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ELUCIDATING THE EFFECT OF SILICON SOLUBILIZER ON YIELD ATTRIBUTES IN DIFFERENT GENOTYPES OF RICE (*ORYZA SATIVA* L.)

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Abstract

Silicon is accumulated in plants higher than the essential major nutrients. Although it is not considered as an essential element earlier, but recent literature supports essentiality of silicon in plant growth and development. Keeping the above facts in mind a field experiment was conducted at G. B. Pant University of Agriculture and Technology, Pantnagar to elucidate the effect of Silixol (liquid source of silicon) on yield character of rice (*Oryza sativa* L.). Foliar application of 0.2% aqueous solution of Silixol was used in different genotypes of rice namely DRRH-3, PA-6129, PA-6201, PA-6444, PHB-71 and BPT-5204. Silicon as liquid silixol improved various yield different characters of yield attributes. Si solubilizer response needs more studies in terms of soil as well as foliar application for understanding its role in essentiality.

Key words : Genotypes, panicle, rice, silixol, solubilizer, yield.

Introduction

Rice (*Oryza sativa* L.) is the staple food and the main foodstuff of more than half the population of the earth. It is very adaptable to environmental conditions and grown all over the world, except in the poles, under different weather conditions (Tanaka and Park, 2006).

Silica is one of the most common substances found in the crust of the earth and in the ashes of plants. Silicon is involved in the metabolism of plant, which is one of the three criteria required for essentiality established by (Arnon and Stout, 1939) and due to the positive effects of silicon in growing rice, it is considered a necessary element for this crop (Johnson and Hendricks, 1997). Plants absorb silicon in the form of mono silisic acid $Si(OH)_4$, which is accumulated in cell walls as silica gel (Elawad and Green, 1979; Rodrigues and Datnoff, 2005). Silicon is mainly found in the aerial parts of rice: in the blade epidermis, the sclerenchyma, the vascular tissues, and the bundle sheaths of leaves. In this study, silicon caused an increase in leaf area index, panicle weight, grain weight, which are the ultimate results of increased photosynthetic activity of the leaves. Rice exhibits the greatest uptake of silicic acid in the grass family. Silicic acid is transported through the Lsi2 transporters at the proximal side of these cells (Ma *et al*., 2006, 2007, 2011). In maize, barley, pumpkin and wheat, orthologues of rice Lsi1 and Lsi2 have been shown to be involved in Si absorption (Chiba *et al*., 2009; Mitani *et al*., 2009*a*, 2009*b*, 2011; Montpetit *et al*., 2012).

The application of silicon enhances the mechanical strength of epidermal cells on rice leaf surface, keeping the rice leaves erect and avoiding mutual shading. The deposition of silicon confers rigidity and strength to the culms and thereby facilitates non- lodging, enhanced interception of sunlight and photosynthesis. Silicon reduces chaffiness and shattering of grain (Jones and Handreck, 1967). Its presence in plant tissue at high concentrations does not cause any toxicity or damage to the plant (Ma *et al*., 2006). Silicon for rice cultivation

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enhanced the quality and yield. Positive effects and importance of silicon as a nutrient element in rice plants have been reported in several studies (Deren *et al*., 1992; Ando *et al*., 2002; Hayasaka *et al*., 2008; Kamenidou *et al*., 2009).

Role of silicon may have positive effect in plant health and growth. Many scientists working on role of silicon in plant growth have concluded that reduced amount of silicon in plant develops necrosis, disturbance in leaf photosynthetic efficiency, growth retardation and reduces grain yield in cereals. Silicon is an important micronutrient for healthy and competitive growth of all cereals including rice in Asia (Brunings *et al*., 2009). Among the most controversial impacts and benefits of silicon is its ability to reduce transpiration and to increase photosynthesis rates in some plants such as rice (*Oryza sativa* L.), corn (*Zea mays* L.), soybeans (*Glycine max* L.) and wheat (*Triticum aestivum* L.) (Kupfer and Kahnt, 1992; Gao *et al*., 2004; Kamenidou *et al*., 2009). Similarly, recent research on the beneficial effect of silicon is an upregulation of the phenylpropanoid pathway producing antimicrobial phenolic compounds and flavonoids (Shetty *et al*., 2011, 2012).

Materials and Methods

Experimental site and plant material

In order to study the effect of silicon solubilizers on yield attributes in rice, an experiment was conducted in the Norman E. Borlaug Crop Research Centre (CRC) and Department of Plant Physiology of G. B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), India, using six rice genotypes namely DRRH-3, PA-6129, PA-6201, PA-6444, PHB-71 and BPT-5204. The experiment was carried out using the split plot design with three replications.

Field preparation and silicon treatment

To conduct the experiment, nursery was raised with six genotypes of rice. In case of liquid silicon treatment, first the seeds of different genotypes of rice were dipped in 0.2% silixol (liquid source of liquid) for 24 hours and then grown in nursery. For the control seeds, dipping was not done. After 21 days, seedlings were transplanted to the puddled field. Phosphorus and potassium were applied as basal dose at the time of puddling and the concentration was 45 kg/ha and 60 kg/ha. Nitrogen @ 100 kg/ha (in the form of urea) was applied in three split doses as 50% of N at 10-15 days after transplanting, 25% at the time of tillering and 25% at the time of panicle initiation. Foliar application of silixol was given at the time of tillering, panice initiation (PI), flowering and milky grain stage.

Statistical analysis

The data were analysed using two-way analysis of variance (ANOVA) by using STPR statistical software followed by test at a significance level of $p<0.05$

Results

Results of different yield parameters as panicle weight, 1000 grain weight, grain yield, HI as mention in tables.

Panicle weight

Silicon supply increased the photo assimilation of carbon and also promoted the assimilated carbon to the panicle in rice. In silixol application, the panicle weight (table 1) at the time of flowering stage observed maximum in DRRH-3 (6.12) and minimum in BPT-5204 (3.62).

Table 1 : Effect of foliar application of silicon solubilizers on panicle weight at flowering in different rice genotypes.

Name of the rice genotypes	Panicle weight at flowering		Mean
	Control	Liquid silicon solubilizer treatment	
DRRH-3	5.63±0.19	6.12±0.14	5.87
PA-6129	5.38±0.04	5.24±0.14	5.31
PA-6201	3.84±0.01	4.49±0.11	4.16
PA-6444	4.60±0.07	4.29±0.07	4.44
PHB-71	4.78±0.17	5.70±0.18	5.24
BPT-5204	4.31±0.14	3.62±0.06	3.96
Mean	4.76	4.91	
	Genotype (G)	**Treatment (T)**	**TxV**
S.Em.±	0.06	0.83	
CD at 5%	0.36	0.24	0.34

1000 Grain weight

Grain weight, in case of rice is positively correlated with productive or effective tillers.

It was observed that application of silicon solubilizers and silicon fertilizers increased the 1000 grain yield per plant compared to the control condition. The yield related parameter 1000 grain weight was observed maximum in PA-6201 genotypes. However minimum 1000 grain weight was found in BPT-5204 (table 2).

Grain yield, HI

Grain yield increases by the application of silicate, independently of soil type. By foliar application of silixol grain yield was observed maximum in PA-6444 (1018.0), minimum in BPT-5204 (652.1) (table 3). Harvest index was observed maximum in PA-6129 (58.8) and minimum in BPT-5204 (36.5) (table 4).

Table 2 : Effect of foliar application of silicon solubilizers on 1000 grain weight in different rice genotypes.

Name of the rice genotypes	1000 Grain weight		Mean
	Control	Liquid silicon solubilizer treatment	
DRRH-3	16.03±0.39	16.90±0.23	16.47
PA-6129	24.21±0.03	24.29±0.62	24.25
PA-6201	21.15±0.41	27.83±0.60	24.49
PA-6444	23.65±0.27	23.87±0.12	23.76
PHB-71	23.79±0.49	23.51±0.21	23.65
BPT-5204	14.47±0.28	13.92±0.22	14.19
Mean	20.55	21.72	
	Genotype (G)	**Treatment (T)**	**TxV**
S.Em.±	0.20	0.21	
CD at 5%	1.24	0.64	1.24

Table 3 : Effect of foliar application of silicon solubilizers on grain yield in different rice genotypes

Name of the rice genotypes	Grain Yield		Mean
	Control	Liquid silicon solubilizer treatment	
DRRH-3	894.50±43.13	767.43±63.94	830.96
PA-6129	920.16±47.61	827.50±65.32	873.83
PA-6201	858.33±30.22	863.16±85.48	860.75
PA-6444	1045.66±34.32	1018.00±63.76	1031.83
PHB-71	994.33±8.29	924.66±22.21	959.50
BPT-5204	687.66±66.88	652.16±30.28	669.91
Mean	900.11	842.15	
	Genotype (G)	**Treatment (T)**	**TxV**
S.Em.±	17.22	36.52	
CD at 5%	101.92	107.75	152.38

Table 4 : Effect of foliar application of silicon solubilizers on HI in different rice genotypes.

Name of the rice genotypes	HI		Mean
	Control	Liquid silicon solubilizer treatment	
DRRH-3	42.07±0.65	41.26±0.19	41.67
PA-6129	55.73±1.86	58.88±1.08	57.30
PA-6201	49.87±1.89	54.58±1.30	52.22
PA-6444	45.18±1.71	46.67±1.59	45.92
PHB-71	53.63±0.52	55.30±1.57	54.47
BPT-5204	36.10±0.89	36.57±0.56	36.33
Mean	47.10	48.87	
	Genotype (G)	**Treatment (T)**	**TxV**
S.Em.±	0.14	0.96	
CD at 5%	0.84	2.84	4.02

Discussion

The increment in panicle weight due to the application of silicon solubilizers might be due to decreased rate of pre-mature senescence in rice leaves. Similarly, in case of rice, it was reported that by applying silicon, panicle weight increased to 10% compared with control (Sunilkumar and Geetakumari, 2002). Silicon also made rice plants more resistant to fungal diseases therefore elevated the percentage panicle per square meter of area (Ma *et al*., 2008). It was reported that silicon is responsible to control stomatal activity, photosynthesis and water use efficiency which ultimately results in better vegetative, reproductive growth, which ultimately increased the panicle weight (Ahmad *et al*., 2007; Surapornpiboom *et al*., 2008).

Silicon inhibits the premature senescence in rice leaves. The application of silica raised the total number of filled grain per panicle, because it increased the levels of carbohydrates and dry matter production. If silica was not applied, the percentage of filled spikelets decreased by 40%. Silicon raises the total number of spikelets per panicle and increases the 1000-seed weight; and thereby the harvest index goes up (Mao *et al*., 2009). It was reported that applying silicon raised grain yield through increasing the total number of spikelets per panicle, the percentage of filled spikelets and the 1000 grain weight. It was also observed that the absence of silicon decreased the percentage of filled spikelet and lowered the total number of spikelets per panicle (Malidareh, 2011).

Conclusion

As researchers and growers become aware of Si and its potential in agriculture, it is likely that this often overlooked element will be recognized as a viable means of sustainably managing plant diseases, improve the different traits of the plant. From above results, the following conclusion was observed during the experiment. Thus results highlight that these genotypes is significantly perform better as compared to other genotypes.

Effective, amount of silicon application and affordable sources of Si are needed for improvement of crop. The most important role of this element does not lie in its general acceptance of essentiality, but rather in its most striking and unique function or role in conferring tolerance in plants to various adverse conditions. Again, the most important aspect for further studies on Si in plant biology should be focused not only on accumulating some direct lines of evidence to demonstrate that Si is part of plant constituents or metabolites but also on making full use of the role in environmental remediation.

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