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EFFECT OF DIFFERENT SOURCES OF SILICA ON NUTRIENT CONTENT OF LEAVES AND FRUITAT DIFFERENT STAGES OF ALPHONSO MANGO (*Mangifera indica* L.) IN LATERITIC SOIL.

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ABSTRACT

The study was conducted to know the effect of application of chemical fertilizer in combination with silicon on yield and quality parameter of mango (*Mangifera indica* L.) in Lateritic soil of Konkan region. Four sources of silicon were used for study with three different concentrations. There were total thirteen treatments viz., T_1(RDF i.e, FYM 10 kg, 3 kg urea:3 kg SSP : 2 kg and Sulphate of potash kg per tree^{-1}), T_2 (T_1 + 2t calcium silicate hectare^{-1}), T_3 (T_1 + 3t calcium silicate hectare^{-1}),T_4 (T_1 + 4t Calcium Silicate hectare^{-1}), T_5 (T_1 + Rice husk ash @ 1.0 kg tree^{-1}),T_6 (T_1 + Rice husk ash @ 1.5 kg tree^{-1}), T_7 (T_1 + Rice husk ash @2.0 kg tree^{-1}), T_8 (T_1 + Silixol spray @ 0.5 ml L^{-1}), T_9 (T_1 + Silixol spray @ 1.0 ml L^{-1}), T_{10} (T_1 + Silixol spray @ 1.5 ml L^{-1}), T_{11} (T_1 + Potassium silicate spray @ 0.5 per cent), T_{12} (T_1 + Potassium silicate spray @ 1.0 per cent) and T_{13} (T_1 + Potassium silicate spray @ 1.5 per cent) replicated thrice in RBD design. Two trees for each treatment were selected. The spraying schedule of crop protection was followed and the recommended dose of fertilizer applied during month of June both years of experimentation through urea, single super phosphate, sulphate of potash and FYM, respectively. During the course of investigation the nutrient content in mangoleaves andnutrient content in mangofruit pulpat mature and ripe stage were studied.It is revealed from the study that use of foliar spray of 1.5 ml L^{-1} stabilized silicic acid i.e, Silixol showed beneficial effect on nutrient content in mango leaves and fruit pulp at various stages.

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KEY WORDS: Calcium silicate, Potassium silicate, Rice husk ash, Silicon, Stabilized silicic acid titratable acidity, TSS, Total sugar.

Introduction

Mango (*Mangifera indica* L.) belongs to family Anacardiaceae is universally accepted as the finest tropical fruit of the world and has been called, in the orient, "King of the fruits". Mango is rightly known as 'National Fruit of India', owing to its nutritional richness, unique taste and flavour, religious and medicinal importance. It is the third widely produced fruit crop of the tropics after banana and citrus. It is originated from South East Asia, the Indo-Burma region, in the foothills of the Himalayas Mukherjee[3]. Plants can only absorb Si in the form of soluble mono silicic acid, a non-charged molecule. Mono silicic acid, or plant available silicon is a product of slicon-rich mineral dissolution. Plant available silicon deposits of amorphous silica, known as phytoliths, in the plant tissues. Phytoliths from litter may contribute 1-2 per cent of the weight of the soil and they normally degrade slowly to return soluble Si to the soil. Although silicon is beneficial for plant growth it plays a vital role as a physio-mechanical barrier in most plants. Despite its deposition on cell walls, its active involvement in a multitude of physiological and metabolic processes is also evident. Plants deprived of silicon often show poor development and reproduction, but it depends on the type of plant species. In general, plants belonging to the family *Gramineae* accumulate much more silicon than that by other species belonging to other families. It has also been reported that most dicot plants absorb silicon passively but legumes can efficiently exclude silicon from their roots[2]. However, in rice, a known silicon accumulator, uptake and transport of silicon takes place through active process[1].

Materials and Methods

Seventy eight uniformly grown alphonso mango trees were selected for the experiment. These 25 years old trees were at 10x10 m spacing with uniform vigour and growth. These trees were manured uniformly with 3 kg Urea, 3 kg SSP and 1 kg SOP and 10 kg FYM per tree for the first trial and same dose was applied for the second experimental trial.Total nitrogen, phosphorous, potassium and silicon were determined by appropriate standard methods. The plant samples were digested in 1:1 conc. H_2SO_4:30 % H_2O_2 and the total nitrogen content were determined by Kjeldhal plus apparatus [7].1.0 g of plant sample was digested in diacid mixture of HNO_3 and $HClO_4$ in the ratio of 3:1 and cooled digested material transferred to 100 ml volumetric flask and final volume was made to 100 ml with distilled water with repeated washing of digestion flask. The P and K concentration in prepared samples were determined by appropriate standard methods [6]. The silica was determined by rapid micro-determination method. The silica was converted into molybdenum reactive form with 10 percent ammonium molybdate solution, which was estimated colorimetrically using ascorbic acid, on spectrophotometer at 660 nm wavelength [5].

Results and Discussion

Nutrient contents of leaves

The data presented in the Table 1 indicated that significant differences observed on total nitrogen content in leaf of alphonso mango during different stages of fruit development in both the years of experimental trial.The total N content varied from 1.21 to 1.45 per cent at flowering stage, from 0.83 to 1.28 percent at egg stage and from 0.91 to 1.48 percent at harvesting indicated that N concentration decreased with fruit development stages from flowering to egg stage there after it was increased at harvest stage. During second year 2012-13 the N content varied from 0.93 to 1.60 percent at flowering stage, from 0.77 to 1.27 percent at egg stage and from 0.88 to 1.49 percent at harvesting indicated that N concentration decreased with fruit development stages but it was increased at harvest stage. The N content in mango leaves during all fruit development stages found statistically significant and T_{10} (1.5 ml L^{-1}Silixol spray) was recorded highest in total nitrogen content in mango leaves during development of fruit.

The total P content of the mango leaves (Table 2) indicated that there was increase in phosphorous content of mango leaves with different sources of silica application. The results showed that phosphorous content in mango leaves declined with development stages of fruit *i.e.* from flowering to harvesting of fruit.Total P content ranging 0.054 to 0.123 percent at flowering stage, 0.049 to 0.105 percent at egg stage and from 0.046 to 0.112 per cent at harvest.Same trend was also observed in second year trial with increase in concentration of silica application phosphorous content in mango leaves increased and phosphorous content in mango leaves decreased with all development stages of fruit. The phosphorous content in mango leaves ranging 0.052 to 0.188 percent at flowering stage, 0.052 to 0.159 percent at egg stage and from 0.044 to 0.175 per cent at harvest.

Total potassium content in mango leaves gradually declined from flowering to egg stage but thereafter it was increased in potassium content at harvest stage during both the experimentation. The data presented in the Tables indicated that there were significant differences obtained on potassium content of mango leaves with the application of various sources of silica and with different concentrations during all development stages in both the years of experimental trials. Potassium content in mango leaves was observed highest in treatment T_{13} during all the fruit development stages in both the year of experimentation.

During first year 2011-12 potassium content of mango leaves ranged 0.49 to 1.07 per cent at flowering stage, 0.35 to 0.88 percent at egg stage and 0.52 to 1.21 percent at harvesting.The potassium content in mango leaves ranged 0.58 to 1.44 percent at flowering stage, 0.48 to 1.11 percent at egg stage and 0.53 to 1.41 per cent at harvest. Similar trend was also noticed in second year trial with increase in concentration of silica increased the potassium content in mango leaves. However, it was declined from flowering to egg stage thereafter it was declined with fruit development stages except at harvest stage which was increased.

Silica content in mango leaves gradually declined with all fruit development stages with the exception at harvest stage of second year experimentation it was increased instead of decreasing. During first year 2011-12 silica content of mango leaves was statistically significant at all stages of fruit development. The silica content ranged from 0.52 to 1.10 percent at flowering stage, from 0.40 to 0.79 percent at egg stage and from 0.37 to 0.71 percent at harvesting due to application of different sources of silica (Table 4).Similar trend was observed in second year trial as in first year trial except at harvest stage instead of declining silica content in leaves it increased. Silica content in mango leaves increased as increase in concentration of silica application increased.The silica content in mango leaves varied 0.42 to 1.17 percent at flowering stage, 0.41 to 1.02 percent at egg stage and from 0.40 to 1.14 percent at harvest.

Nutrient content of fruit pulp

At all stages, N content in mango fruit pulp was observed to be graded from lowest concentration of silica to highest concentration of silica. There was sharp increase in N content of mango fruit pulp observed with stage of fruit development during both the year of research trial. During first year 2011-12 nitrogen content of mango fruit pulp was found to be statistically significant with the applications of silica sources with various concentrations at flowering stage. The treatment T_{10} (0.79 percent) found to be highest nitrogen content in mango fruit pulp which was significantly superior over all other treatments except T_7(0.72 percent), T_9 (0.73 percent). At harvest stage treatment T_{10} (1.5 ml L^{-1} Silixol) recorded highest nitrogen content in mango fruit pulp with value of 1.21 per cent which was significantly superior over all the other treatments except T_9 (1.13 percent), T_8 (1.09 percent), T_3 (1.14 percent) and T_4 (1.12 percent). During second year 2012-13 the N content in fruit pulp of mango as influenced by silica application Table 5 showed that its content varied from 0.63 to 0.91 percent at egg stage and 0.67 to 1.44 percent at harvesting.

During first year 2011-12 phosphorous content of mango fruit pulp was statistically significant at all stages of fruit development. The data presented in Table 6 indicates that P content varied from 0.043 to 0.061 per cent at egg stage, from 0.046 to 0.068 per cent at harvesting.The treatment T_7 (0.061 per cent) found to be highest phosphorous content in mango fruit pulp which was significantly superior over T_1 (0.043per cent), T_5 (0.050 per cent), T_2 (0.049 per cent), T_3 (0.050 per cent) and T_{11} (0.048per cent) rest of the treatments were found at par. At harvest stage, the highest phosphorous content in mango fruit pulp was observed in T_7 (0.068 percent) which was significantly superior over T_1 (0.049 per cent), T_2 (0.051 percent), T_3 (0.051 percent) and T_{11} (0.046per cent) rest of the treatments were at par. Same trend was also observed in second year trial to that of first year where with increase in concentration of silica application phosphorous content in mango fruit pulp increased and phosphorous content in mango fruit pulp increased with developmental stages of fruit. The phosphorous content in mango fruit pulp varied from 0.055 to 0.113 per cent at egg stage and from 0.059 to 0.117 per cent at harvest.

During first year 2011-12 potassium content of mango fruit pulp was statistically significant at all stages of fruit development. The data presented in Table 2-6 indicated that K content varied from 0.429 to 0.497 per cent at egg stage, from 0.475 to 0.677 percent at harvesting. The treatment T_{13} (0.497 percent) was recorded highest K content in mango fruit pulp and found significantly superior over T_1 (0.429 percent) rest allother treatments found at par. T_1 (control) was found to have lowest K content mango fruit pulp with value of 0.429 per cent. At harvest stage, the highest K content in mango fruit pulp observed in T_{13} (1.5 per cent foliar application of Potassium Silicate) having value of 0.677 per cent which was recorded significantly superior over T_1 (0.475 per cent), T_2 (0.494 per cent), T_3 (0.518 per cent), T_5 (0.521 per cent), T_6(0.555 per cent), T_8(0.603 per cent), T_9(0.612 per cent), T_{11}(0.609 per cent)rest of the treatments were found at par. The K content in mango fruit pulp was found statistically significant at egg stage. The treatment T_{13} (1.5 per cent foliar application of Potassium Silicate) obtained highest K content in mango fruit pulp having value 0.601 per cent which was significant over T_1 (0.449 per cent) rest of the treatments were at par.At harvest stage, the treatmentT_{13} (1.5 per cent foliar application of Potassium silicate) reported highest K content in mango fruit pulp having value 0.790 per cent which was significantly superior over all treatments except T_4, T_7, T_{10} and T_{12} which were at par.

During first year (2011-12) Si content of mango fruit pulp were statistically significant at all stages of fruit development. The data presented in Table 8 indicated that Si content varied from 0.026 to 0.063 per cent at egg stage, from 0.026 to 0.070 per cent at harvesting. Silica content in leaves showed sharp change with the application of stabilized silicic acid as compare to control and other sources of silica. The treatment T_{13} found to be highest during egg stage and at harvest on first year trial.Similar trend was observed in second year trial with increase in concentration of silica application Si content in mango fruit pulp increased and as fruit goes to maturity concentration of silica gradually increased.The Si content in mango fruit pulp was varied from 0.032 to 0.069 per cent at egg stage and from 0.039 to 0.081 per cent at harvesting.

Conclusion

Use of foliar application of silica during initial stages of fruit growth (before flowering, pea, marble and egg stage) increased nutrient content in leaves of mango at various stages and nutrient content in mango fruit pulp. However, amongst the various treatments tried, the application of Stabilized silicic acid *i.e*, silixol @ 1.5 ml lit^{-1} (T_{10}) with five sprays during initial stages of fruit growth (before flowering, 15 days after flowering, 30 days after flowering, 45 days after flowering and 60 days after flowering) was found to be good.

TABLE-1: Effect of silica application on pH of pulp at different stages of fruit growth in alphonso mango.

Treatments	pH (2011-12)				pH (2012-13)			
	At egg stage	At harvest	At ripe stage	At end of shelf life	At egg stage	At harvest	At ripe stage	At end of shelf life
T_1	2.76	2.98	4.12	4.34	2.59	2.81	3.95	4.52
T_2	2.64	3.08	4.26	4.70	3.16	3.60	4.78	5.22
T_3	2.69	3.08	4.30	4.72	3.21	3.60	4.82	5.24
T_4	2.71	3.15	4.34	4.73	3.23	3.67	4.86	5.24
T_5	2.68	3.04	4.19	4.71	3.05	3.41	4.56	5.08
T_6	2.76	3.03	4.22	4.75	3.13	3.41	4.59	5.08
T_7	2.76	3.07	4.28	4.76	3.20	3.45	4.65	5.09
T_8	2.77	3.30	4.30	4.76	3.19	3.67	4.67	5.05
T_9	2.77	3.63	4.73	4.79	3.29	4.00	5.13	5.18
T_{10}	2.81	3.62	4.76	4.80	3.33	4.24	5.28	5.22
T_{11}	2.74	3.14	4.27	4.67	3.11	3.51	4.64	5.04
T_{12}	2.74	3.19	4.29	4.70	3.18	3.56	4.66	5.07
T_{13}	2.74	3.27	4.30	4.74	3.19	3.64	4.67	5.11
Mean	2.74	3.20	4.33	4.70	3.14	3.58	4.71	5.09
SEm ±	0.017	0.102	0.111	0.060	0.121	0.102	0.110	0.039
C. D at 5%	0.049	0.297	0.324	0.176	0.353	0.297	0.321	0.115

TABLE-2: Effect of silica application on titratable acidity of pulp at different stages of fruit growth in alphonso mango.

Treatments	Titratable acidity (%) (2011-12)				Titratable acidity (%) (2012-13)			
	At egg stage	At harvest	At ripe stage	At end of shelf life	At egg stage	At harvest	At ripe stage	At end of shelf life
T_1	3.99	3.56	0.49	0.23	4.28	3.48	0.45	0.28
T_2	3.81	2.85	0.39	0.21	3.97	2.77	0.39	0.24
T_3	3.81	2.75	0.37	0.20	3.71	2.66	0.37	0.21
T_4	3.81	2.71	0.33	0.19	3.70	2.65	0.34	0.20
T_5	3.68	3.18	0.47	0.21	3.85	2.83	0.43	0.23
T_6	3.67	2.94	0.45	0.21	3.78	2.75	0.41	0.22
T_7	3.71	2.74	0.44	0.19	3.60	2.62	0.41	0.21
T_8	3.66	2.22	0.32	0.18	3.58	2.33	0.33	0.18
T_9	3.58	1.93	0.29	0.17	3.49	2.06	0.30	0.17
T_{10}	3.56	1.78	0.27	0.16	3.42	1.86	0.28	0.16
T_{11}	3.72	2.81	0.39	0.19	3.70	2.70	0.37	0.20
T_{12}	3.72	2.34	0.36	0.18	3.65	2.44	0.34	0.19
T_{13}	3.72	2.25	0.35	0.18	3.47	2.33	0.33	0.18
Mean	**3.73**	**2.62**	**0.38**	**0.19**	**3.71**	**2.58**	**0.37**	**0.21**
S. Em ±	**0.048**	**0.102**	**0.012**	**0.007**	**0.15**	**0.16**	**0.02**	**0.02**
C. D at 5%	**0.139**	**0.297**	**0.035**	**0.020**	**0.43**	**0.48**	**0.07**	**0.06**

TABLE-3: Effect of silica application on TSS of pulp at different stages of fruit growth in alphonso mango.

Treatments	TSS (^{O}Brix) 2011-12				TSS (^{O}Brix) 2012-13			
	At egg stage	At harvest	At ripe stage	At end of shelf life	At egg stage	At harvest	At ripe stage	At end of shelf life
T_1	7.64	7.72	17.00	10.20	7.26	7.41	18.22	9.42
T_2	7.73	7.77	18.17	12.27	7.74	8.30	18.26	11.80
T_3	7.80	8.17	18.30	12.80	7.86	8.55	18.46	12.87
T_4	7.94	8.30	18.43	13.20	8.05	8.74	18.83	13.10
T_5	7.74	7.77	17.77	10.73	7.86	8.53	18.31	10.90
T_6	7.79	8.00	18.10	10.87	7.94	8.57	18.59	11.20
T_7	7.80	8.07	18.33	12.47	8.05	8.69	19.06	12.97
T_8	8.09	8.37	19.27	15.15	8.15	8.77	18.70	14.68
T_9	8.12	8.90	19.37	15.70	8.32	8.86	19.45	15.30
T_{10}	8.19	8.93	20.22	16.00	8.44	9.02	21.43	15.47
T_{11}	7.71	7.90	18.33	11.70	7.71	8.21	18.68	11.83
T_{12}	7.75	8.10	18.53	12.50	7.83	8.40	18.95	12.97
T_{13}	7.76	8.40	18.60	13.17	8.10	8.63	19.15	13.43
Mean	**7.85**	**8.18**	**18.49**	**12.83**	**7.95**	**8.49**	**18.93**	**12.76**
S.Em ±	**0.061**	**0.255**	**0.509**	**0.449**	**0.199**	**0.298**	**0.555**	**0.498**
C. D at 5%	**0.178**	**0.744**	**1.486**	**1.310**	**0.582**	**0.870**	**1.620**	**1.454**

TABLE-4: Effect of silica application on total sugar of pulp at different stages of fruit growth in alphonso mang.

Treatments	Total sugar (%) 2011-12				Total sugar (%) 2012-13			
	At egg stage	At harvest	At ripe stage	At end of shelf life	At egg stage	At harvest	At ripe stage	At end of shelf life
T_1	3.21	3.33	11.11	10.56	2.94	3.35	14.27	12.16
T_2	3.31	3.43	11.75	10.72	3.31	3.75	15.70	13.34
T_3	3.26	3.82	12.31	10.56	3.64	4.26	15.99	13.57
T_4	3.28	3.74	12.76	10.77	3.73	4.43	16.49	14.09
T_5	3.19	3.57	11.04	10.67	3.69	4.00	15.71	13.55
T_6	3.22	3.37	11.77	10.59	3.80	4.50	15.99	13.80
T_7	3.25	3.49	12.10	10.76	4.16	4.80	16.36	13.93
T_8	3.10	3.80	14.34	10.58	3.70	4.50	17.08	14.48
T_9	3.35	3.98	15.49	10.68	4.13	5.00	17.55	14.82
T_{10}	3.20	3.97	16.50	10.76	4.36	5.22	18.27	15.77
T_{11}	3.27	3.50	12.79	10.87	3.27	3.72	15.36	13.58
T_{12}	3.32	3.70	13.60	10.65	3.61	4.11	16.05	13.96
T_{13}	3.25	3.66	14.39	10.78	3.92	4.40	16.84	14.53
Mean	**3.25**	**3.64**	**13.07**	**10.69**	**3.71**	**4.31**	**16.28**	**13.97**
S. Em ±	**0.02**	**0.14**	**0.24**	**0.02**	**0.15**	**0.17**	**0.55**	**0.47**
C. D at 5%	**0.05**	**0.41**	**0.70**	**0.06**	**0.42**	**0.50**	**1.60**	**1.36**

TABLE-5: Effect of silica application on ascorbic acid of pulp at different stages of fruit growth in alphonso mango.

Treatments	Ascorbic acid (mg 100 g^{-1}) 2011-12				Ascorbic Acid (mg 100 g^{-1}) 2012-13			
	At egg stage	At harvest	At ripe stage	At end of shelf life	At egg stage	At harvest	At ripe stage	At end of shelf life
T_1	83.13	78.07	54.73	43.27	79.15	76.66	43.97	36.98
T_2	83.36	77.70	51.34	38.22	83.69	78.31	52.45	37.43
T_3	83.92	77.83	54.96	41.24	84.14	78.38	54.96	37.55
T_4	84.08	78.50	53.20	38.87	84.33	79.11	55.94	37.62
T_5	84.54	79.42	55.08	38.61	83.61	79.05	52.64	38.61
T_6	85.44	79.48	50.75	38.74	83.86	79.48	53.74	38.74
T_7	87.16	77.14	52.84	37.62	87.17	79.81	55.11	38.87
T_8	87.88	77.70	54.31	37.70	87.40	80.03	53.75	41.24
T_9	88.24	78.45	50.44	37.43	89.03	83.06	56.24	41.81
T_{10}	88.33	79.82	50.75	37.55	89.20	86.69	59.04	43.27
T_{11}	86.08	78.35	54.73	38.19	84.90	78.35	51.33	38.19
T_{12}	86.52	78.57	56.44	41.81	86.58	78.89	53.50	41.81
T_{13}	86.51	80.32	53.72	38.76	87.23	81.22	55.82	38.76
Mean	**85.78**	**78.57**	**53.33**	**39.08**	**85.41**	**79.93**	**53.73**	**39.30**
S. Em ±	**0.44**	**0.73**	**0.68**	**0.29**	**0.80**	**1.47**	**1.85**	**0.25**
C. D at 5%	**1.27**	**2.14**	**1.99**	**0.85**	**2.33**	**4.29**	**5.39**	**0.72**

TABLE-6: Effect of silica application on fruit yield of alphonso mango.

Treatments	Fruit yield (2012)			Fruit yield (2013)			
	Number of fruits tree^{-1}	Av. Wt. of fruit (g)	t ha^{-1}	Number of fruits tree^{-1}	Av. Wt. of fruit (g)	t ha^{-1}	Pooled t ha^{-1}
T_1	69.67	206.00	1.44	108.67	213.67	2.32	1.88
T_2	125.67	229.20	3.04	151.33	225.67	3.56	3.30
T_3	134.67	267.40	3.60	196.33	251.67	4.94	4.27
T_4	161.33	223.60	3.61	199.00	251.00	4.99	4.30
T_5	94.00	245.00	2.30	156.33	239.33	3.74	3.02
T_6	117.33	232.20	2.72	189.33	245.67	4.65	3.69
T_7	132.33	251.60	3.33	215.33	262.33	5.65	4.49
T_8	221.67	303.20	6.72	234.33	308.67	7.23	6.98
T_9	233.00	288.80	6.73	274.67	322.67	8.86	7.80
T_{10}	252.67	315.60	7.97	283.67	336.67	9.55	8.76
T_{11}	132.67	251.20	3.33	189.33	263.00	4.98	4.16
T_{12}	147.67	203.20	3.00	191.33	230.00	4.40	3.70
T_{13}	157.00	226.40	3.55	197.67	246.33	4.87	4.21
Mean	**141.40**	**249.49**	**3.67**	**199.03**	**261.28**	**5.37**	**4.51**
S. Em ±	**12.37**	**9.37**	**0.37**	**28.36**	**20.710**	**0.75**	**0.58**
C. D at 5%	**36.11**	**27.36**	**1.09**	**82.78**	**60.45**	**2.19**	**1.69**

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