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Effect of active silica on performance of maize (*Zea mays*) under organic farming

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ABSTRACT

A field experiment was conducted during *kharif* 2018–19 at Organic Unit of Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan. The experiment consisting of six soil applications in main plots (0, 50, 75, 100, 125 and 150 kg/ha) and six foliar applications of active silica in sub plots (no spray, water spray, 0.25, 0.50, 0.75 and 1.0%) was carried out in split-plot design with three replications. Results indicated that significantly higher number of rows/cob, number of grains/row, test weight, grain, stover and biological yield was recorded with 150 kg/ha active silica application. Similarly, higher protein content in grain, Si content and uptake by plant at 60, 75 DAS and harvest, and N, P and K content and uptake in grain as well in stover was recorded at 150 kg/ha active silica application. Among foliar application, the spray of 1.0% active silica significantly enhanced the yield attributes, yield, protein content in grain, Si content and uptake by plant at 60, 75 DAS and harvest; and N, P and K content and uptake in grain as well in stover in maize (*Zea mays* L.) under organic production system.

Keywords: Active silica, Maize, Nutrient content, Organic farming, Uptake

Health and food security are critical issues now a days. Communicable and non-communicable diseases are speeding now days owing to low quality food. Production of crop without use of any synthetic fertilizers and chemicals are the main theme of organic farming. The International Federation of Organic Agriculture Movement (IFOAM) defines organic farming as "a production system that sustains the health of soil, ecosystem and people". Organic maize (*Zea mays* L.) is a principal cereal crop of the world and maize lived in third place after wheat and rice in India. The benefits from Si application in crop production may be including enhanced resistance against bacterial, fungal disease and insect, as well as tolerance to stresses such as drought, cold, toxic metals, promotes upright growth, prevents lodging and promotes favorable exposure of leaves to light resulted increased yield. Plant subjected to drought, treated with Si, and maintained higher stomatal conductivity, relative water content and water potential. It helps leaves become larger and thicker, thus limiting the loss of water through transpiration and reduce water consumption and show greater influence on the development of plant roots, thus allow better root resistance in dry soil and its faster growth. Si increases drought tolerance by maintaining plant water balance, erectness of leaves, photosynthetic activity, structure of xylem vessels and high transpiration rate in plant by application of Si resulted increasing in dry matter accumulation and grain yield (Mole *et al.* 2003, Hattori *et al.* 2005). Basal application of Si increased yield of maize by 8.6%, increased utilization rate and absorbing ability of nutrients (Ren *et al.* 2001) and responds positively to Si supplements (Zhou *et al.* 2002). N, P and K content increase in grain and stover owing to availability of N, P and K increased in soil, because of N has synergetic effect with Si. Si increased retention capacity of soil and increased solubility of P which leading to increased nutrients efficiency of phosphatic fertilizer and positive response of higher silica application towards K could be linked to cell wall (Pati *et al.* 2016).

MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2018–19 at the organic unit of Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan. The experiment consisting of 36 treatment combinations of six active silica of soil application in main plots, viz. 0

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(S_1), 50 (S_2), 75 (S_3), 100 (S_4), 125 (S_6) kg/ha and six foliar application of active silica in sub plot, viz. no spray (F_1), water spray (F_2), 0.25 (F_3), 0.50 (F_4), 0.75 (F_5) and 1.0% (F_6) was carried out in split-plot design with three replication. Soil application of active silica was applied before sowing and foliar spray of active silica was done at 30 DAS and initiation of tasseling. Harvest index was calculated as (Donald and Hamblin 1976).

$$\text{HI } (\%) = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

The protein content was estimated by multiplying N content of seed with a factor 6.25 (AOAC 1960). Si content was estimated in plant using method suggested by Ma and Takahashik (2002). The N, P and K content of grain and straw were estimated by colorimetric method using spectronic 20 after development of colour with Nessler‘s regent (Snell and Snell 1949), Vandomolybdo phosphoric acid yellow colour method (Jackson 1973) and Flame photometer method (Jackson 1973), respectively. The uptake of Si (at 60, 75 DAS and harvest), N, P and K (at harvest) were determined by multiplying nutrient content with their respective dry matter. All these estimates were analyzed by standard statistical procedure (Panse and Sukhatme 1985).

RESULTS AND DISCUSSION

Effect on yield attributes: Data regarding yield attributes showed significant variations due to soil application of active silica at various level and recorded significantly maximum number of cobs/plant, number of rows/cob, number of grains/row, number of grains/cob and test weight with 150 kg/ha active silica (Table 1). Whereas, number of cobs/plant and number of grains/row were found to be at par with 125 kg/ha active silica; and number of rows/cob number of grains/cob and test weight were at par with 100, 125 kg/ha active silica. These findings are also supported by the results of Singh *et al.* (2007) and Hattori *et al.* (2007).

Among foliar application, 1.0% spray of active silica recorded significantly higher number of cobs/plant, number of rows/cob, number of grains/row, number of grains/cob and test weight over control. However, number of cobs/plant remained at par with 0.25, 0.50 and 0.75%, number of rows/cob and test weight was found at par with 0.50 and 0.75% and number of grains/row and number of grains/cob were at par with 0.75% foliar spray (Table 1). These might be due to enhanced photosynthetic activity, density of grain by improving the translocation and accumulation of carbohydrates and increase in number of filled grains which influenced the biomass of grains, and ultimately grain weight increased when it was applied at initiation of tasseling stage. These results are in close agreement with the finding of Ahmed *et al.* (2013) and Lavinsky *et al.* (2016).

Effect on grain, stover and biological yield: Soil application of active silica revealed that grain, stover and biological yield were significantly increased with increasing dose of active silica up to 150 kg/ha. Whereas, grain and biological yield were found at par with 125 kg/ha and stover yield was at par with 100, 125 kg/ha active silica (Table 1). Similar results were also observed by Lavinsky *et al.* (2016) and El-Temsah (2017). In case of foliar spray, significantly higher grain, stover and biological yield were recorded with 1.0% foliar application (Table 1) and it

Table 1 Effect of active silica on yield attributes, yield and harvest index of maize under organic farming (pooled of two years)

Treatment	Number of cobs/plant	Number of rows/cob	Number of grains/row	Number of grains/cob	Test weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Soil application									
S1	1.30	9.17	18.47	194.19	197.64	2219	3421	5640	39.72
S2	1.44	9.49	19.46	208.32	201.84	2403	3841	6245	38.43
S3	1.44	9.95	20.23	217.20	203.64	2478	3964	6442	38.43
S4	1.46	11.05	21.57	227.38	207.71	2681	4180	6861	39.17
S5	1.47	11.34	21.81	234.57	210.39	2801	4294	7095	39.59
S6	1.53	11.47	22.42	235.86	211.78	2816	4349	7165	39.43
SEm±	0.02	0.17	0.28	2.89	1.74	41	81	84	0.74
CD at 5%	0.06	0.51	0.83	8.53	5.14	122	240	247	NS
Foliar application									
F1	1.26	9.05	17.95	193.88	197.20	2244	3414	5658	39.77
F2	1.42	9.67	18.84	207.24	200.69	2485	3863	6348	39.21
F3	1.47	10.49	20.41	220.10	204.94	2542	3956	6498	39.30
F4	1.48	10.92	21.91	228.21	209.12	2664	4201	6865	38.78
F5	1.49	11.08	22.19	231.69	209.96	2723	4267	6990	39.01
F6	1.50	11.25	22.65	236.40	211.10	2741	4348	7089	38.70
SEm±	0.02	0.13	0.23	2.31	0.95	28	53	59	0.44
CD at 5%	0.05	0.37	0.64	6.48	2.67	78	148	164	NS

Table 2 Effect of active silica on protein, Si, N, P and K content of maize under organic farming (pooled of two years)

Treatment	Protein (%)	Si in plant (%)			N (%)		P (%)		K (%)	
		At 60 DAS	At 75 DAS	At harvest	Grain	Stover	Grain	Stover	Grain	Stover
Soil application										
S1	9.54	0.701	0.926	1.317	1.527	0.621	0.299	0.129	0.314	1.289
S2	9.59	0.777	0.950	1.406	1.534	0.637	0.300	0.130	0.327	1.310
S3	9.73	0.850	1.109	1.910	1.556	0.661	0.304	0.135	0.356	1.336
S4	10.14	0.910	1.203	2.400	1.622	0.707	0.311	0.142	0.415	1.395
S5	10.27	0.940	1.310	2.895	1.643	0.714	0.312	0.143	0.423	1.403
S6	10.33	0.944	1.347	3.091	1.653	0.718	0.313	0.144	0.424	1.421
SEm±	0.09	0.007	0.009	0.016	0.014	0.006	0.002	0.001	0.004	0.010
CD at 5%	0.26	0.020	0.025	0.049	0.042	0.017	0.007	0.004	0.011	0.029
Foliar application										
F1	9.52	0.707	0.926	1.326	1.524	0.651	0.301	0.131	0.366	1.331
F2	9.67	0.710	0.928	1.329	1.547	0.665	0.304	0.135	0.376	1.357
F3	9.79	0.881	1.138	2.086	1.566	0.671	0.306	0.136	0.377	1.359
F4	10.09	0.940	1.252	2.399	1.615	0.685	0.308	0.139	0.379	1.364
F5	10.24	0.942	1.295	2.885	1.639	0.693	0.310	0.140	0.380	1.368
F6	10.28	0.943	1.307	2.993	1.646	0.694	0.310	0.141	0.381	1.377
SEm±	0.07	0.005	0.007	0.012	0.011	0.003	0.001	0.001	0.002	0.006
CD at 5%	0.20	0.013	0.019	0.034	0.031	0.010	0.004	0.003	0.006	0.017

remained at par with 0.50 and 0.75% for grain and stover yield and 0.75% for biological yield. This might be due to Si accumulation in plant parts which reduce its lodging and enhanced resistance against biotic and abiotic stress, ultimately resulted into higher biological yield. Similar results were also observed by Patil *et al.* (2017) and Sarma *et al.* (2017). There was non-significant difference observed with different doses of active silica in soil as well as foliar application on harvest index.

Effect on protein: Protein content in grain (Table 2) was found significantly higher with soil application of 150 kg/ha active silica which was at par with 100 and 125 kg/ha. With respect to foliar application, significantly higher protein content was found at 1.0% active silica which remained non-significant with 0.50 and 0.75%. Application of active silica directly affects the synthesis of various amino acids and enhanced activity of enzymes in plants which leads to higher protein content (Ahmad *et al.* 2012 and 2013).

Effect on nutrient content: Soil application of active silica significantly increased the Si content in plant at 60, 75 DAS and harvest up to 150 kg/ha. However, this treatment remained at par with 125 kg/ha at 60 DAS. The N, P and K content in grain and stover significantly increased with 150 kg/ha which was at par with 125 kg/ha. These findings are closely associated with Ren *et al.* (2001). The content of Si in plant was increased with increasing the doses of active silica, because of plant required more Si for growth and metabolism. Similar results were also reported by Singh *et al.* (2006). The N, P and K content increase in grain and stover owing to availability of N, P and K increased in soil (Pati *et al.* 2016). Whereas, the foliar application of active silica significantly increased the Si content in plant at 60, 75 DAS and harvest at 1.0% foliar spray. Though, it was at par with 0.50 and 0.75% at 60 DAS and 0.75% at 75 DAS. Foliar application of 1.0% active silica significantly increased the N, P and K content in grain and stover. This influence was found more effective when silicon application at initiation of tasseling stage (reproductive stage) of maize was done than vegetative stage. Ren *et al.* (2001) also reported similar results.

Effect on nutrient uptake: Results (Table 3) indicated that Si uptake by plant at 60, 75 DAS and harvest was significantly increased by soil application of 150 kg/ha active silica, whereas it was at par with 125 kg/ha at 60 and 75 DAS. The uptake of Si in plant was increased with increasing the doses of active silica, because of plant required more Si for growth and metabolism. Significantly higher uptake of N, P and K by grain and stover was noted up to 150 kg/ha. Our results are in line with the findings of Ren *et al.* (2001). Increased N, P and K uptake with the increasing doses of active silica could be attributed to the better availability of N, P, and K and their transport to the plant from the soil. The higher nutrient uptake was mainly due to higher biological yield (Lalithya *et al.* 2014 and Meshram *et al.* 2015). Among the foliar application, Si uptake by plant at 60, 75 DAS and harvest was significantly increased with 1.0% active silica, whereas it was at par with 0.50 and 0.75% at 60 DAS and 0.75% at 75 DAS.

Table 3 Effect of active silica on uptake of Si, N, P and K of maize under organic farming (pooled of two years)

Treatment	Si uptake (kg/ha)			N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	At 60 DAS	At 75 DAS	At harvest	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
Soil application												
S1	28.30	53.31	89.78	33.99	21.30	55.29	6.66	4.42	11.08	6.99	44.07	51.06
S2	31.23	55.23	95.17	36.96	24.50	61.46	7.21	5.02	12.23	7.88	50.38	58.25
S3	35.15	66.73	133.77	38.59	26.21	64.80	7.53	5.35	12.88	8.83	52.99	61.82
S4	39.29	76.04	181.40	43.58	29.62	73.20	8.34	5.94	14.28	11.14	58.36	69.50
S5	42.32	89.09	236.68	46.08	30.69	76.77	8.74	6.14	14.88	11.85	60.28	72.13
S6	43.26	92.29	256.08	46.62	31.30	77.92	8.82	6.27	15.09	11.95	61.95	73.90
SEm±	0.84	1.27	2.76	0.83	0.54	1.10	0.17	0.11	0.21	0.20	1.19	1.24
CD at 5%	2.47	3.76	8.15	2.45	1.61	3.23	0.50	0.34	0.63	0.57	3.50	3.66
Foliar application												
F1	27.94	56.01	98.12	34.34	22.33	56.67	6.76	4.50	11.26	8.32	45.56	53.87
F2	29.43	57.44	99.81	38.54	25.76	64.30	7.59	5.21	12.79	9.46	52.49	61.95
F3	37.35	71.50	157.62	39.90	26.71	66.61	7.78	5.42	13.21	9.67	53.98	63.65
F4	41.05	80.10	184.20	43.12	28.88	72.00	8.22	5.85	14.07	10.20	57.42	67.61
F5	41.64	83.08	219.84	44.65	29.66	74.31	8.44	6.01	14.44	10.43	58.52	68.95
F6	42.13	84.57	233.28	45.26	30.28	75.54	8.51	6.15	14.66	10.57	60.06	70.63
SEm±	0.41	0.67	1.41	0.47	0.36	0.62	0.10	0.07	0.13	0.12	0.71	0.72
CD at 5%	1.15	1.86	3.95	1.31	1.01	1.73	0.28	0.20	0.36	0.33	1.98	2.01

The uptake of N, P and K by grain and stover were found significantly higher with 1.0% which remained at pat with 0.75% foliar application. This influence was found more effective when silicon applied at initiation of tasseling stage compared to vegetative stage.

From the above results, it is concluded that soil application of 150 kg/ha active silica significantly enhances the crop yield, nutrient content and uptake. Among foliar application, spray of 1.0% active silica improves the yield and quality and nutrient uptake. Overall, 150 kg/ha active silica through soil application or 1.0% foliar spray may be recommended to increase the maize productivity and nutrient uptake under organic farming condition.

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