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Effect of foliar application of silicon on okra (*Abelmoschus esculentus* L.)

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Abstract
A field experiment was carried out, with a view to study the effect foliar application of silicon on okra (*Abelmoschus esculentus* L.) 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.

Keywords: Okra, Orthosilicic acid and OSAB – Si plus

Introduction
Latin binomial names for okra are *Abelmoschus esculentus* and *Hibiscus esculentus* (Kumar *et al.*, 2010) [1], and it is commonly known as bhindi in India. It probably originated in Ethiopia and is widely spread all over tropical, subtropical and warm temperate regions of the world. Okra plays an important role in the human diet by supplying fats, proteins, carbohydrates, minerals and vitamins. 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) [2].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) [3].

There are contradictory opinions on the effects of Si in the plant. This is partly due to the unpredictable and limited absorption and uptake of Si by the plant. Nevertheless there is increasing proof that Si has many beneficial roles in crop performance. Silicon (Si) after oxygen is the most common element of the earth's crust. Silicon is present in almost any soil type, mainly as silicates, silicon dioxide, (mono- and poly) silicic acid and biogenic silica, but only monosilicic acid ($Si(OH)_4$) is plant available, but its concentration is very low due to its instability. The solubility of monosilicic acid can be decreased by interactions with heavy metals, iron, aluminium and manganese. Due to these factors, there is a silicic acid deficiency in many types of soil. So far Si-fertilizers (like silicates, diatomaceous earth and biogenic silica sources such as rice-hull ash), orthosilicic acid are used as an indirect source of silicic acid for increasing growth and yield. By transformation from these silicon sources monosilicic acid is formed and taken up by the roots, transported via the xylem in the transpiration stream and distributed within plant tissues. In leaf sheaths and leaf blades silicic acid polymerizes into amorphous silica, which is deposited into the cell wall, cell lumen, intracellular spaces and trichomes increasing tissue strength. Although the dry weight of Si in the dry matter of plants ranges from <0.1% to >10%, Silicic acid uptake by the plant is mainly an active process mediated by specific transporters. Physiological studies have shown that the differences in Si uptake and accumulation result from the capacity of the roots to absorb silicic acid. Based on their Si content plants have been classified as Si accumulator, intermediate-type and excluder species. Besides this Silicon plays an important role in increasing the uptake and transport of nutrients like nitrogen, phosphorous, potassium, calcium and magnesium thus increasing the concentration of these nutrients in leaves and fruits thereby resulting in higher yield of superior quality fruits with prolonged storability.

Silicon (Si) constitute 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) [4]. Silicon content in soil ranges from < 1 to 45% by dry weight (Sommer *et al.*, 2006) [5] 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) [6]. 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) [7].The quantity of silicon removed from the world arable soils is estimated as 210-224 million tons annually (FAO, 1998) [8]. The usefulness of silicon in different spheres of human life was well elucidated (Vasanthi *et al.,* 2012) [9].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 occurance of diseases with foliar application of silicon fertilizer resulting in increased the plant height and growth of okra plants. (Liu, 1997) [10]. Similar results in potato with application of silicon was reported by Luz *et al*., (2008) [11]. In tomato silicon fertilizer application induced higher growth reported by Gowda *et al.,* (2015) [12]. 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) [13].

Treatment containing Oligomeric silicic acid and Boric acid at 0.02% at 30, 45 and 60 DAS recorded better growth (Table 1). 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) [14]. Adatia and Besford (1986) [15] and Seung *et al.,* (2005) [16] 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) [17], Savant *et al*., (1999) [18] and Yoshida (1975) [19] in zinnia.

Yield parameters (Table 2) *viz.*, number of fruits per plant (19.92, 17.24 and 15.19), fruit weight (201.81 g, 177.50 g 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) [20]. Similarly, Tesfagioris *et al.,* (2008) [21] 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) [22] reported that increased pollen fertility in melon plants with the application of silica resulting in more yield.

Further more 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 [23] and Creamer *et al.*, 2005) [24]. Slicon was also reported to alleviate water stress by its reduction effect on the diameter of stomatal pores (Efimova and Dokynchan, 1986) [25] 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) [26].Silicon playes key role in retaining the water capacity of stressed cells, which thereby can tolerate severe drought (Crusciol *et al*., 2009) [27]. Silicon was reported to enhance rigidity, strenthning and elasticity of cell wall also it promotes plant growth by correcting the cytokinnins under stress conditions (Hanafy *et al.*, 2008) [28].

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

Treatments	Fruit per plant of okra				Fruit weight (g)				Yield (kg/ha)			
	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

Conclusion

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.

References

1. Kumar S, Dagnoko S, Haougui A, Ratnadass A, Pasternak D, Kouame C. Okra (*Abelmoschus spp.*) in West and Central Africa: potential and progress on its improvement. African J Agric. Res. 2010; 5:3590-3598.
2. Bayer C, Kubitzki K. Malvaceae. In: The Families and Genera of Vascular Plants. Flowering Plants Dicotyledons, K. Kubitzki (ed.). Springer, Berlin Heidelberg, 2003; V: 225-311.
3. Reddy MT, Haribabu K, Ganesh M, Reddy KC, Begum H. Genetic divergence analysis of indigenous and exotic collections of okra [*Abelmoschus esculentus* (L.) Moench]. J Agric. Tech. 2012; 28:611-23.
4. Ehrlich HL. Geomicrobiology. Marcel Dekker Inc., Newyork, 1981, 393p.
5. Sommer MD, Fuzyakov, Breuer J. Silicon pools and fluxes in soils and landscapes-a review. J Plant Nutr. Soil Sci. 2006; 169:310-329.
6. Epstein E. The anomaly of silicon in plant biology. Proc. Natl. Acad.Sci. USA. 1994; 91:11-17.
7. Epstein E. Silicon. Annu. Rev. Pl. Physiol. Mol. Biol. 1999; 50:641-664.
8. FAO. World Agricultural Center, FAOSTAT agricultural statistic data – base gateway, 1998.
9. Vasanthi N, Saleena LM, Anthoni Raj S. Silicon in day today life. World J. Appl. Sci. 2012; 17:1425-1440.
10. Liu HY. Preliminary report on effect of silicon fertilizers on tomato growth. J. of guaizhou Agri. 1997; 16:76-77.
11. Luz JM, Rodrigues CR, Goncalves MV, Coelho L. The effect of silicate on potatoes in minas gerais, Brazil. IV Silicon in Agriculture Conference, 2008, 48p.
12. Gowda DC, Lingaiah HB, Nachegowda V, Anil Kumar S. Effect of speciality fertilizers on growth and yield of tomato (*Solanum Lycopersicon* L.). Plant Archives. 2015; 15(01):335-338.
13. Liu HY. Preliminary report on effect of silicon fertilizers on tomato growth. J of guaizhou Agri. 1997; 16:76-77.
14. Emrich EB, Souza RJ, De Lima AA, De Figueiredo FC, Silva DRG. Cultivation of tomato in organic substrates under leaf spraying of potassium silicate in protected environment. CIENCIA E Agrotecnologia. 2011; 35(1):56-61.
15. Liang YC, Chen XM, Ma TS, Liu LR. Effect of silicon on growth, yield and quality of tomato. Agri. Sci. 1993; 4:48-50.
16. Adatia MH, Besford RT. The effect of silicon in cucumber plants grown in re-circulating nutrient solution. Annals of Botany. 1986; 58:43-351.
17. Elawad SH, Street JJ, Gascho GJ. Response of sugarcane to silicate source and rate of growth and yield, 1982.
18. Savant NK, Korndorfer GH, Datnoff LE, Gii. Silicon nutrition and sugarcane production. J of Plant Nutri. 1999; 22:1853-1903.
19. Yoshida S. Effects of silica and nitrogen supply on some characters of the rice plant. Plant and Soil. 1975; 31:4856.
20. Gilman JH, Zlesak DC, Smith JA. Application of potassium silicate decrease black spot infection in Rosa hybrida. Hort Sci. 2003; 38:44-1147.
21. Tesfagiorgis HB, Laing MD, Morris MJ. Uptake and distribution of silicon on zucchini and zinnia and its interaction with other elements. IV Silicon in Agriculture Conference, 2008, 101p.
22. Aziz TM, Akhtar MS, Ahmed I. Differential growth response of cotton genotypes infected with root rot to silicon nutrition. Pakistan J of Soil Sci. 2001; 20:101-108.
23. Glenn DM, Prado E, Erez A, McFerson J, Puterka GJ. A reflective, processed-kaolin particle film affects fruit temperature, radiation reflection, and solar injury in apple. J Amer. Soc. Hort. Sci. 2002; 27:188-193.
24. Creamer R, Sanogo S, El-Sebai OA. Kaolin-based foliar reflectant affects physiology and incidence of beet curly top virus but not yield of Chile pepper. Hort Sci. 2005; 40(3):574-576.
25. Efimova GV, Dokynchan SA. Anatomo-morphological construction of epidermal tissue of rice leaves and increasing of its protection function under silicon effect. Agric. Biol. 1986; 3:57-61.
26. Romero-Aranda MR, Cuartero OJJ. Silicon alleviates the deleterious salt effect on tomato plant growth by improving plant water status. J Plant Physi. 2006; 163:847-855.
27. Crucicol CAC, Pulz AL, Lemos LB, Soratto RP, Lima GPP. Effects of silicon and drought stress on tuber yield

and leaf biochemical characteristics in potato. Crop Physiology and Metabolism. 2009; 49:949-954.

28. Hanafy AH, Harb EM, Higazy MA, Morgan SH. Effect of silicon and boron foliar applications on wheat plants grown under saline soil conditions. Int. J Agric. Res. 2008; 3(1):1-26.