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INFLUENCE OF SILICON SOLUBILIZERS ON GROWTH AND YIELD OF RICE GENOTYPES

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ABSTRACT

A Field experiment was conducted at Indian Institute of Rice Research (IIRR), Hyderabad during *kharif* 2014 and *kharif* 2015 to study the influence of silicon solubilizers on growth and yield of eight rice genotypes. The treatments comprised of control (T_0), silixol @ 0.2% (T_1) and Imidazole @0.05% (T_2) and sprayed at tillering stage. The experiment was laid out in split plot design, replicated thrice. Growth and physiological traits *viz.,* plant height, tiller number, leaf area and dry matter accumulation measured at different intervals and grain yield significantly increased under silicon solubilizer treatments compared to control.

KEY WORDS: Rice, silicon, solubilizer, genotypes, yield

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food crops and play vital role in the national food grain supplyin the world and forms the backbone for more than 50 per cent of the world's population and contributes to 42 per cent of total food grains production as well as 45 per cent of the total cereal production in the country. Silicon is the second most abundant element in the earth's crust and rice is one of the most effective silicon-accumulating plant. Rice accumulatesupto 10 per cent of dry weight in the shoots, roots and contributes to enhanced resistance to disease and insects (Ishiguru, 2001). Silicon (Si) deposits in the leaves, stems, and hulls in the form of amorphous silica gel (SiO_2nH_2O) and soluble silicic acid ($Si(OH)_4$. Although silicon is the second largest element present in the soil it is not available for plants due to its presence in the amorphous form. Plants absorb silicon from the soil solution in the form of monosilicic acid, also called orthosilicic acid [H_4SiO_4] (Lewin and Reimann, 1969). This molecule is highly unstable and readily becomes into non available form *i.e.* polymeric silicic acid or forms complex with other compounds to form metasilicates. For the effect Si needs to be absorbed in the form of silicic acid [$Si(OH)_4$], where along with water, it follows the transpiration stream to finally deposit as silica (Sangster *et al.,* 2001). Silicon nutrition in rice has problems like low soil solubility, so the silicon carrier molecule like Imidazole is known to influence silicon uptake and accumulation in crop plants.

MATERIALS AND METHODS

The present study was aimed at evaluating the relative performance of eight rice genotypes for morphological, physiological and yield characters. These genotypes were evaluated in a field experiment, laid out in split plot design where silicon solubilizer treatments were considered as main plots ((T_0) Control, (T_1) Silixol @ 0.2% , (T_2) silicon solubilizer Imidazole @ 0.05%) and rice genotypes (DRRH 3(V_1), PA 6129(V_2), PA 6201 (V_3), PA6444(V_4), PHB 71 (V_5), BPT 5204(V_6), CO 39 (V_7) and HR 12 (V_8)) as sub plots and replicated thrice in *kharif* 2014 and 2015 at Indian Institute of Rice Research, Hyderabad. Prophylactic measures were taken for protecting the crop from pest and diseases. During crop growth period, the silicon solubilizers were sprayed at tillering stage. Data on plant height (cm), tiller number, total plant dry weight(g hill^{-1}), leaf area (cm^{-2}) were recorded at 20 days interval and grain yield was recorded at harvest in both control and silicon solubilizer treatments. The data was statistically analyzed as described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

All the physiological characters *viz.,* plant height, number of tillers, leaf area, total plant dry matter and yield, used for evaluating rice genotypes under silicon solubilizer treatments and control conditions significantly varied between silicon solubilizer treatments and genotypes at different intervals (Table1). Plant height, tillers number and total dry matter increased continuously from 20 Days After Transplating (DAT) to 100 DAT, whereas leaf area increased up to 80 DAT and then decreased at 100 DAT. The rice genotypes differed in their response to silicon solubilizer treatments and control in terms of physiological and yield traits.

Among the genotypes, PHB 71(V_5), PA6129 (V_2) and PA6201 (V_3) recorded significantly higher plant height, number of tillers, leaf area, dry matter and higher yield under silicon solubilizer treatments as well as control. All the above characters were lowest for the genotype Co39(V_7). Genotype HR 12(V_8) maintained highest plant height and dry matter accumulation but recorded lowest yield.

At maturity, Imidazole showed highest plant height by 9.06 per cent, 7.13 per cent; number of tillers per hill by 31.97 per cent, 13.74 per cent; dry matter by 9.87 per cent, 16.13 per cent; leaf area by 23.53 per cent, 19.45 per cent and grain yield by 15.37 per cent, 25.29 per cent over control and silixol. Imidazole also increased the plant height by 8.92 per cent, 6.44 per cent; number of tillers per hill by 14.50 per cent, 8.92 per cent; dry matter by 6.31 per cent, 8.26 per cent; leaf area by12.06 per cent, 8.96 per cent and grain yield by 4.53 per cent, 18.28 per cent over control during *kharif* 2014 and 2015, respectively. Imidazole (T_2) showed better performance compared to silixol (T_1) and control (T_0) at all growth stages in both saeasons.

Increasing plant height under silicon application made leaves and stem more erect thus decreasing self-shading and improving photosynthetic rate. Application of silicon enhanced the total number of tillers per m^2 in rice significantly. These results are similar to the findings of Fabricio *et al.* (2003); Mobasser *et al.* (2008) and Li *et al*. (2012). The increase in number of tillers might be attributed due to increased availability of phosphorus and other beneficial effect of silicon on growth of rice. These results are in confirmative with those reported by Sawant *et al.* (1994).

Singh *et al.* (2005), Singh *et al.* (2007), Muriithi *et al.* (2010) and Sudhakar *et al.* (2004) reported increase in growth and dry matter of paddy due to silicon application through different organic and inorganic sources. The maintenance of photosynthetic activity due to silicon fertilization could be one of the reasons for increased dry matter production in rice crop. Sarma *et al.,* (2017) reported the similar results of significant increased total dry matter in all the genotypes by the application of silicon solublizers. This could be achieved by enhancing the plant physiological and agronomical efficiency of converting light energy into biomass and partioning greater part of it to grains.

Significant increase in leaf area with increase in rate of silicon application was reported in rice by Ma (2003).The application of silicon increased leaf area which enhanced the photosynthetic rate and prevented destruction of chlorophyll (Gerami *et al.,* 2012), increased source, sink strength and provided resistance against diseases (Gu *et al.,* 2011).

The improvement in grain yield might be due to an enhanced growth, yield components and nutrient uptake of rice with the addition of Si (Deren *et al.* 1994 and Pati *et al.* 2016). It is attributed to advantage gained in grain filling and grain weight because of better translocation of photosynthates (*R*ani and Narayanan (1994) and Rani *et al*., 1997). The supply of silica resulting in physical environment leading to better aeration, root activity, nutrient absorption and the consequent complementary effect would have resulted in higher grain and straw yield of rice. Plants become more resistant to fungal disease, and raised the percentage of the filled spikelets and seed yield by increase of cell wall thickness below the cuticle, imparting mechanical resistance to the penetration of fungi, and improvement of the leaf angle, making leaves more erectand enhanced carbohydrate translocation from vegetative part to grain or seeds (Sarma *et al.,* 2017).

CONCLUSION

Among the silicon solubilizer treatments, imidazole treatment (T_2) showed best performance compared to silixol treatment (T_1) and among the genotypes PHB 71(V_5), PA6129 (V_2) and PA6201 (V_3) were superior in terms of growth and yield under both control and treatments.

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1. Influence of silicon solubilizers on growth parameters of rice genotypes at harvest during *kharif* 2014 and 2015

kharif 2014	Plant height				Tiller number				Total dry matter				Leaf Area			
Genotypes	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean
DRRH3(V1)	109.24	115.80	113.20	**112.75**	15.00	18.33	18.00	**17.11**	38.90	43.67	45.20	**42.59**	616.80	633.38	680.30	**643.49**
PA 6129(V2)	104.60	122.30	115.20	**114.03**	14.00	16.00	24.00	**18.00**	45.93	50.77	47.03	**47.91**	635.52	759.99	838.60	**744.70**
PA6201(V3)	103.40	117.30	120.50	**113.73**	15.00	16.00	21.00	**17.33**	41.80	42.85	43.20	**42.62**	579.40	710.50	831.32	**707.07**
PA6444(V4)	101.34	107.10	126.00	**111.48**	12.00	16.33	17.00	**15.11**	41.20	41.30	48.50	**43.67**	591.90	677.00	802.12	**690.34**
PHB 71(V5)	114.50	124.20	123.10	**120.60**	12.00	16.33	27.00	**18.44**	48.27	47.50	50.37	**48.71**	628.90	679.00	977.00	**761.63**
BPT 5204(V6)	102.60	116.30	112.20	**110.37**	14.67	13.67	18.00	**15.45**	43.23	45.37	47.30	**45.30**	595.90	694.80	783.41	**691.37**
CO 39(V7)	86.40	87.20	87.50	**87.03**	11.55	13.00	15.33	**13.29**	34.07	39.57	40.47	**38.03**	435.00	567.00	613.89	**538.63**
HR 12(V8)	174.60	186.30	180.20	**180.37**	11.00	13.33	14.30	**12.88**	46.17	50.03	51.07	**49.09**	452.50	528.07	730.00	**570.19**
Mean	**112.09**	**122.06**	**122.24**		**13.15**	**15.38**	**19.33**		**42.45**	**45.13**	**46.64**		**566.99**	**656.22**	**782.08**	
	T	G	T ×G		T	G	T ×G		T	G	T ×G		T	G	T ×G	
SE m ±	0.118	0.486	0.797		0.724	1.081	1.897		0.376	0.735	1.248		0.942	1.293	2.297	
CD (P=0.05)	0.476	1.393	2.303		2.932	3.096	NS		1.516	2.104	3.779		3.797	3.704	7.031	

kharif 2015	Plant height				Tiller number				Total dry matter				Leaf Area			
Genotypes	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean
DRRH3(V1)	98.20	120.40	102.40	**107.00**	13.33	13.67	15.00	**14.00**	36.95	37.60	39.17	**37.91**	670.00	422.00	480.00	**524.00**
PA 6129(V2)	109.10	112.40	112.50	**111.33**	14.33	16.00	15.67	**15.33**	39.99	42.13	48.27	**43.46**	460.00	780.00	578.00	**606.00**
PA6201(V3)	103.10	112.50	113.20	**109.60**	14.33	15.33	15.00	**14.89**	37.57	41.30	45.65	**41.51**	418.00	426.00	604.00	**482.67**
PA6444(V4)	99.50	103.40	105.70	**102.87**	13.67	12.67	14.33	**13.56**	35.05	34.84	46.89	**38.93**	430.00	474.00	636.00	**513.33**
PHB 71(V5)	107.20	110.10	119.60	**112.30**	13.33	17.00	18.00	**16.11**	39.51	42.74	44.83	**42.36**	434.00	608.00	768.00	**603.33**
BPT 5204(V6)	99.40	108.40	108.20	**105.33**	13.33	13.33	14.00	**13.55**	34.20	35.67	40.14	**36.67**	528.00	462.00	620.00	**536.67**
CO 39(V7)	80.50	78.90	81.20	**80.20**	10.33	13.00	14.67	**12.67**	32.17	34.09	32.13	**32.80**	478.00	438.00	510.00	**475.33**
HR 12(V8)	173.20	180.20	189.50	**180.97**	10.33	12.00	12.67	**11.67**	40.63	52.21	46.79	**46.54**	400.00	404.00	420.00	**408.00**
Mean	**108.78**	**115.79**	**116.54**		**12.87**	**14.13**	**14.92**		**37.01**	**40.07**	**42.98**		**477.25**	**501.75**	**577.00**	
	T	G	T ×G		T	G	T ×G		T	G	T ×G		T	G	T ×G	
SE m ±	1.449	2.350	4.074		0.739	0.818	1.517		0.058	0.20	0.33		1.021	1.223	2.229	
CD (P=0.05)	5.844	6.730	NS		NS	2.342	NS		0.236	0.573	0.956		4.117	3.503	6.931	

(T_0) Control, (T_1) Silixol @ 0.2%, (T_2) Imidazole @ 0.05%

2. Influence of silicon solubilizers on yield and yield components of rice genotypes at harvest during *kharif* 2014 and 2015

***Kharif*2014**	Grain Yield Kg/ha				HI				Test wt			
Genotypes	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean
DRRH3(V1)	8583.33	8850.00	9773.33	**9068.89**	42.08	46.69	50.92	**46.56**	16.04	17.71	18.25	**17.33**
PA 6129(V2)	8056.67	9433.33	10456.67	**9315.56**	53.64	46.96	51.26	**50.62**	24.21	24.98	25.09	**24.76**
PA6201(V3)	9201.67	9163.33	9416.67	**9260.56**	49.87	50.06	52.00	**50.64**	21.15	22.53	22.11	**21.93**
PA6444(V4)	8945.00	9013.33	9600.00	**9186.11**	45.18	46.15	54.15	**48.49**	23.65	22.75	24.00	**23.47**
PHB 71(V5)	9943.33	9146.67	10036.67	**9708.89**	55.74	51.62	52.11	**53.16**	23.80	24.06	24.00	**23.95**
BPT 5204(V6)	6876.67	7323.33	8916.67	**7705.56**	36.11	48.36	50.14	**44.87**	14.47	18.23	18.84	**17.18**
CO 39(V7)	5270.56	5786.67	6530.37	**5862.53**	36.20	37.60	40.66	**38.15**	16.19	18.20	19.17	**17.85**
HR 12(V8)	4670.28	5620.12	6278.21	**5522.87**	34.26	35.57	36.49	**35.44**	14.95	15.80	17.61	**16.12**
Mean	**7693.44**	**8042.10**	**8876.07**		**44.13**	**45.37**	**48.47**		**19.31**	**20.53**	**21.13**	
	T	G	T ×G		T	G	T ×G		T	G	T ×G	
SE m ±	91.829	189.729	320.819		0.245	0.781	1.288		0.107	0.183	0.315	
CD (P=0.05)	370.22	543.390	949.616		0.987	2.236	3.744		0.430	0.523	0.943	

***Kharif*2015**	Grain Yield Kg/ha				HI (%)				Test wt (g)			
Genotypes	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean
DRRH3(V1)	6733.33	7583.33	7993.33	**7436.66**	40.10	42.90	44.90	**42.63**	16.30	17.90	18.40	**17.53**
PA 6129(V2)	5663.33	10910.00	9233.33	**8602.22**	41.50	54.00	46.90	**47.47**	22.20	22.40	23.30	**22.63**
PA6201(V3)	7783.33	8173.00	9236.67	**8397.67**	42.00	45.50	52.50	**46.67**	19.30	20.50	19.90	**19.90**
PA6444(V4)	7166.67	7166.67	7780.00	**7371.11**	40.50	40.30	39.90	**40.23**	21.30	21.60	21.50	**21.47**
PHB 71(V5)	8013.33	8763.33	9353.33	**8710.00**	46.80	48.10	53.84	**49.58**	21.00	21.40	22.20	**21.53**
BPT 5204(V6)	5596.67	6296.67	7196.67	**6363.34**	36.70	39.74	41.83	**39.42**	17.10	17.30	16.50	**16.97**
CO 39(V7)	4886.67	5780.00	6530.00	**5732.22**	34.05	37.13	40.66	**37.28**	19.40	19.90	20.20	**19.83**
HR 12(V8)	4660.00	5063.33	5953.33	**5225.56**	30.67	34.07	39.49	**34.74**	14.83	18.30	18.60	**17.24**
Mean	**6312.92**	**7467.04**	**7909.58**		**39.04**	**42.72**	**45.00**		**18.93**	**19.91**	**20.08**	
	T	G	T ×G		T	G	T ×G		T	G	T ×G	
SE m ±	38.65	106.87	177.411		0.921	2.005	3.377		0.189	0.258	0.459	
CD (P=0.05)	155.85	306.08	517.96		3.715	5.743	NS		0.763	0.740	1.407	

T_0 Control, Silixol (T_1), Imidazole (T_2)