International Journal of Agriculture and Nutrition
www.agriculturejournal.net
Online ISSN: 2664-6072; Print ISSN: 2664-6064
Received: 05-02-2019; Accepted: 06-03-2019; Published: 13-03-2019
Volume 1; Issue 2; 2019; Page No. 28-30

Silicon solubilizer confers biotic stress tolerance in rice genotypes

Geeta Kandpal[1], MK Nautiyal[2]
[1] Ph.D, Department of Plant Physiology, College of Basic Sciences and Humanities, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India
[2] Professor & Associate Director (Seeds), Department of Genetics & Plant Breeding, College of Agriculture, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Abstract
Silicon accumulation in plants reduces transpiration rate, confers resistance against pests, diseases, and improves the productivity of crops. In the present study, the effect of Silixol (liquid source of silicon) treatments in different rice genotypes such as DRRH-3, PA-6129, PA-6201, PA-6444, PHB-71 and BPT-5204 was evaluated under field condition at G. B. Pant University of Agriculture and Technology, Pantnagar. The results obtained from the application of 0.2% aqueous solution of Silixol showed improved than control plants. Further, the silicon treated plants were less affected as compared to control plants. It also provides resistance to biotic stresses, and the further exploitation of present study may be useful in understanding its role in essentiality for rice crop.

Keywords: Biotic stress, genotypes, productivity, rice, silicon, Silixol

Introduction
Rice (*Oryza sativa* L.) is the staple food and the main foodstuff of more than half population of the earth. It is very adaptable to environmental conditions and grown all over the world, under various climatic conditions [1]. Silica is one of the most common substances present in the earth crust and plants ashes. The concentration of silicon in soil solution ranges from 0.1 to 0.6mM [2, 3]. Plants actively absorb the silicon in the form of mono silisic acid Si(OH)4, which accumulates in cell walls as silica gel.4 Silicon is mainly found in the blade epidermis, sclerenchyma, vascular tissues, and bundle sheaths of the aerial parts of rice plant. In roots, silica is found in all tissues [2, 4]. It is more abundant in older leaves as compared in young leaves. Accumulation rate of silicon is often several times higher than the different essential macro nutrients such as nitrogen, phosphorus and potassium [5, 6]. Monocots store more silicon in comparison to dicots [7]. Rice and wheat actively absorb the silicon as compared to other crops. In rice silicic acid is transported through the Lsi2 transporters at the proximal side of these cells.8 In several plant species, orthologues of rice Lsi1 and Lsi2 have involved in the absorption of silicon [9-12]. In the application of silicon fertilizers and solubilizers, rice can accumulate silicon in the stem and leaves up to 10- 15% of its dry weight [13].
Due to several positive effects of silicon on growth and developmental processes, it is considered a necessary element for rice crop [14, 15]. It's concentration does not cause any damage to the plant.16 Silicon reduces chaffiness and shattering of grain [13, 17]. Silicon makes rice plants more resistant to fungal, diseases and insect infection, because thick silica cuticle double layer formed in rice leaves become render them and difficult for the sucking and chewing pests for feeding and for penetration by pathogenic fungi [18, 19]. It induces resistance to pathogen attack in plants by accumulating phenolics and phytoalexins4 and upregulating the phenylpropanoid pathway [19]. The proper amount of silicon has been found to reduce the probability of plants being grazed by herbivores. The poor silicon uptake led to enhances the susceptibility to diseases such as rice blast, leaf blight of rice, stem rot and grain discoloration of rice [20, 21].
Due to the beneficial effect, silicon act as a important nutrient element in rice plants [3, 22-24].
The productivity of rice reported to be higher in temperate regions as than the tropics [4, 25]. Silicon for rice cultivation enhanced the quality and yield. Silicon play an important and benificial micronutrient for development and growth of all cereals including rice [26]. Further, it also providing improved loss of transpiration and tolerance to several stresses in plants by maintaining antioxidant machinery [24, 27-29].
Therefore, the present study is intended to evaluate beneficial effects of silicon solubilizer on biotic stress response in different genotypes of rice. This study showed that silicon improves rice productivity, and confers resistance to different diseases in rice genotypes

Materials and Methods
Experimental site and Plant material
In order to study the effect of silicon solubilizer on biotic stress response in rice crop during Kharif 2014, 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), and flowering and milky grain stage.

Diseases and insects infestations were recorded in percentage at the time of panicle initiation and flowering. For this purpose, number of injuries either by disease or by insect (Blast, bacterial blight, yellow stem borer (YSM), leaf folder) was calculated by numbers from each plot. On the basis of rating score the number of infected plants was counted in percentages. For this purpose the calculation was done by this formula (number of infected plant/total number of plant) x 100.

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 $p < 0.05$.

Result & Discussion

The effect of silicon solubilizers on rice genotypes namely DRRH-3, PA-6129, PA-6201, PA-6444, PHB-71 and BPT-5204 was evaluated on the bases of number of diseases and insects' infection and are shown in (Table 1-2).

Number of diseases and insects Infection

Results showed that the silicon treated plants were less affected as compared to control plants. At PI stage, BPT-5204 and PHB-71 were highly resistant genotypes and PA-6201, PA-6129 and DRRH-3 were most susceptible for the infection. Similarly, at flowering, BPT-5204, PHB-71 and PA-6444 were found highly tolerant and PA-6129, PA-6201 and DRRH-3 were found highly susceptible genotypes. In both stages disease and insects infection percentages is less than 20% (Table 1).

Table 1: Effect of foliar application of silicon solubilizers on diseases & insects infection in different rice genotypes

Name of the rice genotypes	Number of Diseases & Insects Infection (%)(Panicle Initiation)											
	Blast			Bacterial blight			YSM			Leaf folder		
	Control	Liquid silicon Solubilizer treatment	Mean	Control	Liquid silicon solubilizer treatment	Mean	Control	Liquid silicon solubilizer treatment	Mean	Control	Liquid silicon solubilizer treatment	Mean
DRRH-3	16±1.15	10±1.15	13.0	18±1.15	10 ±1.15	14.0	18 ±1.15	12±1.15	15.0	13±1.15	08±1.15	10.5
PA-6129	14±1.15	10±1.15	12.0	16±1.15	12±1.15	14.0	16 ±1.15	08 ±1.15	12.0	10±1.15	08±1.15	09.0
PA-6201	14± 1.15	12±1.15	13.0	14±1.15	12 ±1.15	13.0	16 ±1.15	10 ±1.15	13.0	10 ±1.15	06±1.15	08.0
PA-6444	10±1.15	06±1.15	08.0	08 ±1.15	04±1.1 0	06.0	14 ±1.15	06 ±1.15	10.0	10±1.15	04±1.15 07.0	
PHB-71	08±1.15	04 ±1.15	06.0	06±1.15	2.6 ± 0.6	4.30	14 ±1.15	04±1.15	09.0	08±1.15	04 ±1.15	06.0
BPT-5204	06 ±1.15	2.6±0.66	4.30	04 ±1.15	2.6 ±0.66	3.33	11.3 ±0.6	06 ±1.15	8.66	5.3 ±0.81	2.6 ±0.66	04.0
Mean	11.3	7.44		11.0	7.22		14.8	7.66		9.38	5.44	
	Genotype(G	Treatment(T)	TxV	Genotype (G)	Treatment (T)	TxV	Genotype (G)	Treatment(T)	TxV	Genotype(G)	Treatment(T	TxV
S.Em. ±	0.37	0.65		0.30	0.53		0.22	0.39		0.27	0.47	
CD at 5%	1.11	1.92	2.72	0.89	1.55	2.19	0.66	1.15	1.63	0.79	1.38	1.95

The effects of silicon as a beneficial element is imperative to enhances the crop productivity and improve nutritional value for the plant and also enhance resistance to biotic stresses including fungal pathogens and insect pests.16 The results revealed the fact that silicon solubilizer treatment had a significant effect on infestation by disease and insects. Further, silicon also made rice plants more resistant to fungal diseases therefore elevated the percentage panicle per square meter of area. Application of silicon in rice plants increased the thickness of cell wall, thereby imparting mechanical resistance to the penetration of fungi. This study suggests that silicon could be key player in the sustainable production of rice. Multiple reports suggests the a mechanical role as a barrier for the invading pathogen either by reducing the rate of progress of the disease or by restricting the lesion size and production of spores for secondary infection, and by inducing host resistance by enhancing the levels of preformed inhibitors like phenolics or by mediating the synthesis of post infectionally formed antifungal phyotalexins or by activating oxidative enzymes.30

Apart from its as a beneficial element in promoting plant growth and developmental processes, silicon enhances resistance to bacterial blight of soilless- and soil-cultured rice.24 It has been shown that the foliar application of silicon on plants usually reduce the development of the infection. Plant defence were stimulated through the production of phenolic compounds callose or methyl aconitate.31 Therefore, its potential application in agriculture practices might be a solution for environmental constraint and thereby sustainable rice production.

Conclusion

In conclusion, silicon application on rice plant offers promising results with respect to reducing susceptibility to stress. The genotype which was highly benifitted by the application of silicon in terms of fungal, bacterial diseases and insect infestation such as BPT-5204, PHB-71, PA-6444 were found to be mitigated. These genotypes significantly performed better as compared to other genotypes. Silicon acts as an important element for plant growth but beneficial effects of this element on the growth, development, and disease resistance observed in rice plant species. Further, silicon element plays a most striking and unique function in conferring tolerance in plants against various abiotic stresses such as low and high temperature, salinity and drought, and heavy metal stresses. The outcome of the present study will comprehend researchers and growers for the usefulness of silicon and its potential application in agriculture sector for both realizing into crop protection and production and improvement, suggesting a practical solution of sustainably managing plant diseases and environmental stresses to advance the different physiological traits in rice crop.

Acknowledgments
The authors wish to acknowledge All India Coordinated Rice Improvement Programme of ICAR and Indian Institute of Rice Research, Hyderabad for providing the necessary inputs for conducting the research work.

References
1. Tanaka A, Park YD. Significance of the absorption and distribution of silica in the growth of the rice plants. Soil Sci. Plant Nut 2006; 2: 99-12.
2. Epstein E. Silicon. Annu Rev Plant Physiol Plant Mol Biol. 1999; 50:641-664.
3. Kamenidou S, Cavins TJ, Marek S. Evaluation of silicon as a nutritional supplement for greenhouse zinnia production. Sci Hortic. 2009; 119:297-301.
4. Rodrigues FA, Jurick WM, Datnoff LE, Jones JB, Rollins JA. Silicon influences cytological and molecular events in compatible and incompatible rice-Magnaporthe grisea interactions. Physiol Mol Plant Pathol. 2005; 66:144-159.
5. Ma JF, Tamai K, Yamaji N, Mitani N, Konishi S, Katsuhara M, Ishiguro M, Murata Y, Yano M. A silicon transporter in rice. Nature. 2006; 440:688-691.
6. Nakata Y, Ueno M, Kihara J, Ichii M, Taketa S, Arase S. Rice blast disease and susceptibility to pests in a silicon uptake-deficient mutant. JCP. 2008; 27:865-868.
7. Rodrigues FA, Datnoff LE, Korndorfer GH, Seebold KW, Rush MC. Effect of silicon and host resistance on sheath blight development in rice. Plant Dis. 2001; 85:827-832.
8. Ma JF, Yamaji N, Mitani N, Tamai K, Konishi S, Fujiwara T, Katsuhara M, Yano M. An efflux transporter of silicon in rice. Nature. 2007; 448:209-212.
9. Chiba Y, Mitani N, Yamaji N, Ma JF. HvLsi1 is a silicon influx transporter in barley. Plant. 2009; 57:810-818.
10. Mitani N, Chiba Y, Yamaji N, Ma JF. Identification and characterization of maize and barley Lsi2-like silicon efflux transporters reveals a distinct silicon uptake system from that in rice. Plant Cell. 2009; 21:2133-2142.
11. Montpetit J, Vivancos J, Mitani-Ueno N, Yamaji N, Remus-Borel W, Belzile F, Ma JF, Belanger RR. Cloning, functional characterization and heterologous expression of TaLsi1, a wheat silicon transporter gene. Plant Mol Biol. 2012; 79: 35-46.
12. Sasaki A, Yamaji N, Ma JF. Transporters involved in mineral nutrient uptake in rice. J Exp Bot 2016; doi: 10.1093/jxb/erw060.
13. Jones LHP, Handreck KA. Silica in soils, plants and animals. Adv Agron. 1967; 19:107-149.
14. Johnson LH, Hendricks KA. Silica in soils and plants. Agron. J. 1997; 19:107-109.
15. Ning D, Song A, Fan F, Li Z, Liang Y. Effects of slag-based silicon fertilizer on rice growth and brown-spot resistance. PLoS One 2016; 9:e102681.
16. Pilon-Smits EA, Quinn CF, Tapken W, Malagoli M, Schiavon M. Physiological functions of beneficial elements. Curr Opin Plant Biol. 2009; 12:267-74.
17. Wu L, Lou YS, Meng Y, Wang WQ, Cui HY. Effects of silicon supply on diurnal variations of physiological properties at rice heading stage under elevated UV-B radiation. Ying Yong Sheng Tai Xue Bao. 2015; 26:32-38.
18. Vasanthi N, Saleena LM, Raj SA. Silicon in crop production and crop protection - a review. Agri Reviews. 2014; 35:14-23.
19. Ma JF, Takahashi R. Role of silicon in enhancing the resistance of plant to biotic and abiotic stresses. Soil Sci Plant Nutr. 2009; 50:11-18.
20. Kobayashi T, Kanda E, Kitada K, Ishiguro K, Torigoe K. Detection of rice panicle blast with multispectral radiometer and the potential of using airborne multispectral scanners. Phytopathol. 2001; 91:316-323.
21. Massey FP and Hartley SE. Experimental demonstration of the antiherbivore effects of silica in grasses: impacts on foliage digestibility and vole growth rates. Proc R Soc B 2006; 273:2299-2304.
22. Ando H, Kakuda K, Fujii H, Suzuki K, Ajiki T. Growth and canopy structure of rice plants grown under field conditions as affected by Si application. Soil Sci Plant Nutr. 2002; 48:429-432.
23. Hayasaka T, Fujii H, Ishiguro K. The role of silicon in preventing appressorial penetration by the rice blast fungus. Phytopathol. 2008; 98:1038-1044.
24. Song A, Xue G, Cui P, Fan F, Liu H, Yin C, Sun W, Liang Y. The role of silicon in enhancing resistance to bacterial blight of hydroponic- and soil-cultured rice. Sci Rep 2016; doi: 10.1038/srep24640.
25. Savant NK, Snyder GH Datnoff LE. Silicon management and sustainable rice production. Adv Agron. 1997; 58:151-199.
26. Brunings AM, Datnoff LE, Ma JF, Mitani N, Nagamura B, Rathinosabapathi M, Kirst M. Differential gene expression of rice in response to silicon and rice blast fungus Magnaporthe oryzae. Ann Appl Biol. 2009; 155:161-170.
27. Kupfer C, Kahnt G. Effects of application of amorphous silica on transpiration and photosynthesis of soybean plants under varied soil and relative air humidity conditions. J Agron Crop Sci. 1992; 168:318-325.
28. Zellner W, Frantz J, Leisner S. Silicon delays Tobacco ringspot virus systemic symptoms in Nicotiana tabacum. J Plant Physiol. 2015; 168:1866-1869.
29. Manivannan A, Soundararajan P, Muneer S, Ko CH, Jeong BR. Silicon mitigates salinity stress by regulating the physiology, antioxidant enzyme activities, and protein expression in Capsicum annuum 'Bugwang'. Biomed Res Int 2016; doi: 10.1155/2016/3076357.
30. Fauteux F, Remus-Borel W, Menzies JG, Belanger RR. Silicon and plant disease resistance against pathogenic fungi. FEMS Microbiol Lett. 2005; 249:1-6.
31. Guntzer F, Keller C, Meunier JD. Benefit of plant silicon for crops: A review. Agron Sustainable Dev. 2012; 32:201-213.