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Growth, yield and uptake of wheat (*Triticum aestiveum* L.) as influenced by doses of silicon and its time of application under organic farming

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Abstract
A field experiment was conducted to study the effect of silicon (diatomaceous earth) on growth, yield and nutrient uptake of wheat during *rabi* 2017-18 at Instructional Farm, Rajasthan College of Agriculture, Udaipur on clay loam soils having medium fertility status. Results showed that application of silicon significantly increased grain and straw yield as well as yield-attributing parameters such as plant height, number of effective tillers/meter row length, number of spikelet's/ear, number of grains/ear, ear length and grain weight/ear at harvest of wheat under organic farming. The greatest grain and straw yields were observed with the application of silicon 8 g/litre as compared to 2, 4 g/litre and control. The concentration and uptake of silicon, nitrogen, phosphorus and potassium in grain and straw were also greater under this treatment compared to others. Amongst stage of silicon application, tillering stage registered significant improvement in most of the yield attributes, consequently grain, straw and biological yields over CRI and jointing stages. It was concluded that application of 8 g silicon/litre of water at tillering stage resulted increased grain, straw yield, nutrient uptake and economics of NPK and silicon.

Keywords: Wheat, silicon, stage of silicon application, wheat, nutrient uptake, economics

Introduction
Wheat (*Triticum aestivum* L.) is the most widely cultivated crop providing food and nutrition to the two third population of the world. It is the second most important staple food crop of India after rice. It has significantly contributed towards success of the green revolution and has greatly helped to transform our country from a situation of "ship to mouth" to self sufficiency. India ranks second in wheat production next to China, producing 97.44 million tons from 30.72 million hectares of land with the productivity of 3172 kg/ha (Government of India, 2016). Organic agriculture is gaining momentum worldwide. There is a growing demand of organic food. Organically grown wheat is a principal cereal crop of the world. In India, wheat second place after rice contributing substantially to the national food security by providing more than 50 per cent of the calories to the people who mainly depend on it (Choudhary *et al*., 2017) [1]. Area and production of organic wheat is increasing in India due to high demand in the national and international market (Ravishankar *et al*., 2016) [2]. Package and practices of organic wheat have been developed in India and Rajasthan by Sharma *et al*., (2015) [3]. Although silicon is the second most abundant element in mineral soils. In crop production, the benefits from silicon fertilization may include increase the growth and biomass, yield and quality of a broad range of crops including rice, wheat, maize, barley, millet, sorghum and sugarcane that actively take up and accumulate high amounts of Si in their organs. The yield increment, however, may be attributable not only to the beneficial effects of silicon including growth promotion, lodging resistance and biotic and abiotic stress resistance but also to some indirect effects such as pH adjustment and acquisition of macro- and micronutrients contained in the silicate fertilizers (Liang *et al*., 2018) [5]. It is well known that diatomaceous earth is an organic source of naturally occurring substance, the fossilized remains of salt or freshwater organisms (unicellular algae-like plants) called diatoms. Diatoms are predominantly composed of amorphous silica (SiO_2). Amorphous DE is known to be a good source of plant-available Si as amorphous silica is more easily solubilized than crystalline silica, having high cation exchange and retention capacity.

The improved retention of phosphate could potentially be attributed to the action of several mechanisms, including the formation of a complex between the phosphate ion and surface hydroxyls of the amorphous silica (Leung and Kimaro 1998) [4].

Materials and Methods

The field experiment was conducted at the Instructional Farm, Department of Agronomy, Rajasthan Collage of Agriculture, Udaipur during *rabi* season of 2017-18 and which is situated at 24º35' N latitude and 72º42' E longitude. The region falls under the agro climatic zone IVa of Rajasthan *i.e.* Sub-humid Southern Plain and Aravalli Hills of Rajasthan. The soil of experimental site was clay loam having pH 8.10, organic carbon 0.73%, available nitrogen 248.1 kg/ha, phosphorus 20.6 kg/ha and potassium 4.78 kg/ha in the plough layer. The treatment consisted combinations of five doses of silicon [control (only water spray), 2, 4, 6 and 8 g/litre] and applied at 3 stages (CRI, tillering and jointing stages). These 15 treatments combinations were evaluated under factorial RBD with three replications. Wheat variety Raj. 4120 was used as test crop. It is most suitable for timely sowing and under irrigated condition. The variety was released by CVRC. Wheat variety Raj. 4120 was drill sown at 22.5 cm row distance on 29th November, 2017 using 100 kg/ha seed rate. Silicon solutions were prepared as per treatment application, for example 2 g silicon/litre of water of silicon solution prepared by adding 2 g of silicon to one litre of water. After dilution the silicon solution has to be filtered before using it for spraying. The spray solution of silicon was sprayed at the time of CRI, tillering and jointing stages. About 550 litre/ha water was used during silicon spray in the experimental field. For 2, 4, 6 and 8 g/litre spray 11, 22, 33 and 44 kg silicon/ha were used with 550 litre water by using power sprayer. For silicon diatomaceous earth (DE) source was used DE is an organic source and are predominantly composed of amorphous silica (SiO2). During the crop growth period, hand weeding operations were performed with hand hoe. Net return and B C ratio was calculated on the basis of prevailing market prices of inputs and produce. LAI, chlorophyll, protein content, nutrient content and their uptake were worked out by using standard methods for analysis and formula. Data of each character collected were statistically analyzed using standard procedure of variance analysis.

Results and Discussion

Effect of doses of silicon

All doses of silicon application were found significant in enhanceing plant height of wheat under organic farming at all the stage of observation and 8 g/litre recorded the highest plant height at harvest compared to 2, 4 g/litre and control. At the same time plant height recorded under 8 and 6 g silicon/litre water were found statistically at par with each other. Dry matter accumulation by the wheat crop, LAI and total chlorophyall content was significantly increased with all the doses of silicon over control. It was evident from the results that application of silicon improved plant growth parameters and chlorophyll pigment concentration over control. The beneficial effects of silicon on plant growth characters and dry matter accumulation are linked with reduced transpiration. In the present study, an increase in growth parameters was observed due to the exogenous application of silicon in wheat. Increase in plant height can be attributed towards enhanced cell division and elongation caused by silicon (Jaleel *et al.,* 2009) [6].

Yield attributing characters *viz*. effective tillers/metre row length, number of spikelets/ear, number of grains/ear, ear length, grain weight/ear and test weight were significantly influenced by all doses of silicon compared to control. 8 and 6 g/litre were found statistically at par with respect to aforsaid yield attributes and ranked first and second in this respect. The maximum grain yield (4493 kg/ha) was recorded under 8 g/litre and found statistically at par with 6 g/litre (4413 kg/ha). The straw yield during experimentation was significantly increased with all doses of silicon. The highest straw yield obtained with 8 g/litre (6377 kg/ha). The biological yield increased significantly by various doses of silicon. 8 and 6 g/litre gave better results being at par with each other. Different doses of silicon failed to record significant influence on harvest index of wheat under organic condition. The highest protein content (10.54 per cent) was recorded under 8 g/litre and the lowest being reported under control (10.7 per cent). Lavinsky *et al.* (2016) [7] reported that the contribution of carbohydrates from photosynthetic activity for longer period might have resulted in efficient translocation of food material into the sink (grain) thereby increased the number of filled grains percentage. This might be due to increased synthesis of carbohydrates and that might have increased the sink size and capacity. Silicon application, that may significantly reduce empty spikelet's number in wheat and increase fertility, increased spikelets per ear that ultimately increased crop yield.

Application of silicon 8 g/litre recorded significantly higher NPK and Si content at harvest in grain and straw and nutrient uptake by the wheat crop under organic farming over control. The highest net returns (₹ 103588/ha) and BC ratio (1.91) were obtained with the application of silicon 8 g/litre As nutrient uptake by crop is primarily a function of yield and nutrient content. Subramanian and Gopalswamy (1991) [8] reported that silicon applied plant gained maximum benefits of ample nitrogen availability. Increasing silicon levels increased phosphorus content due to decreased retention capacity of soil and increased solubility of phosphorus leading to increased efficiency of phosphotic fertilizer. Positive response of higher silicon application towards potassium can be linked to silicification of cell wall (Pati *et al.*, 2016) [9].

Effect of stage of silicon application

Application of silicon at tillering stage significantly increase in plant height, plant dry matter, LAI and total chlorophyall content in leaves of wheat under organic farming over CRI stage. Tillering is the production of expanding auxiliary bud which is clearly associated with nutritional condition of the mother clump because tillers receive carbohydrate from mother clump during early growth period and this was improved by silicon application at this stage (Liang *et al*., 1994). Total chlorophyall content in leaves of wheat under organic farming was significantly increased with application of silicon at tillering stage over CRI and jointing stages. Yield attributing characters *viz*. effective tillers/metre row length, number of spikelets/ear, number of grains/ear, ear length, grain weight/ear and test weight were significantly influenced by application of silicon at different stages. The higher number of tillers at later stages of crop growth might be due to the higher silicon availability to plants through the various sources of silicon. This is in confirmative with the findings of Savant *et al*. (1997) [10] and Singh and Singh (2005) [11]. Application of silicon at tillering stage significantly increased protein, NPK and Si content in grain and straw and nutrient uptake by the crop over CRI stage. The concentration and

uptake of nutrients (nitrogen, phosphorus, potassium and silicon) at various growth stages and at harvest of the crop were higher when silicon was applied at tillering stage. This was probably due to better and continuous availability of silicon under the treatment. From the present experimental finding it may be suggested that silicon nutrition of crop Application of silicon at tillering stages recorded maximum net return (₹ 102574/ha) and BC ratio (1.90) of wheat over the application of silicon at CRI stage (₹ 95534) and B C ratio (1.77).

Conclusion

Results of this study revealed that silicon application markedly improves the growth and yield components, and finally the grain yield of wheat under organic farming. The exogenous application of Si fertilizer into the soil significantly increases the uptake of Si by the wheat, which reasonably could be predicted to provide an increase in biomass production and consequently grain yield of wheat. From the present findings, it can be concluded that the application of silicon 8 g/litre of water and silicon application at tillering stage would help in the sustainable production of wheat under organic farming in this locality.

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Organic Farming for funding the work through the project.

Table 1: Effect of silicon on growth and yield attributes of wheat under organic farming at harvest

Treatments	Plant height (cm)	DMA (g/plant)	LAI	Total chlorophyll (mg/g)	Effective tillers/metre row length	Number of spikelet's/ear	Number of grains/ear	Ear length (cm)	Grain weight/ear (g)
Doses of silicon									
Control (only water spray)	84.78	46.2	1.65	1.74	119.89	17.11	40.70	11.19	2.09
2 g/litre	88.22	49.0	1.68	1.91	123.11	18.78	42.59	11.63	2.19
4 g/litre	89.89	51.9	1.70	1.92	127.44	19.44	43.42	11.99	2.39
6 g/litre	93.44	54.6	1.73	2.08	136.67	20.67	45.89	12.42	2.56
8 g/litre	93.67	54.7	1.74	2.18	138.00	20.78	45.92	12.78	2.58
SEm±	1.15	1.00	0.01	0.05	1.11	0.40	0.66	0.14	0.03
CD (P=0.05)	3.33	2.89	0.028	0.133	3.21	1.16	1.92	0.40	0.10
Stages of silicon application									
CRI	88.87	48.3	1.67	1.83	122.93	18.27	42.34	11.69	2.20
Tillering	92.07	54.5	1.74	2.10	134.47	20.40	45.61	12.34	2.49
Jointing	89.07	51.2	1.69	1.97	129.67	19.40	43.15	11.98	2.40
SEm±	0.89	0.77	0.01	0.04	0.86	0.31	0.51	0.11	0.03
CD (P=0.05)	2.58	2.24	0.021	0.103	2.48	0.90	1.49	0.31	0.07

Table 2: Effect of silicon on nitrogen, phosphorous, potassium and silicon content of wheat

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Silicon content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Doses of silicon								
Control (only water spray)	1.611	0.521	0.539	0.114	1.611	0.521	1.054	1.211
2 g/litre	1.644	0.537	0.554	0.118	1.644	0.537	1.118	1.282
4 g/litre	1.646	0.553	0.562	0.138	1.646	0.553	1.120	1.313
6 g/litre	1.679	0.571	0.577	0.146	1.679	0.571	1.205	1.382
8 g/litre	1.687	0.573	0.577	0.152	1.687	0.573	1.224	1.384
SEm±	0.010	0.006	0.005	0.003	0.010	0.006	0.024	0.025
CD (P=0.05)	0.030	0.019	0.016	0.008	0.030	0.019	0.069	0.072
Stages of silicon application								
CRI	1.626	0.526	0.542	0.115	1.626	0.526	1.099	1.271
Tillering	1.673	0.571	0.581	0.143	1.673	0.571	1.197	1.365
Jointing	1.661	0.555	0.563	0.142	1.661	0.555	1.137	1.308
SEm±	0.008	0.005	0.004	0.002	0.008	0.005	0.018	0.019
CD (P=0.05)	0.023	0.014	0.012	0.006	0.023	0.014	0.053	0.056

Table 3: Effect of silicon on yield, harvest index, net return and B C ratio of wheat under organic farming

Treatments	Yield (kg/ha)			Net return (Rs./ha)	B C ratio
	Grain	Straw	Biological		
Doses of silicon					
Control (only water spray)	4067	5611	9678	88225	1.64
2 g/litre	4177	5705	9882	91642	1.70
4 g/litre	4222	5714	9936	92829	1.72
6 g/litre	4413	6283	10696	100877	1.86
8 g/litre	4494	6377	10871	103588	1.91
SEm±	104	190	195	-	-
CD (P=0.05)	302	552	565	-	-
Stages of silicon application					
CRI	4073	5620	9692	88190	1.64
Tillering	4487	6179	10665	102574	1.90

Jointing	4264	6016	10280	95534	1.77
SEm±	81	148	151	-	-
CD (P=0.05)	234	427	437	-	-

Reference

1. Choudhary Roshan, Sharma SK, Choudhary RS. Effect of Bio herbal growth promoter on growth and yield of wheat grown under organic management. Chemical Science Review and Letters. 2017; 6:1022-1026.
2. Ravishankar N, Sharma SK, Singh DK, Panwar AS. Organic farming in India production issues and strategies. Indian Farming. 2016; 66:16-23.
3. Sharma SK, Triwedi Amit, Choudhary Roshan, Jajoria DK, Ameta OP. Status and Research Experiences on Organic Farming in Rajasthan. DOR, MPUAT, Udaipur, 2015, 1-22.
4. Leung WH, Kimaro A. Sorptive behavior of silica and its enhancement with phosphate treatment. Virginia Journal of Science. 1998; 49:173-82.
5. Liang Y, Nikolic M, Bélanger R, Gong H, Song A. Book on Silicon in agriculture- From theory to practices, 2018, 209-233.
6. Jaleel CA, Manivannan P, Wahid A, Farooq M, Al-Juburi HJ, Somasundaram R *et al*. Drought stress in plants: a review on morphological characteristics and pigments composition. International Journal of Agriculture Biology. 2009; 11:100-105.
7. Lavinsky AO, Detmann KC, Reis JV, Avila RT, Sanglard ML, Pereira LF *et al*. Silicon improves rice grain yield and photosynthesis specifically when supplied during the reproductive growth stage. Plant Physiology. 2016; 206:125-132.
8. Subramaniarn S, Gopalswamy A. Effect of moisture, organic matter, phosphate and silicate on availability of silicon and phosphorus in rice soil. Journal of the Brdian Society of Soil Science. 1991; 39:99-103.
9. Pati S, Pal B, Badole S, Hazra GC, Mandal B. Effect of silicon fertilization on growth, yield, and nutrient uptake of rice. Commun Soil Sci Plant Anal. 2016; 47:284-290.
10. Savant NK, Datnoff LE, Snyder GH. Depletion of plant-available silicon in soils: A possible cause of declining rice yields. Communications in Soil Science and Plant Analysis. 1997; 28:1245-1252.
11. Singh AK, Singh R, Singh K. Growth, yield, and economics of rice (Oryza sativa) as influenced by level and time of silicon application. Indian Journal of Agronomy. 2005; 50:190-193.