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## RESPONSE OF AONLA (*EMBLICA OFFICINALIS* GAERTN.) PLANTS ON LEAF NUTRIENT STATUS, QUALITY AND YIELD TO FOLIAR APPLICATION OF MICRO-NUTRIENTS IN RED AND LATERITIC REGION OF WEST BENGAL, INDIA

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### ABSTRACT

Aonla (*Embllica officinalis* Gaertn.) was found highly susceptible to micronutrients deficiency, lead to cause the browning symptoms in fruits. To resolve the issue, an investigation was conducted in consecutive two years at the Regional Research Sub-Station, B.C.K.V., Birbhum-India. Nine treatments such as T<sub>1</sub> - Control (water spray), T<sub>2</sub> - 0.4% ZnSO<sub>4</sub>, T<sub>3</sub> - 0.8% ZnSO<sub>4</sub>, T<sub>4</sub> - 0.2% Borax, T<sub>5</sub> - 0.4% Borax, T<sub>6</sub> - 0.4% ZnSO<sub>4</sub> + 0.2% Borax, T<sub>7</sub> - 0.4% ZnSO<sub>4</sub> + 0.4% Borax, T<sub>8</sub> - 0.8% ZnSO<sub>4</sub> + 0.2% Borax and T<sub>9</sub> - 0.8% ZnSO<sub>4</sub> + 0.4% Borax were organised in a RBD design and replicated thrice. Two foliar spraying of micronutrients were done as per treatments during the set of fruit (March-April) and pea stages (June-July) of fruit development. According to the findings, the maximum volume (30.10 ml), weight (30.35 g), length (3.75 cm), diameter (3.78 cm), flesh thickness (1.75 cm) of aonla's fruit, TSS (10.92°Brix), total sugar (6.62%), juice content (49.45%), ascorbic acid (536.73 mg/100 g of flesh pulp), fruits/plant (1090.00), yield/plant (33.18 kg), leaf zinc and boron (21.23 and 33.75 ppm) and minimum browning symptom (14.42%) were observed with foliar feeding of 0.8% ZnSO<sub>4</sub> + 0.4% Borax/plant. After two years of research, this can be summarized that foliar application of 0.8% ZnSO<sub>4</sub> + 0.4% Borax/plant could improve yield, quality and leaf micronutrients status and minimizing the browning symptoms in the fruits of Aonla particularly in micronutrients deficit regions such as Red and Laterite zones.

**Key words** : Aonla, Micro-nutrient, Fruit quality, Browning symptom, Leaf nutrient status.

### Introduction

Aonla or Indian goose berry, an indigenous fruit crop of Asia, is commercially cultivated in Rajasthan, Maharashtra, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka and Gujarat. This is one of the most nutritious fruits next to Barbados cherry (Asenjo, 1953) as it includes tannins, phyllambin, ellagic acid and gallic acid, all of which prevent vitamin-C from oxidising (Yadav and Shukla, 2009). The plant is rather hardy and suitable even for waste land. Besides having nutritional and medicinal values, cultivation of Aonla is also highly

remunerative for small and marginal farmers. Aonla cultivation is becoming more common these days due to its high market demand, cheap maintenance costs and adaptability to a variety of agro-climatic conditions.

Among plant nutrients, the role of micronutrients is crucial in numerous aspects of plant metabolism i.e., cell wall construction, photosynthesis, respiration, chlorophyll synthesis, enzymatic activities, nitrogen reduction and fixation as well as hormone synthesis (Das, 2003). Several earlier findings revealed that Aonla is highly susceptible to micronutrients deficiency and the deficiency

micronutrients are a major cause of browning of fruits. Therefore, a sufficient supply of micronutrients is important for optimal plant development and greater development, better blooming and higher fruit set lead to higher yield (Ram and Bose, 2000). Micronutrients affected the fruit's quality (Shekhar *et al.*, 2010). It's possible that the significant improvement in fruit quality is because of the catalytic impact of micronutrients, especially when they're present in higher concentrations. For ensuring crop quality and productivity, the micronutrients zinc and boron are crucial in orchard plant nutrition programmes. The processes of N metabolism, flowering and fruiting, hormone transport as well as cell division are all significantly influenced by zinc and boron (Babu and Singh, 2001). Fruit physico-chemical characteristics are raised when higher quantities of zinc and boron are applied together. Boron is thought to cause the inactivation of excess growth hormone by forming a complex molecule. Although, the role of this element in increasing plant physiological activities is well recognized. Synthesis of tryptophan, prerequisite for auxin synthesis, is the cause of zinc's significant impact on fruit yield. Greater fruit retention and less fruit drop are associated with auxin synthesis, resulting in higher fruit production. Foliar spray of boron and zinc improves plant nutrition as well as photosynthetic capacity, which results in faster metabolite synthesis, mainly carbohydrates and their transfer to fruits. Zinc is required for protein synthesis, seed formation and fruit maturity, whereas boron is required for cell division and elongation, which increases fruit weight. Since little information is available regarding micro-nutrient management of Aonla, particularly in red and lateritic tracts of India. The current investigation was undertaken to progress a foliar spray schedule of micronutrients for quality production of Aonla in Red and Lateritic region of West Bengal.

## Materials and Methods

### Location of research plot and treatment specifications

This current research was carried out at Bidhan Chandra Krishi Viswavidyalaya's Regional Research Sub-Station, Birbhum, India during the period from 2019 to 2021. The site of the experiment, Regional Research Sub-Station is situated at 23°68'N latitude and 87°69'E longitude with average altitude of 30m above MSL. These trees are uniform in height and of 12 years old. A Randomised Block Design (RBD) was used to set up the experiment and it was replicated thrice with nine treatments ( $T_1$  - Control as water spray;  $T_2$  - 0.4%  $ZnSO_4$ ;  $T_3$  - 0.8%  $ZnSO_4$ ;  $T_4$  - 0.2% Borax;  $T_5$  - 0.4%

Borax;  $T_6$  - 0.4%  $ZnSO_4$  + 0.2% Borax;  $T_7$  - 0.4%  $ZnSO_4$  + 0.4% Borax;  $T_8$  - 0.8%  $ZnSO_4$  + 0.2% Borax and  $T_9$  - 0.8%  $ZnSO_4$  + 0.4% Borax).

### Time and method of application of micro-nutrients

Two foliar spraying of micro-nutrients was done at fruit set (March-April) and pea stage (June-July) of fruit development. In 50-100 ml of warm water, the indicated amount of borax was dissolved and spray volume was adjusted by mixing it in normal water. Lime weighing half of the measured weight of  $ZnSO_4$  was added in solution for adjusting neutral pH of spray solution.

### Recommended package of practices

Recommended package of practices including application of recommended dose of fertilizer (N:P:K @ 600:300:600 g/plant), weed control and plant protection measures were practiced accordingly.

### Measurement of plant growth parameters

Per cent enhancement in height of the plant as well as canopy spread in E-W and N-S direction was evaluated using a measuring tape before fertilizer application and at harvest, was calculated in meters (m) and represented as percent increase during the investigation period.

### Calculation of fruit physical parameters

Browning symptoms of fruits were observed visually up to the harvesting time and calculated in percentage, volume of fruit was measured utilizing the water displacement procedure using a measuring cylinder, fruit length and diameter were evaluated with the help of slide callipers, thickness of the pulp was measured using a centimeter scale, fruit and stone weight were calculated using an electronic balance.

### Calculation of fruit bio-chemical parameters

Among the bio-chemical parameters, TSS was evaluated by utilizing Hand Refractometer, titratable acidity and total sugar were measured by the method detailed in A.O.A.C. (1980) and lastly, ascorbic acid content was measured by Rangana (2002).

### Estimation of leaf nutrient status

Leaf zinc content was determined using di-acid digested material and an Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978). Leaf boron content was determined spectrophotometrically by Azomethine-H method (Wolf, 1971 and Gupta, 1979).

### Statistical analysis

Statistical analysis was carried out following the process detailed by Panse and Sukhatme (1985).

## Results and Discussion

### Impact of micro-nutrients on plant physical characters

Results showed significant influence of micro-nutrients on plant height as well as canopy spread in North-South (N-S) and East-West (E-W) direction (Table 1). From pooled analysis, highest increase in plant height (23.19%) was observed in T<sub>9</sub> (0.8% ZnSO<sub>4</sub> + 0.4% Borax) whereas the minimum value (20.94%) was in control (Water spray). The per cent increase in canopy spread in the E-W direction (14.03%) and in N-S direction (12.23%) were recorded maximum in T<sub>9</sub> whereas the minimum per cent increase in canopy spread in the East-West direction (11.63%) and in North-South direction (9.63%) were recorded under control. Zinc is a necessary mineral for the production of chlorophyll, which is clearly tied to the plant's ability to photosynthesize; hence enhancement in vegetative growth could be attributable to its stimulative effect (Khan *et al.*, 2009).

### Effect of micro-nutrients on fruit physical characters

According to the pooled data, it is clear that maximum

percentage of fruits showing browning symptom (24.19%) was recorded in control whereas lowest percentage of fruits showing browning symptom (14.42%) was measured from T<sub>9</sub> that was statistically at par with T<sub>7</sub> (0.4% ZnSO<sub>4</sub> + 0.4% Borax), T<sub>8</sub> (0.8% ZnSO<sub>4</sub> + 0.2% Borax) and T<sub>6</sub> (0.4% ZnSO<sub>4</sub> + 0.2% Borax). The information in Table 2 made it abundantly evident that the significant variation on fruit length and diameter was observed with the application of various combinations of treatments. Fruit length varied between 2.30 cm to 3.75 cm and diameter varied between 2.63 cm to 3.78 cm.

Maximum fruit volume of 30.10 ml, flesh thickness of 1.75 cm and average fruit weight of 30.35 g were obtained from the treatment T<sub>9</sub>, whereas the minimum fruit volume (26.27 ml), flesh thickness (1.11 cm) and fruit weight (26.88 g) were in control (Tables 3 and 4). Maximum stone weight (2.05 g) was recorded with 0.2% Borax spray followed by 0.4% Borax and lowest value (1.62 g) was recorded with T<sub>9</sub>. Boron has a key function in the accumulation of additional photosynthates, which is linked to fruit size, weight and volume. Since boron is involved in nitrogen metabolism, cell division and cell

**Table 1 :** Impact of micro-nutrients on per cent enhancement in plant height and canopy spread of Aonla.

Treatments	Increase in canopy spread (%)			Increase in plant height (%)					
				E-W			N-S		
	19-20	20-21	Pooled	19-20	20-21	Pooled	19-20	20-21	Pooled
T <sub>1</sub>	19.48 (26.18)	22.40 (28.24)	20.94 (27.22)	10.04 (18.47)	13.21 (21.30)	11.63 (19.93)	8.62 (17.07)	10.64 (19.03)	9.63 (18.08)
T <sub>2</sub>	20.39 (26.83)	23.33 (28.87)	21.86 (27.87)	10.98 (19.34)	13.85 (21.84)	12.42 (20.62)	9.65 (18.09)	11.88 (20.15)	10.77 (19.15)
T <sub>3</sub>	20.66 (27.02)	23.54 (29.01)	22.10 (28.03)	11.16 (19.51)	14.13 (22.07)	12.65 (20.82)	9.82 (18.26)	12.15 (20.39)	10.99 (19.35)
T <sub>4</sub>	19.99 (26.55)	22.77 (28.49)	21.38 (27.53)	10.51 (18.91)	13.38 (21.48)	11.95 (20.21)	9.00 (17.45)	11.16 (19.51)	10.08 (18.50)
T <sub>5</sub>	20.15 (26.66)	22.98 (28.63)	21.57 (27.66)	10.73 (19.11)	13.67 (21.69)	12.20 (20.44)	9.33 (17.78)	11.59 (19.90)	10.46 (18.87)
T <sub>6</sub>	20.84 (27.15)	23.96 (29.30)	22.40 (28.24)	11.59 (19.90)	14.74 (22.57)	13.17 (21.27)	10.18 (18.60)	12.44 (20.64)	11.31 (19.65)
T <sub>7</sub>	21.05 (27.30)	24.23 (29.48)	22.64 (28.40)	11.77 (20.06)	15.24 (22.97)	13.51 (21.55)	10.41 (18.82)	12.74 (20.90)	11.58 (19.89)
T <sub>8</sub>	21.31 (27.48)	24.65 (29.76)	22.98 (28.64)	11.93 (20.20)	15.59 (23.25)	13.76 (21.77)	10.76 (19.14)	13.08 (21.19)	11.92 (20.19)
T <sub>9</sub>	21.56 (27.66)	24.82 (29.87)	23.19 (28.78)	12.18 (20.42)	15.87 (23.47)	14.03 (21.99)	10.99 (19.35)	13.47 (21.52)	12.23 (20.46)
S.Em(±)	0.043	0.024	0.029	0.037	0.028	0.023	0.025	0.025	0.018
CD(0.05)	0.129	0.074	0.089	0.113	0.084	0.068	0.076	0.077	0.054

\*Data in the parenthesis are angular transformed value.

**Table 2 :** Impact of micro-nutrients on per cent of fruits showing browning symptom, fruit length and diameter of Aonla.

Treatments	% fruits showing browning symptom			Fruit length (cm)			Fruit diameter (cm)		
	19-20	20-21	Pooled	19-20	20-21	Pooled	19-20	20-21	Pooled
T <sub>1</sub>	24.25 (29.49)	24.12 (29.40)	24.19 (29.45)	2.18	2.41	2.30	2.46	2.79	2.63
T <sub>2</sub>	18.02 (25.10)	15.94 (23.52)	16.98 (24.33)	2.66	2.81	2.74	2.96	3.09	3.03
T <sub>3</sub>	17.87 (24.99)	15.76 (23.36)	16.82 (24.20)	2.78	2.95	2.87	3.10	3.28	3.19
T <sub>4</sub>	17.62 (24.80)	15.39 (23.08)	16.51 (23.96)	2.31	2.53	2.42	2.67	2.86	2.77
T <sub>5</sub>	17.41 (24.65)	15.11 (22.85)	16.26 (23.77)	2.45	2.67	2.56	2.78	3.00	2.89
T <sub>6</sub>	16.78 (24.16)	13.94 (21.90)	15.36 (23.05)	2.94	3.17	3.06	3.22	3.40	3.31
T <sub>7</sub>	16.14 (23.64)	13.23 (21.31)	14.69 (22.52)	3.09	3.42	3.26	3.35	3.58	3.47
T <sub>8</sub>	16.53 (23.97)	13.59 (21.61)	15.06 (22.82)	3.40	3.68	3.54	3.47	3.77	3.62
T <sub>9</sub>	15.96 (23.52)	12.88 (20.99)	14.42 (22.29)	3.58	3.92	3.75	3.61	3.94	3.78
S.Em(±)	0.630	0.624	0.437	0.024	0.022	0.017	0.032	0.062	0.038
CD(0.05)	1.906	1.887	1.320	0.072	0.066	0.052	0.096	0.189	0.116

\*Data in the parenthesis are angular transformed value.

**Table 3 :** Impact of various micro-nutrients on fruit volume and flesh thickness of Aonla.

Treatment	Fruit volume (ml)			Flesh thickness (cm)		
	19-20	20-21	Pooled	19-20	20-21	Pooled
T <sub>1</sub>	25.54	26.99	26.27	1.01	1.20	1.11
T <sub>2</sub>	26.67	28.68	27.68	1.23	1.43	1.33
T <sub>3</sub>	26.95	29.07	28.01	1.30	1.51	1.41
T <sub>4</sub>	26.01	27.74	26.88	1.09	1.28	1.19
T <sub>5</sub>	26.24	28.19	27.22	1.16	1.36	1.26
T <sub>6</sub>	27.27	29.55	28.41	1.41	1.60	1.51
T <sub>7</sub>	27.69	30.00	28.85	1.49	1.68	1.59
T <sub>8</sub>	28.00	30.97	29.49	1.56	1.79	1.68
T <sub>9</sub>	28.61	31.59	30.10	1.62	1.88	1.75
S.E.m(±)	0.040	0.037	0.031	0.030	0.026	0.018
CD(0.05)	0.122	0.110	0.093	0.091	0.078	0.055

elongation, foliar nutrient feeding may have resulted in enhanced fruit size and volume. The findings are in accordance with results of Singh *et al.* (2009) and Shukla *et al.* (2008) in Aonla. This improvement in the size as well as volume of fruit could be owing to zinc's direct involvement in growth or it could be just because of higher

accumulation and translocation of food ingredients. The reduced stone weight might be attributed to the nutrients' role in the fruit's build-up of more flesh which decreased finally stone weight.

#### Impact of various micro-nutrients on fruit bio-chemical characters

Perusal of the data presented in Tables 5 and 6 revealed significant variation in TSS, total sugar, titratable acidity as well as ascorbic acid content of the pulp due to application of various micro-nutrient combinations.

From the pooled analysis, maximum TSS content (10.92°Brix), ascorbic acid content (536.73 mg/100 g of pulp), juice percentage (49.45%) were observed from the treatment T<sub>9</sub> (0.8% ZnSO<sub>4</sub> + 0.4% Borax) compared with minimum TSS content (9.43°Brix), ascorbic acid content (475.89 mg/100 g of pulp) as well as juice percentage (46.16%) in plants under control. Significant reduction in acidity content (1.46%) was observed from plants treated with treatment T<sub>9</sub> compared to 2.05% in control. Highest total sugar content (6.62%) was recorded

**Table 4 :** Impact of various micro-nutrients on fruit weight and stone weight of Aonla.

Treatment	Fruit weight (g)			Stone weight (g)		
	19-20	20-21	Pooled	19-20	20-21	Pooled
T <sub>1</sub>	25.58	28.17	26.88	1.84	1.89	1.87
T <sub>2</sub>	26.98	29.82	28.40	1.80	1.82	1.81
T <sub>3</sub>	27.35	30.12	28.74	1.74	1.78	1.76
T <sub>4</sub>	26.29	29.09	27.69	1.98	2.11	2.05
T <sub>5</sub>	26.77	29.56	28.17	1.88	1.93	1.91
T <sub>6</sub>	27.69	30.67	29.18	1.76	1.81	1.79
T <sub>7</sub>	28.42	31.29	29.86	1.69	1.74	1.72
T <sub>8</sub>	28.04	30.86	29.45	1.64	1.70	1.67
T <sub>9</sub>	28.89	31.80	30.35	1.59	1.65	1.62
S.Em(±)	0.075	0.158	0.081	0.035	0.027	0.016
CD(0.05)	0.227	0.479	0.245	0.106	0.082	0.049

in T<sub>9</sub>, that was found statistically at par with T<sub>7</sub> (0.4% ZnSO<sub>4</sub> + 0.4% Borax), while the lowest was observed from the treatment T<sub>1</sub> (5.63%). This enhancement in sugars fraction caused by foliar boron and zinc supplementation could be owing to their roles in metabolite photosynthesis as well as sugar translocation from plant's other parts to the developing fruits (Singh *et al.*, 2012). It could also be attributable to micronutrients, which have been linked to fruit quality in both direct and indirect ways (Kumar and Shukla, 2005). Zinc supplementation raised ascorbic acid levels, possibly due to enhanced growth as well as the availability of additional metabolites for ascorbic acid production.

**Table 5 :** Impact of micro-nutrients on TSS, titratable acidity and total sugar content of Aonla.

Treatment	TSS (°Brix)			Titratable acidity (%)			Total sugar (%)		
	19-20	20-21	Pooled	19-20	20-21	Pooled	19-20	20-21	Pooled
T <sub>1</sub>	9.17	9.68	9.43	2.09	2.00	2.05	5.60	5.65	5.63
T <sub>2</sub>	9.88	10.38	10.13	1.86	1.78	1.82	6.01	6.16	6.09
T <sub>3</sub>	10.01	10.55	10.28	1.80	1.74	1.77	6.08	6.29	6.19
T <sub>4</sub>	9.51	9.91	9.71	1.99	1.95	1.97	5.84	5.94	5.89
T <sub>5</sub>	9.73	10.12	9.93	1.92	1.89	1.91	5.93	6.07	6.00
T <sub>6</sub>	10.19	10.71	10.45	1.72	1.68	1.70	6.25	6.46	6.36
T <sub>7</sub>	10.49	11.06	10.78	1.59	1.49	1.54	6.41	6.60	6.51
T <sub>8</sub>	10.30	10.96	10.63	1.66	1.56	1.61	6.36	6.53	6.45
T <sub>9</sub>	10.65	11.19	10.92	1.52	1.40	1.46	6.54	6.69	6.62
S.Em(±)	0.031	0.031	0.018	0.039	0.044	0.035	0.098	0.038	0.043
CD(0.05)	0.095	0.093	0.056	0.117	0.134	0.107	0.295	0.116	0.131

**Table 6 :** Impact of micro-nutrients on ascorbic acid and juice volume measurement of Aonla.

Treatment	Ascorbic acid (mg/100 g flesh pulp)			Juice (ml)		
	19-20	20-21	Pooled	19-20	20-21	Pooled
T <sub>1</sub>	442.08	509.70	475.89	43.19	49.12	46.16
T <sub>2</sub>	464.54	526.33	495.44	44.67	50.86	47.77
T <sub>3</sub>	470.00	530.48	500.24	44.85	51.18	48.02
T <sub>4</sub>	450.17	515.61	482.89	44.13	50.28	47.21
T <sub>5</sub>	455.36	519.53	487.45	44.31	50.49	47.40
T <sub>6</sub>	488.19	539.81	514.00	45.04	51.61	48.33
T <sub>7</sub>	505.16	552.51	528.84	45.62	52.24	48.93
T <sub>8</sub>	498.77	546.66	522.72	45.38	51.89	48.64
T <sub>9</sub>	512.32	561.13	536.73	45.90	52.99	49.45
S.Em(±)	0.711	0.992	0.807	0.130	0.159	0.123
CD(0.05)	2.149	3.000	2.440	0.393	0.481	0.373

### Impact of various micro-nutrient treatments on yield characters of Aonla plants

The information in Table 7 clearly showed the significant variation in number of fruits/tree at harvest due to various micro-nutrient treatments. From the pooled data, highest number of harvestable fruits/tree with 1090 numbers was observed in T<sub>9</sub> and lowest with 865 was observed in control. Finally, application of 0.8% ZnSO<sub>4</sub> + 0.4% Borax produced highest yield of 33.18 kg fruits per tree compared with 23.32 kg fruits per tree in control. Results regarding fruit yield are in accordance with those of other various researchers (Meena *et al.*, 2014) and (Chandra and Singh, 2015) in Aonla cv. NA-7.



**Table 7 :** Impact of various micro-nutrients on number of fruits/tree and yield of Aonla.

Treatment	Number of fruits/tree			Yield (kg/tree)		
	19-20	20-21	Pooled	19-20	20-21	Pooled
T <sub>1</sub>	810	920	865	20.72	25.92	23.32
T <sub>2</sub>	900	980	940	24.28	29.22	26.75
T <sub>3</sub>	910	990	950	24.89	29.82	27.35
T <sub>4</sub>	860	950	905	22.61	27.64	25.12
T <sub>5</sub>	880	960	920	23.56	28.38	25.97
T <sub>6</sub>	950	1030	990	26.31	31.59	28.95
T <sub>7</sub>	970	1070	1020	27.57	33.48	30.52
T <sub>8</sub>	1000	1100	1050	28.04	33.94	30.99
T <sub>9</sub>	1020	1160	1090	29.47	36.89	33.18
S.Em (±)	4.907	4.031	3.301	0.154	0.184	0.108
CD(0.05)	14.838	12.188	9.981	0.466	0.556	0.326

**Table 8 :** Impact of micro-nutrients on leaf zinc and boron content of Aonla.

Treatment	Leaf zinc (ppm)			Leaf boron (ppm)		
	19-20	20-21	Pooled data	19-20	20-21	Pooled data
T <sub>1</sub>	19.66	17.87	18.77	10.75	9.69	10.22
T <sub>2</sub>	30.11	31.94	31.03	11.05	10.03	10.54
T <sub>3</sub>	30.38	32.04	31.21	11.21	10.19	10.70
T <sub>4</sub>	19.84	18.05	18.95	19.27	21.06	20.17
T <sub>5</sub>	19.96	18.16	19.06	19.59	21.24	20.42
T <sub>6</sub>	31.07	33.99	32.53	19.83	21.68	20.76
T <sub>7</sub>	31.55	34.22	32.89	20.09	22.02	21.06
T <sub>8</sub>	31.98	34.81	33.40	19.97	21.85	20.91
T <sub>9</sub>	32.47	35.03	33.75	20.36	22.10	21.23
S.Em (±)	0.608	0.988	0.714	1.442	1.068	1.227
CD(0.05)	1.840	2.988	2.159	4.360	3.229	3.711

### Impact of micro-nutrients on nutrient status of leaf of Aonla plants

The information in Table 8 clearly showed that there were significant variation in leaf zinc and boron content due to various micro-nutrient treatments.

From the pooled analysis, highest zinc content (33.75 ppm) was observed in T<sub>9</sub> (0.8% ZnSO<sub>4</sub> + 0.4% Borax) and that was statistically at par with T<sub>8</sub>, T<sub>7</sub> as well as T<sub>6</sub>, whereas lowest value (18.77 ppm) was observed in T<sub>1</sub> followed by T<sub>4</sub> (0.2% Borax). Maximum leaf boron content (21.23 ppm) was recorded from T<sub>9</sub> whereas the minimum boron content (10.22 ppm) was observed under control. These observations are in confirmation with the findings of Singh *et al.* (2007). It was found that Zn is transferred through the phloem to another location of use based on the rise in Zn concentration in the petiole

(Kurešová *et al.*, 2010). Zn applied foliarly raised leaf Zn concentration by 50 per cent compared to control and B applied foliarly raised leaf B concentration by 75 per cent compared to control (Jeyabaskaran and Pandey, 2008).

### Conclusion

In the present investigation, micro-nutrient spray was done at fruit set (March-April) and pea stage (June-July) of fruit development. There were nine treatments with different dose of ZnSO<sub>4</sub> and borax. The micro-nutrient treatments had a substantial impact on plant growth parameters, physico-chemical parameters of fruits, yield parameters and leaf nutrient status of Aonla plants, in comparison to the controlled plants. Finally, this can be summarised from the investigation that application of either 0.8% ZnSO<sub>4</sub> + 0.4% Borax per plant or 0.8% ZnSO<sub>4</sub> + 0.2% Borax per plant improves yield as well as quality of Aonla plants in the Red-Laterite zone of West Bengal.

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### Author's contribution

Conceptualisation and designing of the research work (SD and KKM); Execution of field or lab experiments and data collection (SD, SD, SR and TM); Analysis of data and interpretation (SD, CM and SB); Preparation of manuscript (SD, MAH and KKM).

### Declaration

The authors do not have any conflict of interest.

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