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Effect of silicon addition on the growth and yield of rice plants

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ABSTRACT

Two pot experiments were conducted at National Research Center during two successive seasons to study the effect of silicon addition with different fertilizer treatments on the growth and yield of rice plants. Treatments namely a) Nitrogen alone, b) nitrogen + phosphorus, c) nitrogen + potassium and nitrogen + Phosphorus + Potassium with or without silicon was added in the form sodium meta silicate ($Na_2SiO_3.5H_2O$) under submerged soil. The obtained results can be summarized in the following: The plant height was highly significant increased by silica addition to all the fertilizer treatment (N, NK, NP, NPK) with some exceptions, which did not reach the significance level of 5%. The dry matter of roots, shoots and grain yield significantly increased by Si addition to all the used fertilizers. The highest value of plant height, dry matter of roots, shoots and grains were obtained by using the NPK + Si treatment followed by NP + Si, NK + Si and N + Si in decreasing order. Application of Si with the fertilizer treatments significantly increased the Si content and uptake by all the different parts of rice plant (roots, shoots and grains) as they compared with those without Si addition.

Key words: Significant, silica, yield, fertilizer, increased, NPK.

Introduction

Rice is the second cash crop in Egypt. More than million feddans are cultivated annual with rice. Optimizing soil conditions for plant growth would comprise water regime to meet aeration, water requirements, and fertilization to meet nutrient requirements. Rice growing under different soil water levels prevailing under rainfed condition have largely been ignored (Mukherjee and Mandal, 1995).

The production of rice consumes much more water than that of other crops. Flooding conditions require large quantities of water, which is used not only for growth of rice plants but also as a management tool during cultivation (McCanley, 1990).

Flooded conditions require large quantities of water than that the other crops, which is used net only for growth of rice plants but also as a management tool during cultivation. The chemistry of soil managements is important to the nutrition of low and rice and to the processes of soil formation in flooded and poorly drained soils.

Soil, water and fertilizer management are considered the most important factors in rice production, Nitrogen is frequently the most limiting nutrient in rice production. It is usually low in most arid under and conditions (Cai *et al*., 2008).

Silicon has not been proven to be an essential element for higher plants, but its beneficial effects on growth have been reported in a wide variety of crops, including rice, wheat, barley and cucumber. Si fertilizer is applied to crops in several countries for increased productivity and sustainable production (Ma *et al*., 2001). Also, Abou- Baker *et al.* (2011) mentioned that application of Si as potassium silicate produced the highest values of pods number/plant, pods weight and seed yield (g/plant and kg/fed.) at harvesting. The amount of Si in soil may vary donsiderably from 1% to 45% (Sommer *et al*., 2006). Most Si is present in the soil as insoluble oxides or silicates, but plants can easily absorb silicilc acid $Si(OH)_4$ from soil. The aim of our work was to study the effect of Si application with different fertilized treatments on some growth parameters and dry matter of roots shoots and grain of rice plants.

Material and Methods

Two pot experiments were conducted during two successive seasons to study the effect of silicon addition on the growth and yield of rice plants. Soil sample used in this experiment was taken from Sakha farm, which has the following properties:

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Soil samples at depth of (0-30 cm) from the surface layer of clay loam soil has a 26.7% sand, 39.6% silt and 33.7% clay pots, contain air dried soil were arranged in a complete randomize design.

Saturation capacity 27.08, pH 8.0, ECe 2.53 mmohs/cm, $CaCO_3$ 4.0%, organic matter 1.6%, available N 18.5 ppm, available P 2.5 ppm, available K 280 ppm, and available Zn 0.77 ppm.

The mentioned determinations were conducted according to Jackson, (1982).

The experiment included of four fertilizer treatments: a) Nitrogen alone (0.8 gm/pot (Urea), b) Nitrogen + Phosphorus (0.8 gm/Pot (Urea + 0.8 gm/pot superphosphate), c) Nitrogen + Potassium (0.8 gm/pot Urea + 0.8 gm/pot Potassium Sulphate) and d) Nitrogen + Phosphorus + Potassium (0.8 gm/pot Urea + 0.8 gm/pot Supperphosphate + 0.8 gm/pot Potassium Sulphate).

For each treatment, eight pots were prepared as previously explained in experiment I; rice seeds were sown, and the seedlings were thinned to three per pot after two weeks from germination. After thinning, silicon was added to four pots at a rate of 1.87 gm Si/pot in the form of sodium meta silicate (Na_2 $SiO_3.5H_2O$) with irrigation water. The plants of the four other pots of each treatment were not supplied with silicon. Throughout the growth period which lasted 140 days, the pots received sufficient distilled water for flooding.

The plant height was measured at the end of the experiment, while roots, shoots and grains of the rice plants were dried in an aerated oven at 70°C for 24 hours in order to obtain the oven dried weight. The plant materials were then ground and stored, separately, in polyethylene bags.

The digested material was raised to 100 ml, filtered through ashless whatman No. 44 paper, and silica was determined gravimetrically according to Wolf, (1982). The filtrate was received in clean plastic bottles.

Statistical analysis:

The pots of the experiments were distributed in a randomized block design with four replicates for each treatment and analysis of variance and comparisons between means were performed using the least significant difference (L.S.D.) method at 1% and 5% according to Steel and Torrie, (1980).

Results and Discussion

Effect of Si application with different fertilizers on growth and yield of rice plants:

This experiment was designed to study in more details the effects of sodium meta silicate addition to different fertilizer treatments (N, NK, NP, NPK) on growth and yield of rice plants grown for two successive seasons in Sakha clay loam soil.

Effect on the growth and yield of rice plants

Data on plant growth (plant height, dry matter of roots, shoots and grain yield) of rice plants as affected by addition of sodium meta silicate to different fertilizer treatments are presented in Table (1) and illustrated in Figs. 1 and 2. As can be seen, plant height was highly significantly increased by silica addition to all the fertilizer treatments compared with control (without Si fertilizer). The highest results were reached through the use of 1.87 gm Si/pot as sodium meta silicate in addition to NPK fertilizer treatments in weight of grain, straw and roots (41.61, 48.86 and 29.48g/pot) where application of N fertilizer alone were (27.54, 32.94 and 19.56g/pot) at first season and (34.75, 42.47 and 24.35g/pot) and in the second season were (20.00, 27.38 and 15.50 g/pot). Zhu *et al*. (2004) reported that silicate solutions had the superiority effect compared with sulphate solutions. This may be refer to silicon which promotes the growth of various higher plant species, although there is a plenty supply of sulphate by addition of all commercial fertilizers and rarity of silicate supply. In addition to role of Si in increasing growth as mentioned by Hashemi *et al*. (2010) they found that silicon nutrition ameliorated the deleterious effects of salinity on the growth of canola plants through lowering tissue Na^+ contents, maintaining the membrane integrity of root cells as evidenced by reduced lipid peroxidation increased reactive oxygen species scavenging capacity and reduced lignifications. However, these increases did not reach the significant level of 5% for the N and NK treatments in the second season. The greatest plant height was obtained by adding Si to the NPK fertilizer treatment followed by NP + Si, NK + Si and N + Si in decreasing order. These results were true for both growing seasons, and confirmed the findings of Abou-Baker *et al*. (2011) and Pandey and Yadav, (1999) reported that spraying silicon increased grain yield/plant of wheat. They referred that to an increase in plant water status, chlorophyll content, biological yield and harvest index, coupled with reduced values of water potential, increase, in dry matter accumulation, dry matter production rate, leaf area/plant at the flowering stage, productive tillers, grain and grain yield/main spike and per plant and transpiration rate coupled with a decrease in stomata conductance. The positive effect of Si addition on plant height was also obtained by Hanafy Ahmed *et al*. (2008) Agarie *et al.* (1993) who stated that application of silicate materials increased plant height, stem diameter of sugar cane, corn and rice plants when they are compared with those without Si additions.

The dry matter of roots, shoots and grain yield of rice plants (Table 1 and Figs. 1 and 2) were affected by the application of sodium meta silicate to the different fertilizers (Hossain *et al*., 2002; Ma, 2004). Furthermore, this increase in plant growth due to Si application not only takes places under normal growth conditions, but also under stressful conditions.

Results show almost exactly the same trend mentioned in the case of plant height. This is logical because the dry matter yield is more or less just another expression of the plant height at least in the case of this experiment. Data also show that the highest dry matter production for all the used treatments was obtained for shoots followed by grain yield and roots of rice plants in decreasing order. Furthermore, the NP + Si treatment gave higher roots, shoots and grains dry matter as they compared with those obtained by using NK + Si or N+Si treatment. Confirm this results El-Beshbeshy, (1994) who indicated that the combinations of silicate and phosphate were more effective in increasing the yield of barley plants and Wang and Galletta, (1998) concluded that foliar spray with K silicate increased plant growth of strawberry. Also these results are in harmony with those reported by Parveen and Ashraf, (2010), they found that, applied Si in varying levels significantly increased the shoot length of maize plants under saline conditions. Silicon treatment (100 ppm) had significantly increased shoot length of rose (Hwang *et al*., 2008; Reezi *et al*., 2009) and wheat plants Hanafy Ahmed *et al*. (2008).

Table 1: Effect of silicon application on plant height (cm), dry matter of roots, shoots and grain yield of rice plants grown for two seasons.

Fertilizer Treatments	Plant height		Dry weight (g / pot)					
			Roots		Shoots		Grain	
	-Si	+Si	-Si	+Si	-Si	+Si	-Si	+Si
	First season							
N	71.25	79.50	19.56	24.58	32.94	42.41	27.54	34.64
NK	72.25	81.75	20.31	25.82	33.31	44.13	28.72	36.80
NP	72.89	86.00	21.00	27.08	33.79	46.70	29.93	39.31
NPK	72.58	89.00	22.26	29.48	34.58	48.86	30.74	41.61
LSD 5 %	2.53		1.52		1.45		2.93	
LSD 1%	3.44		2.06		1.97		3.98	
	Second+ season							
N	68.00	68.90	15.50	19.65	27.38	34.38	20.00	25.00
NK	69.15	70.10	15.75	20.25	28.00	36.30	22.00	28.30
NP	72.25	73.75	17.00	22.00	29.13	39.06	23.10	30.50
NPK	73.00	74.25	18.25	24.35	30.66	42.47	25.50	34.75
LSD 5 %	1.25		0.60		1.42		1.16	
LSD 1%	1.71		0.81		1.94		1.58	

- Si without silicon addition. + Si with silicon addition.

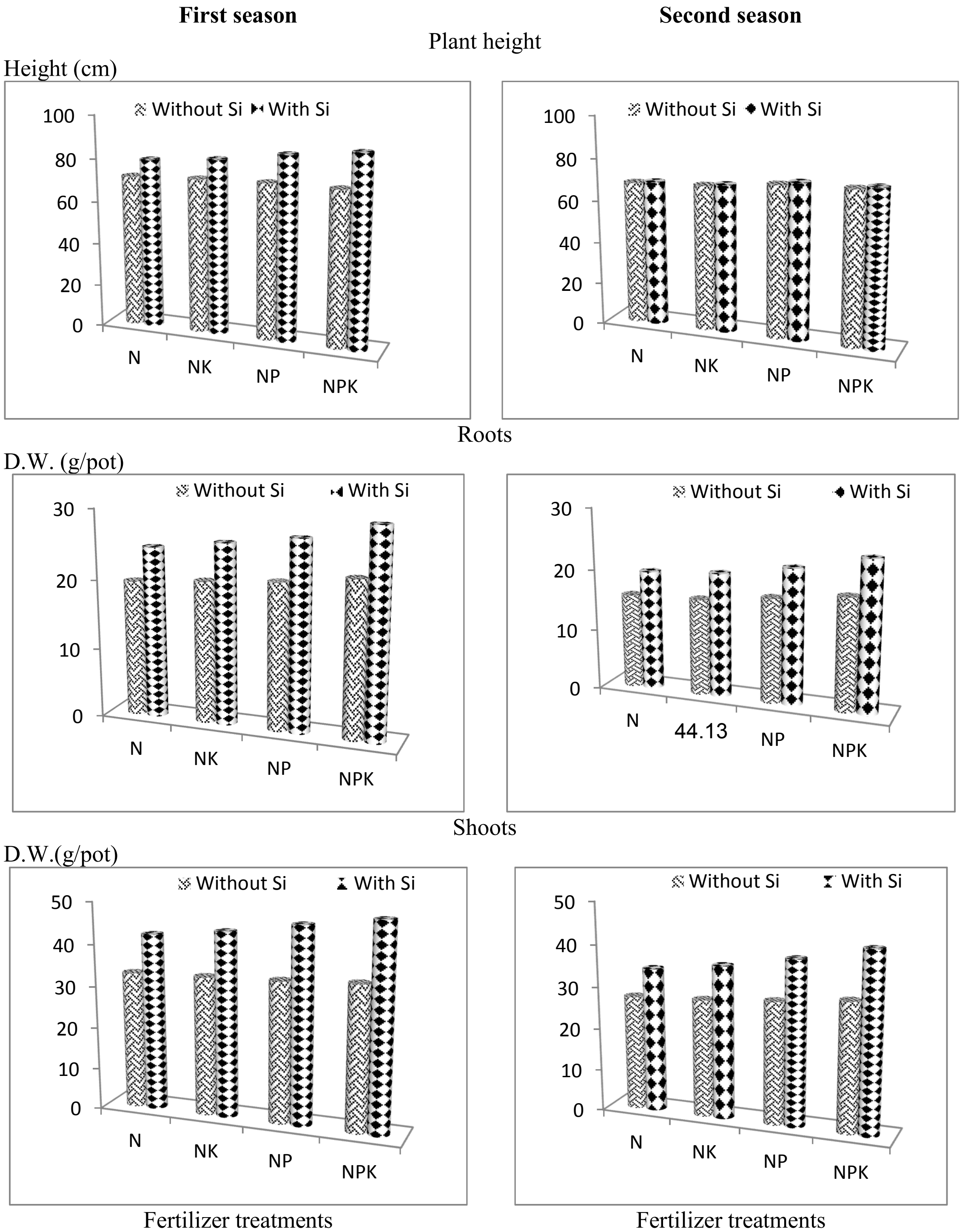


Fig. 1: Effect of silicon application on plant height (cm) and dry weight production (g/pot) of different parts of rice plant.

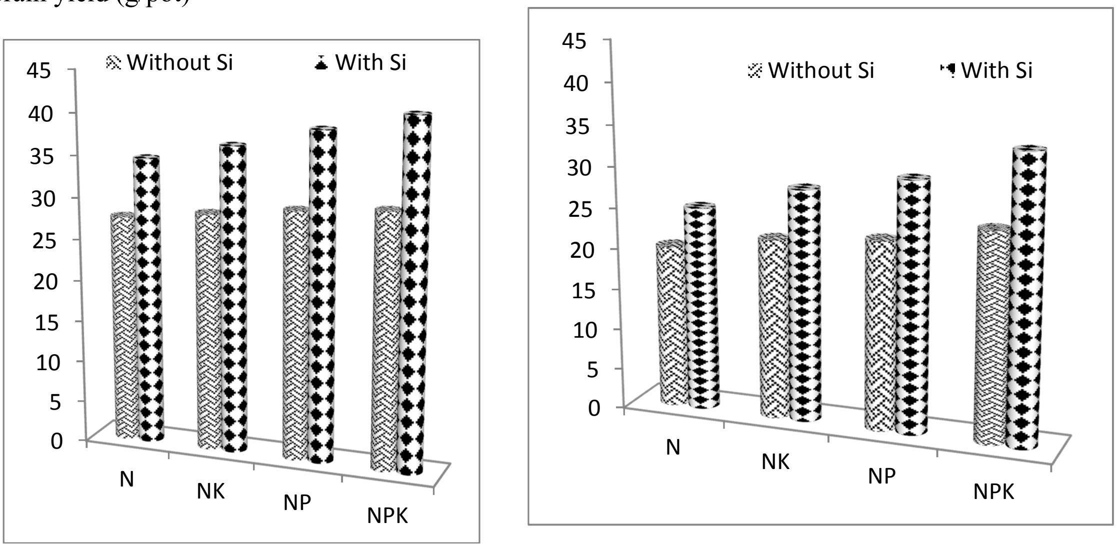
Generally, the dry matter production of rice plants for the second season was lower than that obtained in the first one. However, they reflected the same trend mentioned above. This may be due to some variation of climatic factors which affect both metabolic activity and transpiration, as a result of which there was an increase in the content and uptake of nutrients by the plants in the first season. The previous explanation confirmed by Hanafy Ahmed *et al*. (2008) showed that the lowest level of silicon significantly increased all the studied growth characters of wheat plants, while all levels of silicon significantly increased number of spikes and grains as well as grains yield when compared with control non-sprayed plants.

The positive effect of Si + NK on increasing growth and yield of rice plants if compared with those obtained by using N+Si treatment may be due to potassium assists in the processes which ensure carbon assimilation and the transport of photosynthates through the plant for increasing sugars, proteins and growth. Also, potasium is important for water regulation, intake and increase water use efficiency. Sufficient potassium help plants resist frost, drought and certain diseases. Tahir *et al.* (2006) reported that potassium has a significant role in improving plant water status and mitigating the toxic effects of Na. Furthermore the positive effect of Si + NP on increasing growth and yield of rice plants may be due to the Si effect on the reduction of transpiration and the increasing of water use efficiency in leaves, which in turn reduced the decline in photosynthesis and chlorophyll destruction in older leaves. The maintenance of photosyntetic activity was regarded as one of the main reasons for the dry weight increases observed as a result of Si application (Agarie *et al.,* 1992). Also silicon nutrition, however, enhanced plant growth parameters and led to the prevention of lignin and the Na^+ accumulation in shoots, reduced levels of lipid peroxidation in the roots and higher levels of chlorophyll. Parveen and Ashraf, (2010) showed that application of Si significantly increased the root dry mass of both maize cultivars under saline regimes.

First season **Second season**

Grain Yield

Grain yield (g/pot)



Fertilizer treatments Fertilizer treatments

Fig. 2: Effect of silicon application on grain yield (g/pot) of rice plant.

The used soil in this experiment was low in available P and this increases the effect of Si on growth of rice plants as recommended by Ma and Takahashi, (1991a) who stated that the beneficial effect of Si on growth of rice was clearly shown when P was low. In this concern silicate can increase the quantity of mobile phosphates in the soil (Singh and Sarkar 1992; O'Reilly and Sims 1995). This effect may have resulted from decreased Mn and Fe uptake, thus increasing P availability within P deficient plants. On the other hand; Ma and Takahashi, (1991a) stated that the beneficial effect of silicate on rice growth do not result from increasing P availability in soil. The Si effect may be attributed to decreasing Mn uptake which improve P utilization in the plant. Moreover, the highest grain yield obtained in this experiment by Si addition to the different fertilizer treatments may be due to the increase of the percentage of filled spikelets and 1000 grain weight and the reduction of grain discoloration and panicle damage. In this connection. The effect of Si addition on the growth and grain yield of rice plants are in a good agreement with those previously reported by Abou-Baker *et al*. (2011), Mosalem *et al.* (1992) and Zanouny *et al.* (1994). Furthermore, Hanfy Ahmed (2008) reported that the enhancement effect on shoot height of wheat plants supplied with Si might be induced through its role in both cell division and cell expansion by their effect on RNA and DNA synthesis.

Conclusion

Generally, Addition of Si has a positive effect on rice growth and yield. The highest values of plant height, dry matter of roots, shoots and grains by the different parts of rice plant were obtained when the NPK + Si treatment was used.

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