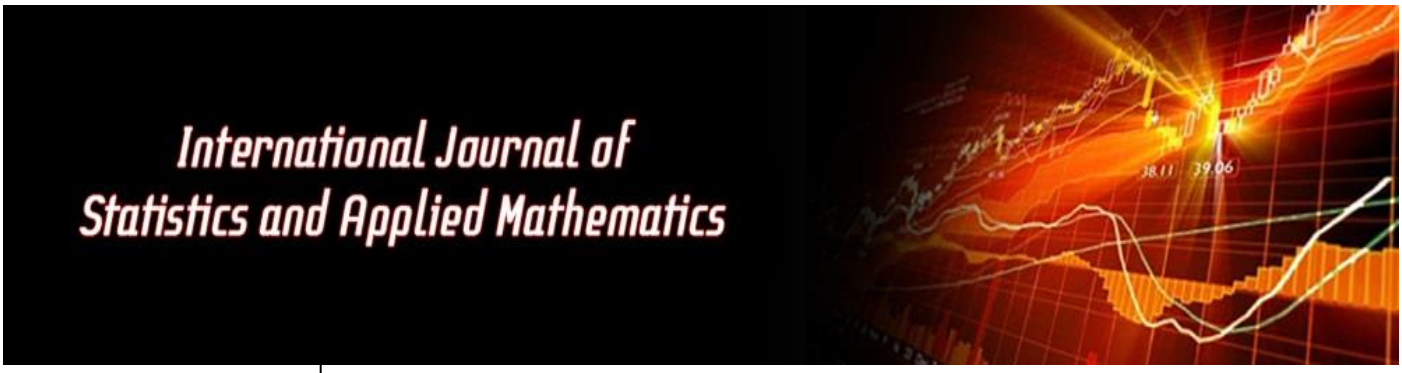

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Sandeep Tiwari
M.Sc. Scholar, Department of Fruit Science, CSA University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

RKS Gautam
Assistant Professor, Department of Fruit Science, CSA University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

AK Dwivedi
Assistant Professor, Department of Fruit Science, CSA University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Ravi Pratap
Ph.D. Scholar, Department of Fruit Science, CSA University of Agriculture & Technology, Kanpur, Uttar Pradesh, India.

Jitendra Kumar Shukla
Ph.D. Scholar, Department of Fruit Science, CSA University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Dr. Akash Shukla
Assistant Professor, Department of Horticulture, PSS Central Institute of Vocational Education, Bhopal, Madhya Pradesh, India

Corresponding Author:
Ravi Pratap
Ph.D. Scholar, Department of Fruit Science, CSA University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Effect of foliar application of boron, zink and gibberellic acid on fruit drop, fruit yield and quality parameter of Aonla cv. NA-7

Sandeep Tiwari, RKS Gautam, AK Dwivedi, Ravi Pratap, Jitendra Kumar Shukla and Dr. Akash Shukla

Abstract
At CSAUAT, Kanpur (Uttar Pradesh), India, a study was conducted to determine the effect of foliar applications of boron, zinc, and gibberellic acid on fruit drop, yield, and quality parameters of Aonla (*Emblica Officinalis*) cv. NA-7 during the years, i.e., 2021, on plants that are 20 years old. Borax (0.2, 0.4, and 0.6%), $ZnSO_4$ (0.1, 0.3, and 0.5%), and GA_3 (20, 40, and 60 ppm), together with control, were the 10 treatments in the randomised block design experiment. Plants treated with borax at 0.6% showed significantly less fruit drop (67.45%), higher fruit retention (32.55%), and specific gravity (1.12 g/cm^3). Maximum fruit length (3.70 cm), weight (28.28.90 g), volume (26.67 cc), and pulp weight (26.59 g) were recorded in fruits produced by plants treated with borax at 0.6%, while total sugar (12.06%), TSS (14.73^{0}Brix), fruit yield (80.50 kg/plant) and fruit content with higher moisture contents (93.45%) were recorded in fruits produced by plants treated with $ZnSO_4$ at 0.3%. However, in the month of August in the northern plains of India, plants treated with $ZnSO_4$ @ 0.3% produced fruits with the highest ascorbic acid concentrations (608.45 mg/100 g pulp).

Keywords: Gibberellic acid, fruit drop, Aonla, boron, yield and quality

Introduction
Indian Gooseberry, also known as Aonla, or *Emblica Officinalis* Gaertn., is a tropical South East Asian native that is primarily grown in central and southern India. Additionally, the plants are found frequently in mixed deciduous forests in India that rise to elevations of 1300m on hills, as well as naturally existing in other tropics-nations across the world. Aonla fruit is valued for its strong nutritional and therapeutic qualities, which are processed into a variety of value-added goods and herbal medications.
Gibberellins have been used extensively to increase stalk length and fruit production, including uniform crop emergence, cell division and elongation to increase fruit size, improvement of fruit quality and storage life, postponement of fruit maturity, reduction of fruit cracking and drop issues, improvement of fruit retention, production of seed lessness, and augmentation of sugar content in various fruit crops at various concentration (Pandey and Sinha 1995) [3].
Zinc is needed for the formation of tryptophan, which serves as an auxin precursor and helps to reduce fruit drop. A lack of auxin caused by a zinc deficiency hinders the development of cell walls, which increases osmotic pressure and restricts water intake. Zinc is either directly or indirectly required for the production of proteins.
Boron is crucial for the growth of pollen tubes, ovule development, and fruit set. The foliar application of PBR's and nutrients can also reduce the severity of damage brought on by fruit falling, which also aids in increasing Aonla's output and fruit quality. These were kept in mind as the current inquiry was conducted. With these factors in mind, the current inquiry was conducted to learn more about how gibberellic acid, zinc and boron affect only fruits.

Materials and Methods
At the CSA University of Agriculture & Technology, Kanpur-208002, (Uttar Pradesh), India, the Department of Horticulture conducted an experiment on Aonla cv.

NA 7 plants that were 20 years old during the year 2021. For foliar spraying, 30 uniformly growing trees were chosen at random. Three replications, 10 treatments of borax (0.2, 0.4, and 0.6%), $ZnSO_4$ (0.1, 0.3, and.5%), and GA_3 (20, 40, and 60 ppm) along with control were used in this randomized block design experiment. GA_3 and micronutrients were applied topically to the leaves of fruit during the month of August. The prescribed schedule for the Aonla plantation was followed for the usual cultural operations, plant protection measures and basal application of manures and fertilizer. The observations on fruit retention, fruit drop, and yield were made along with numerous other physico-chemical fruit characteristics. Data were examined, and the mean results are shown here. TSS was calculated using a hand refractometer and displayed in ^{0}Brix. By using the standard procedure outlined in AOAC (1980) [1], several chemical parameters, including total sugars, ascorbic acid, and acidity were measured.

Results and Discussion

Fruit drop and retention per cent

With the spray of nutrients and plant bio-regulator, fruit loss was significantly lower and fruit retention was higher when compared to control (Table 1). Borax @ 0.6% and GA_3 @ 60 ppm treatments resulted in the lowest fruit loss (67.45%) and highest fruit retention percent (32.55%), respectively, while control plants had the highest fruit drop (81.25%) and lowest fruit retention percent (18.15%). (Water spray). The decrease in fruit drop percentage and increase in fruit retention percentage in Aonla fruits could be attributed to the fact that boron and zinc are important elements in the cell wall (middle lamella) of plant cells. In order to prevent fruit drop, zinc is essential for the pedicel, which is connected to the proximal end of fruits. The indirect effect of boron on auxin synthesis delays the formation of the abscission layer during the early stages of fruit growth, boosting fruit retention percentage, much to how borax spray reduces fruit drop. The results of the current study are consistent with those of Singh and Singh (2015) [5], Verma *et al*. (2016) [10], and Singh *et al*. (2016) [6] in Aonla.

Fruit yield

In comparison to the control, the application of plant nutrients and a plant bio-regulator considerably enhanced the fruit yield/plant (Table 1). Borax @ 0.6% treated plants had the highest fruit output per plant (80.05 kg), which was followed by plants treated with 60 ppm GA_3 (79.25 kg). In contrast, the control group, which received no nutrients or plant bio-regulators, had the lowest fruit yield per plant (68.65 kg). These findings are supported by Tripathi and Shukla's (2006) [9], and Chandler, Singh and Tripathi's (2010) [7] in strawberry cv. Chandler, Chandra *et al*. (2015) [2], and Verma *et al*. (2016) [10] in Aonla are in agreement with these findings. The significant rise in fruit yield in plants treated with GA_3 may be attributed to their direct involvement in photosynthesis, which increases fruit size, weight, volume, and yield.

Fruit size (Length and width)

With the spray of nutrients and plant bio-regulator had a considerable impact on fruit size (Table 1). When treated with GA_3 at 60 ppm, plants treated with borax at 0.6% as a foliar treatment produced fruits that were substantially larger than those produced by control plants, measuring 3.70 cm in length and 4.80 cm in width (3.18 and 3.29 cm, respectively). All additional applications of GA_3, borax, and zinc sulphate likewise resulted in noticeably larger fruits than the control. Fruit size decreases in comparison to their increased concentrations of nutrients and plant bio-regulators but stays much higher than those that are not treated. Gibberellic acid administration caused fruits to grow larger, which could be attributed to a substantial increase in cell division and cell elongation. These results are supported by those from Shukla *et al*. (2011) [4], Singh and Singh (2015) [5], Chandra *et al*. (2015) [2], Verma *et al*. (2016) [10], and Singh *et al*. (2016) [6] in Aonla.

The weight, volume, and specific gravity of fruits were significantly influenced by the foliar application of nutrients and a plant bio-regulator. Significantly, Borax @ 0.6% application resulted in the highest weight, volume and specific gravity of fruit (28.28 g, 26.67 ccs, and 1012 g/cm3, respectively), followed by GA_3 @ 60 ppm treatment (28.06 g, 26.46 ccs, and 1.12 g/cm3, respectively), while untreated control plants produced the lowest weight, volume and specific gravity of fruit (24.29 g, 22.91 c Additionally, it has been observed that as nutrient and plant bio-regulator doses are decreased, fruit weight, volume, and specific gravity likewise decrease but remain noticeably greater than in the control group (Table 1). Gibberellic acid and nutrients are delivered to the fruits throughout their growth and development and are either directly or indirectly related to photosynthesis in plants. The fruits' weight and volume expand as a result of the increase in food that is stored there. Fruits gain weight and size, which causes their specific gravity to increase. In the Aonla, Shukla *et al*. (2011) [4] support these findings. Verma *et al*. (2016) [10], Singh *et al*. (2016) [6], Chandra *et al*. (2015) [2], Singh and Singh (2015) [5] in Aonla.

Fruit pulp weight

Fruit pulp weight was significantly increased by foliar applying micronutrients and a plant bio-regulator (Table 1). Fruits obtained from untreated (control) plants had the least amount of pulp weight compared to those harvested from plants treated with borax at 0.6% (26.59 g), GA_3 at 60 ppm (26.39 g), and $ZnSO_4$ at 0.3% (25.76 g) (22.84 g). Under all other treatments, the fruits' pulp content was significantly higher than it was under the control. The findings from Verma *et al*. (2016) [10] and Chandra *et al*. (2015) [2] Aonla's experiments are in agreement with these Verma, *et al*. (2016) [10] findings.

Fruit stone weight and pulp: stone ratio

Utilizing plant bio-regulators and micronutrients, measurements of stone and pulp: Stone ratio were made in comparison to controls (Table 1). The fruits produced by the plants treated with borax @ 0.6% had a pulp: Stone ratio of 17.57%, which was higher than the minimum weight of stone (1.55 g) under treatment with $ZnSO_4$ @ 0.1%. While under control, the highest stone weight and the minimum pulp: Stone ratio were measured (1.85 g and 13.13 percent, respectively). These findings from Chandra *et al*. (2015) [2], Verma *et al*. (2016) [10] and Singh *et al*. (2016) [6] in Aonla provide support for these findings. The improvement in the pulp-to-stone ratio may be due to the increased accumulation of food substances in the intercellular space and elongated cells of the mesocarp.

Fruit moisture per cent

Significantly higher fruit moisture content (93.45%) was found in the fruit produced by $ZnSO_4$ @ 0.3% treated plants, followed closely by $ZnSO_4$ @0.5% treated plants (93.25%),

while control plants (89.89%) had the lowest fruit moisture content. Plant life uses pre-harvest treatments using GA_3, borax, and zinc sulphate for a variety of reasons. Additionally, they have a direct or indirect impact on a variety of enzyme systems in plants. Among them, the roles of GA_3 and nutrients in the activation of the amylase enzyme, which is in charge of turning starch into sugar, are well documented. Further research is necessary because there is currently no report accessible.

TSS and total sugars

The highest levels of TSS and total sugars were found in the fruit produced by plants treated with foliar applications of $ZnSO_4$ at 0.3%, followed by borax at 0.6% (14.72 ^oBrix and 12.05%, respectively), while the lowest levels were found in untreated fruit plants (14.12 ^oBrix and 11.55%, respectively) (Table 2). The rise in TSS and total sugars with GA3 and boron application may be due to the fact that these plant bio-regulators and nutrients are beneficial in the process of photosynthesis, which causes the accumulation of oligosaccharides and polysaccharides in bigger proportions. These vitamins and minerals also control enzyme activity and convert carbs into simple sugars. These results agree with those reported by Shukla *et al*. (2011) [4] in the Aonla. Verma *et al*. (2016) [10] and Singh *et al*. (2016) [6] and Singh, and Singh (2015) [5] in Aonla.

Titratable acidity

Utilizing a plant bio-regulator and micronutrients reduced the titratable acidity content of fresh fruits. The fruits made from the plant treated with $ZnSO_4$ at 0.5% had the lowest titratable acidity percent (1.58%), followed closely by fruits made from plants treated with GA_3 at 60 ppm (1.64%) and borax at 0.6% (1.67%), while fruits made from untreated control plants had the highest concentration (2.00%). (Table 2). Fruits' decreased acidity may be caused by an increase in TSS and total sugars. Chemically induced acids may have either been used as a substrate for respiration or transformed into sugars and their derivatives through reactions involving the reversal of the glycolytic pathway, or both. The findings of Shukla *et al*. (2011) [4], Chandra *et al*. (2015) [2], Verma *et al*. (2016) [10] and Singh *et al*. (2016) [6] Singh and Singh (2015) [5] in Aonla have supported the results.

Ascorbic acid

The fruit from the plant treated with $ZnSO_4$ @ 0.3% had the highest ascorbic acid content (608.45 mg/100g), followed closely by those from the plants treated with $ZnSO_4$ @ 0.5% (604.50 mg/100g), while the untreated control plants had the lowest ascorbic acid content (574.67 mg/100g) (Table 2). This increase in the ascorbic acid level with calcium nitrate administration may be caused by low rates of oxidation and continuous production of its precursor, glucose-6-phosphate, during the conversion of starch into other sugars. The conclusion is consistent with that of Shukla *et al*. (2011) [4], Chandra *et al*. (2015) [2], Verma *et al*. (2016) [10] and Singh *et al*. (2016) [6] Singh, and Singh (2015) [5], Chandra *et al*. (2015) [2], Tripathi and Shukla (2011) [8] in Aonla.

Table 1: Effect of foliar application of Boron, Zinc and Gibberellic Acid on physical parameter of aonla cv. NA-7

Symbols	Treatments	Length (cm)	Fruit Weight (g)	Width (cm)	Fruit volume (cc)	Fruit Drop (%)	Fruit Retention (%)	Pulp Weight (g)	Stone weight (g)	Pulp: Stone ratio	Specific gravity (g/cm^3)	Yield (Kg/plant)
T_1	Borax @ 0.2%	3.43	26.21	3.53	24.72	77.15	22.85	24.65	1.56	16.80	1.08	74.12
T_2	Borax @ 0.4%	3.57	27.24	3.69	25.69	72.35	27.65	25.62	1.57	17.35	1.10	77.25
T_3	Borax @ 0.6%	3.70	28.28	3.83	26.67	67.45	32.55	26.59	1.61	17.57	1.12	80.05
T_4	$ZnSO_4$ @ 0.1%	3.49	26.65	3.61	25.13	75.27	24.73	25.06	1.55	17.19	1.09	75.35
T_5	$ZnSO_4$ @ 0.3%	3.58	27.39	3.71	25.83	71.20	28.80	25.76	1.57	17.45	1.11	77.45
T_6	$ZnSO_4$ @ 0.5%	3.53	26.95	3.65	25.42	72.45	27.55	25.35	1.58	17.06	1.09	76.33
T_7	GA3 @ 20 ppm	3.47	26.51	3.59	25.01	75.66	24.34	24.94	1.57	16.89	1.08	74.90
T_8	GA3 @ 40 ppm	3.54	27.02	4.66	25.48	73.15	26.85	25.41	1.59	16.99	1.10	76.45
T_9	GA3 @ 60 ppm	3.67	28.06	4.80	26.46	67.75	32.25	26.39	1.60	17.54	1.12	79.25
T_0	Control (water spray)	3.18	24.29	3.29	22.91	81.25	18.15	22.84	1.85	13.13	1.01	68.65
S.E. (Did.)+		0.10	0.97	0.12	0.51	1.82	1.036	0.42	0.05	0.48	0.01	2.07
CD at 5%		0.21	2.05	0.27	1.07	3.83	2.17	0.89	0.10	1.02	0.02	4.35

Table 2: Effect of foliar application of Boron, Zinc and Gibberellic Acid on chemical parameter of aonla cv. NA-7

Symbols	Treatments	Fruit moisture (%)	T.S.S. (^{0}Brix)	Total Sugar (%)	Titratable Acidity (%)	Ascorbic acid (mg/100 pulp)
T_1	Borax @ 0.2%	92.05	14.51	11.88	1.82	588.10
T_2	Borax @ 0.4%	92.65	14.65	11.99	1.72	600.15
T_3	Borax @ 0.6%	92.95	14.72	12.05	1.67	602.25
T_4	$ZnSO_4$ @ 0.1%	92.97	14.66	12.00	1.89	591.12
T_5	$ZnSO_4$ @ 0.3%	93.45	14.73	12.06	1.75	608.45
T_6	$ZnSO_4$ @ 0.5%	93.25	14.70	12.04	1.58	604.50
T_7	GA3 @ 20 ppm	92.25	14.54	11.90	1.78	589.25
T_8	GA3 @ 40 ppm	92.77	14.62	11.97	1.70	601.75
T_9	GA3 @ 60 ppm	92.98	14.66	12.01	1.64	603.30
T_0	Control (water spray)	89.89	14.12	11.55	2.00	574.67
S.E. (did.)+		0.33	0.07	0.10	0.02	2.59
CD at 5%		0.69	0.16	0.21	0.04	5.44

Conclusion

In view of the results obtained from present investigation, it can safely be concluded that plants treated with Borax @ 0.6% have significantly reduced fruit drop (67.45%), minimum amount of titratable acidity (1.67%) and increased fruit retention (32.55%), maximum length (3.70 cm), width

(4.80 cm), weight (26.59 g), volume (28.28cc), specific gravity (1.12 g/cm3), pulp weight (26.59 g), pulp: stone ratio (17.57%) and yield (80.05 Kg/plant). Plants treated with $ZnSO_4$ @ 0.1 have significantly reduced the stone weight (1.5 gm.). The maximum TSS and Total sugar were found with the treatment of $ZnSO_4$ @ 0.3%. Quality fruits with more retention percent, plants of Aonla cv. NA-7 should be sprayed with GA_3 @ 100 ppm in the months of August in the north Indian plains of U.P.

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Conflict of Interest: None

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