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Effect of Biogenic Silica Nanoparticles on Blast and Brown Spot Diseases of Rice and Yield Component

Gabr, W. E.[1]; A. A. Hassan[1]; I. M. Hashem[2] and Zeinab A. Kalboush[1]
[1] Rice Pathol. Dept., Plant Pathol. Res. Inst., Agric. Res. Center, Egypt.
[2] Rice Dept., field crops Res. Inst., Agric. Res. Center, Egypt.
Corresponding author: E-mail, zeinab.rrtc@yahoo.com

ABSTRACT

Rice is considered as one of the most important food crops in the world. Rice plants infected by several plant pathogens. In Egypt, however important diseases of rice namely blast and brown spot are major limitation on rice production and becoming more sever on rice grown in silicon depleted soil. Disease that occurs to plant may reduce the ability of the plant to survive and in more severe cases could eventually lead to plant death. Two field experiments were carried out to study the effect of different sources of biogenic silica nanoparticles on blast, brown spot diseases and yield component in rice at Rice Research and Training Center Experimental Farm, Sakha, Kafr El-Sheikh, Egypt. The effect of different sources of silica on the behavior and infection by rice blast on Sakha 101 rice variety had been studied in the first experiment. While the second experiment included the behavior and infection by brown spot of Egyptian Hybrid Rice One under silica nanoparticles biogenic treatments. The silica treatments were white rice husk, rice husk nanoparticles, white rice straw, rice straw nanoparticles, Mg_2O_8 Si_3, and K_2 SiO_2. Chemical fungicides (Beam and Del-Cup) and tap water were used as control. Different biogenic and chemical silica led to decreasing blast disease infection in Sakha 101 compared with control (tap water). Most of the agronomic characters of Sakha 101 were affected significantly by different treatments. All treatment of different biogenic and chemical silica sources decreased the leaf infection percent and severity for brown spot disease on Egyptian Hybrid Rice One. Different treatments significantly affected panicle length, number of filled grains per panicle, number of unfilled spikelets per panicle, 1000-grain weight, and grain yield and harvest index of Egyptian Hybrid Rice One. The result of this study suggests that silica caused decrease the intensity of blast and brown spot diseases.

Keywords: white rice husk, rice husk nanoparticles, white rice straw, rice straw nanoparticles, *Magnaporthe oryzae, Bipolaris oryzae*

INTRODUCTION

Rice is one of the most important food security crops and as a result of population increase; the demand for rice has increased year after year. Rice production has to be increased to cover the rice needs all over the world.

The most important diseases on rice in Egypt are rice blast (*Magnaporthe oryzae*), brown spot (*Cochliobolus miyabeanus*), bakanae rice disease (*Fusarium moniliforme*), and sheath blight (*Rhizoctonia solani*). This study focused on rice blast and brown spot. Rice blast is one of the most important diseases on rice. It is caused by the hemi-biotrophic fungus *M. oryzae* and can infect all aerial parts of rice, leading to neck and panicle rot, collar rot, leaf blast and node blast. Annual losses caused by rice blast can vary between 10% and 30% of the harvest. Brown spot is caused by the necrotrophic fungus *C. miyabeanus* (teleomorph) or *Bipolaris oryzae* (anamorph). It is one of the most divesting and prevalent disease of rice (Ou 1985). *C. miyabeanus* can also cause blight on small rice seedlings (Webster and Gunnell 1992). In plants broad spectrum resistance is a rare phenomenon. Often when a plant is tolerant towards one type of stress, trade-offs occur making the same plant more susceptible towards another type of stress. The only exception is Si, which is well known to protect plants against different pathogens: *M. oryzae, Xanthomonas oryzae pv. oryzae, C miyabeanus* and *R solani* (Van Bockhaven *et al.,* 2012).

Silicon is an important and necessary element for rice growth, which has useful effects on rice growth. In shortage of Si, the plant goes to nutritional tribulation. Therefore, Si causes plant resist against pests and illnesses, so it is recommended that in mineral nutrition argument of rice silicate fertilizer should be used. Moghadam and Heidarzadeh 2014 surveyed pure silicate fertilizer, rice husk and rice husk ash at different levels on rice. They reported that by applying related treatments morphological specifications, plant height, number of tillers, leaf area, leaf stem and total dry weight and silicon density in leaf texture and stem and a progressive process which in tillering stage was significant 1%level. Also by applying treatments at different levels there was witness of increasing in grain yield that was significant at 5% level.

Silicon application increases rice resistance to blast on both partially resistant and susceptible cultivars (Seebold *et al.,* 2001). Rodrigues *et al.* (2004) discovered that infected leaves of Si- plants (Si non-amended plants) displayed intense chlorosis compared with the leaves of Si+ plants (Si amended plants). It was described that Si merely acts as a physical barrier, due to the silica deposition in the leaves, which hampers fungal penetration into the epidermis. Later it became increasingly clear that this passive role of Si is not the only determinant for the Si-elicited stress protection (Jones and Handreck, 1967). Silicon-induced brown spot resistance is the result of a constriction of the fungal progression in the mesophyll. The role of ROS, accumulation of lignin and callose seem to be negligible factors in the resistance. Very few reports suggest that Si application might lead to a very timely and local boost in ROS production leading to resistance (Ghareeb *et al.,* 2011; Sun et al. 2010; Shetty *et al.,* 2012). More articles can be found on the ROS catching effect of Si during infection and abiotic stress (Liang et al. 2005; Nwugo and Huerta 2011; Van Bockhaven *et al.* 2012).

The purpose of this study is to use natural sources of silica to increase the resistance of rice plants to blast and brown spot as alternative methods of fungicide use and increase of quality and grain yield.

MATERIALS AND METHODS

1: Silica sources {biogenic nanoparticles (Si NPs) and chemical Silica}: The author in previous study (Kalboush, *et al.,* 2017) had perpetrated and synthesized biogenic nanoparticles to obtain white rice straw (WRS), rice straw nanoparticles (RSNPs) with SiO2 content of 55.72%, white rice husk (WRH) and rice husk nanoparticles (RHNPs) with SiO2 content of 76.3%, from Kalboush, *et al.,* 2017. The particles size for RSNPs and RHNPs were 73.6 nm and 133.7 nm with spherical shape. Size and morphology of Silica nanoparticles were confirmed by X-ray diffraction (XRD) and transmission electron microscopy (TEM). Concentrations of RSNPs and RHNPs sterile deionized water. All solutions were stored at 4^o C until use. The chemical sources of silica were Mg_2O_8 Si_3 and K_2SiO_2 with 25% (w/v) of SiO_2 content.

2. Effect of different sources of silica on rice blast and brown spot diseases incidence: The present investigation was carried out at the Experimental Farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, during 2015 and 2016 seasons. The effect of sprayed with biogenic Si NPs chemical Silica on blast and brown spot diseases, and yield component on rice.

Two separated experiments were carried out; in the first experiment Sakha 101 as susceptible rice cultivar for rice blast disease was used while Egyptian hybrid 1 used for rice brown spot in the second experiment.

Different treatments of biogenic, chemical silica, fungicides with determined concentration plus control (water) were used in complete randomized block design in both experiments as indicated below:

Treatment	Concentration
1. White rice husk (WRH)	0.45g/l
2. Rice husk nanoparticles (RHNPs)	0.45g/l
3. White rice Straw (WRS)	0.45g/l
4. Rice Straw nanoparticles (RSNPs)	0.45g/l
5. Mg2O8 Si3	2g/l
6. Mg2O8 Si3	3g/l
7. K2SiO2	2ml/l
8. K2 SiO2	3ml/l
9. Beam (Tricyclazole) fungicide in Exp.1	0.5g/l 5ml/l
OrDel Cup (Copper Sulfate Pentahydrate) Exp.2	0
10. Control	

All treatment sprayed at 30 days after transplanting and booting stages. Nitrogen fertilizer supplied in the form of urea (46.5% N) in two equal splits, i.e., half as basal incorporated into the dry soil immediately before flooding, followed by the second dose 30 days after transplanting. Pre-germinated seeds were uniformly broadcasted in the nursery on 6th and 9th May of the two seasons, respectively. Twenty-five day old seedlings of each genotype were transplanted at 20 X 20 cm spacing with two seedlings per hill. Plot size was 12 m^2. All other agronomic practices were followed as recommended during the growing seasons.

3. **Disease assessment:**

One hundred leaves were randomly collected from each plot to determine leaf blast and brown spot infection at intervals of 15 days started from the appearance of primary infection. Percentage of the infected leaves was calculated, while severity of infection was estimated by counting the total number of infection (type 4 lesion type or more) blast lesions/100 leaves. Neck rot infection was estimated by collecting one hundred panicles from each plot one week before harvesting. The severity of neck rot infection was calculated using the formula adopted by Townsend & Huberger (1943) as follows:

$$S = \frac{sum\,(n \times v)}{10N} \times 100$$

Where:

S= severity of panicle blast infection,

n= number of panicles within infection category (from one with one infected primary branch of the panicle to 10 for the complete infection in the uppermost internode of the panicle as neck infection);

V= numerical values of infection categories,

N= Total number of panicles, and

10= constant, highest numerical value

4-Agronomic characters: The studied characters include plant height cm, number of tillers per hill, panicle length (cm), number of filled grains per panicle, number of unfilled spikelets per panicle, 1000-grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), and harvest index.

5-**Data Analysis:** Data were statistically analyzed using analysis of variance (ANOVA) of the complete block design was applied in field experiments. The complete block design was adopted according to Gomez and Gomez (1984). The treatment means were compared using the least significant difference (LSD) at 5%.

RESULTS AND DISCUSSION

Characterization of Silica NPs:

Characterization by X-ray diffraction (XRD):The X-ray diffraction of RSNPs showed a broad between 27° and 32°, centered at 23°, typical for amorphous silica (Fig. 1A). On the other hand, X-ray diffraction of RHNPs showed a broad between 20° and 30°, centered at 30°, typical for amorphous silica (Fig. 1B). XRD pattern of RHNS shows a broad peak at 2ϴ=220 which confirms the amorphous nature of RHNS (Dominic *et al.,* 2013).

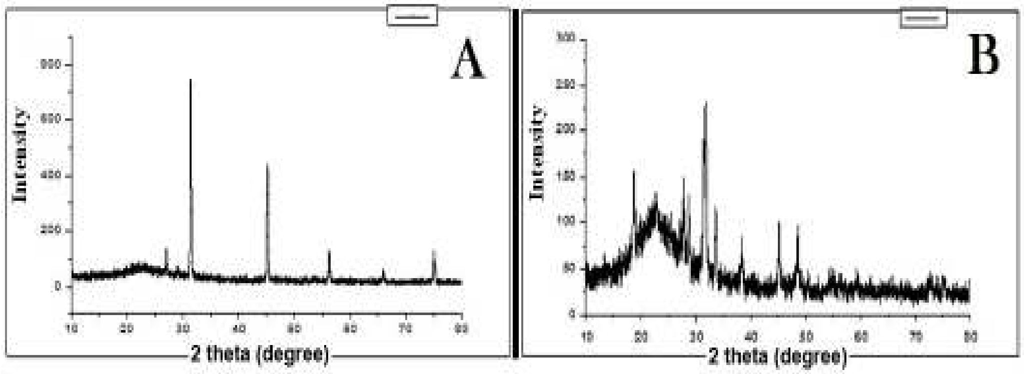

Fig 1: X-ray diffraction of synthesized rice straw nanoparticles (A) and rice husk nanoparticles (B).

TEM images of samples dried from highly diluted RHNPs and RSNPs suspension on carbon grid surface showed the dispersed silica to be of spherical shape and size particle 73.6 nm and 133.7 nm, respectively shown in fig. (2).

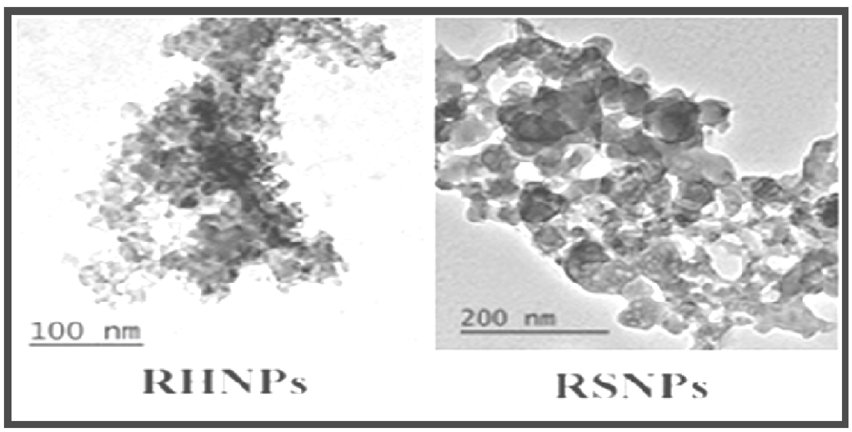

Fig.2: TEM images of RHNPs and RSNPs.

Effect of biogenic and chemical silica on rice blast disease incidence.

Different biogenic and chemical silica led to reduction in blast disease infection in the treated rice leaves of Sakha 101 *cv* compared with untreated control (tap water). The best treatments were observed in treatments of beam, K_2SiO_2 3ml/l, K_2SiO_2 2ml/l that produced 4.00, 14.0 and 16.0 spot/ 100 leaves respectively for flag leaf infection (Table 1). RHNPs and RSNPs showed promising results compared with control in reduction of rice blast disease and produced 13.0 and 22.0 spot/100 leaves, respectively for flag leaf infection (Table 1).

Data presented in Table (2) of panicle blast infection in experiment 2 showed that Beam and K_2SiO_2 treatments gave the best result followed by RHNPs and RSNPs which gave the promising results compared with control with high infection of panicle and lowest grain yield. The application of Si to rice plants to control rice blast is an alternative approach that is gaining increased interest (Park *et al.* 2006; Rodrigues *et al.* 2003). Normally blast can be controlled through chemical fungicides, this will lead to the establishment of races of the pathogen resistant to these chemicals and the pesticides have a negative effect to the environment (Gao *et al.* 2011). Using Si for disease control is both economically viable and environmentally friendly (Abed-Ashtiani *et al.* 2012; Sun et al. 2010). However, given its universal nature, the beneficial effect of Si is only noticeable in soils that are Si deficient, like most rice fields (Foy, 1992)

Silicon application increases rice resistance to blast on both partially resistant and susceptible cultivars (Seebold et al. 2001). Rodrigues et al. (2004) discovered that infected leaves of Si- plants (Si non-amended plants) displayed intense chlorosis compared with the leaves of Si+ plants (Si amended plants). It was described that Si merely acts as a physical barrier, due to the silica deposition occurred in both adaxial and abaxical leaf blades of rice plant that received Si, which hampers fungal penetration into the epidermis. In the leaf blades of rice Si is deposited on a 2.5 µm layer right beneath the 0.1 µm cuticle layer thus forming affine cuticle –Si double layer (Ma and Takahashi, 2002). This double cuticle layer protects plant from multiple biotic and abiotic stresses. Later it became increasingly clear that this passive role of Si is not the only determinant for the Si-elicited stress protection (Jones and Handreck 1967).

In addition, application of Si contributes to hypersensitive cell death (Rodrigues *et al.* 2005) and increases the epidermal cell wall thickness of rice leaves (Kim *et al.* 2002). Silicon also affects the response of rice to rice blast at a transcriptional level (Brunings *et al.,* 2009).

Table 1. Effect of silica sources on leaf percent and severity infection of rice blast disease on Sakha 101 rice cultivar under field conditions in 2015 and 2016 seasons.

Treatment	Conc.	Leaf infection %		Severity (Spot 100 leaves)		Flag Leaf %		Severity flag	
		2015	2016	2015	2016	2015	2016	2015	2016
White rice husk	0.45g/l	29.33	28.00	52.0	36.00	18.67	18.67	46.67	28.00
Rice husk nanoparticles	0.45g/l	20.00	22.67	37.3	29.33	10.67	10.67	26.67	13.33
White rice Straw	0.45g/l	34.67	32.00	60.0	44.00	21.33	21.33	54.67	22.67
Rice Straw nanoparticles	0.45g/l	24.00	25.33	44.0	32.00	18.67	18.67	41.33	22.67
Mg_2O_8 Si_3	2g/l	22.67	22.67	41.3	32.00	17.33	17.33	37.33	20.00
Mg_2O_8 Si_3	3g/l	20.00	18.67	38.7	25.33	13.33	13.33	36.00	17.33
K_2SiO_2	2ml/l	21.33	21.33	36.0	26.67	14.67	14.67	33.33	16.00
K_2 SiO_2	3ml/l	20.00	14.67	36.0	18.67	12.00	12.00	32.00	14.67
Beam	0.5g/l	9.33	5.33	21.3	8.00	2.67	2.67	17.33	4.00
Control	-	57.33	44.00	241.3	160.00	36.00	36.00	197.33	106.67
L.S.D. 0.05		5.537	5.087	26.69	7.876	4.719	4.719	9.368	7.626

Table 2. Effect of silica sources on panicle percent and severity infection of rice blast disease on Sakha 101 rice cultivar under field conditions in 2015 and 2016 seasons.

Treatments	Concentration	Panicle %		Severity %	
		2015	2016	2015	2016
White rice husk	0.45g/l				
Rice husk nanoparticles White	0.45g/l				
rice Straw	0.45g/l	29.33 21.33	34.67 24.00	7.000 4.733	5.600 4.033
Rice Straw nanoparticles	0.45g/l	37.33 28.00	40.00 28.00	7.500 5.633	6.033 5.133
Mg_2O_8 Si_3	2g/l	29.33 21.33	28.00 22.67	6.067 5.000	4.767 4.133
Mg_2O_8 Si_3	3g/l	20.00 14.67	24.00 17.33	5.500 4.433	4.067 3.500
K_2SiO_2	2ml/l	5.33	9.33	3.100	2.900
K_2 SiO_2	3ml/l	56.00	52.00	20.500	18.500
Beam	0.5g/l				
Control	-				
L.S.D. 0.05		4.73	6.66	0.782	0.472

Agronomic and yield studied characters are affected significantly by different treatments on Sakha 101 rice cultivar.

Panicle length, number of filled grains per panicle, number of unfilled spikelets per panicle, 1000-grain weight, grain yield, straw yield and harvest index were affected significantly by different treatments (Tables 3, 4 and 5). On the other hand, plant height and number of tillers per hill were not affected. Application of beam recorded the highest values of panicle length, number of filled grains per panicle, 1000-grain weight, grain yield, straw yield and harvest index. The lowest number of unfilled spikelets per panicle was recorded when beam was applied without any significant difference with RHNPS. Control treatment (tap water spray) recorded the lowest values of panicle length, number of filled grains per panicle, 1000-grain weight, grain yield, straw yield and harvest index. Ahmed et al. 2013 reported that plant height, number of tillers per plant, number of productive tillers, abortive kernal, while straw yield, branches per panicle, spike per panicle, 1000 grain weight, paddy yield, grain starch were performed better where silica was applied to rice plants. Gholami and Falah, 2013 found that siliceous fertilizers significantly increased stems and leaves silicon concentration, tiller number, leaves dry weight, 1000-grain weight and yield. These results are in agreement with those reported by Moghadam and Heidarzadeh, 2014**.**

Table 3. Effect of silica sources on plant height, no. of tillers and panicle length on Sakha 101 rice cultivar under field conditions in 2015 and 2016 seasons.

Treatments	Conc.	Plant height cm		No. of tillers $hill^{-1}$		Panicle length cm	
		2015	2016	2015	2016	2015	2016
White rice husk	0.45g/l	90.07	91.23	23.63	25.33	24.13	24.13
Rice husk nanoparticles White	0.45g/l	89.67	90.07	24.00	25.33	25.40	25.07
rice Straw	0.45g/l	89.33	91.30	23.63	24.60	24.07	23.94
Rice Straw nanoparticles	0.45g/l	90.00	90.20	23.43	25.33	25.10	24.80
Mg_2O_8 Si_3	2g/l	88.70	90.63	24.33	25.00	25.37	25.13
Mg_2O_8 Si_3	3g/l	89.33	91.13	24.67	25.00	25.43	25.07
K_2SiO_2	2ml/l	89.33	90.47	25.00	24.67	25.27	25.17
K_2 SiO_2	3ml/l	88.67	90.47	25.00	25.00	25.43	25.20
Beam	0.5g/l	87.67	90.77	25.67	25.33	26.60	26.81
Control	-	87.67	90.80	23.67	24.00	23.20	22.87
L.S.D. 0.05		NS	NS	NS	NS	0.52	0.68

Table 4. Effect of silica sources on no. of filled grain, no. of unfilled spikelets and 1000-grain weight on Sakha 101 rice cultivar under field conditions in 2015 and 2016 seasons.

Treatments	Conc.	No. of filled grain panicle^{-1}		No. of unfilled spikelets panicle^{-1}		1000-grain weight	
		2015	2016	2015	2016	2015	2016
White rice husk	0.45g/l	84.63	85.70	7.93	7.07	27.47	27.00
Rice husk nanoparticles White	0.45g/l	91.20	91.20	4.97	5.30	28.17	28.10
rice Straw	0.45g/l	85.07	87.03	7.80	8.80	27.17	27.90
Rice Straw nanoparticles	0.45g/l	90.17	92.80	9.83	7.22	27.90	28.13
Mg_2O_8 Si_3	2g/l	91.47	91.97	8.53	8.03	27.93	28.07
Mg_2O_8 Si_3	3g/l	92.50	92.27	7.50	7.73	28.17	28.23
K_2SiO_2	2ml/l	91.30	90.97	6.70	9.03	28.27	28.29
K_2 SiO_2	3ml/l	94.93	93.40	7.77	7.50	28.60	28.77
Beam	0.5g/l	95.47	94.93	4.53	5.08	28.83	28.93
Control	-	80.37	81.60	19.63	15.40	26.53	25.87
L.S.D. 0.05		1.99	2.09	1.99	2.48	0.49	0.63

Table 5. Effect of silica sources on grain yield, straw yield and harvest index on Sakha 101 rice cultivar under field conditions in 2015 and 2016 seasons.

Treatments	Concentration	Grain yield t ha^{-1}		Straw yield t ha^{-1}		Harvest index	
		2015	2016	2015	2016	2015	2016
White rice husk	0.45g/l	9.55	9.89	13.31	14.03	0.418	0.413
Rice husk nanoparticles	0.45g/l	10.93	11.10	14.33	14.89	0.433	0.427
White rice Straw	0.45g/l	10.44	10.72	13.91	14.22	0.429	0.430
Rice Straw nanoparticles	0.45g/l	10.49	10.82	13.66	13.99	0.434	0.436
Mg_2O_8 Si_3	2g/l	10.62	10.98	14.08	14.15	0.430	0.437
Mg_2O_8 Si_3	3g/l	10.91	11.09	14.12	14.38	0.436	0.435
K_2SiO_2	2ml/l	10.94	10.94	14.08	14.24	0.437	0.434
K_2 SiO_2	3ml/l	11.02	11.27	14.68	14.87	0.429	0.431
Beam	0.5g/l	11.57	11.72	14.79	15.02	0.439	0.438
Control	-	8.10	8.08	12.22	12.82	0.399	0.387
L.S.D. 0.05		0.24	0.17	0.96	0.53	0.018	0.011

Effect of biogenic and chemical silica on rice brown spot disease incidence.

Results indicated that all treatment of different biogenic and chemical silica sources decreased the leaf infection percent and severity for brown spot disease. The highest treatment was obtained from RHNPs, RSNPs, K_2SiO_2 and Mg_2O_8 Si3 in tables (6 and 7).

The application of Si leads to a reduction in brown spot disease severity that ranges between 40 and 70%. Ghareeb *et al*. 2011; Sun *et al.* 2010; Shetty *et al.* 2012 reported that The efficacy of Si treatment depends on the scoring method, used cultivar, growing conditions, but Si always induces a significant reduction in disease severity. However, Si only gives a full range of protection when it is applied continuously and the active effect of Si-application caused by silicic acid in the plant cells is dominant over the passive effect of the silica deposition in the leaves in conferring Si-induced brown spot resistance. Silicon-induced brown spot resistance is the result of a constriction of the fungal progression in the mesophyll. Silica application to resulted in more pronounced cell silicate in leaves and papilla's who more extracted and larger. Silicon layers were formed in the epidermal cell walls of rice and increasing Si treatment increase the thickness of the layer resulting in improving levels of resistance to brown spot (Ning *et al.,* 2014). The role of ROS, accumulation of lignin and callose seem to be negligible factors in the resistance. Very few reports suggest that Si application might lead to a very timely and local boost in ROS production leading to resistance. More articles can be found on the ROS catching effect of Si during infection and abiotic stress (Liang et al. 2005; Nwugo and Huerta 2011; Van Bockhaven *et al*. 2012). With the application of Si, rice plants seem to have more phenolic compounds. These compounds have antimicrobial activity and their polymerization and cross-linking leads to the accumulation of lignin and cell wall fortification, which hamper pathogens at the site of infection (Rodrigues *et al.* 2005). C. miyabeanus can produce toxins that down regulate the PAL pathway and accumulation of phenolic compounds leading to susceptibility (Vidhyasekaran et al. 1992). However, the phenolic compounds probably have a fungi toxic effect on C. miyabeanus, resulting in hampered mesophyllic growth inside rice leaves. Silicon-induced resistance to diseases is linked to an accumulation of phenolic compounds. Many authors link this to the deposition of silica at the site of infection (Zeyen *et al.* 1993).

Table 6. Effect of silica sources on leaf percent and severity infection of rice brown spot disease on Egyptian hybrid rice one cultivar under field conditions in 2015 and 2016 seasons.

Treatment	Concentration	Leaf infection %		Severity (Spot 100 leaves)		Flag Leaf %		Severity flag	
		2015	2016	2015	2016	2015	2016	2015	2016
White rice husk	0.45g/l	20.00	28.00	92.00	92.00	16.00	18.67	52.00	29.33
Rice husk nanoparticles	0.45g/l	12.00	40.00	57.33	54.67	10.67	9.33	49.33	22.67
White rice Straw	0.45g/l	36.00	29.33	112.00	112.00	25.33	25.33	88.67	49.33
Rice Straw nanoparticles	0.45g/l	28.00	22.67	100.00	84.00	21.33	21.33	76.00	32.00
Mg_2O_8 Si_3	2g/l	20.00	17.33	61.33	64.00	16.00	16.00	52.00	34.67
Mg_2O_8 Si_3	3g/l	13.33	17.33	52.00	52.00	10.67	9.33	44.00	28.00
K_2SiO_2	2ml/l	12.00	20.00	56.00	61.33	9.33	6.67	48.00	32.00
K_2 SiO_2	3ml/l	8.00	14.67	52.00	48.00	5.33	5.33	41.33	26.67
Del-Cup	5ml/l	18.67	22.67	68.00	60.00	14.67	13.33	48.00	36.00
Control	-	58.67	72.00	356.00	356.00	52.00	48.00	212.00	204.00
L.S.D. 0.05		6.517	4.699	7.320	8.731	4.788	5.383	8.340	7.902

Table 7. Effect of silica sources on discolored grain percent of rice brown spot disease on Egyptian hybrid rice one cultivar under field conditions in 2015 and 2016 seasons.

Treatments	Conc.	Discolored grain %	
		2015	2016
White rice husk	0.45g/l	13.33	18.67
Rice husk nanoparticles White	0.45g/l	9.33	13.33
rice Straw	0.45g/l	21.33	25.33
Rice Straw nanoparticles	0.45g/l	14.67	21.33
Mg_2O_8 Si_3	2g/l	14.67	18.67
Mg_2O_8 Si_3	3g/l	10.67	14.67
K_2SiO_2	2ml/l	9.33	16.00
K_2SiO_2	3ml/l	5.33	10.67
Del-Cup	5ml/l	12.00	21.33
Control	-	52.00	58.67
L.S.D. 0.05		4.500	6.174

Agronomic and yield studied characters are affected significantly by different treatments on Egyptian Hybrid one rice cultivar.

The effect of different silica treatments on agronomic and yield characters were showed in tables 9, 10 and 11. The results indicated that different treatments significantly affected panicle length, number of filled grains per panicle, number of unfilled spikelets per panicle, 1000-grain weight, and grain yield and harvest index. Plant height and number of tillers per hill did not affect by the treatments. Application of RHNPs, K_2SiO_2 2 and 3 g/ l or Del-Cup produced the highest values of panicle length, number of filled grains per panicle, 1000-grain weight and grain yield. Control treatment (tap water spray) recorded the lowest values of panicle length, number of filled grains per panicle, 1000-grain weight, grain yield and harvest index. Control and white rice straw application produced the highest values of number of unfilled spikelets per panicle. All the treatments increased the harvest index significantly over the control without any significant differences among them. Moghadam and Heidarzadeh 2014 found that by applying silica to rice plants, plant height, number of tillers, leaf area, leaf stem and total dry weight and silicon density in leaf texture and stem and a progressive process which in tillering stage was significant 1%level. Also by applying silica at different levels there was a witness of increasing in grain yield that was significant at 5% level. They suggested that rice husk and its ash can be used as recyclable mineral nutrient instead of chemical fertilizer.

Table 9. Effect of silica sources on plant height, no. of tillers and panicle length on Egyptian hybrid rice one cultivar under field conditions in 2015 and 2016 seasons.

Treatments	Conc.	Plant height cm		No. of tillers $hill^{-1}$		Panicle length cm	
		2015	2016	2015	2016	2015	2016
White rice husk	0.45g/l	98.33	98.00	26.00	26.07	24.04	24.03
Rice husk nanoparticles White	0.45g/l	100.00	98.00	25.67	25.60	25.07	25.00
rice Straw	0.45g/l	99.00	98.33	25.33	25.13	24.17	23.97
Rice Straw nanoparticles	0.45g/l	100.67	99.33	25.33	26.33	23.93	23.73
Mg_2O_8 Si_3	2g/l	100.00	98.67	26.17	26.00	24.18	24.03
Mg_2O_8 Si_3	3g/l	99.00	97.00	26.27	26.17	24.30	24.20
K_2SiO_2	2ml/l	99.33	97.00	26.67	25.83	25.10	25.02
K_2SiO_2	3ml/l	99.33	97.33	26.33	26.00	25.00	25.01
Del-Cup	5ml/l	98.33	97.67	26.33	26.07	25.10	25.03
Control	-	100.33	97.00	26.07	25.13	23.93	23.67
L.S.D. 0.05		NS	NS	NS	NS	0.34	0.66

Table 10. Effect of silica sources on no. of filled grain, no. of unfilled spikelets and 1000-grain weight on Egyptian hybrid rice one cultivar under field conditions in 2015 and 2016 seasons.

Treatments		No. of filled grain panicle^{-1}		No. of unfilled spikelets panicle^{-1}		1000-grain weight	
		2015	2016	2015	2016	2015	2016
White rice husk	0.45g/l	90.80	90.07	9.33	9.93	24.43	24.07
Rice husk nanoparticles White	0.45g/l	93.97	93.67	6.03	6.13	25.13	24.37
rice Straw	0.45g/l	89.67	89.07	10.33	10.93	24.20	24.17
Rice Straw nanoparticles	0.45g/l	93.10	91.50	6.90	8.50	24.17	24.13
Mg_2O_8 Si_3	2g/l	93.07	93.02	5.93	6.60	24.63	24.03
Mg_2O_8 Si_3	3g/l	93.47	92.37	5.53	5.17	24.47	24.03
K_2SiO_2	2ml/l	94.03	94.57	5.97	5.43	25.17	24.50
K_2SiO_2	3ml/l	94.40	94.83	5.60	5.57	25.20	24.73
Del-Cup	5ml/l	95.05	94.90	5.97	5.39	25.23	24.77
Control	-	88.50	88.07	11.50	11.93	23.60	23.13
L.S.D. 0.05		1.29	1.40	1.26	1.43	0.56	0.66

Table 11. Effect of silica sources on grain yield, straw yield and harvest index on Egyptian hybrid rice one cultivar under field conditions in 2015 and 2016 seasons.

Treatments	Conc.	Grain yield t ha^{-1}		Straw yield t ha^{-1}		Harvest index	
		2015	2016	2015	2016	2015	2016
White rice husk	0.45g/l	12.14	12.09	14.60	13.97	0.454	0.464
Rice husk nanoparticles White	0.45g/l	12.90	12.83	14.48	14.42	0.471	0.471
rice Straw	0.45g/l	12.09	12.04	14.11	13.85	0.461	0.465
Rice Straw nanoparticles	0.45g/l	12.04	12.16	14.24	14.12	0.458	0.463
Mg_2O_8 Si_3	2g/l	12.44	12.35	14.43	14.23	0.463	0.465
Mg_2O_8 Si_3	3g/l	12.51	12.37	14.24	14.03	0.468	0.469
K_2SiO_2	2ml/l	12.85	12.78	14.52	14.28	0.469	0.472
K_2SiO_2	3ml/l	12.90	12.88	14.56	14.38	0.470	0.472
Del-Cup	5ml/l	13.02	12.98	14.62	14.42	0.471	0.474
Control	-	11.75	11.68	14.29	13.98	0.451	0.455
L.S.D. 0.05		0.25	0.18	NS	0. NS	0.018	0.011

CONCLUSION

It can be concluded that, Si plays as cuticle role in the resistance of some plants to disease and more information has to be delivered to farmers and rice grown to assist the agricultural field to effectively manage and control plant diseases.

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تأثير جزيئات السيليكا المتناهية الصغر الحيوية علي مرضي اللفحة والتبقع البني و المحصول ومكوناتة في الارز

وائل السعيد جبر ، عمرو عبد الباري حسن، ابراهيم محمد هاشم و زينب عبد النبي كلبوش
مركز البحوث الزراعية - مركزبحوث الارز بسخا

يعتبر الارز واحد من اهم المحاصيل الغذائية علي مستوي العالم. حيث يصاب بالعديد من المسببات النباتية. يعتبر مرضي اللفحة والتبقع البني من اخطر الامراض التي تؤثر علي محصول الارز في مصر. تم زراعة التجربة في موسمين زراعة في مزرعة مركز البحوث والتدريب علي الارز ، سخا ، كفر الشيخ، مصر. اهداف التجربة دراسة تأثير المصادر المختلفة من جزيئات السيليكا المتناهية الصغر الحيوية علي مرض اللفحة ، التبقع البني والمحصول ومكوناتة في الارز. تم في التجربة الاولي دراسة تأثير المصادر المختلفة من السيليكا علي السلوك والعدوي لمرض الفحة الارز علي الصنف سخا ١٠١ . بينما في التجربة الثانية تم دراسة السلوك والعدوي علي مرض التبقع البني في الصنف هجين مصري واحد باستخدام معاملات السيليكا المتناهية الصغر الحيوية. وكانت معاملات السيليكا قشر الارز الابيض (تم حرقة فر فرن حرق) ، جزيئات قشر الارز المتناهية الصغر، وقش الارز الابيض، جزيئات قش الارز المتناهية الصغر، سيليكات الماغنسيوم وسيليكات البوتاسيوم. المبيدات الفطرية الكيماوية (البيم الديل كب) ومياة الصنبور تم استخدامها للمقارنة. و كانت اهم النتائج المتحصل عليها ان السيليكا الحيوية والكيماوية المختلفة ادت الي تقليل الاصابة بمرض اللفحة علي صنف سخا ١٠١ مقارنة باستخدام مياة الصنبور. معظم الصفات المحصولية المدروسة علي الصنف سخا ١٠١ تأثرت معنويا بالمعاملات المختلفة. حيث وجد ان كل معاملات السيليكا الحيوية والكيماوية المختلفة ادت الي تقليل الشدة ونسبة الاصابة بمرض التبقع البني علي صنف هجين مصري واحد . وكانت المعاملات المختلفة تأثير معنويا علي طول السنبلة، وعدد الحبوب الممتلئة للسنبلة، وعدد السنيبلات العير ممتلئة للسنبلة، وزن الالف حبة، محصول الحبوب و دليل الحصاد علي صنف هجين مصري واحد.