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Pooja
Department of Agriculture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Roshan Choudhary
Department of Agriculture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Raveena
Chaudhary Sarvan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India

Anamika Nepali
Department of Agriculture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Deepak Kumar
Department of Agriculture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Somdutt
Department of Agriculture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Gaurav Singh Gurjar
Department of Agriculture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Corresponding Author:
Pooja
Department of Agriculture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Chlorophyll content at different stages and net return as influenced by doses and stage of silicon application in wheat

Pooja, Roshan Choudhary, Raveena, Anamika Nepali, Deepak Kumar, Somdutt and Gaurav Singh Gurjar

Abstract
A field experiment was conducted to study the effect of silicon (diatomaceous earth) on chlorophyll content, net return and BC ratio 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 chlorophyll content at 60, 75, 90 DAS and at harvest of wheat under organic farming. Amongst stage of silicon application, tillering stage registered significant improvement in chlorophyll content. It was also reported that net return was maximum at 8g/liter Si application at tillering stage. It was concluded that application of 8 g silicon/litre of water at tillering stage resulted increased chlorophyll at all stages and economics wheat.

Keywords: Wheat, silicon, stage of silicon application, chlorophyll content, 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) [4]. It has been estimated that India will need at least 109 million ton of wheat by 2020. Our country has witnessed spectacular growth in production and productivity, which has made country not only self-sufficient but also surplus wheat exporter. In Rajasthan state, it is grown on 3.10 million hectare with production 10.4 million tone having productivity of 3367 kg/ha (Government of Rajasthan, 2017) [5], which is still lower than many states *viz*. Punjab and Haryana *etc*. There is need to further increase in production to fulfill the requirement of burgeoning population, maintenance of adequate buffer stock and to meet out demand of processing industries.
Balanced nutrition results in increased production potential for wheat plants, to grow and develop in the presence of essential mineral elements. In addition to these essential elements, there are other elements that benefit plant nutrition, such as silicon (Si) (Takahashi and Miyake, 1977) [11]. An adequate supply of silicon to paddy from Tillering to elongation stage increases the number of grains per panicle and the percentage of ripening (Korndorfer *et al*., 2001) [6]. It is also suggested that the silicon plays a crucial role in preventing or minimizing the lodging incidence in the cereal crops. (Singh *et al*., 2005) [10]. Silicon plays a significant role in imparting both biotic and abiotic stress resistance and thereby enhances productivity. It does not damage the plants upon its excess accumulation. High accumulation of silicon in paddy has been demonstrated to be necessary for healthy growth and no adverse effect on yield. Due to this reason, silicon has been recognized as an "agronomically essential element" in Japan and silicate fertilizers have been applied to paddy soils (Ma, 2004) [7]. In recent years, silicon has been regarded as quasi-essential element (Epstein, 2005) [3]. Several studies suggest that silicon enhances disease resistance in plants, imparts turgidity to the cell walls and has a putative role in mitigating the metal toxicities. In organic production, natural sources of silicon can be used to increase the growth and yield of organic wheat. The 100% natural fresh water silicon flour is being used in crops, vegetables and fruit as organic pesticide and bioenhancers.

Therefore, use of silicon in wheat can help in enhancing the growth and productivity and it can be used as 100% organic input.

Materials and Methods

A field experiment entitled "Effect of Silicon on Growth, Yield and Quality of Organic Wheat (*Triticum aestivum* L.)" was conducted during *rabi* season of 2017-18 at the Instructional Farm, Department of Agronomy, Rajasthan Collage of Agriculture, Udaipur which is situated at $24^0 35'$ N latitude and $72^0 42'$ E longitude. The region falls under the agro climatic zone IVa of Rajasthan *i.e.* Sub-humid Southern Plain and Aravalli Hills of Rajasthan. These observation shows that the maximum and minimum temperatures ranged between 23.47 to 31.71 ºC and 5.21 to 13.03 ºC, respectively during *rabi*, 2017-18 and mean annual rainfall of Udaipur is 637 mm.

Experimental details

(i)	Total number of treatment combinations	:	15
(ii)	Experimental design	:	Randomized Block Design (Factorial)
(iii)	Replications	:	03
(iv)	Total number of plots	:	45
	Plot size		
(v)	Gross	:	5.0 m x3.6 m =18 m^2
	Net	:	4.0 m x3.15 m =12.6 m^2
(vi)	Plant geometry	:	22.5 cm x 5 cm
(vii)	Crop & variety	:	Wheat *cv* Raj. 4120
(viii)	Seed rate	:	100 kg/ha
(ix)	Manure application	:	Through organic source as per package of practices of wheat under organic condition

Chlorophyll content

At 60, 75, 90 DAS and at harvest, young uppermost leaves of plants were picked up, placed in polythene bags and immediately brought to the laboratory. They were thoroughly washed in running tap water, 0.1 N HCL and then distilled water in succession. Excess surface water was removed by putting in between folds of blotting papers. Leaves were chopped into five pieces with scissors and made in to homogeneous samples before processing them for chlorophyll content. A sample of 100 mg was taken from each experimental unit and then grinds it in mortar and pestle. Chlorophyll content of fresh leaf samples was determined by using the colorimetric method (Arnon, 1949). The total chlorophyll content was determined by following formula:

$$\text{Total chlorophyll content (mg/g fresh weight of leaf)} = 20.2\,(A_{645}) + 8.02\,(A_{663}) \times \frac{V}{1000 \times W\,(g)}$$

Where
V = volume of extract (ml) & W = weight of leaf sample (g)

Net return

To find out the more profitable treatment, economics of different treatments were worked out in terms of net returns ('000/ha) on the basis of prevailing market rate so that the most remunerative treatment could be recommended.

Benefit cost ratio

Treatment wise benefit-cost ratio was also calculated to ascertain economic viability of the treatments by using the following formula:

$$\text{B:C ratio} = \frac{\text{Net return ('000/ha)}}{\text{Total cost ('000/ha)}}$$

Result and Discussion

An appraisal of data revealed that all the doses of silicon foliar application applied in the experiment at different growth stages caused a significant increment in the chlorophyll content at all the stage of observations over the control as presented in table 1. Among the different Si doses, foliar application of 8 g Si litre^{-1} recorded the maximum chlorophyll content (3.32, 3.49, 2.30 and 2.18 mg/g) at each successive stages (60, 75, 90 DAS and at harvest) of observation which was found statistically at par with foliar dose of 6 g Si litre^{-1}. Tillering stage recorded higher chlorophyll content at 60, 75, 90 DAS and at harvest as compared to CRI stage (Table)
Similarly, Chen *et al*. (2011) [2] reported that silicon application improved the growth of salt treated barley by improving the chlorophyll content and photosynthetic activity rate of crop leaf cell organelles. Furthermore, silicon application resulted in an increase in chlorophyll content and an improvement in the antioxidant system in *Lycopersicon esculentum* plants exposed to salt stress, but the regulatory mechanism responsible for this effect was not explained (Alaghabary *et al*., 2004) [1]. Feng *et al*. (2010) investigated the interaction between silicon and nitrogen and reported an increase in the levels of chlorophyll a in plants. Foliar application of silicon especially at the tillering + anthesis stages was very effective in promoting resistance in wheat plants to drought conditions by maintaining cellular membrane integrity and relative water content, and increasing chlorophyll content (Maghsoudi *et al*., 2016) [8]. The LAI and chlorophyll content of rice at tillering and flowering stages was due to silicon application at this stage which caused the erectness of leaves, and in turn reduced self shading and increase the rate of photosynthesis (Rani and Narayanan, 1994) [9]. Economic evaluation of different doses of silicon in wheat presented in Table 2 indicate that maximum net return 103'000/ha and B C ratio (1.91) was obtained with application of silicon 8 g /litre. It is also shown that application of silicon at tillering stage recorded maximum net return 102'000/ha as well as B C ratio of 1.90 as compared to other treatments (Table 2).

Table 1: Effect of silicon on total chlorophyll content in leaves at different crop growth stages of wheat under organic farming

Treatments	Total chlorophyll (mg/g)			
	60 DAS	75 DAS	90 DAS	At harvest
Doses of silicon				
Control (only water spray)	2.67	2.86	2.07	1.74
2 g/litre	2.82	2.98	2.11	1.91
4 g/litre	2.90	3.05	2.19	1.92
6 g/litre	3.15	3.31	2.29	2.08
8 g/litre	3.32	3.49	2.30	2.18

S.Em±	0.013	0.02	0.02	0.05
CD (P=0.05)	0.037	0.070	0.054	0.133
Stages of silicon application				
CRI	2.95	3.00	2.07	1.83
Tillering	3.02	3.25	2.35	2.10
Jointing	2.95	3.18	2.16	1.97
S.Em±	0.010	0.02	0.01	0.04
CD (P=0.05)	0.029	0.054	0.042	0.103

Table 2: Effect of silicon on economics of wheat under organic farming

Treatments	Net return ('000/ha)	BC ratio
Doses of silicon		
Control(only water spray)	882	1.64
2 g/litre	916	1.70
4 g/litre	928	1.72
6 g/litre	1008	1.86
8 g/litre	1035	1.91
S.Em±	-	-
CD (P=0.05)	-	-
Stages of silicon application		
CRI	881	1.64
Tillering	1025	1.90
Jointing	955	1.77
S.Em±	-	-
CD (P=0.05)	-	-

Conclusion

The results showed that foliar application of silicon ranging from 2 to 8 g Si litre^{-1} brought about significant variation in chlorophyll content, net return and BC ratio of organic wheat at different growth stages. Application of silicon at the rate of 8 g Si litre^{-1} recorded a significantly higher increase in chlorophyll content, net return and BC ratio. If we talk about stage of application, tillering stage recorded significantly highest chlorophyll content, net return and BC ratio in organic wheat.

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