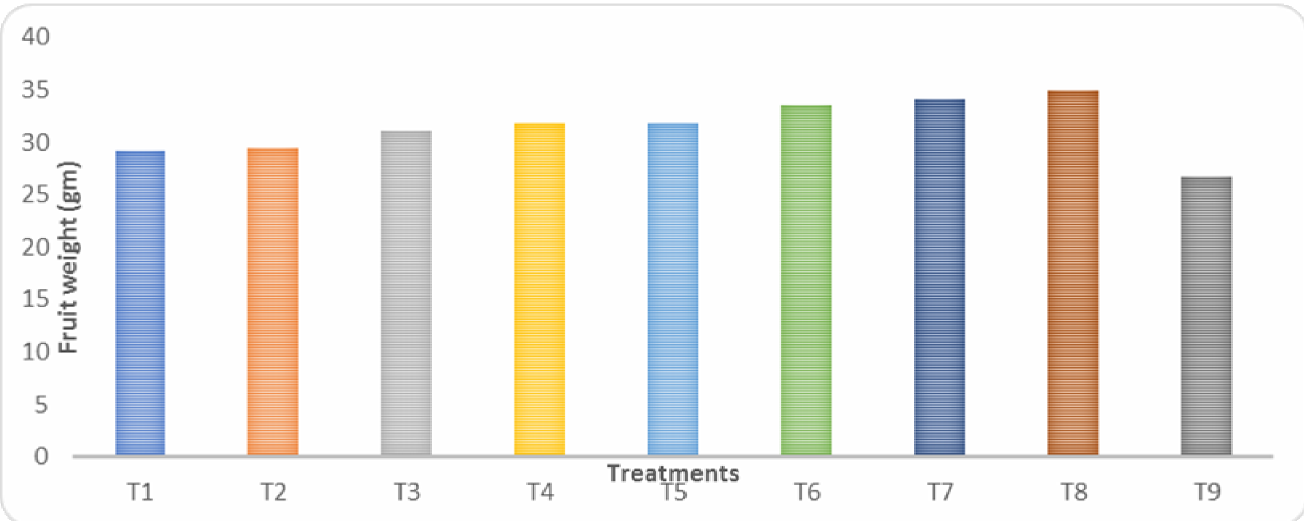

Fig. 1 : Effect of foliar application of calcium, zinc and boron on fruit weight (gm)

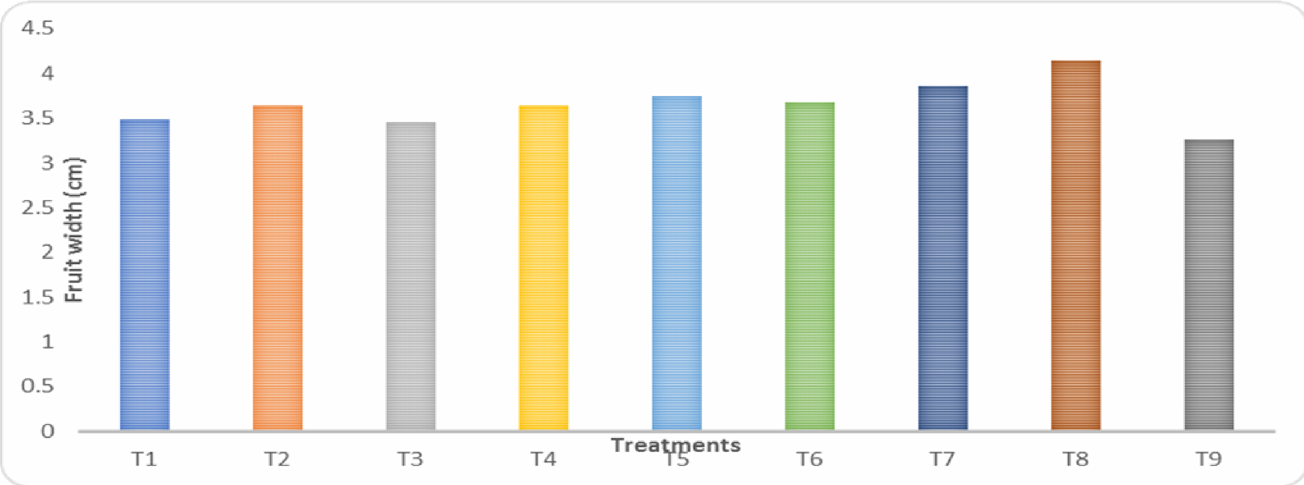

Fig. 2 : Effect of foliar application of calcium, zinc and boron on fruit width (cm)

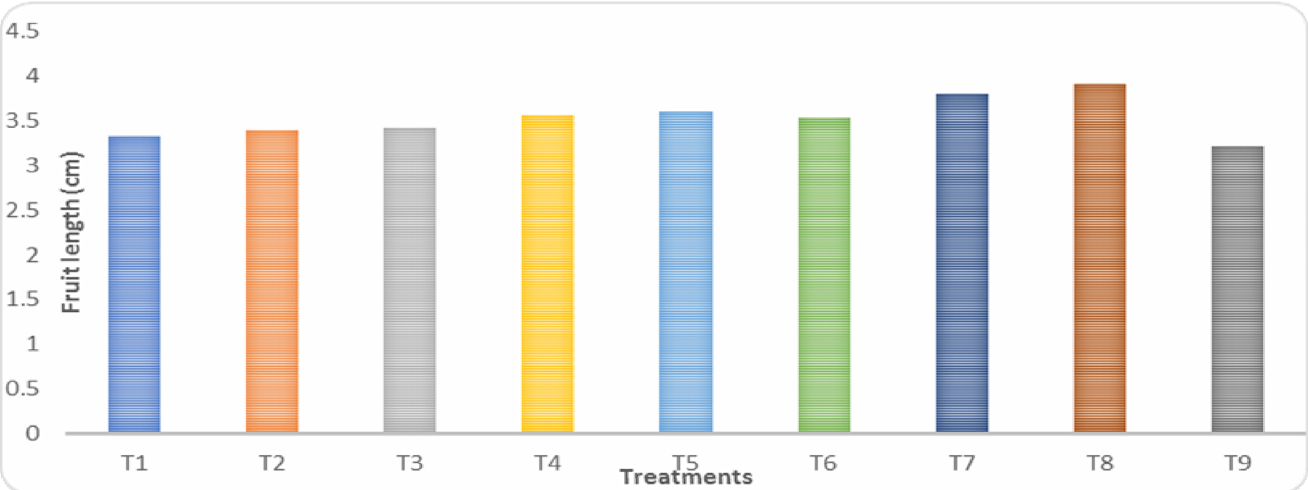

Fig. 3 : Effect of foliar application of calcium, zinc and boron on fruit length (cm)

3. Fruit length (cm)

The results on fruit length revealed that, the foliar application of calcium, zinc and boron significantly increases fruit length (Fig.3). The highest fruit length (3.91 cm) was recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %). Whereas, the lowest fruit length (3.21 cm) was recorded in T_9 (control). This significant increment in fruit length must probably be due to the resultant growth-stimulating effect of boron and zinc. Besides, zinc is a vital component of enzymes such as proteinase and dehydrogenase. It acts as a catalyst in chlorophyll formation and this will lead to an increase in the photosynthetic activity of plants and hence greater accumulation of photosynthates and metabolites. It also promotes starch formation in plants while boron plays an important role in cell growth, cell elongation, cell division, cell enlargement and also the transport of sugar and photosynthates from source to sink within the plant system. This ultimately resulted in an increase in fruit length. Similar results have been reported by Meena *et al.* (2014), Chandra and Singh (2015), Mayura *et al.* (2016), Kumar *et al.* (2017), Mishra *et al.* (2017) in aonla and Gurung *et al.* (2016) in citrus.

4. Fruit volume (cc)

The results on fruit volume revealed that, the foliar application of calcium, zinc and boron significantly increases fruit volume (Fig. 4). The highest fruit volume (33.09 cc) was recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %). Whereas, the lowest fruit volume (24.92 cc) was recorded in T_9 (control). This significant increment in fruit volume due to foliar feeding of nutrients resulting in rapid cell growth, cell division, cell elongation and development and increase in fruit volume the spray of boron might be due to its involvement in hormone metabolism, which enhances cell division and cell proliferation. The involvement of zinc directly in growth and boron stimulates the rapid translocation of water and sugar in the fruit which is ultimately reflected in the volume of fruit in treated plants. Similar results were also found by Singh *et al.* (2012), Vishwakarma *et al.* (2013), Chandra and Singh (2015), Verma *et al.* (2016) in aonla and Singh *et al.* (2015) in mango.

Table 2 : Effect of foliar application of calcium, zinc and boron on fruit volume and specific gravity in aonla fruit

Treatments	Fruit volume (cc)	Specific gravity (gm/cm^3)
T_1 $CaCl_2$ 1.0 %	27.23	1.06
T_2 $CaCl_2$ 1.5 %	27.66	1.07
T_3 $ZnSO_4$ 0.4 %	28.72	1.06
T_4 $ZnSO_4$ 0.6 %	30.01	1.08
T_5 Borax 0.4 %	29.86	1.07
T_6 Borax 0.6 %	31.73	1.08
T_7 $CaCl_2$ 1.0 % + $ZnSO_4$ 0.4 % + Borax 0.4 %	32.22	1.09
T_8 $CaCl_2$ 1.5 % + $ZnSO_4$ 0.6 % + Borax 0.6 %	33.09	1.10
T_9 Control	24.92	1.06
SE(m) ±	0.25	0.006
CD at 5%	0.75	0.017

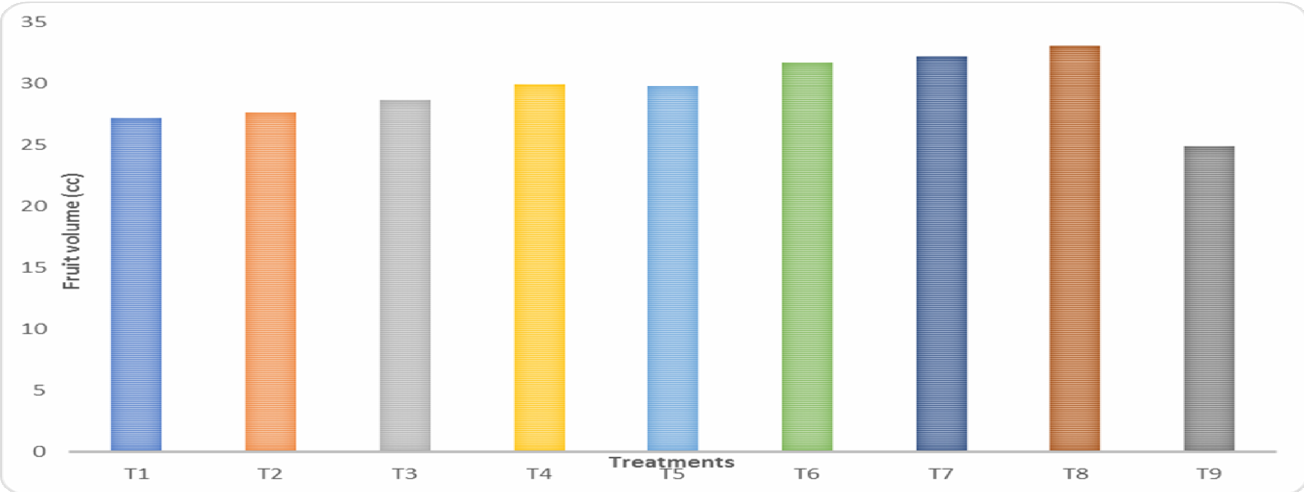

Fig. 4 : Effect of foliar application of calcium, zinc and boron on fruit volume (cc)

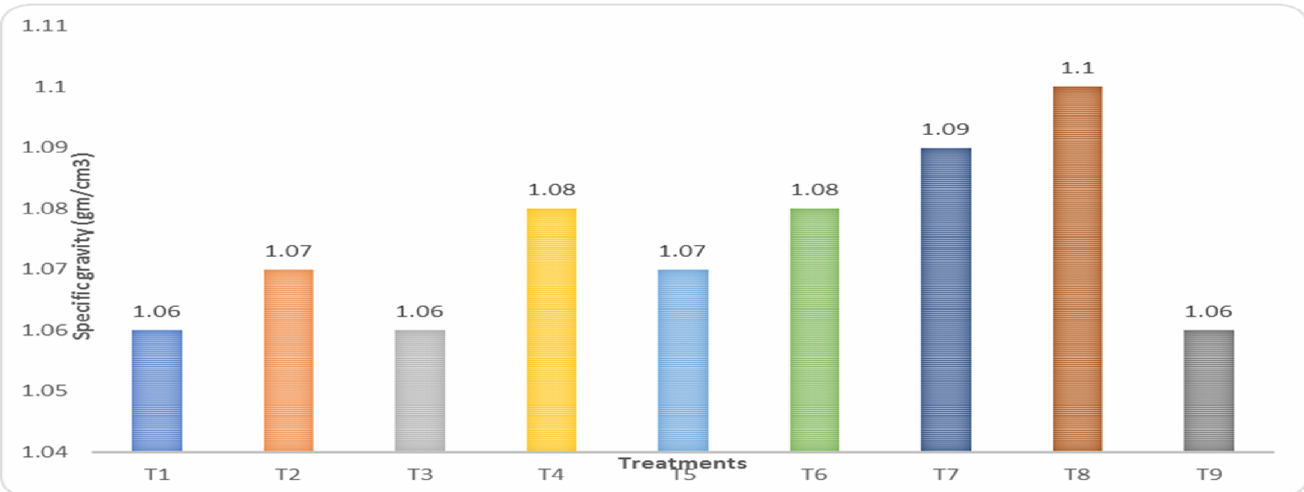

Fig. 5 : Effect of foliar application of calcium, zinc and boron on Specific gravity (gm/cm^3)

5. Specific gravity (gm/cm^3)

The results on specific gravity revealed that the foliar application of calcium, zinc and boron significantly increases specific gravity (Fig. 5). The highest Specific gravity (1.10 gm/cm^3) 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 lowest Specific gravity (1.06 gm/cm^3) was recorded in T_9 (control). The intake of zinc and boron may have increased specific gravity since it increased fruit pulp and decreased stone weight. These findings follow the results of various other workers such as Chandra and Singh (2015), Verma *et al.* (2016) and Kumar *et al.* (2017) in aonla.

6. Pulp weight (gm)

The results on pulp weight revealed that, the foliar application of calcium, zinc and boron significantly increases pulp weight (Fig.6). The highest pulp weight (33.41 g) was recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %). Whereas, the lowest Pulp weight (24.91 g) was recorded in T_9 (control). This significant increment in pulp weight must probably be due to the resultant growth-stimulating effect of boron and zinc. Besides, zinc is a vital component of enzymes such as proteinase and dehydrogenase. It acts as a catalyst in chlorophyll formation and this will lead to an increase in the photosynthetic activity of plants and hence greater accumulation of photosynthates and metabolites. It also promotes starch formation in plants while boron plays an important role in cell growth, cell division, cell enlargement and elongation and also the translocation of sugar and photosynthates from source to sink within the plant system. These findings follow the results of Singh *et al.* (2012), Kumar *et al.* (2017), Abhijith *et al.* (2018) in aonla and Singh *et al.* (2015) in mango.

Table 3 : Effect of foliar application of calcium, zinc and boron on pulp weight, stone weight and pulp stone ratio in aonla fruit

Treatments	Pulp weight (gm)	Stone weight (gm)	Pulp stone ratio
T_1 $CaCl_2$ 1.0 %	28.11	1.67	16.79
T_2 $CaCl_2$ 1.5 %	27.83	1.67	16.66
T_3 $ZnSO_4$ 0.4 %	29.59	1.44	20.50
T_4 $ZnSO_4$ 0.6 %	30.36	1.45	20.98
T_5 Borax 0.4 %	30.16	1.53	19.52
T_6 Borax 0.6 %	32.05	1.56	20.20
T_7 $CaCl_2$ 1.0 % + $ZnSO_4$ 0.4 % + Borax 0.4 %	32.48	1.63	19.93
T_8 $CaCl_2$ 1.5 % + $ZnSO_4$ 0.6 % + Borax 0.6 %	33.41	1.54	21.74
T_9 Control	24.91	1.84	13.51
SE(m) ±	0.16	0.011	0.22
CD at 5%	0.47	0.034	0.65

7. Stone weight (gm)

The results on stone weight revealed that, the foliar application of calcium, zinc and boron significantly decreases the stone weight (Fig. 7). The lowest stone weight (1.44 g) was recorded in T_3 (Zinc sulphate 0.4 %).). Whereas, the highest stone weight (1.84 g) was recorded in T_9 (control). This decrease in the stone weight of fruits might be due to the synergistic effect of zinc. Which is also involved in the rapid synthesis of metabolites, mainly carbohydrates, and their movement from stone to fruit pulp, resulting in higher pulp content and decreased stone weight. A similar finding has also been reported by Tiwari *et al.* (2017) in aonla.

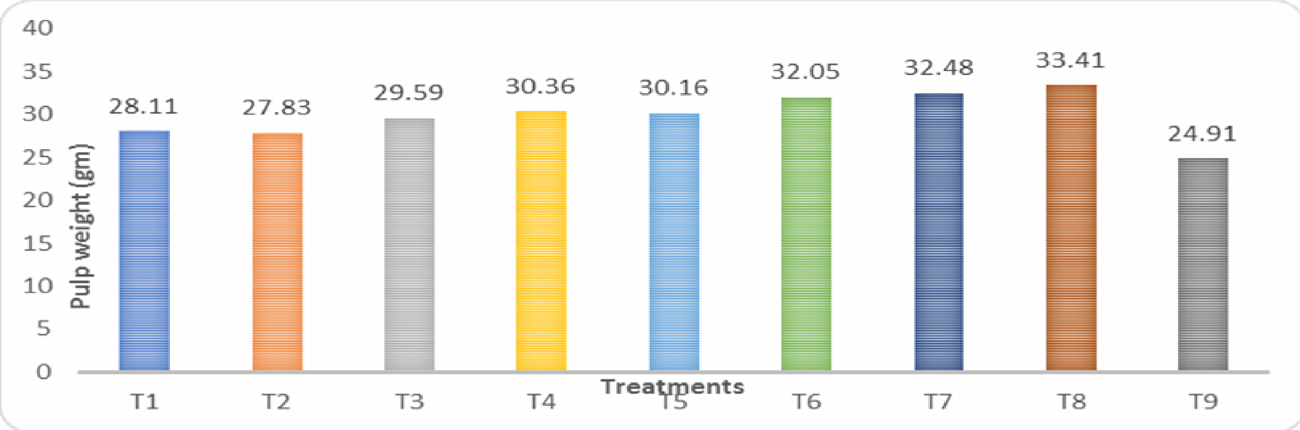

Fig. 6 : Effect of foliar application of calcium, zinc and boron on pulp weight (gm)

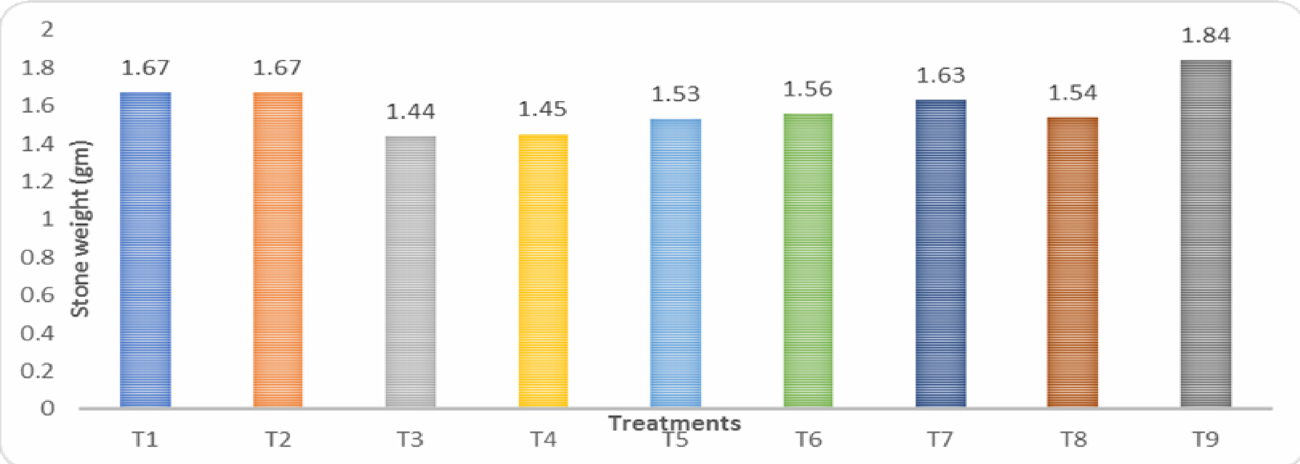

Fig. 7 : Effect of foliar application of calcium, zinc and boron on stone weight (gm)

8. Pulp stone ratio

The results on the stone ratio revealed that the foliar application of calcium, zinc and boron significantly increases the stone ratio. The highest pulp stone ratio (21.74) was recorded in T_8 (Calcium chloride 1.5 % + Zinc sulphate 0.6 % + Borax 0.6 %). Whereas, the lowest pulp stone ratio (13.51) was recorded in T_9 (control). The increase in pulp stone ratio may be linked to an acceleration in biochemical activities and the accumulation of metabolites in plant parts, which is most likely due to zinc's synergistic effect on the conversion and translocation of total sugars and minerals during fruit development and maturation, both of which increase pulp content. These results are in support of the findings of Chandra and Singh (2015), Kumar *et al.* (2017) and Abhijith *et al.* (2018) in aonla.

Conclusions

The findings reported in the present investigation clearly indicate that the treatment T_8, which consisted of a combination of 1.5% calcium chloride, 0.6% zinc sulphate, and 0.6% borax, significantly outperformed the other treatments. This particular treatment resulted in the highest enhancement of fruit quality, as evidenced by the maximum values in fruit weight, width, length, volume, specific gravity, pulp weight, and pulp to stone ratio, while maintaining a lower stone weight when compared to the control group. These results underscore the potential benefits of using a combined foliar application of these nutrients to improve the yield and quality of aonla fruits. It is hoped that these findings will contribute to the development of more effective cultivation practices for aonla, ultimately leading to increased productivity and profitability for growers. The success of treatment T_8 paves the way for further research to optimize the concentrations and combinations of these essential nutrients for even better outcomes in aonla cultivation.

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