The Bioscan 9(1): 159-162, 2014
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

RESPONSE OF SOIL AND FOLIAR APPLICATION OF SILICON AND MICRO NUTRIENTS ON LEAF NUTRIENT STATUS OF SAPOTA

K. A. LALITHYA*, H. P. BHAGYA, K. BHARATHI AND KULAPATI HIPPARAGI
K. R. C. College of Horticulture,
Arabhavi - 591 218, Gokak, U.H.S., Bagalkot, INDIA
e-mail: kalalithya0@gmail.com

KEYWORDS
Sapota
Leaf
Nutrient status
Foliar spray
Silicon

Received on :
20.08.2013

Accepted on :
11.01.2014

***Corresponding author**

ABSTRACT

The field experiment was conducted to know the response of soil and foliar application of silicon and micronutrients on nutrient status of sapota at College of Horticulture Mudigere, Chikamagalur district during the year 2010-2012. Silicon sources like potassium silicate and calcium silicate and micronutrient contents like solubor and kiecite –G were used. Macro nutrients like nitrogen (1.583 %), phosphorous (0.175 %) and the potassium (1.20 %) and silicon content (1.20 %) in leaf were recorded highest with potassium silicate spray with 8 ml per litre. Whereas micronutrient content has not increased considerably with respect to application of silicon sources. The maximum content of iron (179.89 ppm), copper (7.61 ppm), zinc (35.13 ppm) and manganese (91.16 ppm) was recorded in the leaf due to foliar spray of micronutrients at 4 ml per litre. As macro nutrient and silicon content was more in the treatment with foliar application of potassium silicate at 8 ml per litre resulted in more yield and quality of fruits.

INTRODUCTION

Silicon is considered as an important beneficial element as it helps in growth and development of plant. Most of the plants absorb silicon in the form of monosilicic acid ($Si(OH)_4$). Cereals and grasses contain 0.2 - 2.0 per cent Si, where as dicotyledons accumulate 1/10th of its concentration. Si is deposited in the walls of epidermal cells after absorption by the plants, contributes considerably to stem strength. Silicic acid is not much mobile element in plants (Savant *et al.,* 1999). Therefore a continued supply of this element would be required particularly for healthy and productive development of plant during all growth stages (Yoshida, 1975).

Silicon is not considered as an essential element, but it has positive growth effect including increased dry mass and yield, enhanced pollination and most commonly increased disease resistance (Gillman *et al.,* 2003). The role of silicon in plant biology is known to multiple stresses including biotic and abiotic stresses. It is also known to increase drought tolerance in plants by maintaining plant water balance, photosynthetic activity, erectness of leaves and structure of xylem vessels under transpiration rates (Melo *et al*., 2003).

Silicon is known to effectively mitigate various abiotic stresses such as manganese, aluminium and heavy metal toxicities, salinity, drought, chilling and freezing stresses (Liang *et al*., 2007). Matoh *et al*. (1991) observed improved water economy and dry matter yield with Si application and further it enhanced leaf water potential under water stress conditions, reduced incidence of micronutrient and metal toxicity. Three contrasted genotypes of *Musa* sp. like *M. acuminata* cv. Grande Naine, *M. acuminata* sp. Banksii and *M. balbisiana* sp. Tani were grown for 6 weeks under optimal conditions in hydroponics and were subjected to a wide range of Si supply (0-1.66 mM Si) to quantify the Si uptake and distribution in banana, as well as the effect of Si on banana growth. The rate of Si uptake and the Si concentration in plant tissues increased markedly with the Si supply (Henriet *et al*., 2006).

The foliar application of macro and micro-nutrients have very important role in improving fruit set, productivity and quality of fruits. It has also beneficial role in 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 shown significant response to improve yield and quality of fruits (Kumar and Verma, 2004). Kinnow mandarin trees were sprayed with manganese (0.5 %), zinc (0.5 %) and magnesium (0.5 %) and the performance of the treated plants were compared with untreated plants Dhinesh Babu *et al*. (2005).

Therefore, based on the possible benefits of silicon and micro nutrients, the present study was planned to know the response of soil and foliar application of silicon and micro nutrients on the following objective.

To study the nutrient content in sapota leaf as influenced by application of Silicon and micro nutrients.

MATERIALS AND METHODS

Experimental site was located in the hilly region of Karnataka at 13°7′ North latitude, 75°57′ East longitude and is at an altitude of 982 meter above the mean sea level. The average annual rainfall of an area is 2400 mm. The average maximum temperature of the location is 33°C and the average minimum temperature is 10°C and the relative humidity ranges from 60 to 90 per cent.

Experimental details

Field experiments were conducted at College of Horticulture, Mudigere Chikamagalur District during 2010-2012. Experiments were laid out in Randomized Complete Block Design with eleven treatments *viz.,* T_1: control (no silicon application), T_2: Potassium silicate (foliar applicaton) at 6 ml per litre, T_3: Potassium silicate (foliar applicaton) at 8 ml per litre, T_4: Calcium silicate (soil application) with 1 kg per tree, T_5: Calcium silicate (soil application) with 1.5 kg per tree, T_6: Calcium silicate (soil application) with 2.0 kg per tree, T_7: Calcium silicate (soil application) with 2.5 kg per tree, T_8: boron (foliar application) at 2 g per litre, T_9: boron (foliar application) at 3 g per litre, T_{10}: micronutrients (foliar application) at 3 ml per litre and T_{11}: micronutrients (foliar application) at 4 ml per litre.

Leaf analysis

Leaf sampling and processing

Sapota leaves (20-30) were collected from the basal 10th leaf of the shoot all around the tree canopy in each treatment at harvest period. Leaf samples were taken to the laboratory and processed. Leaf samples were washed in detergent followed by tap water and distilled water. Leaves were shade dried and then dried in hot air oven at 70°C for 48 hours. The dried leaves were grounded to fine powder by using mixer and stored in air tight butter paper bags for nutrient analysis.

The leaf samples were analysed for total nitrogen, phosphorous, potassium, calcium, magnesium, micronutrients like iron, zinc, copper, manganese, boron and silicon content in leaf by following standard methods of analysis.

Estimation of total nitrogen, phosphorous and potassium were analyzed as per the procedure given by Jackson, 1973. Calcium and magnesium were analysed as per the procedure given by Jackson, 1967. Micronutrients were estimated by directly feeding the filtered Di or tri acid extract of the plant sample to a calibrated atomic absorption spectrophotometer using respective hollow cathode lamps for each element (Fe, Zn, Mn, Cu). Micronutrient concentration was expressed in parts per million (ppm) on dry weight basis (Page *et al*., 1982).

Estimation of silicon

The sample (0.1g) was digested in a mixture of 7 ml of HNO_3 (70%), 2 ml of H_2O_2 (3%) and 1ml of HF (40%) (Tri acid mixture) using microwave digesting system for 40 min. The digested samples were diluted with 50ml with 4 per cent boric acid (Ma and Takahashi, 2002).

The silicon concentration in the digested solution was determined by transferring 0.5 ml of digested aliquot to a centrifuge tube and added with 1.5 ml of 0.2N HCl (Hydrochloric acid), 0.5 ml of 10 per cent ammonium molybdate and 0.5 ml of 20 per cent tartaric acid and 0.5 ml of reducing agent ANSA (Amino Napthol Sulphonic Acid) was added and the volume was made up to 12.5 ml with distilled water. After one hour, the absorbance was measured at 600 nm with an ultraviolet visible spectrophotometer. Standard solutions with concentration of 0, 0.2, 0.4, 0.8 and 1.2 ppm were prepared by following procedure.

$$\mathrm{Si(\%)} = \frac{\text{Gram ppm} \times \text{Vol. made up after digestion} \times \text{Vol. made up of Aliquot}}{\text{Weight of sample} \times \text{Alquot taken}} \times 100$$

Statistical analysis of experimental data

The experimental data collected relating to different parameters were statistically analysed as described by Sundar Raj *et al.* (1972) and the results were tested at 5 per cent level of significance by Fischer method of analysis of variance.

RESULTS AND DISCUSSION

The highest nitrogen content in the leaf (1.583 %) was observed in treatment with foliar application of potassium silicate at 8 ml per litre (Table 1). Silicon application avoided leaching loss of N and thus helped in more accumulation of nitrogen in leaf. Similar results were observed by Stamatakis *et al.* (2003) in tomato and Kamenidou *et al.* (2008) in ornamental sunflower.

The highest phosphorous content in the leaf (0.175 %) was recorded in treatment with foliar application of potassium silicate at 8 ml per litre and (Table 1). Silicon rendered more P available to the plants reversing its fixation as silicon itself competed for P fixation and thus slowly released P helped in more accumulation of P content in leaf. The above results are in conformity with the findings of Nesreen *et al.* (2011) in beans and Kamenidou *et al.* (2008) in ornamental sunflower.

The highest potassium content in the leaf (1.20 %) was recorded in treatment with foliar application of potassium silicate at 8 ml per litre (Table 1). This might be due to more accumulation of potassium in leaf content. Potassium silicate recorded more per cent of potassium compared to calcium silicate as solution contained potassium along with silicon. Similar results were made by Kamenidou *et al.* (2008) in ornamental sunflower. Nesreen *et al.* (2011) revealed that based on usage of silicon sources increased the nutrient content like magnesium silicate solution gave the highest values of N percentage and P percentage in contrast to which potassium silicate gave the highest K percentage values in plant tissue.

According to Regan and Peter (2011), the improved soil retention and plant uptake of key nutrients indicated the potential use of Agri Power Silica to displace a significant portion of NPK fertilisers. Silicon can help in reducing urea and phosphate inputs thereby reducing costs and significantly reducing the environmental impact of these fertilisers.

The highest calcium content in the leaf (1.140 %) was recorded in treatment with soil application of calcium silicate at 2.5 kg per tree) (Table 1). Calcium silicate as it contain calcium resulted in more uptake of calcium and silicon also helped in uptake of calcium and thus resulted in more accumulation of calcium in leaf. Similar observations were made by Stamatakis *et al.* (2003) in tomato and Prado and Natale (2005) in passionfruit.

The magnesium content in leaf (1.115%) varied significantly

Table 1: Effect of soil and foliar application of silicon and micro nutrients on nutrient content of sapota leaf at the stage of fruit harvest

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
T_1- Control	1.370	0.128	0.085	0.716	0.193
T_2- Foliar application of potassium silicate @ 6 ml/l	1.553	0.174	1.166	1.016	0.253
T_3- Foliar application of potassium silicate @ 8 ml/l	1.583	0.175	1.200	1.043	0.276
T_4- Soil application of calcium silicate @ 1.0 kg/tree	1.466	0.151	1.123	1.076	0.280
T_5- Soil application of calcium silicate @ 1.5 kg/tree	1.473	0.156	1.130	1.080	0.306
T_6- Soil application of calcium silicate @ 2.0 kg/tree	1.500	0.158	1.136	1.096	0.316
T_7- Soil application of calcium silicate @ 2.5 kg/tree	1.533	0.161	1.140	1.115	0.346
T_8- Foliar application of boron @ 2 g/l	1.446	0.143	0.956	0.960	0.203
T_9- Foliar application of boron @ 3 g/l	1.396	0.131	0.940	0.833	0.220
T_{10}- Foliar application of micronutrients @ 3 ml/l	1.426	0.148	1.050	0.976	0.243
T_{11}- Foliar application of micronutrients @ 4 ml/l	1.450	0.150	1.066	1.050	0.250
F-test	*	*	*	*	*
SEm ±	0.027	0.005	0.054	0.026	0.010
CD at 5%	0.080	0.016	0.161	0.076	0.029

* - Significant, NS - Non-significant

Table 2: Effect of soil and foliar application of silicon and micro nutrients on micro nutrients and silicon content of sapota leaf at the stage of fruit harvest

Treatment	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)	B (ppm)	Silicon (%)
T_1- Control	130.99	3.98	15.13	74.08	39.33	0.85
T_2- Foliar application of potassium silicate @ 6 ml/l	156.20	6.20	22.33	60.77	39.66	1.16
T_3- Foliar application of potassium silicate @ 8 ml/l	159.27	6.39	24.65	57.04	40.80	1.20
T_4- Soil application of calcium silicate @ 1.0 kg/tree	141.35	4.80	19.50	72.94	39.50	0.80
T_5- Soil application of calcium silicate @ 1.5 kg/tree	145.51	4.93	20.01	68.31	39.66	0.90
T_6- Soil application of calcium silicate @ 2.0 kg/tree	147.69	5.00	20.65	65.50	39.71	1.05
T_7- Soil application of calcium silicate @ 2.5 kg/tree	149.97	5.03	21.21	63.00	39.85	1.10
T_8- Foliar application of boron @ 2 g/l	139.92	4.31	17.86	81.57	42.00	0.80
T_9- Foliar application of boron @ 3 g/l	138.45	4.06	15.71	78.50	43.33	0.85
T_{10}- Foliar application of micronutrients @ 3 ml/l	178.56	6.70	31.58	89.45	41.83	0.80
T_{11}- Foliar application of micronutrients @ 4 ml/l	179.89	7.16	35.13	91.16	43.16	0.85
F-test	*	*	*	*	NS	*
SEm ±	2.10	0.19	1.09	1.35	1.25	0.07
CD at 5%	6.19	0.58	3.23	3.99	3.71	0.23

* - Significant, NS - Non-significant

among the treatments (Table 1). Calcium silicate contained magnesium along with calcium and thus resulted in more uptake of magnesium by leaf. Silicon also helped in uptake of magnesium. Results are in accordance with Stamatakis *et al.* (2003) in tomato.

The maximum iron content in leaf (179.89 ppm) was recorded in the treatment with foliar spray of micro nutrients with 4 ml per litre (Table 2). Application of micronutrients increased the concentration of iron as it was supplied through micronutrient spray. Application of silicon also helped in uptake of iron. The results are in conformity with findings of Kamenidou *et al.* (2008) in ornamental sunflower and Kamenidou *et al.* (2010) in gerbera.

Maximum copper content in leaf (7.16 ppm) was recorded in treatment with foliar spray of micro nutrients at 4 ml per litre (Table 2). Application of micronutrients increased the concentration of copper as it was supplied through micronutrient spray. Whereas, the leaf concentrations of copper were slightly increased among silicon supplemented plants. Results are in accordance with Kamenidou *et al.* (2010) in gerbera. Frantz *et al.* (2010) investigated that zinnia showed a reduction in PAL (phenylalanine ammonia lyase, a stress-induced enzyme) activity, suggesting Copper stress decreases in tissue exposed to supplemental Si.

The zinc content (35.13 ppm) was found maximum in the leaf due to foliar spray of micronutrients at 4 ml per litre (Table 2). Application of micronutrients increased the concentration of zinc as zinc was supplied through micronutrient spray. Leaf concentrations of copper were slightly increased in plants which were supplemented with silicon. Similar observations were made by Kamenidou *et al.* (2008) in ornamental sunflower.

The manganese content in the leaf (91.16 ppm) was found highest in the leaf due to foliar spray of micronutrients at 4 ml per litre (Table 2). Manganese deficiency was observed in silicon treated plants due to decrease in Mn uptake with application of silicon. Similar results were observed by Kamenidou *et al.* (2008) in ornamental sunflower.

The content of silicon in leaf (1.20 %) was found to be high due to foliar spray of potassium silicate at 8 ml per litre (Table 2). The results are in conformity with findings of Vladimir *et al.* (2001) in citrus and Ma and Yamaji (2006) in rice and Milne *et al.* (2012) in lettuce. The application of silicon fertilizer improved the lettuce nutritional status for Si and increased the percentage of healthy leaves (Ferreira *et al.*, 2010).

In conclusion the result of this study highlights the role of silicon and micronutrients in improving nutrient content in sapota. By using potassium silicate at 8 ml per litre helped in more utilization of macro nutrients and thus resulted in obtaining more yield and quality of sapota.

REFERENCES

Dhinesh Babu, K., Dubey, A. K. and Yadav, D. S. 2007. Effect of micronurtients on enhancing the productivity and quality of kinnow mandarin. *Indian J. Hort.* **64(3):** 353-356.

Ferreira, R. L. F., Souza, R. J. D. E., Carvalho, J. G. D. E., Araujo neto, S. E. D. E., Mendonca, V. and Wadt, P. G. S. 2010. Evaluation of lettuce cultivars fertilized with calcium silicate in greenhouse. *Ciencia e Agrotecnologia.* **34(5):** 1093-1101.

Frantz, J., Locke, J. C., Sturtz, D. S. and Leisner, S. 2010. Silicon in ornamental crops: detection, delivery, and function. *Silicio na Agricultura*. pp. 111-134.

Gillman, J. H., Zlesak, D. C. and Smith, J. A. 2003. Applications of potassium silicate decrease black spot infection in *Rosa hybrida* 'Meipelta'. *Hort Sci.* **38(6):** 1144-1147.

Henriet, C., Draye, X., Oppitz, I., Swennen, R. and Delvaux, B. 2006. Effects, distribution and uptake of silicon in banana (Musa spp.) under controlled conditions. *Pl. Soil*. **287:** 359-374.

Jackson, M. L. 1967. Soil chemical analysis, Printic Hall of India. Pvt. Ltd. New Delhi.

Jackson, M. L. 1973. Soil chemical analysis, Printic Hall of India. Pvt. Ltd. New Delhi.

Kamenidou, S., Cavins, T. J. and Marek, S. 2010. Silicon supplements affect floricultural quality traits and elemental nutrient concentrations of greenhouse produced gerbera. *Scientia Hort.* **123(3):** 390-394.

Kamenidou, S., Cavins, T. J. and Marek, S. 2008. Silicon supplements affect horticultural traits of greenhouse-produced ornamental sunflowers. *Hort. Sci.* **43(1):** 236-239.

Kumar, S. and Verma, D. K. 2004. Effect of micro-nutrients and NAA on yield and quality of litchi cv. Dehradun. Proceedings of International Sem. on Recent Trend in Hi-tech Horticulture and Post Harvest Tech. pp.193.

Liang, Y., Sun, W., Zhu, Y. G. AND Christie, P. 2007. Mechanisms of silicon-mediated alleviation of abiotic stresses in higher plants: A review. *Environmental Pollution*. **147**: 422-428.

Ma, J. F. and Takahashi, E. 2002. In: Soil, fertilizer and plant silicon research in Japan. Elsevier, Amsterdam. pp.1-20.

Ma, J. F. and Yamaji, N. 2006. Silicon uptake and accumulation in higher plants. *Trends in Plant Science*. **11(8).**

Matoh, T. S., Murata and Takahashi, E. 1991. Effect of silicate application on photosynthesis of rice plants. *J. Soil Sci. Pl. Nutr*. **62:** 248-251.

Melo, S. P., Korndorfer, G. H., Korndorfer, C. M., Lana, R. M. and Santan, D. G. 2003. Silicon accumulation and water deficient tolerance in grasses. *Scientia Agricola*. **60:** 755-759.

Milne, C. J. I., Laubscher, C. P. I. and Ndakidemi, P. A. 2012. The alleviation of salinity induced stress with applications of silicon in soilless grown *Lactuca sativa* L. 'Eish'. *International J. Physical Sci.* **7(5):** 735-742.

Nesreen, H. Abou-baker, Abd-eladl, M. and Mohsen, M. Abbas. 2011. Use of silicate and different cultivation practices in alleviating salt stress effect on bean plants. *Australian J. Basic and Applied Sci.* **5(9):** 769-781.

Page, A. L., Miller, R. H. and Keeney, D. R. 1982. Methods of soil analysis, Part-2: Chemical and microbiological properties (2nd Edn.). American Soc. Agronomy and Soil Sci. Soc., America Inc., Publs., Madison, Wilconsin, USA.

Prado, R. De. M. and Natale, W. 2005. Effect of application of calcium silicate on growth, nutritional status and dry matter production of passion fruit seedlings. Revista Brasileira de Engenharia Agricola e Ambiental. **9(2):** 185-190.

Regan Crooks and Peter prentice. 2011. The benefits of silicon fertiliser for sustainably increasing crop productivity. The 5th Intl. Conf. on Silicon in Agric., Beijing, pp. 1-18.

Savant, N. K., Korndorfer, G. H., Datnoff, L. E. and Gii. 1999. Silicon nutrition and sugarcane production: A review. *J. Pl. Nutr.* **22:** 1853-1903.

Stamatakis, A., Papadantonakis, N., Lydakis-Simantiris, N., Kefalas, P. and Savvas, D. 2003. Effects of silicon and salinity on fruit yield and quality of tomato grown hydroponically. *Acta Hort.* **609:** 141-147.

Sundar Raj, N., Nagaraj, S., Venkataramu, M. N. and Jagannath, M. K. 1972. Design and analysis of field experiments, *Univ. Agric. Sci.* pp. 106-110.

Vladimir Matchinkov, Elena Bocharnikova and David Calvert. 2001. Response of citrus to silicon soil amendments. *Proc. Fla. State Hort. Soc.* **114:** 94-97.

Yoshida, S. 1975. Effects of silica and nitrogen supply on some characters of the rice plant. *Pl. Soil.* **31:** 48-56.