Trends in Life Sciences
An International Peer-reviewed Journal
www.sciencejournal.in

ROLE OF NANO-SILICON AND OTHER SILICON RESOURCES WITH NITROGEN AND PHOSPHORUS APPLICATION ON DISEASE PARAMETERS AND YIELD OF RICE (*ORYZA SATIVA*)

*** Hossein Yazdpour[1], Ghorban Noormohamadi[1], Hamid Madani[2], Hossein Heidari Sharif Abad[1] and Hamid Reza Mobasser[3],**
[1]Department of Agronomy, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[2]Department of Agronomy, Arak Branch, Islamic Azad University, Arak, Iran.
[3]Department of Agronomy, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran.
***(Corresponding author:** hossein_yazdpoor@yahoo.com)

ABSTRACT
In order to investigation of role of nano-silicon and other silicon resources with nitrogen and phosphorus application on yield and yield components of rice (Tarom Hashemi variety), this experiment was carried out as factorial in randomized complete blocks design with three replications at north of Iran, Mazandaran province in sari region in 2012 and 2013. Treatment was silicon resources in four levels including calcium silicate and potassium silicate the land use and nano-silicon foliar application and non-application (control), as nitrogen application from Urea resource in two levels including 0 and 70 kg ha^{-1} and phosphorus application from P_2O_5 resource in two levels including 0 and 200 kg ha^{-1}.The results showed that the least percentage of infected leaf blast and grain number of infected blast in panicle in both years was obtained with potassium silicate application and nano-silicon foliar application, respectively. As, the lowest infected blast percentage in panicle was observed with potassium silicate in second year. Nitrogen use cause to increase infected leaf blast equal to 11.61 and 13.08 % and diameter of leaf blast equal to 10.11 and 8.57 mm for first and second year, respectively, as nitrogen use cause to increase infected blast in panicle equal to 78.79 % in second year. The minimum leaf blast diameter in both years had achieved at triple interaction of potassium silicate in non-nitrogen use with both phosphorus rates. Therefore, potassium silicate application was benefit for control of blast disease and increase in grain yield.

KEYWORDS: Blast, Grain yield, Nitrogen, Phosphorus, Silicon resource

INTRODUCTION

Rice is one of the most important crops in the world and after of wheat was accounted a second place in terms of annual production and makes up staple food for half the world's population. Silicon is the second most abundant element in soil, as a very useful element for higher plants is discussed (Nakata *et al*., 2008). Silicon soluble form in soil is Si $(OH)_4$ and so it can be absorbed similarly directly (Chen *et al*., 2010). In food nutrition, silicon has not been considered an essential element in plant nutrition but many benefit effect of that including reduce the heavy metal toxicity, positive effect on photosynthesis, plant resistant to pests and diseases, lodging in cereal and reduce physiological disorders (Rahimi and Kafi, 2010; Romero-Aranda *et al*., 2006). Chen *et al*. (2011) stated that silicon can increase enzyme activity thst has important role for defense reaction to gene expression and blast disease. Benefit effect of silicon in plant are increase resistance of plant to stress (Liang *et al*., 2007; Ma and Yamaji, 2006). In pathology and crop physiology department studies positive relation between silicon and disease and expressed silicon has control bacteria and fungi disease (Datnoff, 2011).

In leaf tissue especially of lignin time or silicon gather in epidermal cell, an effective physical barrier against penetration of Hyfha, that this process cause to plant resistance especially in grass leaves to diseases (Shewood and Vance 1980). Concentration of silicon with 3 to 5 % laid to control of diseases in tissue surface (Datnoff *et al*., 1997). Silicon application increased plant resistance to disease and reason of that was silicon sitting in epidermal cell in leaf blade and defenses enzyme in leaf increased. As, silicon application had decreased H_2O_2 in rice, as ethylene surface in root and leaves (Ge *et al*., 2011). Seebold *et al*. (2000) found that blast surface in leaf and panicle for tolerance cultivars compare to sensitive cultivar with silicon application cause to increase grain yield, in experiment with silicon solubilizing bacteria showed that in treatment soil this biological fertilizer has increase soluble silicon content of soil compare to control treatment. With biological silicon application leaf angle has decreased and plant photosynthesis was improved. As well as, lodging, rice blast, grain discoloration and sheath decay was decreased (Du *et al*., 2011). Fallah

 © 2014 DAMA International. All rights reserved.

(2011) stated that in rice production nitrogen application for enhanced to yield cause to increase blast disease but silicon application had decreased disease extension.

Datnoff and Mitani (2008) in studies effects of nano-silicon stated that in all treatment with silicon application cause to decrease blast extension compare to control treatment. Elawad *et al*. (1982) with studies silicon resource and rate announced that 15 ton/ha silicon use decreased leaf spots in main crop and ratoon equal to 46 and 41 %. Magnesium silicate consumption rate of100 to200kg per hectareincreasedriceyieldfrom21 to33 % (Bernal, 2008). Calcium silicate use in rice with decrease bending moment and lodging cause to increase number of filled spikelet per panicle, due to cause to increase grain yield and silicon and nitrogen interaction has not been significant none of agronomic traits (Mobasser *et al*., 2008). Application of calcium silicate rate of 2tons per hectare increased the plant height, number of tiller per hill, panicle length and thereby increase30-25% grain yield, as excess of 100 kg N ha-^{1} has not reduced grain yield, but simultaneously application of calcium silicate and 150 kg N ha^{-1} cause to increase grain and straw yield (Shashidhar *et al*., 2008).

MATERIAL AND METHODS

In order to survey the role of nano-silicon and other silicon resources with nitrogen and phosphorus application on yield and yield components of rice (Tarom Hashemi variety), an experiment was conducted over two years in paddy field in Sari region, Mazandaran province(36°, 38 N ,53°, 12' E,14 m elevation) from May to September during the 2012 and 2013. This experiment was conducted as factorial in randomized complete blocks design with three replications. Treatment was silicon resources in four levels including non-application or control(S_1), calcium silicate (S_2) and potassium silicate (S_3) the land use and nano-silicon foliar (S_4) application and as nitrogen application from Urea resource in two levels including 0(N_1) and 70 kg ha^{-1}(N_2) and phosphorus application from P_2O_5 resource in two levels including 0(P_1) and 200 kg ha^{-1}(P_2).Calcium silicate, potassium silicate and phosphorus after paddling (7 days before transplanting) without water mixed with soil. Nitrogen was used in three stage the top dress; first stage equal to 60 kg Urea ha^{-1} (7 days after transplanting), second stage equal to 60 kg Urea ha^{-1} in initial heading stage (30 days after transplanting) and third stage was after full heading (60 days after transplanting) equal to 30 kg Urea ha^{-1}.

Time of nano-silicon foliar application with 20 ppm concentration was in three stages including start of tillering (15 days after transplanting), the end of tillering (30 days after transplanting) and after full heading (60 days after transplanting).The field was ploughed with tractor drawn disc plough followed by a through harrowing to break the clods. The field was properly levelled and 5 × 2 m^2 size plots were earmarked with raised bunds all around to minimize the movement of watering and nitrogen. Channels were laid to facilitate irrigation to plots individually and each replication. When rice seedlings were of 20 to 25 cm in height and 4 weeks old; they were uprooted and transplanted to experimental plots with 16 seedlings per m^2(25×25 cm^2).

Nitrogen levels in heading stage and phosphorus rates were done by design map. All operations like plant illnesses controlling and pests controlling were done during the growth process with chemical components. Weed control in specific plots was done by handing several stages after transplanting. Water deep that different stages of rice growth was 5 to 6 cm. The results of soil analyses are shown in Table 1 and the weather conditions in growth season are shown in Table 2.

Table 1. Soil analysis of experimental farm at 0-30 cm

Year	Depth (cm)	EC (ds/m)	PH of paste	K (ave) p.p.m	P (ave) p.p.m	Total N %	O.M %	M Soil Texture
2012	0-30	0.42	7.39	93	2.5	0.12	1.582	**CL**
2013	0-30	1.51	7.99	214	5.8	0.07	1.46	**L-C.L**

 © 2014 DAMA International. All rights reserved.

Table 2. Mean temperature, relative humidity, total sunshine hours, monthly evaporation, amount of rainfall and number of rainy days from planting to harvesting

Months	Year	Number of rainy days	Amount of rainfall (Mm)	Monthly evaporation (Mm)	Total sunshine hours	Relative humidity (%)	Mean Temperature (° C).	Maximum Temperature (° C)	Minimum Temperature (° C)
20Mar-20Apr	2012	10	12.4	110.3	191.7	74	14.8	20.5	**9.2**
	2013	10	12	91.5	157.7	79	14.8	19.3	**9.8**
20Apr-20May	2012	5	10.6	187.5	297.8	71	21.4	27.0	**15.8**
	2013	7	42.6	134.9	267.7	72	18.9	24.6	**13.2**
20May-20June	2012	6	41.4	222.5	288.7	70	25.2	20.6	**19.8**
	2013	8	9.3	166.4	256.5	74	23.9	29.1	**18.7**
20June-20July	2012	14	16.8	144.1	178.9	76	26.1	30.0	**22.2**
	2013	0	0	217.3	286.4	69	26.4	31.7	**21.2**
20July-20Aug	2012	3	2.6	204.6	323.1	70	28.6	34.1	**23.1**
	2013	15	29.5	133.4	157	77	25.9	30.3	**21.4**
20Aug-20Sep	2012	11	100.3	135.7	204.6	75	25.5	29.9	**21.1**
	2013	5	10.8	122.2	180.7	77	26.3	31.1	**21.4**

Sampling methods

For measurement of infected leaf blast percentage, 33 days after transplanting in plots with 4 leaves (leaves under flag leaf) in 5 hills in 6 plants with move randomly in length, width and diameter of each plots has investigated and number and diameter of spots in each leaves measurement (the length and width of spots had measurement with ruler), infected of leaf blast percentage in each plots was calculated with Seebold *et al*. (2000) method. Infected to leaf blast percentage = number of infected leaf × number of total leaves × 100. For measurement of infected panicle blast percentage, 70 days after transplanting with 50 panicles in each plots move randomly in length, width and diameter of each plots has investigated and infected panicle to blast was measurement from last inter-node to panicle. Then infected of panicle blast percentage in each plots was calculated with Seebold *et al*. (2000) method. Infected to panicle blast percentage = number of infected panicle × number of total measurement panicles in plots × 100.

For measurement of infected grain blast percentage, 50 panicles in each plots move randomly in length, width and diameter of each plots has investigated and infected grain to blast was measurement. Then infected of grain blast percentage in each plots was calculated with Seebold *et al*. (2000) method. Infected to grain blast percentage in ach plot = number of infected grain in 50 panicles for each plot × number of total measurement grain in 50 panicles for each plots × 100. Mean of spots diameter traits was achieved from adding the average diameter of spots (the most 10 spots of 4 leaves) and then they are invaded on that numbers mean.Grain yield from panicle in each plot was scaled as final grain yield.

Analysis of data: All the data were subjected to statistical analysis (one-way ANOVA) using SAS software. Differences between the treatments were performed by Duncan's Multiple Range Test (DMRT) at 5% confidence interval.

RESULTS AND DISCUSSION

Disease parameters in rice

Infected leaf blast percentage in both years had significant for silicon treatment in 1% probability levels and for nitrogen treatment in 5% and 1% for first and second years, respectively. As, this trait has significant in 5% probability level at interaction of nitrogen and phosphorous treatment (Table 3). Potassium silicate and nano-silicon resource had decreased infected leaf blast percentage in first year with difference of 10.83 and 9.49% and second year with difference 10.59% and 9.74% compare to control treatment. Nitrogen application for first and second years cause to

 © 2014 DAMA International. All rights reserved.

increase 34.6 and 42.26% of infected leaf blast percentage compare to control treatment (Table 4). As, in second year nitrogen use in two level and non-phosphorous rate with 14.08% and 12.08% was the highest surface (Figure 1). Silicon application increased plant resistance to disease and reason of that was silicon sitting in epidermal cell in leaf blade and defenses enzyme in leaf increased as, silicon application had decreased H_2O_2 in rice, as ethylene surface in root and leaves (Ge *et al*., 2011). Ghanbari Malidarreh (2009) reported that with increased nitrogen use leaf blast percentage had increased. Fallah (2011) stated that in rice production nitrogen application for enhanced to yield cause to increase blast disease but silicon application had decreased disease extension. Datnoff and Mitani (2008) in studies effects of nano-silicon stated that in all treatment with silicon application cause to decrease blast extension compare to control treatment. As, in soluble and non-soluble silicon resource had used for leaf and plant resistance to blast.

Leaf blast diameter in both years was significant by nitrogen treatment and interaction of silicon with nitrogen in 1% probability level, as this parameter in first and second year had significant at triple interaction in 5 and 1% probability level, respectively (Table 3). Nitrogen application in first and second years cause to increase 48.5% and 58.44%of leaf blast percentage compare to control treatment (Table 4). Potassium silicate treatment and non nitrogen use in both years was achieved the lowest leaf blast diameter equal to 2.58 and 2 mm (Figure 2 and 3). Ghanbari Malidarreh *et al.* (2011) reported that silicon use can decrease blast disease extension and blast diameter in rice. In other research stated that silicon application had significant on mean leaf blast diameter that with increase silicon use mean of spots leaf blast decrease (Ghasemi Lemraski, 2010). Results showed that ash resource of silicon (200 g per pod) had suitable results for blast control, as Na2SiO3 application per pod had decreased leaf and panicle blast (Quazi and Mohammed, 2008).

Panicle infected blast had significant only in second year on silicon and nitrogen effect in 5 and 1% probability level, respectively (Table 3). Silicon control treatment had the highest panicle infected to blast and potassium silicate has the lowest panicle infected blast in second year As, nitrogen application in second year has the most panicle infected blast equal to 15.44% compare to control treatment (Table 4). Results in research showed that panicle blast had significant by silicon and nitrogen use in 1% probability level that nitrogen use increase panicle blasting, as silicon use compare to control treatment decreased panicle blast (Ghanbari Malidarreh, 2009). As, Ghasemi Lemraski (2010) found that panicle infected to blast has not significant by silicon and phosphorous treatment but pure phosphorous application with 100 kg/ha and 1000 kg/ha silicon had decreased panicle infected to blast equal to 3.02% and 10%, respectively. Ghanbari Malidarreh (2009) stated that with increase nitrogen application blast extension but silicon use cause to decrease blast disease. Seebold *et al*. (2000) found that blast surface in leaf and panicle for tolerance cultivars compare to sensitive cultivar with silicon application cause to increase grain yield.

Grain infected to blast in both years had significant by silicon treatment in 1% probability levels (Table 3). In both years the most grain infected to blast was observed in silicon control treatment and the least of these traits was obtained for potassium silicate in first year and potassium silicate and nano-silicon in second year (Table 4). Chen *et al*. (2011) stated that silicon can increase enzyme activity thst has important role for defense reaction to gen expression and blast disease. Benefit effect of silicon in plant are increase resistance of plant to stress (Liang *et al*., 2007; Ma and Yamaji, 2006). In pathology and crop physiology department studies positive relation between silicon and disease and expressed silicon has control bacteria and fungi disease (Datnoff, 2011).

Grain Yield

Grain yield in first year has been effect by nitrogen in 1% probability level, as effect by phosphorus rate in 5 % probability level, as in second year it has been significantly effect by silicon resource and nitrogen in 1 % probability level (Table 3). Grain yield in second year with application of potassium silicate has increased 13.2% compare to control treatment. Nitrogen use in every two years cause to increase grain yield equal to 17.4 and 21.6 %. Grain yield in first year with application of phosphorus rate has increase 10.5 % (Table 4). Nolla *et al*. (2012) found that silicon use with reduce lodging and increase number of filled spikelet per panicle and 1000-grain weight due increase grain yield. Application of magnesium silicate cause to increase grain yield equal to 21-32% in rice (Bernal, 2008). Silicic acid foliar application with 10 days distance in rice plant was cause to increase number of panicle per plant due increased grain yield (Bhavya *et al*., 2011). Potassium silicate application cause to increase grain yield equal to 34.2 % compare to control treatment (Wang and Du, 2011).application of 2 ton per hectare calcium silicate cause to increase number of tiller per hill and panicle length as due increase 25-30% in grain yield compare to control treatment.

 © 2014 DAMA International. All rights reserved.

Tab 3. Analysis of variance of experimental characteristics.

S.O.V.	DF	Leaf blast		Leaf blast diameter		Panicle blast		Grain blast		Grain Yield	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Replication	2	412.68**	124.19**	237.01**	123.48**	188.58	101.02	1.41	0.18	1125550.33*	363450.521
Silica(S)	3	324.30**	331.01**	2023	26.80	344.39	672.63*	4.11**	1.98**	191050.17	802656.80**
Nitrogen(N)	1	107.10*	181.55**	130.68**	120.01**	494.08	1333.52**	0.12	0.75	4604124.08**	10104427.69**
S × N	3	9.77	8.26	135.14**	71.25**	332.47	300.35	0.87	0.54	573019.42	164809.41
Phosphorus(P)	1	13.55	0.98	11.80	3.47	8.33	143.521	0.01	0.08	1577600.08*	482202.52
S × P	3	1.41	7.04	1.00	1.12	208.72	167.58	0.91	0.20	270546.97	40881.132
N × P	1	9.63	35.28*	4.44	4.50	18.75	50.02	0.21	0.33	233344.08	32292.19
S × N × P	3	22.98	13.76	70.05*	64.34**	95.81	119.08	0.15	0.61	597262.97	59861.69
Experimental error	30	23.78	6.32	19.05	15.52	181.27	202.26	0.817	0.50	289717.00	146204.12
C.V %	-	48.19	22.56	51.60	56.34	18.87	19.34	38.74	39.37	16.61	10.15

Ns, **, *: significant and non-significant, respectively, at the level of %1 and %5

Table 4. Mean comparison for leaf blast percentage, Leaf blast diameter (mm), Panicle blast percentage, Grain blast percentage and Grain yield (Kg/ha)

Treatments	Leaf blast (%)		Leaf blast diameter(mm)		Panicle blast (%)		Grain blast (%)		Grain yield (Kg/ha)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Silica										
S_1	15.92a	16.86a	7.617a	7.083ab	78.25a	80.67a	3.042a	2.325a	3165 a	3558 b
S_2	13.2a	14.27b	8.483a	7.208ab	72.83a	79.25ab	2.567ab	1.892ab	3191 a	3566 b
S_3	5.092b	6.267c	7.450a	5.025b	67.67a	66.25c	1.742c	1.458b	3429 a	4100 a
S_4	6.625b	7.12c	10.28a	8.658a	66.58a	67.92bc	1.983bc	1.492b	3176 a	3845 ab
Nitrogen										
N_1	8.625b	9.194b	6.808b	5.412b	68.13a	68.25b	2.283a	1.667a	2930 b	3309 b
N_2	11.61a	13.08a	10.11a	8.575a	74.54a	78.79a	3.133a	1.917a	3550 a	4226 a
Phosphorus										
P_1	9.587a	11.00a	7.693a	6.725a	71.75a	71.79a	2.317a	1.750a	3059 b	3667 a
P_2	10.95a	11.28a	8.954a	7.262a	70.92a	75.25a	2.350a	1.833a	3421 a	3868 a

.*: Means with similar letters in each column are not significantly different at the %5 level of probability.
S_1= non application or control, S_2= Calcium silicate, S_3= Potassium silicate, S_4= Nano-silicon foliar application, N_1= 0, N_2=70 kg ha^{-1}, P_1= 0, P_2= 200 kg ha^{-1}

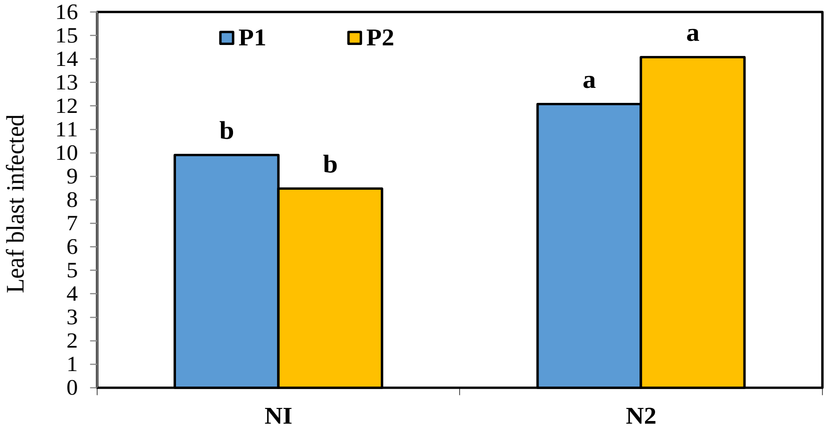

Figure 1. Interaction of nitrogen and phosphorus on leaf blast infection in 2013
N1= 0, N2=70 kg ha^{-1} P1= 0, P2= 200 kg ha^{-1}

 © 2014 DAMA International. All rights reserved.

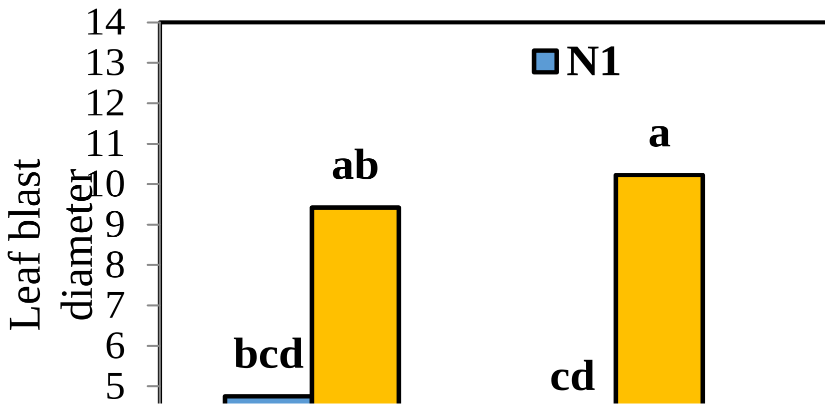

Figure 2. Interaction of silicon resource and nitrogen on leaf blast diameter in 2013
S1= non application or control, S2= Calcium silicate, S3= Potassium silicate, S4= Nano-silicon foliar application, N1= 0, N2=70 kg ha^{-1}

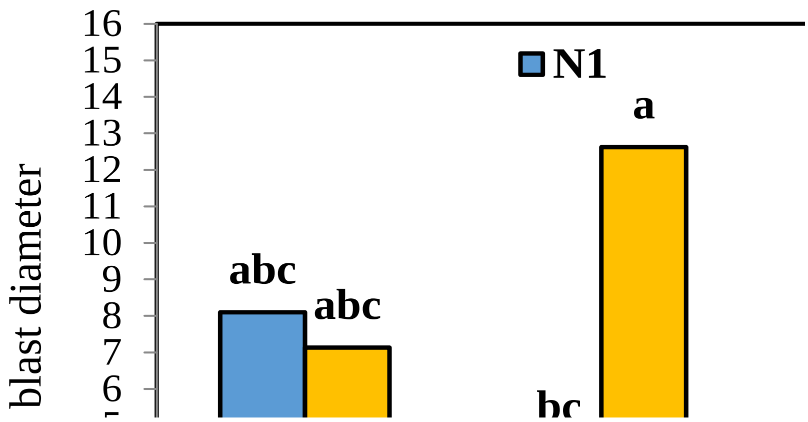

Figure 3. Interaction of silicon resource and nitrogen on leaf blast diameter in 2012
S1= non application or control, S2= Calcium silicate, S3= Potassium silicate, S4= Nano-silicon foliar application, N1= 0, N2=70 kg ha^{-1}

The highest grain yield was arrived with use of 100 kg N ha^{-1} (Shashidhar, 2008). Silicon use with increase tolerance to drought and number of tiller per plant had due to increase grain yield and dry matter in plant (Nolla *et al*., 2012).

REFERENCE

Bernal J. (2008). Response of rice and Sugarcane to Magnesium Silicate in different Soils of Colombia, South America. Proceedings of the 4th International Conference on Silicon in Agriculture.26-31 October 2008. South Africa.

Bhavya H.K., Nachegowda V., Jaganath S., Sreenivas K.N. and Prakash N.B. (2011). Effect of foliar silicic acid and boron acid in Bangalore blue grapes. International Conference on Silicon in Agriculture September 13-18, Beijing, China.

Chen J.N., Cai K.Z., Ge S.B. and Luo S.M. (2011). Silicon and salicylic acid induced defense response in rice (Oryza sativa L.)Against Magnaporthe grisea. Proc. 5th Int. Con. Silicon Agricult.13-18 September 2011 Beijing, China

Chen W., Yao X., Cai K. and Chen J. (2010). Silicon alleviates drought stress of rice plants by improving plant water status, Photosynthesis and mineral nutrient absorption. *Biol. Trace Element Res.* 142: 67-76.

 © 2014 DAMA International. All rights reserved.

Datnoff L.E. (2011).Silicon and biotic stress. International Conference on Silicon in Agriculture September 13-18, 2011 Beijing, China.

Datnoff L.E., Deren C.W. and Snyder G.H. (1997). Silicon fertilization for disease management of rice in Florida. Crop port 16:525-531.

Datnoff L.E., Ma J. and Mitani N. (2008). Influence of insoluble and soluble silicon on leaf blast development in rice. Proceedings of the 4th International Conference on Silicon in Agriculture.26-31 October 2008. South Africa .36-37

Du Y.H., Zhuang Z.J., Zhang C.Y., Xu Z.W. and Chen H.Y. (2011). A novel silicate-dissolving bacteria strain: Silicate-releasing capacity in soil and its agronomic implications in rice. Proceedings of the 5th International Conference on Silicon in Agriculture.13-18 September 2011 Beijing, China

Elawad S.H., Street J.J. and Gascho G.H. (1982). Response of sugarcane to silicon source and rate. II. Leaf freckling and nutrient content. *Agronomy J*. 74:484-487.

Fallah A., Osko T., Khosravi V., Mohammadian M. and Rosttami M. (2011). Reduction of chemical pesticides by using of silicate fertilizer in paddy fields. Proc. 5th Int. Con. Silicon Agricult.13-18 September 2011 Beijing, China

Ge S.B., Cai K.Z., Liu M. and Luo S.M. (2011). The Possible role of roots in silicon-induced resistance in rice against blast. Proc. 5th Int. Con. Silicon Agricult.13-18 September 2011 Beijing, China

Ghanbari-Malidarreh A. (2009). The Effect nitrogen and silicon rates on yield, agronomic and physiological charactristic of rice (*Oryza sativa* L.) in two irrigation systems (flooding and deficit). Ph.D. Thesis. Islamic Azad University Scince and recerchTehran Branch.PP:160

Ghanbari-Malidarreh A., Ghasemi-Lemraski M., Alavi S.V. and Mobasser H.R. (2011). Interaction effects of silicon and phosphorus fertilizer on blast disease severity in rice (*Oryza sativa* L. var. Tarom). Proc. 5th Int. Con. Silicon Agricult.13-18 September 2011 Beijing, China

Ghasemi-Lemraski M. (2010). Effect of application silicon and phosphorus fertilizers rats on yield, yield components and Blast disease intensity of rice in Mazandaran Province. M.Ss.Thesis. Islamic Azad University Qaemshahr Branch.PP:92

Liang Y., Sun W. and Zhu Y.G. (2007). Mechanisms of silicon-mediated alleviation of abiotic stresses in higher plants: A review. Environ. Pollut. 147: 422-428.

Ma J.F. and Yamaji N. (2006). Silicon uptake and accumulation in higher plants. *Trends Plant Sci.* 11: 392-397.

Mobasser H.R., Ghanbari-Malidareh A. and Sedghi A.H. (2008). Effect of silicon application to nitrogen rate and spilitting on agronomical characteristics rice (*Oryza sativa* L.). Proceedings of the 4th International Conference on Silicon in Agriculture.26-31 October 2008. South Africa .57-58

Nakata Y., Ueno M., Kihara J., Ichili M., Taketa M.S. and Arase S. (2008). Rice blast disease and susceptibility to pests in a silicon uptakedeficient mutant. *Crop Protection.* 27, 865-868.

Nolla A., Faria R.J., Korndorfer G.H. and Silva T.R.B. (2012). Effect of Slicon on drught tolerance of upland rice. *J. Agriculture Environ.* (1):269-267

Quazi S. and Mohammed M. (2008). Assessing the effectiveness of silicon content materials against blast disease of rice. *Proc. 4th Int. Con. Silicon in Agricult.* 26-31 October 2008. South Africa.

Rahimi Z. and Kafi M. (2010). Effects of salinity and silicon application on biomass accumulation, sodium and potassium content of leaves and roots parslane (*Portulaca oleracea* L.). J. Water and Soil. 2: 24. 367-374. (In Persian)

Romero-Aranda M.R., Jurado O. and Cuartero J. (2006). Rapid isoelectric focusing in a vertical polyacrylamide system. *Ann. Biochem.* 167: 290-294.

Seebold K.W., Datnoff L.E., Correa-Victoria F.G., Kucharek T.A. and Senyder G.H. (2000). Effect of silicon rate and host resistance on blast, scald, and yield of upland rice. *Plant Diseases.* 84:871-876

Shashidhar H.E., Chandrashekhar N., Narayanaswamy C., Mahendra A.C. and Prakash N.B. (2008). Calcium silicate as silicon source and its interaction with nitrogen in aer. *Proc. 4th Int. Con. Silicon in Agricult. 26-31 October 2008. South Africa.*

Shewood R.T. and Vance C.P. (1980). Resistance of fungal penetration in gramineae. Phytopathology. 70: 273-279.

Wang D.J. and Du F.B. (2011).Agonomic effects of silicon-potash fertilizer in wheat/maize and wheat/ soybean rotation system during 2008-2010**.** *Proc. 5th Int. Con. Silicon Agricult. 13-18 September 2001 Beijing, China.* 200-201.

 © 2014 DAMA International. All rights reserved.