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Response of Okra (*Abelmoschus esculentus* L.) to Foliar Application of Silicon

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A B S T R A C T

A field experiment was carried out, with a view to study the Response of okra (*Abelmoschus esculentus* L.) to foliar application of silicon at Vegetable Research Scheme, Regional Horticultural Research Station of the Navsari Agricultural University, Navsari, Gujarat, India between 2015 to 2017 during summer season. The experiment was conducted in Randomized Block Design with three repetitions. Foliar application of Orthosilicic acid and Oligomeric silicic acid + Boric acid (OSAB – Si plus) was given at 30, 45 and 60 DAS at 0.02, 0.04 and 0.06 percentage level. The results revealed that higher values for growth and yield characters namely, plant height, chlorophyll content, number of fruits per plant and fruit yield (kg/ha) were recorded higher Oligomeric silicic acid + Boric acid (OSAB – Si plus) at 0.02 percentage level during all the three years of experiment.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] popularly known as lady's finger, is believed to be a native of Ethiopia. It is herbaceous annual plant belongs to family Malvacae growing in warm season as well as rainy season of both tropical and subtropical regions of the world. Okra is extensively grown in India throughout the year for its tender non-fibrous edible fruit. It is very popular among the farmers because of easy in growing and has wider adaptability range. It has good nutritional value. Besides being a vegetable, it also has medicinal and industrial important. India is the largest producer of okra. It is mainly used for its tender green fruits as vegetable in many countries (Bayer and Kubitzki, 2003). Okra has a prominent position among vegetable fruits due to its high nutritive and medicinal value, ease of cultivation and wider adaptability to varying weathers (Reddy *et al.*, 2012).

Silicon (Si) constitutes 27.8% (w/w) in earth's crust which occurs as silica (SiO_2) and

silicates (SiO_3) but not in its elemental form (Ehrlich, 1981). Silicon content in soil ranges from < 1 to 45% by dry weight (Sommer *et al.,* 2006) while the silica (Si to SiO_2 - 2.1; Si to SiO_3 - 2.6) constitute 50-70% of the soil mass varying from less than 20% to almost 100%. All plants rooting in soil therefore contain silicon.

Yet it is considered as a plant nutrient "anomaly" as its essentiality for plants is not yet established (Epstein, 1994). But soluble silicon was found to enhance plant growth and yield of many crop plants, protect them from pests and diseases and hence accepted as an agronomically beneficial element (Epstein, 1999).The quantity of silicon removed from the world arable soils is estimated as 210-224 million tons annually (FAO, 1998). The usefulness of silicon in different spheres of human life was well elucidated (Vasanthi *et al.,* 2012). Objective of this research was to investigate the effect of foliar applicaton of silicon on overall performance of okra during the summer season.

Materials and Methods

The experiment was undertaken at the Vegetable Research Scheme, Regional Horticultural Research Station of the Navsari Agricultural University, Navsari, Gujarat, India during summer season of 2015 to 2017. The experiment was conducted in Randomized block design with three repetition. Details of the treatments are., T_1 - Orthosilicic acid 0.02 % (At 30,45 & 60 DAS), T_2 - Orthosilicic acid 0.04 % (At 30,45 & 60 DAS), T_3 - Orthosilicic acid 0.06 % (At 30,45 & 60 DAS), T_4- Oligomeric silicic acid and Boric acid (OSAB- Si Plus) 0.02 % (At 30,45 & 60 DAS), T_5-Oligomeric silicic acid and Boric acid (OSAB- Si Plus) 0.04 % (At 30,45 & 60 DAS), T_6-Oligomeric silicic acid and Boric acid (OSAB- Si Plus) 0.06 % (At 30,45 & 60 DAS) and T_7- Control. Furthermore during all three growing season sowing of okra was completed during second fortnight of February. All the recommended cultural practises and manure and fertilizer was given regularly.

For recording different field observations, five plants of okra from each net plot area were selected randomly in the beginning and tagged with the labels. Plant height was measured with help of meter tape at final harvest, number of fruits per plant of taaged plant count individually and yield (kg/ha) were worked out with the yield from net plot area.

Results and Discussion

The data presented in table 1 revealed that the application of OSAB- Si Plus (Oligomeric silicic acid and Boric acid at 0.02 %) at 30, 45 and 60 DAS recorded maximum plant height (88.79 cm, 87.26 cm, and 79.57 cm). Decreased in occurrence of diseases with foliar application of silicon fertilizer resulting in increased the plant height and growth of okra plants (Liu, 1997). Similar results in potato with application of silicon were reported by Luz *et al.,* (2008). In tomato silicon fertilizer application induced higher growth reported by Gowda *et al.,* (2015).

In case of chlorophyll content of okra same treatment OSAB – Si plus(Oligomeric silicic acid and Boric acid at 0.02 %) recorded higher chlorophyll content during all the three year of experiments (1.47, 1.38 and 1.20 mg/100 g, respectively). Similar results were observed by Liu (1997) with the application of silicon fertilizers increased the chlorophyll content in leaves of tomato plants. Similar results in tomato were also reported by Emrich *et al.,* (2011).

Treatment containing Oligomeric silicic acid and Boric acid at 0.02 % at 30, 45 and 60 DAS recorded better growth (Table 1).

Table.1 Effect of Silicon on growth characters of okra

Treatments	Plant height (cm)				Chlorophyll content mg/100g			
	2015	2016	2017	POOLED	2015	2016	2017	POOLED
T_1	82.93	81.32	71.45	78.57	1.15	1.03	0.68	0.95
T_2	81.59	78.94	71.95	77.49	1.03	0.84	0.63	0.83
T_3	79.82	79.76	73.46	77.68	0.99	0.95	0.74	0.89
T_4	88.79	87.26	79.57	85.21	1.47	1.38	1.20	1.35
T_5	80.11	80.01	70.21	76.77	1.34	1.25	1.01	1.20
T_6	77.64	75.78	71.42	74.95	1.02	0.80	0.69	0.84
T_7	64.88	64.68	67.86	65.80	0.70	0.67	0.57	0.65
S. Em ±	**4.47**	**4.22**	**3.57**	**2.30**	**0.03**	**0.06**	**0.04**	**0.03**
CD at 5%	**13.28**	**12.54**	**NS**	**6.50**	**0.09**	**0.18**	**0.12**	**0.08**
CV%	**11.26**	**10.79**	**9.87**	**10.38**	**5.35**	**12.26**	**10.21**	**9.72**

Table.2 Effect of Silicon on yield characters of okra

	Fruit per plant of okra				Fruit weight (g)				Yield (kg/ha)			
Treatments	2015	2016	2017	POOLED	2015	2016	2017	POOLED	2015	2016	2017	POOLED
T_1	15.87	13.79	9.21	12.96	161.68	135.13	105.39	134.07	11996.28	10009.62	7911.92	9972.61
T_2	14.77	13.59	9.23	12.53	148.13	128.54	100.81	125.83	11370.83	9521.29	7553.30	9481.81
T_3	13.07	13.34	11.09	12.50	132.13	131.50	116.52	126.72	9632.28	9740.36	8524.30	9298.98
T_4	19.92	17.24	15.19	17.45	201.81	177.50	161.58	180.30	14968.50	13148.32	11996.73	13371.18
T_5	17.42	16.08	12.30	15.27	176.58	171.00	132.08	159.89	13099.99	12666.47	9941.97	11902.81
T_6	13.77	13.34	10.39	12.50	140.83	120.51	114.47	125.27	10451.84	8926.66	8410.54	9263.01
T_7	11.17	11.08	9.05	10.44	113.71	106.81	99.23	106.58	8192.34	7912.03	7239.30	7781.22
S. Em ±	**0.84**	**0.69**	**0.54**	**0.40**	**8.31**	**6.40**	**5.90**	**3.90**	**618.04**	**474.18**	**478.92**	**295.63**
CD at 5%	**2.50**	**2.06**	**1.60**	**1.13**	**24.68**	**19.02**	**17.52**	**11.04**	**1836.30**	**1408.87**	**1422.94**	**836.30**
CV%	**11.12**	**9.86**	**9.88**	**10.39**	**10.82**	**9.23**	**9.94**	**9.88**	**10.85**	**9.23**	**10.89**	**10.09**

The increase in growth parameter due to the stimulation of growth by silicon could be either indirect, owing to the protective effects of silicon against pathogens or direct as it impacts both morphological changes and physiological processes in plants. It seems that it is involved directly or indirectly in cell metabolism (Liang *et al.,* 1993). Adatia and Besford (1986) and Seung *et al.,* (2005) reported the increased plant height with the application of silica as salicylic acid in cucumber. Similar findings were also reported by Elawad *et al.,* (1982), Savant *et al.,* (1999) and Yoshida (1975) in zinnia.

Yield parameters (Table 2) *viz.,* number of fruits per plant (19.92,17.24 and 15.19), fruit weight (201.81 g, 177.50g and 161.58 g) as well as yield kg/ha (14968.50, 13148.32 and 11996.73) during all the three respective years (2015,2016 and 2017) were found maximum in treatment T_4 (Oligomeric silicic acid and Boric acid at 0.02 %) at 30, 45 and 60 DAS.

Silicon is still not consider as essential element, positive effect has been reported in case of increase in yield, enhanced pollination and most commonly increased disease resistance has been very well presented in melons (Gilman *et al.,* 2003).Similarly, Tesfagioris *et al.,* (2008) reported that increased plant yield with the application silicon base chemicals results in maximum growth in Zucchini and Zinnia by decreasing the disease incidence. Aziz *et al.,* (2001) reported that increased pollen fertility in melon plants with the application of silica resulting in more yield.

Furthermore promotional effect of the foliar application of silicon on growth and yield characters of okra found in this research, may be related to the direct effect of silicon on plant resistance to both biotic and abiotic stress including drought (Glenn *et al.,* 2002 and Creamer *et al.,* 2005). Slicon was also reported to alleviate water stress by its reduction effect on the diameter of stomatal pores (Efimova and Dokynchan, 1986) which in turns, reduces transpiration rate resulting in reduction in water loss. Another possible effect of silicon in the improvement in the efficiency of osmotic adjustment of plant tissues (Romero-Aranda and Cuartero, 2006). Silicon playes key role in retaining the water capacity of stressed cells, which thereby can tolerate severe drought (Crusciol *et al.,* 2009). Silicon was reported to enhance rigidity, strengthening and elasticity of cell wall also it promotes plant growth by correcting the cytokinnins under stress conditions (Hanafy *et al.,* 2008).

The study investigated the response of okra to foliar application of silicon on growth and yield characters of okra. Among the all treatments, T_4 - Oligomeric silicic acid and Boric acid (OSAB - Si Plus) 0.02 % (At 30, 45 & 60 DAS) were found best.

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