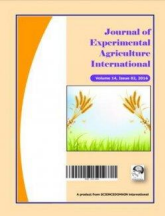

Journal of Experimental Agriculture International

25(4): 1-11, 2018; Article no.JEAI.42551
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Identification of Resistant Germplasm to Rice Blast under Silicon Amendment in Uganda

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Authors' contributions

This work was carried out in collaboration between all authors. Author VMLJ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VMLJ and MK managed the analyses of the study. Author ATH helped in lab. work. Authors PR and PW managed correcting the grammatical, technical work and literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2018/42551
Editor(s):
(1) Francesco Montemurro, Professor, C.R.A. SSC - Research Unit of the Study of Cropping Systems, Metaponto, Italy.
Reviewers:
(1) Anuj Kumar, University of Arkansas, USA.
(2) S. A. C. N. Perera, University of Peradeniya, Sri Lanka.
(3) Oluwatoyin Sunday Osekita, Adekunle Ajasin University, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/25991

Case Study

Received 1st May 2018
Accepted 5th July 2018
Published 24th August 2018

ABSTRACT

Rice blast caused by *Magnaporthe grisea* is one of the most serious diseases of rice, causing yield losses of 50 – 100% in susceptible varieties worldwide. Durable host resistance has been hard to achieve given large pathogen diversity and capacity of pathogen to mutate. It has been suggested that silicon enhances durable resistance in partially resistant genotypes. A study was conducted to evaluate rice genotypes for their reaction to *M. grisea* under silicon amendments and to detect genotypes with high silicon uptake. Sixty-seven genotypes were evaluated for their reaction to *Magnaporthe grisea* under silicon amendments in a CRD in three replications in a screen house. Seeds were planted in soil amended with silica gel at the rate of 0, 29, and 58 g per 180 g of soil. Genotypes were inoculated with a virulent strain of *Magnaporthe grisea* (Namulonge isolate) 21 days after planting. Seven plants were inoculated per genotype. Data were taken on lesion size induced by blast one week after inoculation and, interpreted from 9 to 0. Data were also taken on leaf blast severity and used to compute area under disease progress curve (AUDPC). Twenty-four

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genotypes were highly resistant (HR), twenty - two were resistant (R), fourteen were moderately resistance (MR), four were moderately susceptible (MS) and three were susceptible (S). Silicon concentration significantly (P <.001) impacted on the reaction of genotypes to blast. The interaction of genotypes with silicon was also highly significant (P <.001). AUDPC was significantly influenced by silicon concentration (P = 0.008). The genotypes that consistently showed resistance to rice blast disease were recommended to similar conditions. The sixty-seven genotypes were screened for the capacity to absorb silicon. Twenty-day old seedlings were placed into 50 ml plastic bottles containing one-half concentration of Kimura B solution, adjusted with 0, 5, 10 and 15 mM silicon respectively. Each bottle was wrapped with an opaque plastic membrane for 12 hours after Si application. 0.9 ml of silicon uptake solution was drawn from each bottle and silicon concentration determined. Final silicon uptake ability readings were highly significant among genotypes. The leaf blast reaction of the genotypes under silicon amendment was found to be directly proportional to their silicon uptake ability which in turn increased with the increasing amount silicon solution absorbed by the plant, from 5, through 10 to 15 Mm/L. Significant correlations of Si uptake abilities to blast disease reactions and area under disease progresses were found in this study.

Keywords: AUDPC; Magnaporthe grisea; yield loss; screening; Oryza sativa.

1. INTRODUCTION

Rice is the principal food grain consumed by half of the world's population [1]. The crop has been cultivated for over 10,000 years [2] with Asia and Africa being the leading consumers.

Globally, the area under rice production is estimated at 150 million hectares with an annual output of 500 million metric tons [3]. India, Indonesia and Bangladesh are among the leading producers of rice globally [4]. In Africa, the crop is cultivated in over 75% of the continent and is an important food security crop in several countries including Benin, Angola, Ghana, Burkina Faso and Uganda [4]. In Uganda rice production from year 2010 to 2014 jumped from 93 to 95 thousand hectares, with a production increase from 214 to 237 thousand tones [5]. Several constraints were responsible for the lack of attaining the potential yield including pests and disease, changing weather patterns and unfavorable soil conditions [6]. Among these constraints, rice diseases like rice yellow mottle virus, bacterial blight and blast presented the most formidable challenge to the farmers [6]. Rice blast, caused by *Magnaporthe grisea,* is one of the most devastating diseases, causing yield losses of 50 to 90% [7]. Identifying sources of resistance to rice blast has been a major objective for many researchers involved in rice breeding programs [8,9].

The control measures suggested by [10] have not been able to mitigate the challenge presented by the disease. In areas where the disease is prevalent, resistant cultivars are expected to have a field life of only 2 to 3 cropping seasons owing to the generation of new virulent forms of the fungus [11] and the great variability of *Magnaporthe grisea* [12]. This implies that there is need to continuously screen available rice germplasm for resistance to the disease and to monitor changes in the pathogen population. Fungicides on the other hand are not only expensive for the resource poor farmers but also associated with potential adverse effects to the environment [13].

There is thus a need to investigate and avail broad alternative spectrum, sustainable and environmentally friendly ways of managing the disease.

Silicon as a macro element plays a vital role in the plant's life cycle, and it is the second most abundant element in the soil after oxygen [14]. It is thought to play a role in improving rice crop yield as much as it is not an essential element [15]. [16] reported that the use of Si to control blast was a viable, economically friendly approach as Si enhances resistance on partially resistant cultivars. Breeding cultivars with a high capacity for silicon uptake could, therefore, provide an alternative to increase rice crop resistance to blast [17]. This study was aimed at identifying rice lines with resistance to rice blast disease under silicon soil amendment and correlate genotypes silicon uptake ability intake concerning resistance to blast.

2. MATERIALS AND METHODS

2.1 Study Area and Genotypes Used

Sixty- seven rice genotypes from different countries (Table 1) were screened with one resistant (IR-64) and one susceptible (NERICA-

14) checks at the National Crops Resources Research Institute (NaCRRI) during 2017. NaCRRI is located at 0°31' N, 32°35' E, with a mean altitude of 1150 m above the sea level. A screening was done under screen house using a single virulent isolate of the pathogen (obtained from Namolonge January 2017). Seeds of test lines and the two checks were planted in 30 cm diameter buckets filled with forest soil (using 7 seeds/pot) in a CRD with three replications. The soil was amended with silicon at rates of 0 g, 29 g, and 58 g silicon per bucket in 3 kg soil per packet. The plants were inoculated with a virulent *Magnaporthe grisea* isolate 21 days after planting. The experiment was repeated once with consistent results.

2.2 Inoculum Preparation and Inoculation

The virulent *Magnaporthe grisea* isolate was cultured in Petri-dishes on oatmeal agar (20g) and incubated at 28°C for 20 days to induce sporulation (Koga, 1994). The fungal spores were harvested by putting 10 ml of sterile distilled water on to the petri dish and then using a brush to pick up the spores. The solution was then poured through a fine gauze to retain the spores Koga (1994). A final spore concentration of 5 x 10^4 spores/ml was obtained using a haemacytometer. Spraying of the spore-containing solution on the rice leaves was done using a hand sprayer. Each plant was sprayed until thoroughly wet.

2.3 Data Collection and Analysis

Data on leaf blast severity were collected on plants by scoring the percentage of the leaf tissue showing typical blast lesions in each pot. The reaction of rice genotypes to blast was then interpreted according to the scale by Shrestha and Misra (1994) as; 0-15% = Resistant (R), 15.130% = Moderately Resistant (MR), 30.1-50% = Moderately Susceptible (MS) and 50.1-100% = Susceptible (S). Data were also collected on lesion size induced by a blast on the inoculated leaves. Disease evaluation for leaf blast was done four times, starting 7 days after inoculation and then every 7 days for the next 21 days. Data on blast severity was subjected to area under disease progress curve (AUDPC) according to [18]; $AUDPC = \sum_{i=1}^{n}[\mathrm{Xi} + 1 + \mathrm{Xi}]/2$ [t i + 1 – t i] where; X_i = blast severity at the ^{i}th observation, t_i = the time in days after appearance of the disease at the ^{i}th day, and n = total number of observations. Data on lesion size was subjected to analysis of variance using Genstat statistical package to establish the significance of observed variations in lesion size among genotypes.

2.4 Silicon Uptake Ability

The sixty- seven rice genotypes (Table 1.) Were screened for silicon uptake ability with one high silicon uptake ability (IR-64) and one low silicon uptake ability (NERICA-14) checks. Four Seeds of test lines and the two checks were planted in each 30 cm diameter buckets filled with forest soil (using 4 seeds/pot) in CRD design in three replications.

The 20-day old seedlings were placed into 50 ml plastic bottles containing a one-half concentration of Kimura B containing the macronutrients (mM): (NH4)2SO4, MgSO4.7H2O, KNO3, CaNO3.4H2O and KH2PO4, and the micronutrients (mM): Na2EDTA-Fe(II), MnCl2.4H2O, H3BO3, Na2MoO4.4H2O, ZnSO4.7H2O and CuSO4.5H2O. The pH of the solution was adjusted to 4.5 using 01 M HCl. The solution was complemented with 0.16, 0.4, and 1.6 mM silicon, respectively. Potassium metasilicate (K2SiO3) was used as the source of silicon. Each bottle was wrapped with an opaque plastic membrane for 12 hours, after the silicon treatment, 0.9 ml liquid of the uptake solution was taken from each bottle for the determination of silicon concentration. Transpiration was also measured by evaluating water loss at each sampling time.

The roots of each genotype were harvested and dried in an oven at 60°C for 2 days.

2.5 Data Collection

The amount of Si uptake was calculated from the depletion of Si in the uptake solutions. Si uptake per plant (SP) was calculated according to the following formula:

SP = $NW_b XCS_b$– (NW_b–WW) X CS_f where NW_b was the amount of nutrient at the beginning of experiment; CS_b and CS_f were the Si concentrations at the beginning, and the end of the investigation, respectively, and WW was the amount of water loss. Si uptake per unit root dry weight (SR) was calculated as SR = SP/RDW where RDW was the root dry weight per plant. The Si concentration in the solution was determined using the colorimetric molybdenum blue method as described by [19].

Table 1. List of selected rice genotypes used for the study in Kampala, Uganda in the two rounds screening of 2017

No.	Genotyp	FLP	S	No.	Genotype	Flbr	S	No.	Genotype	FLP	S
1	METP7	R	AR	24	MET P62	HR	AR	47	IRL 29	R	ARB.
2	MET P9	R	AR	25	MET P67	MS	AR	48	IR 47	R	ARB
3	METP10	HR	AR	26	MET P68	R	AR	49	IRL 53	MS	Egypt
4	METP11	HR	AR	27	IURON2014(230)	R	IRRI	50	IRL 69	R	Egypt
5	METP12	R	AR	28	AGRA 65	MR	CRI, Ghana	51	Yasmin aromatic	S	Egypt
6	METP17	HR	AR	29	AGRA 60	HR	CRI, Ghana	52	Giza 178 high yield	S	Egypt
7	METP18	R	AR	30	AGRA 55	HR	CRI, Ghana	53	GIZA 179	MR	Egypt
8	METP20	MR	AR	31	AGRA 78	HR	CRI, Ghana	54	GIZA 177	MS	Egypt
9	METP23	HR	AR	32	E 22	MS	NARO, Uganda AR	55	GIZA 182	R	Egypt
10	METP24	R	AR	33	SANDY	R	NARO, Uganda	56	E-YASMIN	R	Egypt
11	METP26	HR	AR	34	E 20	HR	IRRI	57	GIZA 178	HR	Egypt
12	METP28	R	AR	35	IURON (2014) 41	HR	IRRI	58	AGRA 41	R	ARB
13	METP30	R	AR	36	IURON (2014) 37	MR	ARB	59	Gigante	R	AR
14	METP36	HR	AR	37	ARC36-2-1-2 (1)	HR	ARB	60	K85	HR	-
15	METP38	MR	AR	38	ARC36-2-P-2-54 (2)	R	ARB	61	K38	MR	China
16	METP41	HR	AR	39	ARC36-4-ET-2 (3)	MR	ARB	62	WITA 9	MR	-
17	METP46	HR	AR	40	ARC39-145-P-3 (4)	HR	ARB	63	K34	MR	China
18	METP48	HR	AR	41	ARC39-145-P-2 (5)	HR	ARB	64	Namche 2	R	-
19	METP49	R	AR	42	ARS126-3-B-1-2 (11)	R	ARB	65	KOMBOKA	HR	IRRI
20	MET P51	HR	AR	43	MGC5 (51)	MR	RB	66	IR 64 (RC)	HR	IRRI
21	MET P52	HR	AR	44	IRL 4	MR	ARB	67	Nerica14 (SC)	S	-
22	MET P53	HR	AR	45	1RL 5	MR	ARB				
23	MET P54	HR	AR	46	IRL 2	HR	ARB				

No: number, RC = Resistant check, SC = Susceptible check, R= Resistant, MR = Moderate resistant, HR, Highly resistant, S = Susceptible, MS = Moderate Susceptible, AR = Africa Rice, ARB = Africa Rice Benin, AR = African Rice and Flbr = Final leaf blast reaction.

2.6 Data Analysis

The data were subjected to analysis in GenStat, and complete randomized design analysis was used.

3. RESULTS

The results of the analysis of variance of the reaction of rice genotypes to *Magnaporthe grisea* and silicon uptake related to the genotypes' resistance are presented in Table 2. The results showed significant differences (P <.001) among genotypes for final leaf blast severities and silicon uptake abilities.

Highly significant variation (P <.001) was observed in the reaction of genotypes to blast at varying Si concentrations. The interaction of rice genotypes with the different Si concentrations was highly significant (P <001). The AUDPC varied significantly among genotypes (P = 0.008) and for the different Si concentrations (P <. 001).

3.1 Reaction of Rice Genotypes to Disease under Si Amendment

The reaction results of rice genotypes to fungus attack under Si amendment is given in Table 1. Twenty-three genotypes were highly resistant (HR), twenty – three were resistant (R), fourteen were moderately resistance (MR), and four were moderately susceptible (MS). Three were susceptible (S) genotypes GIZA 178, high yielder and Yasmin, an Aromatic were susceptible (S) and most of the genotypes showed resistant as the silicon concentration genotypes increased from 0, 29, and 58 mg/l. Twenty-four genotypes were highly resistant (HR) Table 3.

3.2 Relation of Si Uptake Ability of Rice Genotypes to Leaf Blast Reaction under Si Amendment

The results of silicon uptake abilities under different silicon concentrations are presented in Fig. 1 The sum of each silicon uptake abilities under soil silicon amendment concentrations of 0, 29, and 58 mg/l.

3.3 Correlations of Si Uptake Ability to Blast and Silicon Concentrations Amended

The results of correlation between silicon uptake abilities, blast scores and Areas under disease progress curve are presented in Table 4. The silicon uptake abilities under concentration 5, 10, and 15 mg/l to blast reactions and area under the disease progress curve were weak or no correlations (<3) and so do to their areas under the disease progress curve were significant different (< 0.001).

Table 2. Analysis of variance for a reaction of rice genotypes to blast under silicon soil amendment

Source of variation	DF	ms Blast	P - value blast	ms AUDPC	AUDPC	ms Si uptake	P - value Si
Rep	2	9.28		1046.03 ns		1.108	
Geno	66	5.844***	<.001	305.61***	0.01	2.45***	<.001
Si_Conc	2	24.761***	<.001	177.73**	<.001	1.751***	<.001
Geno.Si_Conc	132	4.926***	<.001	88.64***	<.001	1.696**	<.001
Residual	400	1.79		36.83		4.374	
Total	602	1.587		4.766		2470	
Mean		1.5587		42		18814	
Max		0		0		21.6	
Cv%		84.3		127.3		26.8	

***, *** significant at 0.01 and 0.001 probability respectively, ns = non-significant at p> probability, CV = Coefficient of variation, AUDPC = Area under disease progress curve, Geno = Genotype, Si = silicon, Conc = Concentration, df = degree of freedom, Min= Minimum, Max = Maximum, D.F= Degree of freedom, and ms = mean square*

Table 3. Means of a blast, AUDPC and Si uptake for 67 rice genotypes grown in screen house at NACRRI for 2017 two screening rounds

Number	Genotype	Leaf blast score			AUDPC			Si uptake		
		Si concentration			Si concentration			Si concentration		
		Si: 0	Si:29	Si: 58	Si: 0	Si:29	Si: 58	Si: 5	Si: 10	Si: 15
1	MET P7	1	0	0	4	4	0	669	3791	4449
2	MET P9	1	1	0	6	4	0	889	1709	6601
3	METP10	0	0	0	2	0	0	788	2349	6991
4	METP11	0	2	0	14	2	0	1079	1427	6289
5	METP12	1	1	1	6	4	0	537	692	6226
6	METP17	0	0	0	0	0	0	1366	2769	6249
7	METP18	1	1	0	4	4	0	423	1215	3511
8	METP20	2	0	0	12	0	0	371	356	449
9	METP23	0	0	0	2	0	0	511	1465	6598
10	METP24	1	0	1	12	6	0	739	2175	3588
11	METP26	0	0	0	12	2	0	1048	1510	6355
12	METP28	1	0	0	4	0	0	494	570	3142
13	METP30	1	0	0	4	0	0	1507	1065	3443
14	METP36	0	0	0	2	0	0	1308	2291	6151
15	METP38	3	2	2	20	12	2	707	1056	3020
16	METP41	0	0	0	0	0	0	1191	2754	3317
17	METP46	0	0	0	0	0	0	400	1189	6815
18	METP48	0	0	0	0	0	0	1104	3246	14669
19	METP49	1	0	0	0	0	4	971	1249	13803
20	MET P51	0	0	0	0	0	0	2566	2566	2557
21	MET P52	0	0	0	0	0	0	1163	3488	5349
22	MET P53	0	1	0	4	2	0	915	1213	6271
23	MET P54	0	0	0	0	0	0	673	1993	6930
24	MET P62	0	0	0	2	0	0	1366	4073	7554
25	MET P67	5	3	3	30	20	12	673	571	5887

Number	Genotype	Leaf blast score			AUDPC			Si uptake		
		Si concentration			Si concentration			Si concentration		
		Si: 0	Si:29	Si: 58	Si: 0	Si:29	Si: 58	Si: 5	Si: 10	Si: 15
26	MET P68	0	1	1	20	4	2	1272	1909	2843
27	IURON2014(230)	1	0	0	4	4	0	935	815	1615
28	AGRA 65	2	0	0	18	4	0	1303	1862	2205
29	AGRA 60	0	0	0	0	0	0	1082	3075	3645
30	AGRA 55	0	0	0	0	0	0	1674	1674	1653
31	AGRA 78	0	0	0	0	0	0	1185	849	1892
32	E 22	4	2	2	24	14	2	1493	4515	5269
33	SANDY	1	0	0	4	2	0	1525	4713	7461
34	E 20	0	0	0	0	0	0	368	1053	1225
35	IURON (2014) 41	0	0	0	0	0	0	3222	3222	3222
36	IURON (2014) 37	3	3	3	20	20	18	1059	1231	5827
37	ARC36-2-1-2 (1)	1	0	0	4	4	2	110	649	4753
38	ARC36-2-P-2-54 (2)	2	0	0	14	14	10	212	609	12649
39	ARC36-4-ET-2 (3)	3	2	2	16	12	12	687	2050	6623
40	ARC39-145-P-3 (4)	0	0	0	0	0	0	744	1214	1751
41	ARC39-145-P-2 (5)	1	0	0	4	4	0	1157	1873	12275
42	ARS126-3-B-1-2 (11)	2	0	0	12	12	0	391	557	6010
43	MGC5 (51)	3	2	2	16	16	12	967	1792	5472
44	IRL 4	3	2	2	20	16	0	815	935	1599
45	1RL 5	3	2	2	16	12	0	513	612	18614
46	IRL 2	0	0	0	0	0	0	473	531	5863
47	IRL 29	1	0	0	6	0	0	654	377	12031
48	IR 47	1	0	0	6	0	0	629	774	702
49	IRL 53	4	3	3	24	20	18	727	1183	13913
50	IRL 69	1	0	0	8	0	0	875	1245	3935
51	YASIMIN AROMATIC	6	5	5	32	32	28	476	1430	14325
52	GIZA 178 HIGH YIELDER	6	2	2	32	20	32	431	590	16879

Number	Genotype	Leaf blast score			AUDPC			Si uptake		
		Si concentration			Si concentration			Si concentration		
		Si: 0	Si:29	Si: 58	Si: 0	Si:29	Si: 58	Si: 5	Si: 10	Si: 15
53	GIZA 179	3	0	0	16	0	0	570	213	12061
54	GIZA 177	4	2	2	26	12	0	269	790	12629
55	GIZA 182	1	0	0	6	0	0	872	811	13603
56	E-YASMIN	1	1	0	0	8	0	876	987	3926
57	GIZA 178	0	0	0	4	2	0	947	1651	6495
58	AGRA 41	1	1	1	12	4	4	870	685	11950
59	Gigante	1	0	0	4	3	2	1235	2107	2985
60	K85	0	0	0	0	0	0	1107	1968	1744
61	K38	2	0	0	12	12	0	629	796	13841
62	WITA 9	2	0	0	2	0	0	1167	3537	13087
63	K34	3	0	0	16	4	0	12359	12359	12492
64	Namche 2	1	0	0	0	12	6	1828	3493	4728
65	KOMBOKA	1	0	0	0	0	8	434	230	12655
66	IR 64 (RC)	0	0	0	0	0	0	754	805	5522
67	Nerica14 (SC)	5.5	1.67	1.67	12	10	8	172	673	6823
	LSD	2.5	2.3	1.5	9.66	9.6	9.58	290.1	292.2	1820.5
	CV%	110.2	73	75.8	102.2	139.2	142	16.4	10.2	16.6

AUDPC = area under disease progress curve, FLBR = Final leaf blast reaction, Si: 0, Si: 29, Si: 59 Si: 5, Si: 10 and Si: 15 = blast reaction under 0, 29, 58, Si: 5, Si: 10, and Si: 15 mg/l, silicon concentrations respectively, CV = Coefficient of variation, and LSD = least significant difference.

Table 4. Correlation of Si uptake abilities to blast reaction under different silicon concentration during two rounds screening in 2017

	AUDPC	Blast conc0	Blast conc29	Blast conc58	Uptakes conc5	Uptakes conc10	Uptakes conc15
AUDPC	-						
Blast conc0	1.000***	-					
Blast conc29	0.225***	0.225***	-				
Blast conc58	0.458***	0.458***	0.292***	-			
Uptakes conc5	0.046	0.046	-0.027	-0.098	-		
Uptakes conc10	-0.034	-0.034	-0.036	-0.089	0.865***	-	
Uptakes conc15	0.277***	0.277***	0.265***	0.180	0.058	0.042	-

AUDPC = Area under disease progress curve, Blast conc. = blast reaction under concentrations 0, 29 and 58 respectively, silicon Uptake abilities under concentrations 5, 10 and 15 mg/l respectively.

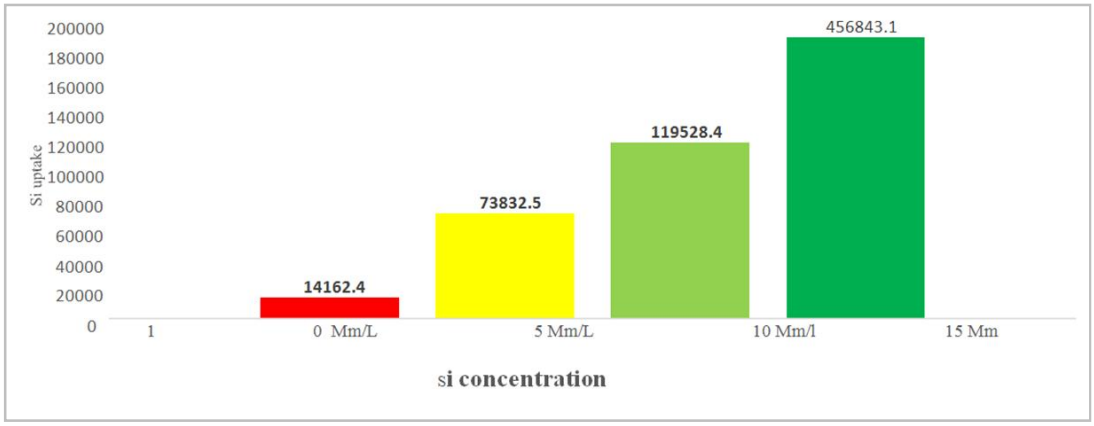

Fig. 1. Silicon uptake at different silicon concentrations for rice genotypes in the screen house (2017 screening) NaCCRRI)

4. DISCUSSION

The results of the screening revealed that genotypes were significantly different for leaf Blast reaction (Table 3.) in the area of NaCRRI, Namulonge, Kampala Uganda. The two screening rounds indicated that genetic variability existed among the screened genotypes. The use of silicon was also useful for enhancing resistance, which is an advantage for improved cultivars for blast resistance. The genotypes used in this study showed an increase in strength when treated with silicon. The genotypes differed in their reaction to blast based on the different silicon concentrations indicating a difference in performance of the rice genotypes under the different silicon concentrations. Similar findings were reported by [8,20] who screened rice genotypes against rice blast. These variations were attributed to different genetic constituents and the amount of silicon added to the soil.

[21] studied the effect of silicon application in increasing resistance to leaf blast in the rice variety cv. Sasanishiki which carries resistance genes *Piks* and *Pia* but is highly susceptible to compatible races of *Magnaporthe grisea* and they found that the plants sown in silicon added soils in a screen house showed decreased blast severity with increase in amount of silica gel applied and the amount of silicon in the leaf was also found to increase with the amount of silica gel used to the soil. These findings indicated that screening under screen house conditions with silicon amendment was useful for increasing

genotypes resistance with resistant genes to rice blast disease.

The analysis of silicon uptake results revealed that genotypes were significantly different for Si uptake ability (Table 3) and indicated that genetic variability existed among the screened genotypes which are an advantage fo.r improved resistance to blast in rice. Similar results were reported by [22] who compared the silicon uptake ability of the Japonica variety cv. Kinmaze and the Indica variety cv.DV85 under three different silicon concentrations (0.16, 0.4 and 1.6 mM) at different time points from 1 to 12 hours.

Significant correlations of Si uptake abilities to blast disease reactions were found in this study (Table 4). Previously reports provided evidence that levels of blast, scald, and brown spot were negatively correlated with the amount of Si fertilizer applied to Si-deficient soils; however, only [23] positively correlated the concentration of Si in *M. grisea* infected leaf tissue and severity of disease. Winslow, [24] compared the incidence of neck blast and seriousness of scald with Si concentration of flag leaves and reported mixed correlations with illness and Si concentration of flag leaf tissue. Because frequency of Si varies by plant part, it is possible that Si content of the flag leaf is not representative of the condition of other diseased tissues. [25] found that the shoot dry matter and grain yield had positive linear relationship with shoot silicon content.

5. CONCLUSION

The screening in the screen house under silicon amendment showed that the silicon uptake by the rice genotypes enhanced the resistance of genotypes to rice blast. The genotypes that were moderately resistant to blast could be used as a source of strength in combination with silicon applications.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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