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ROLE OF SILICON IN THE MANAGEMENT OF SOME RICE DISEASES

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ABSTRACT

Although silicon is not considered an essential element, but a lot of researchers mentioned that plant development, growth and yield have been increased by the application of Silicon to soil and or plant. Also it is known to reduce rice diseases. Experiments were conducted in 1999, 2000 and 2001 to study the effect of different sources of silicon on rice diseases ie. blast, brown spot and false smut in Egypt. So, Silicon was applied to soil at the rate of 10 or 20 g./ m^2 and spray 2 or 4 g./ L. of Magnesium silicate (MgSi) were tried, silica gel 0.25 or 0.5 g/m^2, sodium metasilicate 20 g/m^2 in soil. On the other hand burnt or unburnt rice husk or rice straw at the rate of 100 or 200 g/m^2, were used as silicon sources applied to soil. The conclusion from these experiments can be summarized as follows: MgSi as spray or soil application; burnt rice straw 200 g/m^2 and burnt rice husk 100 g/m^2 significantly decreased both leaf and panicle blast severity. For the brown spot disease, the severity of infection was significantly decreased with all silica sources in seasons 2000 and 2001. The most effective treatments were burnt rice husk at the rate of (100 g/ m^2) in soil, burnt rice straw (200 g/m^2) and MgSi (20g/m^2) incorporated into soil and two sprays of MgSi at complete vegetative growth and one spray at booting stage. The most effective treatment in case of false smut disease was recognized by the application of MgSi sprayed twice during leaf stage and the third one at booting, in spite of the significant decrease due to the addition of other sources of silica on either percent or severity of false smut infection. In addition, an experiment was conducted to study the effect of MgSi at the rate of 2 g/L as a sprayed with Beam individually or alternatively. The results revealed that Beam and MgSi when sprayed at leaf, followed by MgSi at late booting, was the best treatment for both blast and brown spot. While in case of false smut MgSi as foliar application at late booting gave the lowest infection in spite of the significant effect of the other treatments.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops in all rice growing countries. More than one million feddans in Egypt are annually cultivated with rice, which produce about 6 million metric tons of rough rice. (RRTC 2000).Rice diseases are one of the most limiting factors of rice production in Egypt, as well as in other rice producing countries. Blast disease caused by *Pyricularia grisea (cooke*.) scc. is considered the most important disease affecting rice crop in Egypt (Abde-Hak, *et al*., 1981). The second important one is brown spot caused by *Helminthosporium oryzae (*Breada de Hann). In addition to false smut, disease caused by *Ustilaginoidea virens* (Cke.) as a new rice disease in Egypt since 1997.

Silicon (Si) is one of the most abundant elements in the earth's crust and most soils contain considerable quantities of the element (Epstien, 1994). However, repeated cropping can reduce the levels of plant available Si to the point that supplemental Si fertilization is required for maximum production, particularly some soils contain little plant available Si in their native state. Low-Si soils are typically highly weathered, leached, acidic and low in base saturation. Thus, highly weathered soils such as Oxisols and Ultisols can be quite low in soluble Si (Foy, 1992). Belanger *et al*.1995, reported that, soluble Si has enhanced the growth and development of several plant species including rice. In addition, Si amendments proved effectiveness in controlling several important plant diseases. Si can benefit plant growth through greater rice yield, may enhance soil fertility, improve soil physical properties, improve disease and pest resistance, increase photosynthesis, regulate evapotranspiration, increase tolerance to toxic elements such as Fe and Mn and reduces frost damage. (Osuna- Canzalez *el al.,* 1991 and Raid, *et al.,* 1988).

Miyake, and Adachi 1922 noted a higher Si content in leaves of a resistant variety than in those of a susceptible one. Adyanythaya & Rangaswami (1952) and Venkatachalam (1954) reported greater numbers of silicated epidermal cells in resistant than in susceptible varieties .In the 1930s and 1940s, Japanese researchers first indicated that Si was effective in controlling plant diseases, especially in rice (Kozaka, 1965). These studies demonstrated that applications of various Si sources to Si-deficient paddy soils dramatically reduced the incidence and severity of blast. (Takahashi, 1995). Datnoff *et al*. (1991) found that application of calcium silicate slag reduced blast by 30.5% and brown spot by 15% over the control. Hooda, and Srivastava, (1996) reported that all the Si salts significantly reduced rice blast over the control and all the treatments also significantly increased cellulose, hemicellulose, silica, total protein, total phenols, 1000 grain weight and the yield of paddy over untreated. In addition Winslow, (1992) demonstrated that two sources of Si increased grain yield by 48% and significantly reduced the severity of husk discoloration, neck blast, sheath blight, and leaf scald diseases. Datnoff , *et al. (*1997) found that blast incidence was 73% in the non-Si , non-fungicide controled plots and 27% in the benomyl-treated plots . Where Si was applied, blast incidence was 36% in the non-fungicide plots and 13% in the benomyl-treated plots. Brown spot responses were similar to those observed with blast. For both diseases, the best disease control was obtained by using both treatments together.

The current study was carried out to study the role of Si from the respective of different sources and methods of application on the infection incited by the most serious rice diseases in Egypt and improving the varietal tolerance to these diseases.

MATERIALS AND METHODS

Experiments were carried out at the experimental farm of Sakha Agricultural Research Station in 1999, 2000 and 2001 growing seasons.

In 1999 season, a preliminary experiment was carried out using different sources and rates of Silicon on the susceptible rice Cvs Giza 176. Magnesium silicate (Mg Si) was used either as a soil application at the rate of 10g or 20 g/m^2, or as a foliar spray at the rate of 2 or 4 g/L. at both vegetative and late booting stages. Silica gel was used at the rate of 0.25 g or 0.5 g/m^2, while Sodium metasilicate was used at the rate of 100 and 200 g/m^2. Burnt or unburnt rice husk was used as soil application at the rate of 100 and 200 g/m^2 each. Untreated plots surved as control. The most effective treatments from 1999 were selected and used in 2000. MgSi was used as soil application at 20 g/m^2 or spray application at 2 g/L; burnt rice husk at 100 g/m^2, in addition to burnt rice straw at two rates 100 g and 200 g/m^2. In 2000, two susceptible cvs. were used ie. Giza 171 and Giza 176. In season 2001, MgSi was applied as soil application at 20 g/m^2 or as foliar spray at 2 g/L. either two sprays or three sprays as indicated in Tables (2 and 3). Beside, burnt rice straw at the rate of 200 g/m^2 or burnt rice husk (100 g/m^2) as soil application.

In addition, spray of MgSi alone or alternatively with Beam at the rate of 100g. /fed. (0.5g. /L.) was tried compared with Beam alone or untreated plots as indicated in Table (4) using the highly susceptible cv. Giza 171.

The experiment was conducted in a complete randomized block design (CRBD) with four replicates. Plot size was 2.0 X 3.5 m and spacing between hills and rows was 20 X 20 cm. Transplanting was done in the first week of June (thirty day-old seedlings) each season, each hill consisted of three plants. Nitrogen fertilizer was added in the form of urea (46.5%) at the rate of 40 kg of nitrogen per fed; one half of nitrogen dose was incorporated into the dry soil, while the other half was added thirty-five days after transplantation (at panicle initiation). Spray application was done at the first week of July and the first week of August 30and 60-days after transplantation (DAT) for vegetative growth stage. While, for late booting it was applied during the first week of September (90 DAT) for the three seasons of study, 1999, 2000 and 2001.

Estimation of blast infection:

Samples of rice leaves were taken four times at 15-day interval in all seasons of the study starting from thirty days after transplanting. Each sample consisted of one hundred leaves randomly collected to determine leaf blast infection. Percentage of the infected leaves was calculated, while severity of infection was estimated by counting the total number of type (4) blast lesions/100 leaves. Neck rot infection was estimated by collecting one hundred panicles from each plot. The severity of neck rot infection was calculated by using the formula adopted by Townsend and Huberger (1943).

Estimation of brown spot:

In seasons 2000, 2001 samples of rice leaves were taken four times at 15-day intervals, beginning after thirty days of transplanting. Total number of brown spot lesions was taken for each hundred leaves, which were randomly collected from each plot.

Estimation of false smut:

Number of infected panicles/m^2 was taken as disease incidence. While number of smut, balls/ m^2 was considered as severity.

Grain Yield:

Two rows from each plot side were discarded to avoid the border effect, rice plants of the remaining rows were harvested. The weight of the grain yield was recorded on the base of 18% moisture content at the harvest, then adjusted to 14%.

RESULTS AND DISCUSSION

The present study revealed that Silicon fertilization in different sources and rates had a significant effect on reducing blast, brown spot and false smut diseases of rice through the studied seasons.

The obtained data from 1999 season presented in Table (1) show that, under Magnesium silicate (MgSi) either as soil application in two studied rates or spray at both concentrations, leaf blast infection was significantly decreased compared with the control. Also, burnt rice husk at 100g. or 200g. /m^2 was significantly lower in the level of leaf infection. However, the rest of treatments showed insignificant effect in relation to all of the tested sources and rates on panicle infection percent or severity and grain yield.

Table (1) : Evaluation of different sources of Silicon using different rates and methods of application against rice blast expressed in (leaf, panicle) infection and grain yield on the rice cv. Giza 176 at Sakha during 1999.

Silica source	Rates (g)	Methods and time of application	Leaf infection		Panicle infection		Grain yield T/Fed
			percent	Severity	percent	severity	
Magnesium silicate	$10/m^2$	Soil	9.3	12	48.0	10.9	3.31
	$20/m^2$	Soil	8.0	9.3	38.7	9.6	3.41
Magnesium silicate	2/L 2/L	leaf Spray booting spray	4.0	5.3	48.0	11.4	3.15
Magnesium silicate	4/L 4/L	leaf Spray booting spray	9.3	9.3	49.3	11.8	3.04
Husk without burn	$100/m^2$	Soil	10.7	17.3	49.3	12.9	3.31
	$200/m^2$	Soil	13.3	16.0	49.3	13.7	3.11
Burnt rice husk	$100/m^2$	Soil	6.7	6.7	48.0	9.9	3.32
	$200/m^2$	Soil	5.3	5.3	40.0	8.8	3.21
Silica gell	$0.25/m^2$	Soil	8.7	13.3	44.0	12.4	3.18
	$0.5/m^2$	Soil	10.7	17.3	46.7	13.5	3.00
Sodium metasilicate	$20/m^{2s}$	Soil	13.3	25.3	46.7	12.4	3.25
Control	--------	------	18.7	26.0	53.3	15.3	2.85
L.S.D 5%			9.7	14.8	ns	ns	ns

Three sources of Silicon at different rates were selected from the previous season and experiments were carried out during 2000and 2001 growing seasons on Giza 171 for blast. Data presented in (Table 2 and Fig. 1) show that, burnt rice straw at 100 g/m^2 only had no effect on reducing severity of leaf blast, whereas all tested sources and Silicon rates had a significant effect on reducing either leaf or panicle blast infection as compared with control. Three sprays of MgSi (2 g/L.) gave the lowest infection at both leaf and panicle.

table2

fig1

Grain yield was significantly increased in all treatments compared with control. These results are coinciding with the findings of (Winslow 1992, Datnoff *et al.,* 1992 and 1994 Hooda and Srivastava 1996).

Brown spot and false smut diseases were also estimated in both seasons under the same treatments of sources and rates of Silica. Data are presented in Table (3) and Fig. (3). The results show that, brown spot infection was significantly decreased under all treatments compared with control in both seasons with insignificance between treatments. The most effective treatments were burnt rice husk (100 g/ m^2), burnt rice straw (200 g/m^2) and MgSi (20g/m^2) incorporated into soil and two sprays of MgSi at complete vegetative growth and one at booting stage. The results are in agreement with findings of (Datnoff *et al.,* 1991,Winslow 1992 and Datnoff 1997). Also false smut disease was significantly decreased either as an infection percent or severity in both seasons under all tested treatments. Two sprays of MgSi 2 g/L gave the lowest severity of false smut infection in both seasons. Burnt rice straw at the rate of 200 and 100g. /m^2 gave the higher significant increase in the grain yield, during season 2000. While all tested treatments in 2001, the significantly increased yield compared with control treatment.

Another experiment was conducted in 2001 season on Giza 171 rice cv. In which MgSi at the rate of 2 g/L as a spray and Beam were used individually or alternatively with each other was undertaken for managing blast, brown spot and false smut diseases. The obtained results from Table (4) and Figs. (2 and 4) show that the most effective treatments in reducing leaf and panicle infection was the application of Beam at the rate of 0.5g./L. followed by MgSi at the rate of 2g./L both at vegetative growth stage, beside one more application of MgSi at the rate 2g./L. at booting stage (90 DAT). Two application with Beam alone at the rate 0.5g./L. at both vegetative and booting stages came in the second rank. However, all treatments showed significant reduction in leaf and panicle blast infection. Brown spot also significantly decreased in all treatments either alone or alternatively, while the lowest score was obtained when Beam and MgSi were sprayed at leaf stage followed by MgSi at late booting.

table3

table4

fig2,3,4

Also percentage or severity of false smut were significantly decreased sharply in all tested treatments when MgSi was sprayed on leaves at late booting. In addition, the tested treatments significantly increased the yield compared to control treatments. The application of Beam should be applied not later than the late booting stage to avoid any residual effect from late application. These results are in agreement with the findings of Seebold *et al.* (1995) and Datnoff (1994 and 1997) who reported that the greatest disease control was obtained by using both treatments together Silicon and either Benomyl (Benlate) or Propiconzole (Tilt).

Some researchers reported that, the mechanism of resistance in rice due to Si application has been attributed to the formation of a silicate epidermal cell wall layers (Yoshida, 1975 and Takahashi; 1995). This layer is believed to prevent physical penetration and makes the plant cell walls less susceptible to enzymatic degradation by fungal pathogens. In addition, Si is known to redistribute around the infection peg and this preferential accumulation of Si at the point of pathogen penetration could also inhibit hyphal growth and haustoria formation (Samuels *et al*., 1991). Recent research suggests that, it is not only the insoluble form of the Si that protects the plant from fungal ingression but phenols, which accumulate at the infection site (Cherif *et al*., 1994; Belanger *et al*., 1995), Rapid deposition of phenols or lignin at the infection site is a known general defense mechanism of plants to attacked by plant pathogens and the presence of soluble Si may facilitate this mechanism of resistance in rice.

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تأثير مصادر السيلكون فى مقاومة بعض أمراض الارز

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معهد بحوث أمراض النباتات – مركز البحوث الزراعية

عنصر السليكون على الرغم من أنه لا يعتبر من العناصر الرئيسية للنبات إلا أن العديد من الباحثين أكدوا أن نمو النباتات وتطورها وزيادة المحصول له علاقة وثيقة بإضافة السليكون.كذلك أصبح معروفا أن تقليل الإصابة بالأمراض النباتية وخاصة أمراض الأرز مرتبط أيضا بعنصر السليكون.أجريت تجارب بمركز بحوث الأرز بسخا فى مواسم ١٩٩٩،٢٠٠٠،٢٠٠١ لدراسة تأثير المصادر المختلفة للسليكون على أمراض الأرز الهامة (اللفحة-التبقع البنى-التفحم الكاذب) بإستخدام المصادر وطرق الإضافة الآتية: سليكات الماغنسيوم خلطا بالتربة بمعدل ١٠،٢٠جم/م٢ وكذلك رشها على النبات فى مرحلة النمو الخضرى وقبل الطرد بمعدل ٢،٤جم/لتر، سليكا جيل بمعدل ٠,٢٥و٠,٥ جم/م٢ خلطا بالتربة ، مينا سليكات الصوديوم بمعدل ٢٠جم/م٢ فى التربة وكذلك استخدام سرسة وقش الأرز المحروقة والغيرمحروقه بمعدلات ١٠٠،٢٠٠جم/م٢ خلطا بالتربة قبل الزراعة.

ويمكن تلخيص النتائج المتحصل عليها من التجارب فيما يلى:

- وجد أن أستخدام كل من سليكات الماغنسيوم رشا أو مضافة للتربة وقش الأرز بمعدل ٢٠٠جم/م٢ وسرسة الأرز المحروقة بمعدل ١٠٠جم/م٢ كان لها دور كبير فى تقليل الإصابة معنويا على لفحة الأوراق والسنابل.

فيما يتعلق بمرض التبقع البنى وجد أن شدة الإصابة تقل معنويا بإستخدام جميع مصادر السليكا المستخدمة فى موسم ٢٠٠٠،٢٠٠١ وكانت أفضل المعاملات تأثيرا هى سرسة الأرز المحروقة بمعدل ١٠٠جم/م٢ وكذلك قش الأرز المحروق بمعدل ٢٠٠جم/م٢ وأيضا سليكات الماغنسيوم ٢٠جم/م٢ خلطا بالتربة أو رشتين على المجموع الخضرى ورشة قبل الطرد مباشرة.

- بالنسبة لمرض التفحم الكاذب وجد أن كل مصادر السيلكا المختلفة التى أستخدمت قللت الإصابة معنويا لكل من نسبة وشدة المرض وكانت أكثر المعاملات تقليلا للمرض هى سليكات الماغنسيوم رشا مرتين على الأوراق والثالثة قبل الطرد مباشرة
- أهم النتائج المتحصل عليها من تجربة لدراسة تأثير سليكات الماغنسيوم (٢جم/لتر) والبيم ٠,٥جم/لتر سواء كل منها على حدة أو بالتناوب مع الآخر كانت عند إستخدام البيم وسلكات الماغنسيوم رشا على الأوراق تم رش سليكات الماغنسيوم قبل الطرد مباشرة كانت أفضل المعاملات على كل من مرض اللفحة والتبقع البنى بينما التفحم الكاذب كان رش سليكات الماغنسيوم على الأوراق وقبل الطرد أعطت أقل إصابة بالرغم أن باقى المعاملات كان لها تأثير فى تقليل المرض معنويا مقارنة بالكنترول.

Table (2) : Evaluation of different sources of Silicon using different rates and methods of application against rice blast expressed in (leaf, panicle) infection and grain yield on the rice cv. Giza 171 at Sakha during 2000 and 2001.

Silica source	Rate (g)	Methods and time of application	2000					2001				
			Leaf blast		Panicle blast		Grain yield	Leaf blast		Panicle blast		Grain yield
			%	Sev.	%	Sev.	ton/fed.	%	Sev.	%	Sev.	ton/fed.
Magnesium silicate	20 g/m^2	Soil	24	30.70	30.70	12.00	2.19	13.06	20.75	36.00	7.40	3.279
Burnt rice straw	100g/m^2	Soil	32	45.30	45.30	20.10	2.56	----	----	----	----	----
Burnt rice straw	200g/m^2	Soil	34	38.70	45.30	15.60	2.49	14.31	26.88	35.00	6.80	3.465
Burned rice husk	100g/m^2	Soil	26	29.30	40.00	16.10	2.31	12.75	24.13	41.00	10.25	3.312
Magnesium silicate	2g/L	Leaf spray Booting spray	28	41.30	53.30	20.40	2.21	12.75	21.91	31.00	10.75	3.276
Magnesium silicate	2g/L	2 Leaf spray Booting spray	----	----	----	----	----	12.43	16.91	30.00	6.28	3.286
Control	----	----	38	60.00	56.30	24.00	2.10	22.63	42.94	62.00	21.40	2.666
LSD 5%			12.40	16.70	16.71	5.63	0.25	4.80	6.54	15.18	5.64	0.117

Table (3): Evaluation of different sources of Silicon using different rates and methods of application against rice brown spot and false smut diseases and grain yield on the rice cv. Giza 171 at Sakha during 2000 and 2001.

Silica source	Rate (g)	Methods and time of application	2000					2001				
			Brown spot		False smut/m^2		Grain yield T/Fed	Brown spot		False smut/m^2		Grain yield T/Fed
			%	Sev.	%	Sev.		%	Sev.	%	Sev.	
Magnesium Silicate	20 g/m^2	soil	55.33	66.67	0.98	1.82	2.19	30.95	32.75	0.75	1.36	3.279
Burnet rice straw	100 g/m^2	Soil	58.67	70.67	0.79	1.74	2.56	-	-	-	-	-
Burnt rice straw	200 g/m^2	Soil	44.67	47.33	0.68	1.62	2.49	43.55	45.75	1.22	1.93	3.465
Burnt rice husk	100 g/m^2	Soil	34.67	41.33	0.72	1.57	2.31	31.20	32.20	0.68	1.25	3.312
Magnesium Silicate	2 g/L 2 g/L	Leaf spray * booting spray **	40.00	47.33	0.61	0.91	2.21	34.70	42.75	0.61	1.07	3.276
Magnesium silicate	2 g/L 2 g/L	2 leaf spray *** booting spray	-	-	-	-	-	31.55	33.75	1.00	1.86	3.286
Control (untreated)	-	-	88.00	116.67	1.57	3.42	2.10	77.10	80.0	2.22	4.68	2.666
L.S.D. 5%			14.26	26.13	0.294	0.489	0.25	21.97	24.43	0.34	0.51	0.117

*** Time of application was 30 days after transplanting (DAT)**

**** Time of application was 90 days after transplanting (DAT)**

***** Time of application were 30 &60 days after transplanting (DAT) vegetative growth stage**

Table (4) : Rice diseases ie. Blast, brown spot and false smut as affected by Magnesium silicate and beam application at different combinations sprayed at leaf or late booting stages expressed in disease severity and grain yield on rice cv. Giza 171 at Sakha during 2001.

Treatment	Rate (gram)	Time of Application	Blast Severity		Brown Spot Sev.	False Smut/m²		Grain Yield t/fed.
			Leaf	Panicle		%	Sev.	
MagnesiumSilicat Beam	2g/L 0.5g./L.	Leaf ** Late booting***	20.44	7.50	38.50	0.86	2.21	3.164
Beam Magnesium Silicate	0.5g./L. 2g/L	Leaf Late booting	20.06	4.65	42.80	1.25	2.25	3.174
Beam + Mg.Si.* Magnesium Silicate	0.5g./L. 2g/L	Leaf Late booting	13.83	3.85	30.95	2.00	2.79	3.166
Magnesium Silicate Magnesium Silicate	2g/L 2g/L	Leaf Late booting	21.94	10.75	42.75	0.61	1.07	3.276
Beam Beam	0.5g./L. 0.5g./L.	Leaf Late booting	18.94	3.50	44.95	1.86	2.21	3.064
Control (Untreated)	----	----	42.94	21.40	80.00	2.22	4.68	2.666
LSD 5%			10.31	5.15	33.88	0.34	0.65	0.107

* Beam was followed by MgSi as spray 30.T. D.A

** Time of application was 30 days after transplanting (DAT)

*** Time of application was 90 days after transplanting (DAT)