Mysore J. Agric. Sci., 52 (1) : 29-35, 2018

Influence of Soil Application of Silica and Major Nutrients on Leaf and Pulp Nutrient Status of Mango (*Mangifera indica* L.) cv.Kesar

A. VIDYA AND G. S. K. SWAMY
Department of Horticulture, College of Agriculture, UAS, GKVK, Bangalore - 560 065
E-mail : vidyaaswath18@gmail.com

ABSTRACT

A study was conducted to know the influence of soil application of silica and major nutrients on the nutrient status of mango at KRCCH, Arabhavi, Belgaum district. Silica source like Diatomaceous earth (DE) major nutrients contents like urea, single super phosphate and murate of potash was used. Major nutrients like nitrogen (1.51, 2.57 and 2.04 %), phosphorous (0.14, 0.19 and 0.17 %), potassium (0.78,0.89 and 0.79 %) and the silica (2.49, 2.87 and 2.67%) content in leaf were recorded highest with RDF + silica 900 kg/ha, during 2012, 2013 and their pooled data. The treatment also recorded maximum content of nitrogen (3.80, 3.50 and 3.57 %), K (4.17, 4.00 and 4.09 %) and Ca (0.64, 0.66 and 0.60%) were recorded in the leaf. The highest nitrogen content in the pulp (3.80, 3.50 and 3.57%) with soil application of DE at T_7 (RDF + DE 300 kg/ha) and minimum with control (2.87, 2.96 and 2.92%) during 2012 and 2013 and for pooled data, respectively. Treatment with RDF + DE 300 kg/ha resulted in more yield and quality of fruits.

Keynote : : DE (Silicon), mango pulp, mango leaf, major nutrients, RDF

SILICA 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 for 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 high 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. The rate of Si uptake and the Si concentration in plant tissues of banana increased markedly with the Si supply (Henriet *et al.*, 2006). Therefore, based on the possible benefits of silica and major nutrients the present study was undertaken to know the response of soil application of silica along with the major nutrients on leaf nutrient and pulp nutrient content of mango.

MATERIAL AND METHODS

Experimental site was located at Arabhavi which is situated in Northern dry zone (zone-3) of Karnataka state. It lies between 16^0 15' North latitude and 74^0 45' East longitudes with an altitude of 612 m above mean sea level. The mean annual rainfall of this area is about 530 mm distributed over a period of five to six months (June-November) with prominent peaks during July to October. The experiment was laid out on black cotton soils having a depth of 150 cm to 200 cm.

Experimental details

Field experiments were conducted at K R C College of Horticulture, Arabhavi Belgaum district during 2012 and 2013. Experiments were laid out in Randomized Complete Block

Design with nine treatments *viz.*, T_1 control, T_2 : RDF (750:200:700 g/tree/year N, P and K), T_3 : half dose of RDF, T_4 : half dose of RDF+DE 300 kg/ha, T_5 : half dose of RDF+DE 600 kg/ha, T_6 : half dose of RDF+DE 900 kg/ha, T_7 : RDF+ DE 300 kg/ha, T_8 : RDF+ 600 kg/ha and T_9 : RDF+ 900 kg/ha.

Leaf analysis

Leaf sampling and processing

Mango leaves (20-30) were collected from the basal 8th 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 and silicon content in leaf by following standard methods of analysis. 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 silica

The sample (0.1g) was digested in a mixture of 7 ml of HNO3 (70%), 2 ml of H_2O_2 (3%) and 1ml of HF (40%) (Tri acid mixture) using microwave digesting system for 40 minutes. The digested samples were diluted with 50ml with 4 per cent boric acid (Ma and Takahashi, 2002). The silica 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.

$$\text{Si (\%)} = \frac{\text{Gram ppm x Volume made up afterdigestion x Volume made up of Aliquot}}{\text{Weight of the sample x Aliquot taken}} \text{x100}$$

Estimation of micronutrients

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).

$$\text{Micro nutrients} = \frac{\text{Sample reading (graph ppm)}}{\text{Weight of sample (mg)}} \text{(ppm)}$$

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 mango cv. Kesar leaf (1.51, 2.57 and 2.04%) was observed in the treatment with soil application of DE at (T_9) RDF + DE 900 kg/ha during 2012 & 2013 and pooled data as in Table I. Silica application avoided leaching loss of nitrogen and thus helped in more accumulation of nitrogen in leaf. Similar results were observed by Stamatakis *et al.* (2003) in tomato. Casero *et al.* (2002) and Ernani *et al*. (2002) in apple.

The highest phosphorous content in the leaf was recorded in treatment with soil application of (T_8) RDF + DE 600 kg/ha (0.14, 0.19 and 0.17%) during 2012 and 2013 and pooled data (Table I). Silica in solution rendered more P available to plants reversing its fixation as silicon itself competed for P fixation and thus, slowly released P and helped in more uptake. The above results are in conformity with the findings of Pulz *et al*. (2008) in potato, Nessreen *et al.* (2011) in beans. The soil application of silica had a significant influence on potassium content of leaf. The highest potassium content in the leaf (0.78, 0.89 and 0.82%) was recorded in treatment RDF + DE 300 kg/ha (T_7) during 2012 & 2013 and for pooled data, respectively (Table I). This might be due to more accumulation of silicon in leaf which might have attributed in more uptake of potassium due to its synergistic effect. Nessreen *et al.* (2011) in beans recorded that, the application of potassium silicate increased per cent K in leaf. Similar results were observed by Kamenidou *et al.* (2009) in Zinnia, Kamenidou and Toddy (2008) in lrnamental sunflower and Gorecki and Danielski (2009) in cucumber.

The highest calcium content in the leaf was recorded in treatment (T_7) RDF + DE 300 kg/ha of (2.47, 2.62 and 2.60%) during 2012 & 2013 and pooled data, respectively (Table I). Silicon helped in uptake of calcium and thus resulted in more accumulation of calcium in leaf.

The magnesium content in leaf varied significantly among the treatments (Table II). The highest magnesium content in the leaf (0.54, 0.65 and 0.65%) was noticed in treatment T_5 during 2012 and 2013 and pooled data. Silica helped in uptake of magnesium which might have resulted in higher magnesium in leaf.

Iron content in the leaf varied significantly among the treatments and the maximum iron content in leaf was recorded in the treatment with soil application of silica (T_4) as 1/2 of RDF+DE 300

TABLE I

Effect of soil application of silica on leaf nutrient content of mango cv. kesar

Treatments	Leaf Nutrient Content											
	Nitrogen (%)			Phosphorus (%)			Potassium (%)			Calcium (%)		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
T_1	0.96	1.08	1.02	0.01	0.03	0.02	0.24	0.38	0.31	1.11	1.13	1.12
T_2	0.93	1.07	1.00	0.07	0.14	0.11	0.57	0.64	0.61	2.06	1.93	2.00
T_3	0.80	1.18	0.99	0.13	0.17	0.15	0.54	0.66	0.60	2.32	2.48	2.40
T_4	1.00	1.24	1.12	0.10	0.16	0.13	0.73	0.77	0.75	2.40	2.37	2.34
T_5	0.90	1.18	1.04	0.06	0.15	0.11	0.63	0.76	0.70	1.90	2.11	2.01
T_6	1.26	2.20	1.73	0.11	0.18	0.15	0.28	0.37	0.33	1.82	2.23	2.03
T_7	1.35	2.44	1.90	0.09	0.17	0.13	0.78	0.89	0.82	2.47	2.62	2.60
T_8	1.48	2.47	1.98	0.14	0.19	0.17	0.75	0.88	0.81	2.38	2.52	2.50
T_9	1.51	2.57	2.04	0.06	0.13	0.09	0.69	0.84	0.79	2.19	2.29	2.40
S.Em±	0.28	0.17	0.22	0.03	0.03	0.01	0.11	0.09	0.10	0.13	0.15	0.13
CD @5%	0.85	0.51	0.68	0.09	0.09	0.03	0.32	0.28	0.30	0.38	0.42	0.40

T_1- Control T_2- RDF (750:200:700 g/tree/year) T_3- Half of RDF
T_4- Half of RDF + DE 300kg/ha T_5- Half of RDF + DE 600 kg/ha T_6- Half of RDF + DE 900 kg/ha
T_7- RDF + DE 300 kg/ha T_8- RDF + DE 600 kg/ha T_9- RDF + DE 900 kg/ha

TABLE II

Effect of silica *(DE) on leaf nutrient content in mango cv. kesar*

Treatments	Leaf Nutrient Content					
	Magnesium (%)			Silicon (%)		
	2012 - 2013	2013 - 2014	Pooled	2012 - 2013	2013 - 2014	Pooled
T_1	0.10	0.20	0.15	2.11	2.23	2.17
T_2	0.31	0.37	0.34	1.82	2.08	1.95
T_3	0.15	0.27	0.21	2.34	2.58	2.46
T_4	0.25	0.35	0.30	2.49	2.84	2.67
T_5	0.54	0.65	0.60	2.04	2.33	2.16
T_6	0.47	0.67	0.57	1.82	2.19	2.07
T_7	0.45	0.53	0.49	2.00	2.49	2.25
T_8	0.36	0.77	0.57	2.44	2.74	2.59
T_9	0.26	0.75	0.51	2.37	2.54	2.46
S.Em±	0.12	0.10	0.11	0.13	0.13	0.12
CD@5%	0.36	0.31	0.34	0.39	0.35	0.37

T_1- Control T_2- RDF (750:200:700 g/tree/year) T_{3-} Half of RDF
T_4- Half of RDF + DE 300kg/ha T_{5-} Half of RDF + DE 600 kg/ha T_{6-} Half of RDF + DE 900 kg/ha
T_7- RDF + DE 300 kg/ha T_{8-} RDF + DE 600 kg/ha T_{9-} RDF + DE 900 kg/ha

kg/ha (77.30 ppm, 80.00 ppm and 69.57 ppm) during 2012 and 2013 and pooled data, respectively (Table III).

Maximum copper content in leaf was recorded with the treatment (T_4) ½ of RDF + DE 300 kg per hectare (10.03 ppm, 6.87 ppm and 6.52 ppm) and (Table III). The leaf concentrations of copper were slightly increased among silica supplemented plants. The zinc content was found maximum in the leaf due to (T_4) ½ of RDF + DE 300 kg per hectare (63.77 ppm, 69.00 ppm and 62.50 ppm) during 2012 and 2013 and pooled data, respectively (Table III). Silica supplementation would have helped in the uptake of zinc by the mango leaf.

The highest nitrogen content in the pulp (3.80, 3.50 and 3.57%) was noticed with soil application of DE at T_7 (RDF + DE 300 kg/ha) and minimum was recorded in control (2.14, 2.27 and 2.21%) during 2012 & 2013 and for pooled data, respectively (Table IV) . Silica application avoided leaching loss of nitrogen and thus helped in more accumulation of nitrogen in leaf. Similar results were observed by Stamatakis *et al.* (2003) in tomato. Similar results were observed by Casero *et al.* (2002) and Ernani *et al.* (2002) in apple.

The highest phosphorus content in the pulp (0.38, 0.32 and 0.35%) was recorded in soil application of silica at 1/2 RDF + DE 600 kg/ha (T_5) was estimated during 2012 & 2013 and for pooled data, respectively (Table IV). Silica 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.

The highest potassium content in pulp (4.17, 4.00 and 4.09%) was recorded in treatment T_7 (RDF + DE 300 kg/ha) during 2012 & 2013 and pooled data, respectively (Table IV). This might be due to more accumulation of silica in pulp content, which might have attributed in more uptake of potassium due to its synergistic effect. Nessreen *et al.* (2011) in beans recorded that, the application of potassium silicate increased per cent K in pulp. Similar results were made by Casero *et al.* (2002) and Ernani *et al.* (2002) in apples. Highest content of calcium content in the pulp

TABLE III

Effect of soil application of silica on leaf micro nutrient content of mango cv. kesar

Treatments	Micro Nutrient Content											
	Iron (ppm)			Zn (ppm)			Cu (ppm)			Silica (%)		
	2012-13	2013-14	Pooled Data	2012-13	2013-14	Pooled Data	2012-13	2013-14	Pooled Data	2012-13	2013-14	Pooled Data
T_1	67.33	51.20	59.26	22.87	27.33	25.11	06.17	4.33	7.18	2.11	2.23	2.17
T_2	69.90	66.67	68.29	33.00	19.77	26.39	06.67	4.47	5.57	1.82	2.08	1.95
T_3	59.13	52.15	64.73	60.67	31.00	45.84	05.90	5.57	5.73	2.34	2.58	2.46
T_4	77.30	80.0	69.57	63.77	69.00	62.50	10.03	6.87	6.52	2.49	2.84	2.67
T_5	59.40	62.50	60.95	53.77	39.60	46.62	04.87	5.53	5.20	2.04	2.33	2.16
T_6	64.50	70.17	67.34	38.87	51.32	45.10	06.47	6.27	6.37	1.82	2.19	2.07
T_7	67.80	68.67	68.24	45.30	62.67	53.94	07.32	4.00	5.66	2.00	2.49	2.25
T_8	57.60	78.00	67.80	56.00	69.00	62.50	06.93	5.43	6.18	2.44	2.74	2.59
T_9	58.60	79.25	68.93	55.67	61.90	58.79	07.77	5.03	6.40	2.37	2.54	2.46
S.Em±	03.81	2.22	1.73	3.33	1.62	2.96	0.58	0.30	0.39	0.13	0.13	0.12
CD @5%	11.42	6.67	5.20	9.98	4.84	8.89	1.74	0.90	1.17	0.39	0.35	0.37

T_1-Control T_2- RDF (750:200:700 g/tree/year) T_{3-} Half of RDF
T_4- Half of RDF + DE 300kg/ha T_{5-} Half of RDF + DE 600 kg/ha T_{6-} -Half of RDF + DE 900 kg/ha
T_7- RDF + DE 300 kg/ha T_{8-} RDF + DE 600 kg/ha T_{9-} RDF + DE 900 kg/ha

TABLE IV

Effect of soil application of silica on nutrient content of mango pulp cv. kesar

Treatments	Nutrient content of Pulp (%)											
	Nitrogen (%)			Phosphorus (%)			Potassium (%)			Calcium (%)		
	2012-13	2013-14	Pooled Data	2012-13	2013-14	Pooled Data	2012-13	2013-14	Pooled Data	2012-13	2013-14	Pooled Data
T_1	2.14	2.27	2.21	0.23	0.18	0.21	2.99	3.52	3.57	0.40	0.41	0.41
T_2	3.60	3.47	3.54	0.25	0.21	0.23	3.03	3.35	3.19	0.36	0.59	0.48
T_3	2.57	3.73	3.15	0.32	0.20	0.26	3.13	4.14	3.64	0.51	0.62	0.57
T_4	2.97	4.60	3.79	0.35	0.24	0.31	2.72	4.42	3.57	0.50	0.64	0.64
T_5	2.83	3.33	3.08	0.38	0.32	0.35	2.46	4.22	3.34	0.34	0.52	0.43
T_6	3.63	3.23	3.52	0.37	0.30	0.34	2.93	4.40	3.67	0.54	0.62	0.54
T_7	3.80	3.50	3.57	0.32	0.28	0.30	4.17	4.00	4.09	0.64	0.66	0.60
T_8	3.20	3.28	3.24	0.36	0.32	0.34	2.94	3.22	3.08	0.46	0.48	0.50
T_9	3.67	3.20	3.44	0.34	0.37	0.36	3.26	3.84	3.55	0.46	0.54	0.50
S.Em±	0.27	0.24	0.24	0.03	0.02	0.03	0.28	0.21	0.21	0.03	0.05	0.02
CD @5%	0.82	0.72	0.73	0.08	0.07	0.08	0.84	0.64	0.62	0.08	0.16	0.06

T_1- Control T_2- RDF (750:200:700 g/tree/year) T_{3-} Half of RDF
T_4- Half of RDF + DE 300kg/ha T_{5-} Half of RDF + DE 600 kg/ha T_{6-} -Half of RDF + DE 900 kg/ha
T_7- RDF + DE 300 kg/ha T_{8-} RDF + DE 600 kg/ha T_{9-} RDF + DE 900 kg/ha

TABLE V

Effect of soil application of silica on pulp micro nutrient content of mango cv. kesar

Treatments	Micro Nutrient Content											
	Iron (ppm)			Zn (ppm)			Cu (ppm)			Silica (%)		
	2012-13	2013-14	Pooled Data	2012-13	2013-14	Pooled Data	2012-13	2013-14	Pooled Data	2012-13	2013-14	Pooled Data
T_1	69.33	58.30	63.81	20.67	25.22	22.94	5.17	3.33	4.25	2.11	2.20	2.15
T_2	65.22	62.60	63.91	31.18	21.12	26.15	5.72	4.47	5.09	1.70	1.98	1.85
T_3	62.14	72.80	67.47	58.25	28.72	43.48	5.20	4.47	4.83	2.24	2.48	2.36
T_4	71.55	80.30	75.92	60.27	57.12	58.69	8.90	5.87	7.38	2.20	2.64	2.42
T_5	60.30	55.75	58.02	50.67	35.00	42.84	4.28	4.53	4.40	2.00	2.13	2.06
T_6	58.50	68.20	63.35	36.72	50.22	43.47	5.47	5.27	5.37	1.72	2.00	1.86
T_7	61.70	71.60	66.65	41.20	60.25	50.97	6.32	4.00	5.16	2.15	2.50	2.32
T_8	59.20	62.67	60.75	62.22	60.75	61.23	5.92	5.23	5.62	2.45	2.84	2.64
T_9	56.20	68.50	52.35	58.72	55.78	57.25	6.77	5.00	5.88	2.40	2.64	2.50
S.Em±	03.81	2.22	1.73	3.33	1.62	2.96	0.58	0.30	0.39	0.42	0.46	0.44
CD @5%	11.42	6.67	5.20	9.98	4.84	8.89	1.74	0.90	1.17	1.25	1.37	1.30

T_1- Control T_2- RDF (750:200:700 g/tree/year) T_3- Half of RDF

T_1- Control T_2- RDF (750:200:700 g/tree/year) T_3- Half of RDF

T_4- Half of RDF + DE 300kg/ha T_5- Half of RDF + DE 600 kg/ha T_6- Half of RDF + DE 900 kg/ha

T_7- RDF + DE 300 kg/ha T_8- RDF + DE 600 kg/ha T_9- RDF + DE 900 kg/ha

was found (0.64, 0.66 and 0.60%) due to soil application of DE at RDF + DE 300 kg/ha (T_7) and minimum was recorded in control (0.40, 0.41 and 0.41%) during 2012 & 2013 and pooled data, respectively (Table IV) Silicon helped in uptake of calcium and thus resulted in more accumulation of calcium in pulp.

Iron content was higher in pulp (71.55 ppm, 80.30 ppm and 75.92 ppm) in soil application of ½ RDF + DE 300 kg/ha (T_4) during 2012 & 2013 and pooled data, respectively (Table V). Higher copper content in pulp (8.90 ppm, 5.87 ppm and 7.38 ppm) was recorded in soil application of ½ RDF + DE 3000 kg/ha (T_4) which was recorded during 2012 and 2013 and pooled data, respectively. Silica application would have helped in the absorption of copper in the pulp (Table V).

The content of silica in leaf was found to be high due to DE application of (T_4) 1/2 RDF + DE 300 kg/ha (2.49, 2.84 and 2.67%) during 2012 & 2013 and pooled data, respectively (Table II) compared to other treatments.

Highest content of silica in the pulp was found (2.45, 2.84 and 2.64%) due to soil application of silica at RDF + DE 600 kg/ha (T_8) and minimum (1.70, 1.98 and 1.85%) was recorded in T_2 (RDF) during 2012 & 2013 and pooled data, respectively (Table V). Silica after root adsorption, monosilicic acid is translocated rapidly into the leaves and pulp of the mango fruit in the transpiration stream. Silica is concentrated in the epidermal tissue as a fine layer of silicon–cellulose membrane and is associated with pectin and calcium ions. With increasing Si concentration in the plant sap, more uptake of silicon occurs (Meena *et al*., 2013).

In conclusion the results of this study highlights the role of silicon and major nutrients in improving nutrient content in mango. Soil application of RDF + DE300 kg/ha helped in more utilization of major nutrients and soil application of 1/2 RDF +DE 300 kg/ha helped in more utilization of major nutrients and thus resulted in obtaining more yield and quality of mango.

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(*Received :* February, 2018 *Accepted :* March, 2018)