INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 5, No. 12, p. 449-456, 2014

RESEARCH PAPER OPEN ACCESS

Role of nano-silicon and other silicon resources on straw and grain protein, phosphorus and silicon contents in Iranian rice cultivar (*Oryza sativa* cv. Tarom)

Hossein Yazdpour[1*], Ghorban Noormohamadi[1], Hamid Madani[2], Hossein Heidari Sharif Abad[1], Hamid Reza Mobasser[3], Mehdi oshri[4]

[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*

[4]*Department of Agronomy, Firoozkooh Branch, Islamic Azad University, Firoozkooh, Iran*

Key words: Nitrogen, phosphorus, silicon resources.

http://dx.doi.org/10.12692/ijb/5.12.449-456 Article published on December 27, 2014

Abstract

In order to investigation of silicon resources on nitrogen and phosphorus uptake on agronomical traits in rice, this experiment was carried out as factorial in randomized complete blocks design with three replications at Sari region, Mazandaran, Iran in 2012 and 2013. Treatments were silicon resources in four levels including calcium silicate and potassium silicate in soil use and Nano-silicon as foliar application and control , the nitrogen application from Urea resource were in two levels including 0 and 70 kg ha^{-1} and phosphorus application from P_2O_5 resource also were in two levels, 0 and 200 kg ha^{-1}.The results showed that the maximum protein content in grain and straw and the maximum silicon content in grains and straw were derived for Nano-silicon foliar application in every two years. In first year the minimum phosphorus content in grains and straw was achieved by Nano-silicon foliar application and control treatment, respectively. Phosphorus use cause to increase phosphorus concentration in grain and straw in every two years, as cause to increase silicon content in grain and straw in second year was. Generally, silicon soil application could increase phosphorus uptake and Nano-silicon foliar application could be increase protein and silicon content of shoot in rice.

* **Corresponding Author:** Hossein Yazdpour ✉ hossein_yazdpoor@yahoo.com

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). The maximum concentrations of silicon in plants can be seen in places that have the highest evaporation (Henriet *et al.*, 2006). As, Behtash *et al.*, (2010) found that the use of silicon were significantly increased silicon concentration in leaves and roots. Fallah (2008) reported that sodium silicate use cause to increase silicon concentration in root, stem, leaves and panicle in rice, but nitrogen increase cause to decrease to silicon concentration in other parts of rice. Calcium silicate use equal to 500 kg ha^{-1} cause to decrease nitrogen in grain and straw of rice (Ghanbari-Malidarreh *et al.*, 2008).

Greger *et al.*, (2011) reported that potassium silicate use without change to root/shoot cause to increase dry weight and nitrogen concentration in all of studied plant but phosphorus rate in silicon application was increased in wheat. Kindomihou *et al.*, (2011) expressed that SiO_2 has positive correlation with P_2O_5 and magnesium but had negative correlation with calcium, but between SiO_2 and nitrogen has not been correlation. Sandhya *et al.*, (2011) found that silicon foliar application increased calcium and phosphorus rate of grain and straw, as 1000-grain weight has significantly increased. In farming studies that treatment was $N_0P_0K_0$, common application of NPK and NPK application with silicate. Results showed that potassium silicate application increased nitrogen use efficiency compare to control equal to 31.4% and 17.04% compare to conventional fertilizing method, as P_2O_5 use efficiency has increase equal to 24.9% compare to control treatment and 14.5% compare to conventional fertilizing method, as K_2O_5 use efficiency increase 34.26% compare to control treatment and 27% compare to conventional fertilizing method (Wand and Du, 2011).

Therefore, the main objective of this study was to evaluate the effect of silicon resource especially foliar application of Nano-silicon on nitrogen, phosphorus and silicon uptake in tall cultivar of rice in Iran.

Materials and methods

Experimental site

In order to survey the effects of silicon, nitrogen and phosphorus fertilizers on straw and grain protein, phosphorus and silicon contents of rice (Tarom Hashemi variety), an experiment was done in Sari region, Mazandaran province (36°, 38' N , 53°, 12' E, 14m elevation) from May to September during the 2012 and 2013.

Experimental design

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 (S1), calcium silicate (S2) and potassium silicate (S3) the land use and nano-silicon foliar (S4) application and as nitrogen application from Urea resource in two levels including 0 (N1) and 70 kg ha^{-1} (N2) and phosphorus application from P2O5 resource in two levels including 0 (P1) and 200 kg ha^{-1}(P2).

Land preparation and planting

The practice of land preparation was carried out according to conventional procedure. 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 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). 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 hand in several stages after transplanting. Water depth at 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.

During the growth stages, following characteristics were measured randomly from each plot.

Measurements

Tested to determine the amount of nutrients in rice from each plot equal to 20 g sample with 14% humidity, it was sent to the laboratory for testing.

Silicon content of tissue samples were determined by first digesting 1.0 g of dried tissue, changed by Fallah (2004) and Yoshida (1975). Results obtained from plant analysis expressed in absorbance units (mV), were converted to percentages of SiO_2 per kg of plant tissue (Fallah, 2004; Yoshida, 1975). For Phosphorus measurement device SPECTRONIC 20D with colorimetric method with the help of three solutions molibdovanat, standard phosphorus solution and food nutrition solution and results reported the ppm (Emami, 1997). For measurement of grain and straw protein first nitrogen percentage of grain and straw was achieved with Micro-Kjeldahl method, then 6.25% multiplied achieved protein of grain and straw (Emami, 1997).

Statistical analysis

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

Silicon content of grain and straw

Silicon content of grain in first year was significant under silicon, nitrogen and phosphorus effect in 1% probability level, and interaction of silicon with nitrogen in 5%, and in second year had significant on silicon resource in 1% probability level and phosphorus rate in 5%, while silicon concentration of straw in first year only significant on silicon resource in 1% probability level and in second year on significant on silicon and nitrogen effect in 1% and phosphorus effect in 5% probability level (Table 3).

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.C %	O.M %	Clay %	Silt %	Sand %	Soil Texture
2012	0-30	0.42	7.39	93	2.5	0.12	0.92	1.582	34	24	42	CL
2013	0-30	1.51	7.99	214	5.8	0.07	0.85	1.46	27	36	37	L-C.L

Silicon concentration in grain and straw was greatest in both years with Nano-silicon foliar application. Nitrogen application cause to increase silicon concentration of grain in first year, as silicon concentration of straw has increase in second year. As, the most silicon concentration of grain and straw in second year was arrived with phosphorus application (Table 4). The least silicon concentration of grain in first year was achieved at interaction of Si_0N_0. The most silicon concentration of grain was gained in Nano-silicon foliar application and N_0 and N_{70} equal to 4 and 3.5 percentage, respectively (Table 4). Dhamapurkar *et al.*, (2011) found that with increasing amount of silicon were added on silicon content of grain and straw. Application of calcium silicate equal to 3 ton per hectare had cause to increase silicon concentration of grain and straw (Shashidhar, 2008). Silicon foliar application in millet had cause to increase of silicon in grain and straw (Sandhya *et al.*, 2011).

Protein content of grain and straw

Statistically, protein content of grain in every two years was significant under effect silicon and nitrogen in 1% probability level, as in second year significant at interaction of silicon with nitrogen in 1% probability level, but protein concentration of straw in first year only effect by nitrogen and in second year significant effect by silicon and nitrogen in 1% probability level (Table 3). The most protein content of grain and straw in every two year was arrived with Nano-silicon foliar application. Protein rate of grain and straw has increased with nitrogen use in every two year but phosphorus use cause to increase protein content of grain in first year and protein content of straw in second year (Table 4). The maximum protein concentration of grain was achieved at interaction of silicon with nitrogen in first year for N_{70} and Nano-silicon foliar application (Table 4). Silicon use was cause to reduce nitrogen and protein content of rice (Yimamu, 2008). Derena (1997) reported application of potassium silicate reduce nitrogen concentration in all of rice plant tissue. Potassium silicate application increased nitrogen use efficiency compare to control equal to 31.4% and 17.04% compare to conventional fertilizing method, as (Wand and Du, 2011). Elham *et al.*, (2011) found that silicon application in triticale has increased total protein content.

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

Date	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

Table 3. Analysis of variance for experimental characteristics.

S.O.V.	DF	Mean squares											
		Grain						Straw					
		Silicon		Protein		Phosphorus		silicon		Protein		Phosphorus	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Replication	2	0.15	0.77	0.028	1.40*	17.44	427.58	0.77	17.63**	0.00	4.94**	14.33	657.00**
Silicon (S)	3	12.08**	2.97**	1.415**	3.33**	278.75**	433.19	20.24**	13.05**	0.02	3.44**	35.41**	27.37
Nitrogen (N)	1	1.02*	0.04	37.56**	14.72**	481.33**	0.19	0.02	2.68**	0.63**	13.92**	295.02**	36.75
S.N	3	1.08**	0.28	2.057**	0.57	8.89	543.58	0.30	0.31	0.00	0.14	10.69	40.92
Phosphorus (P)	1	0.52	5.35*	1.210	0.66	47628.00**	16837.52**	1.69	7.16*	0.03	1.07**	3451.02**	2976.75**
S.P	3	0.58	0.36	0.17	0.14	34.44**	813.69	0.41	0.14	0.00	0.02	3.24	79.14
N.P	1	0.52	0.15	0.02	0.11	468.75	2.52	1.69	0.01	0.04	0.14	165.02**	200.09
S.N.P	3	0.13	0.49	0.15	0.23	13.86	553.13	0.74	0.227	0.01	0.27	6.24	80.70
Error	30	0.23	0.21	0.09	0.37	7.88	1064.76	0.48	0.293	0.01	0.13	7.73	69.71
C V %		20.58	16.53	3.02	6.6	1.94	20.46	10.07	5.56	4.70	9.23	6.35	13.66

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

Table 4. Mean comparison for Grain Silicon, Grain protein, Grain Phosphorus, Straw Silicon, Straw Protein, Straw Phosphorus content.

Treatments	Grain						Straw					
	Silicon (%)		Protein (%)		Phosphorus (ppm)		Silicon (%)		Protein (%)		Phosphorus (ppm)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
S1	1.42 d	2.30 b	9.95 c	8.59 c	143.7 b	154.9 a	6.08 b	8.69 c	2.12 b	3.50 c	41.33 b	59.92 a
S2	2.33 b	2.63 b	10.21 b	9.37ab	149.7 a	167.7 a	6.25 b	9.42 b	2.15ab	3.94 b	44.00 a	63.33 a
S3	1.92 c	2.65 b	9.80 c	9.01ab	146.0 b	160.4 a	6.41 b	9.61 b	2.15ab	3.62 c	45.33 a	60.58 a
S4	3.75 a	3.48 a	10.58 a	9.83 a	138.2 c	155.1 a	8.83 a	11.18 a	2.22 a	4.51 a	44.42 a	60.67 a
N1	2.21 b	2.79 a	9.25 b	8.65 b	141.2 b	159.6 a	6.91 a	9.49 b	2.04 b	3.35 b	41.29 b	62.00 a
N2	2.50 a	2.73 a	11.02 a	9.76 a	147.5 a	159.5 a	6.87 a	9.96 a	2.27 a	4.43 a	46.29 a	60.25 a
P1	2.25 a	2.43 b	9.97 b	9.09 a	112.9 b	140.8 b	6.70 a	9.34 b	2.13 a	3.74 b	35.29 b	53.25 b
P2	2.46 a	3.10 a	10.30 a	9.32 a	175.9 a	178.3 a	7.08 a	10.11 a	2.18 a	4.04 a	52.28 a	69.00 a
S1N1	1.00d	2.23d	8.99d	7.80d	155.2a	140.2e	6.33b	8.60d	2.02b	2.933f	38.50e	61.83a
S1N2	1.83c	2.36cd	10.91b	9.30bc	154.7a	147.2bc	5.83b	8.79d	2.22a	4.05bc	44.17bcd	58.00a
S2N1	2.00c	2.62cd	9.83c	8.82c	160.7a	146.8bc	6.17b	9.22cd	2.05b	3.45de	41.17de	63.00a
S2N2	2.67b	2.63cd	10.60b	9.93ab	174.7a	152.5a	6.33b	9.63bc	2.25a	4.42b	46.83ab	63.67a
S3N1	1.83c	2.91bc	9.00d	8.75c	158.3a	143.8cd	6.33b	9.15cd	2.02b	3.20ef	42.17cd	63.50a
S3N2	2.00c	2.40cd	10.60b	9.28bc	162.5a	148.2b	6.50b	10.08b	2.29a	4.05bc	48.50a	57.67a
S4N1	4.00a	3.40ab	9.20d	9.24bc	164.2a	134.0f	8.83a	11.00a	2.09b	3.83cd	43.33bcd	59.67a
S4N2	3.50a	3.53a	12.00a	10.44a	146.0a	142.3de	8.83a	11.35a	2.34a	5.18a	45.50abc	61.67a
S1P1	1.50de	2.10d	9.80cd	8.33d	114.3e	144.7ab	5.67c	8.35d	2.09b	3.39d	33.17d	55.17bc
S1P2	1.33e	2.50cd	10.11bc	8.87cd	173.0c	165.2ab	6.50bc	9.04c	2.13ab	3.61d	49.50b	64.67ab
S2P1	2.33c	2.25d	10.10bc	9.37abc	116.3e	154.5ab	6.17bc	8.89cd	2.13ab	3.78cd	35.83cd	52.67c
S2P2	2.33c	3.00bc	10.35ab	9.39abc	183.0a	180.8a	6.33bc	9.97b	2.15ab	4.08bc	52.17ab	74.00a
S3P1	1.83cde	2.10d	9.49d	8.93cd	113.8e	133.7b	6.17bc	9.25c	2.10b	3.50d	37.00c	51.50c
S3P2	2.00cd	3.22ab	10.11bc	9.10bcd	178.2b	187.2a	6.67b	9.98b	2.20ab	3.75cd	53.67a	69.67a
S4P1	3.33b	3.27ab	10.56a	9.73ab	107.0f	130.3b	8.83a	10.88a	2.19ab	4.20ab	35.17cd	53.67c
S4P2	4.17a	3.67a	10.61a	9.95a	169.3d	179.8a	8.83a	11.47a	2.24a	4.71a	53.67a	67.67a
N1P1	2.00b	2.40b	9.12d	8.48b	112.8c	141.1b	6.92ab	9.12c	2.04c	3.26c	34.67c	52.08b
N1P2	2.41a	3.18a	9.39c	8.81b	169.6b	178.1a	6.91ab	9.86b	2.04c	3.45c	47.92b	71.92a
N2P1	2.50a	2.45b	10.84b	9.69a	112.9c	140.5b	6.50b	9.56bc	2.22b	4.23b	35.92c	54.42b
N2P2	2.50a	3.00a	11.20a	9.83a	182.2a	178.4a	7.25a	10.37a	2.33a	4.63a	56.58a	66.08a
S1N1P1	1.00f	2.00e	8.80d	7.39f	113.0ef	146.0abc	6.00b	8.28j	1.99f	2.75h	32.33f	58.33bcde
S1N1P2	1.00f	2.47de	9.27d	8.21ef	167.3c	164.3abc	6.67b	8.92ghij	2.04ef	3.11fgh	44.67d	65.33abcde
S1N2P1	2.00de	2.20e	10.89b	9.28bcde	115.7e	143.3abc	5.33b	8.42j	2.19bcde	4.02cd	34.00ef	52.00de
S1N2P2	1.67ef	2.51cde	10.94b	9.51abcd	178.7b	166.0abc	6.33b	9.17fghij	2.24abcd	4.11bcd	54.33ab	64.00abcde
S2N1P1	2.00de	2.40de	9.82c	8.64de	116.3e	154.3abc	6.33b	8.54ij	2.07def	3.34efgh	35.67ef	50.00e
S2N1P2	2.00de	2.83bcde	9.83c	9.01cde	117.3b	167.0abc	6.00b	9.90defg	2.03ef	3.56defg	46.67d	76.00a
S2N2P1	2.67cd	2.10e	10.33c	10.90abc	116.3e	154.3abc	6.00b	9.23efghij	2.21bcde	4.22bcd	36.00ef	55.33cde
S2N2P2	2.67cd	3.17abcd	10.87b	9.77abcd	188.7a	194.7a	6.67b	10.03cdef	2.28abc	4.62bc	57.67a	72.00ab
S3N1P1	1.67ef	2.017e	8.75d	8.78de	116.3e	122.3bc	6.00b	8.77hij	2.00f	3.04gh	35.67ef	49.33e
S3N1P2	2.00de	3.800a	9.25d	8.70de	171.3c	194.3a	6.67b	9.53efghi	2.03ef	3.35efgh	48.67cd	77.67a
S3N2P1	2.00de	2.17e	10.22c	9.07cde	111.3ef	145.0abc	6.33b	9.73efgh	2.21bcde	3.95cde	38.33e	53.67cde
S3N2P2	2.00de	2.63cde	10.98b	9.49abcd	185.0a	180.0abc	6.67b	10.43bcde	2.37ab	4.14bcd	58.67a	61.67abcde
S4N1P1	3.33bc	3.18abcd	9.19d	9.13cde	105.8g	141.7abc	9.33a	10.90abc	2.12cdef	3.89de	35.00ef	50.67de
S4N1P2	4.67a	3.61ab	9.20d	9.35bcde	162.3d	186.7ab	8.33a	11.10ab	2.07def	3.77def	51.67bc	68.67abc
S1N1P1	1.00f	2.00e	8.80d	7.39f	113.0ef	146.0abc	6.00b	8.28j	1.99f	2.75h	32.33f	58.33bcde
S1N1P2	1.00f	2.47de	9.27d	8.21ef	167.3c	164.3abc	6.67b	8.92ghij	2.04ef	3.11fgh	44.67d	65.33abcde

*Means with similar letters in each column are not significantly different at the %5 level of probability S1= non application or control, S2= Calcium silicate, S3= Potassium silicate, S4= Nano-silicon foliar application, N1= 0, N2=70 kg ha^{-1}, P1= 0, P2= 200 kg ha^{-1}

Phosphorus content of grain and straw

As can be seen in table 3, phosphorus content of grain and straw in first year had significant on silicon resource, nitrogen and phosphorus in 1% probability level, as phosphorus content of grain was significant at interaction of silicon with phosphorus and phosphorus content of straw had significant at interaction of phosphorus with nitrogen in 1% but phosphorus content of grain and straw in second year only significant on phosphorus rate in 1% probability level. The least phosphorus content of grain and straw in first year was achieved with Nano-silicon foliar application and control treatment, as the maximum phosphorus concentration of grain was arrived in first year with calcium silicate application. Nitrogen use in first year was cause to increase phosphorus content of grain and straw and phosphorus use in every two year had increased phosphorus uptake of grain and straw (Table 4). The most phosphorus content of grain in first year had arrived at interaction of phosphorus use with calcium silicate application, but the least phosphorus content of grain in first year has achieved in first year with non-use of phosphorus with Nano-silicon foliar application (Table 4). The maximum rate of straw phosphorus in first year was arrived at interaction of nitrogen and phosphorus application (Table 4). Jianfeng and Takahashi (1990) reported that when phosphorus use was low silicon had a significant effect on P uptake but when phosphorus in take was high when compared to the absence of silicon, silicon sorption strength increases. Therefore, silicon is essential to increase P uptake. Derena (1997) reported that silicon application has reduced nitrogen concentration in all of plant tissue but phosphorus concentration has increased. Wand and Du (2011) found that potassium silicate use in rice cause to increase phosphorus use efficiency has increase equal to 24.9 % compare to control treatment. Nitrogen use cause to reduce phosphorus content of grain (Janguo *et al.*, 2013). Dinesh *et al.*, (2012) reported that the highest use of phosphorus and nitrogen rate have the most phosphorus uptake of straw in rice.

Conclusions

Generally, silicon land use was increased phosphorus uptake and Nano-silicon foliar application were increase protein and silicon content in rice shoot significantly.

References

Behtash F, Tabatabayi SJ, Malakoti MJ, Sarvaroddin MH, Oostan SH. 2010. Effects of Zinc and cadmium on growth, chlorophyll content, photosynthesis and Cd concentration in beet. Journal of Soil Research .Soil and Water Sciences **24(1),** 31-41.

Chen W, Yao X, Cai K, Chen J. 2010. Silicon alleviates drought stress of rice plants by improving plant water status, Photosynthesis and mineral nutrient absorption. Biological trace element search **142**, 67-76.
http://dx.doi:10.1007/s12011-010-8742-x

Derena CW. 1997. Changes in nitrogen and phosphorus concentrations of silicon fertilized rice grown on organic soil. Journal of Plant Nutrition **20(6),** 765-771.
http://dx.doi:10.1080/01904169709365292

Dhamapurkar VB, Talashilkar SC, Sonar KR. 2011. Effect of calcium silicate slag on yield and silicon uptake by rice. Proceedings of the 5th International Conference on Silicon in Agriculture.13-18 September 2011 Beijing, China 40-41.

Dinesh S, Pardeep KS, Ishwer S, Ajit S. 2012. Influence of Different Nitrogen and Phosphorus Levels on Profitability, Plant Nutrient Content, Yield and Quality in Basmati Cultivars, International Journal of IT, Engineering and Applied Science Research **1(1),** 1-4.

Elham S, Raheem H, Ghasemali G, Ramin H. 2011. Growth improvement of triticale for dry tolerance by antioxidant enzyme Analysis. Proceedings of the 5th International Conference on Silicon in Agriculture.13-18 September 2011 Beijing, China 45-46.

Emami A. 1997. Methods of plant analysis. Bulletin 982, Agricultural Extension and Education Research Organization, Institute of Soil and Water Research 126 pp.

Fallah A. 2008. Studies effect of silicon on lodging parameters in rice plant under hydroponics culture in a greenhouse experiment. Proceedings of the 4th International Conference on Silicon in Agriculture.26-31 October 2008. South Africa 38-39.

Fallah A, Visperas RM, Alejar AA. 2004. The interactive effect of silicon and nitrogen on growth and spikelet filling in rice (*Oryza sativa* L.) Philipp. Agaric Scientist **87**, 174-176.

Ghanbari-Malidarh A, Kashani A, Nourmohammadi G, Mobasser H, Alavi V, Fallah A. 2008. Effect of silicon and nitrogen rates on leaf and neck blast, chlorophyll content and yield of rice (*Oryza sativa* L.) in two water management systems (flooding and deficit irrigation) in the north of Iran. Proceedings of the 4th International Conference on Silicon in Agriculture.26-31 October 2008. South Africa 42-43.

Greger M, Landberg T, Vaculik M, Lux A. 2011. Silicon influences nutrient status in plants. Proceedings of the 5th International Conference on Silicon in Agriculture.13-18 September 2011 Beijing, China 56-57.

Henriet C, Draye X, Oppitz I, Swennen R, Delvaux B. 2006. Effects, distribution and uptake of silicon.in banana (*Musa* spp.) under controlled condition. J Plant Soil **287**, 359-374. http://dx.doi:10.1007/s11104-006-9085-4

Janguo BI, Liu Z, Lin Z, Md A, Rehmani MIA, Li G, Wang Q, Ding Y. 2013. Phosphorus accumulation in grains of japonica rice as affected by nitrogen fertilizer. Plant and Soil **389**, 231-240. http://dx.doi:10.1007/s11104-012-1561-4

Jiafeng M, Takahashi E. 1990. Effect of silicon on growth and phosphorus uptake of rice. Plant soil **126**, 115-119.

Kindomihou, V, Téka OS, Adjolohoun S, Holou RAY, Houessou L, Dagbénonbakin G, Agbangba EC, Gruber W, Adandédjan C, Sinsin B, Lejoly J, Meerts P. 2011. Leaf silicification, covariations with minerals concentrations and forage value of three tropical miscellaneous species from sudanian Benin. International Conference on Silicon in Agriculture September 13-18, 2011 Beijing, China 79-81.

Nakata Y, Ueno M, Kihara J, Ichili M, Taketa MS, Arase S. 2008. Rice blast disease and susceptibility to pests in a silicon uptake efficient mutant. Crop Protection **27,** 865-868. http://dx.doi:10.1016/j.cropro.2007.08.016.

Sandhya TS, Prakash NB, Nagaraja A, Nanja-Reddy YA. 2011. Genotypic variation for silicon accumulation and effect of foliar silicic acid on growth and yield of finger millet (*Eleusinecoracana* (L.) *Gaertn*.) . Proceedings of the 5th International Conference on Silicon in Agriculture.13-18 September 2011. Beijing, China 183-185.

Shashidhar HE, Chandrashekhar N, Narayanaswamy C, Mahendra AC, Prakash, NB. 2008. Calcium silicate as silicon source and its interaction with nitrogen in are. Proceedings of the 4th International Conference on Silicon in Agriculture.26-31 October 2008. South Africa 93-94.

Wang DJ, Du FB. 2011. Agronomic effects of silicon-potash fertilizer in wheat/maize and wheat/soybean rotation system during 2008~2010. Proceedings of the 5th International Conference on Silicon in Agriculture.13-18 September 2011. Beijing, China 201-202.

Yimamu F. 2008. Silicon status and its relationship with major physic chemical properties of soils in the northern highlands of Ethiopia .Proceedings of the 4th International Conference on Silicon in

Agriculture.26-31 October 2008. South Africa 76-77.

Yoshida S. 1975. The physiology of silicon in rice. Taipei: Food and Fertilization Technology Center, (FFTC) ASPAC, Technical Bulletin **25,** 1-27.