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ROLE OF NANO-SILICON AND OTHER SILICON RESOURCES WITH NITROGEN AND PHOSPHORUS APPLICATION ON YIELD AND YIELD COMPONENTS OF RICE (*ORYZASATIVA*)

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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 highest grain yield equal to 4100 kg ha^{-1} and biological yield equal to 9456 kg ha^{-1}was produced in second year, as the maximum number of total spikelet per panicle, number of filled spikelet per panicle for every two years were achieved with potassium silicate application. Separate application of nitrogen and phosphorus in second year was cause to increase number of total spikelet per panicle and number of filled spikelet number per panicle. The highest grain yield and biological yield in every two year was achieved with nitrogen use, while phosphorus use was cause to increase grain yield in first year and biological yield in every two years. Generally, potassium silicate application has benefit for increase grain yield.

KEYWORDS: Grain yield, Nitrogen, Phosphorus, Silicon resources

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 for example reduce Al^{+3} in plant, positive effect on photosynthesis, plant resistant to pests and diseases, lodging in cereal and reduce physiological disorders (Khaldbarin and Eslamzade, 2001; Romero-Aranda *et al*., 2006; Rahimi and Kafi, 2010). The maximum concentrations of silicon in plants can be seen in places that have the highest evaporation (Henriet *et al*., 2006). Optimal use of silicon causes the plants leaves to hold vertical curvature. Silicon accumulation in rice could reach up to 10% of dry weight (Nakata *et al*., 2008). Magnesium silicate consumption rate of 100 to200kg per hectare increased rice yield from21 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 increase 30-25% grain yield, as excessof100kg Nha-^{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). 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. 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

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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).This research was carried out for studies effect of silicon resource with nitrogen and phosphorus application on yield and yield components in tall cultivar of rice.

MATERIALS 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 leveled 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 5to 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	TotalN %	O.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**

Method of traits sampling: During the growth time, following characteristics was measured randomly from each plot.

Yield components were analyzed base on different samples of plant to determine the spikelet per panicle, filled spikelet percentage per panicle. 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.

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**

RESULTS AND DISCUSSION

Number of tiller per hill

Number of tiller per hill has significantly in first year effect by nitrogen and phosphorus and in second year only effect by nitrogen in 1 % probability level (Table 3). Number of tiller in first and second year with nitrogen application has increased 20.8 and 24.4 %, respectively. With phosphorus use in first year this trait has increase 9.4 % (Table 4). Application of 2 ton calcium silicate and 200 kg N ha^{-1} was cause to increase number of tiller per hill in rice (Shashidhar *et al*., 2008). Application of 150 kg N ha^{-1} and use of 33.3-50 % of nitrogen in start of tillering cause to increase number of tiller per hill (Mobasser *et al*., 2008).

Number of total spikelet per panicle

Number of total spikelet per panicle in second year had significantly effect by silicon resources and nitrogen in 1 probability level and in phosphorus treatment was significant in 5 probability level but in first year has not been on each of treatment (Table 3). But number of total spikelet per panicle in first and second years with application of potassium silicate had increased equal to 8.3 and 15.9 %, respectively. Nitrogen and phosphorus use in second year cause to increase number of total tiller per panicle equal to 11.7 and 8 %, respectively (Table 4). Ahmad *et al*. (2013) found that silicon cause to increase number of total spikelet per panicle. As, Nolla *et al*. (2012) was stating these results.

Number of filled spikelet per panicle

Number of filled spikelet per panicle in first year has not been significant effect by each of treatment but in second year this trait has significant by silicon resources, nitrogen and phosphorus in 1 % probability level (Table 3). But this trait in every two year was highest with application of potassium silicate and use of nitrogen and phosphorus in second year cause to increase number of filled spikelet per panicle (Table 4). Use of 1250 kg calcium silicate ha^{-1} increase number of filled spikelet per panicle due increase grain yield (Mobasser *et al*., 2008).

A thousand grain weight

1000-grain weight in every two year has not been effect by main effect of treatment but in second year it has been significant effect by silicon resources, nitrogen and phosphorus in 1 probability level (Table 3).The maximum 1000-rin weight with simultaneously application of phosphorus with potassium silicate (Figure 1). Mauad *et al*. (2003) reported that silicon with guttering in lemma ad plea because to increase 1000-grain weight but Mobasser *et al*.(2008) stating that application of calcium silicate with increased number of filled spikelet per panicle due reduce 1000-grain weight. Nolla *et al*. (2012) expressed that silicon has effect on 1000-grain weight. Silicon foliar application has increase phosphorus rate of grain and 1000-grain weight (Sandhya *et al*., 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).

Table 3. Analysis of variance of experimental characteristics

S.O.V.	df	Total number of tillers per hill		Number of spikelet per panicle		Number of filled spikelet per panicle		1000-grain weight		Grain Yield		Biological yield	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Replication	2	13.93*	22.58*	32.20	2.63	28.97	2.17	0.45	0.25	1125550.33*	363450.52	8293504.3**	6476587.00**
Silica(S)	3	1.97	13.26	153.44	469.51**	149.88	303.99**	0.74	0.74	191050.17	802656.80**	1053157.18	3104816.14*
Nitrogen (N)	1	129.36**	234.97**	4.38	1329.20**	3.36	942.53**	0.08	0.52	4604124.08**	10104427.69**	3349.15**	53201774.08**
N×S	3	8.88	4.67	22.23	74.16	12.18	24.11	0.70	0.23	573019.42	164809.41	1525625.96	1650305.14
Phosphorus (P)	1	22.14**	4.81	25.38	604.85*	23.94	364.65**	0.23	1.01	1577600.08*	482202.52	10594741.6**	6869020.08**
S × P	3	2.18	12.43	18.46	7.72	15.55	7.05	0.36	1.62*	270546.97	40881.13	284895.69	865387.25
N × P	1	0.19	0.61	39.06	53.53	33.17	35.88	0.99	0.02	233344.08	32292.19	181425.02	823204.08
S × N × P	3	4.24	2.95	74.38	63.51	45.37	75.02	0.77	0.97	597262.97	59861.69	2178419.02	618579.36
Error	30	3.45	6.00	73.60	29.85	70.57	31.81	0.48	0.58	289717.00	146204.12	1248044.93	902255.58
C.V. %	-	13.11	15.44	11.74	7.49	12.30	7.14	2.94	3.28	16.61	10.15	15.82	10.87

Ns, **, *: significant and non-significant, respectively, at the level of 1 per cent and five per cent

Table 4. Mean comparison for Total number of tillers per hill, number of spikelet per panicle, number of filled spikelet per panicle, A thousand grain weight (gr), Grain yield (Kg/ha) and Biological yield (Kg/ha)

Treatments	Total number of tillers per hill		number of spikelet per panicle		number of filled spikelet per panicle		Athousand grain weight		Grain yield (Kg/ha)		Biological yield (Kg/ha)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Silica												
S_1	13.8 a	15.1 b	71.0 ab	78.2 c	66.6 ab	74.1 b	23.3 a	23.0 a	3165 a	3558 b	6833 a	8323 b
S_2	14.3 a	15.3 ab	69.5 b	83.8 b	64.1 b	78.1 b	23.7 a	23.2 a	3191 a	3566 b	7002 a	8494 b
S_3	13.7 a	15.5 ab	77.5 a	93.0 a	72.1 a	86.0 a	23.9 a	23.6 a	3429 a	4100 a	7492 a	9456 a
S_4	14.6 a	17.4 a	74.2 ab	82.1 bc	70.1 ab	77.5 b	23.4 a	23.2 a	3176 a	3845 ab	6912 a	8959 ab
Nitrogen												
N_1	12.5 b	13.6 b	72.8 a	79.0 b	68.5 a	74.5 b	23.6 a	23.2 a	2930 b	3309 b	6224 b	7755 b
N_2	15.8 a	18.0 a	73.4 a	89.5 a	68.0 a	83.4 a	23.5 a	23.4 a	3550 a	4226 a	7895 a	9861 a
Phosphorus												
P_1	13.4 b	15.5 a	72.3 a	80.7 b	67.5 a	76.2 b	23.6 a	23.1 a	3059 b	3667 a	6590 b	8430 b
P_2	14.8 a	16.1 a	73.8 a	87.8 a	68.9 a	81.7 a	23.5 a	23.4 a	3421 a	3868 a	7530 a	9186 a

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

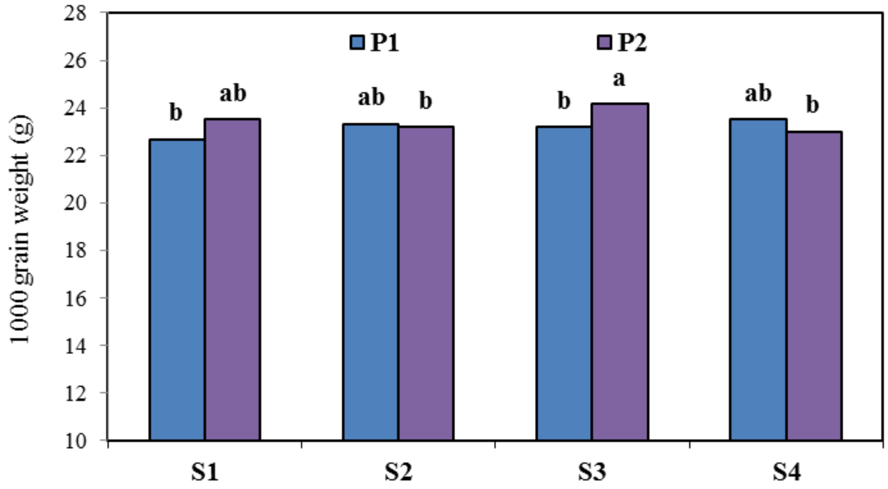

Figure 1. Interaction of silicon resource and phosphorous on 1000-grain weight in 2013
S1= non application or control, S2= Calcium silicate, S3= Potassium silicate, S4= Nano-silicon foliar application, P1= 0, P2= 200 kg ha^{-1}

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. 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).

Biological yield

Simple effect of nitrogen and phosphorus in every two years had significant effect on biological yield in 1 % probability level but silicon resources only in second year has significantly effect in 1 % probability level on this trait (Table 3). Nitrogen and phosphorus application in every two years cause to increase biological yield but biological yield in second year has highest with application of potassium silicate (Table 4). Shoot dry weight has increased in rice with simultaneously silicon and phosphorus application and in control treatment of silicon the highest shoot dry weight was achieved in medium rate of phosphorus (Jiafeng and Takahashi, 1990).

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