Annals of Plant and Soil Research 24(3):476-480 (2022)
https://doi.org/10.47815/apsr.2022.10195

Effect of foliar spray of potassium silicate on growth and yield of paddy (*Oryza sativa L.*)

K.A. SHAH, PRABHU NAYAKA AND A.N. LAD

Krishi Viygan Kendra, Navsari Agriculture University, Navsari-396450 Gujarat, India

Received: April, 2022; Revised accepted: May, 2022

ABSTRACT

A field experiment was conducted during the kharif seasons of 2015-18 on same site at NAU, Navsari, to study the effect of foliar spray of potassium silicate on growth, yield and economics of paddy (Oryza sativa). Seven treatments were tested in complete randomize design with four replication. The foliar spray of 1.0 % potassium silicate at tillering, panicle initiation and grain formation stage recorded significantly superior panicle length (24.0), panicle weight (5.86 g), number of grain panicle (154.4), weight of grain panicle^{-1} (5.09 g), grain (4713 kg ha^{-1}) and straw (6475 kg ha^{-1}) yield as well as gross and net return over control. The lowest value of growth, yield attributes, yield and net return were recorded under control. The remarkably lowest stem borer infestation (1.37%), lodging percentage (0.85%) and sheath mite infestation (2.40%) were also found under the foliar spray of 1.5 % potassium silicate at tillering, panicle initiation and grain formation stage over control.

Key words: Rice, yield, potassium silicate, foliar spray

INTRODUCTION

Rice (*Oriza sativa* L.) is the most important food crop of India. In last few years rice yield has been found diminishing and nutritional imbalance has been reported as one of major concern. In a more specific study of nutrients; the micronutrients now have been found equally important as macronutrients although they are required in a minute quantity. Balancing the micronutrients for rice cultivation enhanced the quality and yield (Ma *et al.*, 2007). Among all the micronutrients assimilated by plants, silicon alone is consistently present at concentrations. similar to those of the macronutrients. Micronutrients such as silicon (Si) are the most important for healthy and competitive growth of all cereals including rice in Asia (Brunings *et al.,* 2009). Silicon is the second most abundant element in the soil after oxygen. Though the solubility of silicate minerals vary under different soil and environmental conditions, Plants growing under natural conditions do not appear to suffer from Si deficiencies. However, Si-containing fertilizers are routinely applied to several crops for increasing the crop yield and quality. Although silicon has not been considered important for vegetative growth, but it aids the plant in healthy development under stresses in different grasses especially rice. Research evidences proved that adequate uptake of silicon (Si) can increase the tolerance of agronomic crops especially rice to both abiotic and biotic stress (Ma and Takahashi, 2002). Plant tissue analysis has revealed the optimum amount of silicon is necessary for cell development and differentiation (Liang *et al.,* 2005). Increased Si supply improves the structural integrity of crops and may also improve plant tolerance to diseases, drought and mineral toxicities Many scientists working on role of silicon in plant growth have concluded that reduced amount of silicon in plant develops necrosis, disturbance in leaf photosynthetic efficiency, growth retardation and reduce grain yield in cereals (Shashidhar *et al.,* 2008). Therefore, present study was designed to study the effect of foliar application of different concentrations of potassium silicate on rice yield under the south Gujarat conditions.

MATERIALS AND METHOD

The field experiment was conducted at Krishi Vigyan Kendra Farm, Navsari Agricultural University, Navsari (Gujarat) during *kharif* season of three consecutive years (2015-16, 2016-17 and 2017-18). The experimental site is located at 20. 94-76^{o} N latitude and 72. 95-20^{o} E longitudes with an altitude of 9 m mean sea level. The soil of the experiential plots was clay in texture having medium to poor drainage, alkaline in reaction (pH=7.86), available nitrogen

Email of the corresponding author: shahkinjal@nau.in and shahkinjal@yahoo.co.in

512 kg ha^{-1}, available phosphorus 49 kg ha^{-1} and available potassium 268 kg ha^{-1}. Total seven treatments consisting of T_1 : control, T_2 : 0.5 % potassium silicate at tillering and panicle initiation stage (PI), T_3 : 0.5 % potassium silicate at tillering, PI and grain formation stage, T_4 : 1.0% potassium silicate at tillering and PI, T_5 : 1.0% potassium silicate at tillering, PI and grain formation stage, T_6 :1.5 % potassium silicate at tillering and PI and T_7 : 1.5 % potassium silicate at tillering, PI and grain formation stage were tested in complete randomized design with four replication. Paddy variety "GNR-3" seeds were used for the raising the nursery. Twenty five days old seedlings were transplanted at a distance of 20 x 15 cm in puddle field in the third week of July during all the three years. The recommended dose of 10 t FYM ha^{-1} was applied at the time of land preparation and entire dose of phosphorus (30 kg P_2O_5 ha^{-1}) and 40 % dose of nitrogen (40 kg N ha^{-1}) applied as a basal application just before transplanting and remaining 40 kg N $ha^{-1}$and 20 kg N ha^{-1}dose of nitrogen were applied at tillering and panicle initiation stage, respectively. Foliar spray of silicon was applied through the potassium silicate as per the treatments. Urea and di ammonium phosphate were taken as fertilizer sources for N and P, respectively. All the plant protection measures were taken as per the recommendation in rice crop. The gross realization in terms of rupee per hectare was worked out on the basis of seed and straw yields for each treatment and the prices of the produce prevailing in the market. The net realization was worked out by subtracting the total cost of cultivation from gross realization. The results were analysis statistically to draw suitable interference as per the standard ANOVA techniques suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth and yield attributes

The data (Table 1) clearly indicated that there was no significant difference in growth parameters due to varying levels of foliar potassium silicate at different crop growth stages. The growth attributes *viz.* plan height (126.4 and 126.2 cm) and effective tillers/m^2 (184.5 and 185.8) were found maximum with the foliar spray of 1.0 and 1.5 % potassium silicate at tillering, panicle initiation (PI) and grain formation stage, respectively. However, there were 5.1 and 9.6 % increase in plant height and effective tillers/m^2 under the foliar application of 1.0 and 1.5 % potassium silicate at tillering, PI and grain formation stage over control, respectively. Similar results were reported by Ahmad *et al.* (2013).

Table 1: Effect of foliar spray of potassium silicate on growth and yields attributes of kharif rice (pooled data of three year)

Treatments	Plant height (cm)	Effective tillers/m^2	Panicle length (cm)	Panicle weight (g)	No. of grain / panicle	Wt. of grain/ panicle(g)
T_1	120.2	169.5	21.4	4.80	127.5	4.17
T_2	121.7	178.0	22.2	5.00	132.2	4.30
T_3	123.6	179.1	22.8	5.22	132.1	4.48
T_4	124.0	181.8	23.6	5.43	135.7	4.75
T_5	126.4	184.5	24.0	5.86	154.4	5.09
T_6	125.6	180.8	23.6	5.87	153.4	5.17
T_7	126.2	185.8	23.8	5.84	150.9	5.26
S. Em. ±	2.24	4.47	0.45	0.14	3.81	0.14
C. D. at 5%	NS	NS	1.28	0.40	10.77	0.39
C.V. %	6.26	8.60	6.81	9.07	9.37	9.98

T_1 : Control, T_2 : 0.5 % potassium silicate at tillering and PI stage, T_3 : 0.5 % potassium silicate at tillering, PI and grain formation stage, T_4 : 1.0 % potassium silicate at tillering and PI stage, T_5 : 1.0 % potassium silicate at tillering, PI and grain formation stage, T_6: 1.5 % potassium silicate at tillering and PI stage and T_7 : 1.5 % potassium silicate at tillering, PI and grain formation stage

Yield attributing characters *viz*, panicle length, panicle weight, number of grain $panicle^{-1}$ and weight of grain $panicle^{-1}$ were significantly influenced by different levels of potassium silicate foliar spray. Foliar spray of 1% potassium silicate at tillering, PI and grain formation stages recorded remarkably higher panicle length (24.0 cm) at harvest and number of grain $panicle^{-1}$

(154.4) over the control and 0.5% potassium silicate at tillering and PI stages. These finding are in accordance with Mobasser *et al*. (2008). Panicle length (5.87 cm) was found significantly higher under the foliar spray of 1.5 % potassium silicate at tillering and PI stage over rest of the treatments except, the foliar spray of 1.0 and 1.5 at tillering PI and grain formation stages, Significantly highest weight of grain panicle^{-1} (5.26 g) was noticed due to foliar spray of 1.5% potassium silicate at tillering, PI and grain formation stage over all other treatments, except treatment 1.0 % potassium silicate at tillering, PI and grain formation stage, and 1.5 % potassium silicate at tillering and PI. The increase in panicle length and panicle weight due to application of potassium silicate might be because of silicon helps in uptake the other essential nutrients elements which play an important role in plant metabolic activity. Similar types of results were observed by Prakash *et al.* (2011).

Yield

The variations in grain and straw yield (Table 2) were found to be significant due to foliar spray of potassium silicate and significantly higher grain yield (4713 kg ha^{-1}) was produced due to foliar spray of 1.0 % potassium silicate at tillering, PI and grain formation stage over control and it was remain at par with the foliar spray of 1.5% potassium silicate at tillering and PI stage as well as 1.5 % potassium silicate at tillering, PI and grain formation stages. The increase in grain yield may be attributed to the reduction in per cent spikelet sterility, increase the rate of photosynthesis, increased the number of tillers and helps in reduction of incidence of pest and disease. These results resemble to the findings reported by Mobasser *et al.* (2008), Malidareh *et al.* (2011) and Prakash *et al.* (2011). Foliar spray of 1.5 % potassium silicate at tillering, PI and grain formation stages recorded remarkably higher straw yield over rest of the treatments, except control and treatment T_2 (0.5% potassium silicate at tillering and PI stages). The improvement in straw yield of rice may be because of silicon is responsible to control stometal activity, photosynthesis and water use efficiency which ultimately results in better vegetative growth and straw yield. This is in conformation with the finding of Ahmad *et al.* (2007) and Surapornpiboom *et al.* (2008).

Table 2: Effect of foliar spray of potassium silicate on yield and economics of different treatments (Avg. of three year)

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	BCR
T_1	3992	5449	40700	76220	35520	1.87
T_2	4173	5805	41990	80011	38021	1.91
T_3	4286	6013	42635	82326	39691	1.93
T_4	4391	6152	42640	84315	41675	1.98
T_5	4713	6475	43610	90124	46514	2.07
T_6	4626	6454	43290	88751	45461	2.05
T_7	4667	6495	44585	89495	44910	2.01

Selling price: Rice grain : 15 Rs./kg Rice straw: 3 Rs./kg

Effect on pest incidence and lodging percentage

The remarkable difference in pest incidence, lodging percentage and sheath mite infestation were found due to application of different levels of potassium silicate at various stages (Table 3). Treatment T_7 (1.5% potassium silicate at tillering, PI and grain formation stage) was found to be significantly lower among all the treatments and recorded 1.37, 2.40 and 0.85 % stem borer infestation, sheath mite infestation and lodging percentage, respectively. The treatment T_6 (1.50 % potassium silicate at tillering and PI stage) was found to be next best treatment and found significantly superior over other treatments as well as control and recorded 3.35 % stem borer infestation, 1.68 % lodging and 3.23 % sheath mite infestation, which was at par with the treatment T_5 (1.0 % potassium silicate at tillering PI and grain formation stage) in case of only sheath mite infestation (3.57 %). These treatments T_7, T_6 and T_5 were found to be best treatments in combating the stem borer, sheath mite and lodging. The control plots noticed remarkable higher stem borer infestation

(10.59 %), sheath mite infestation (5.68%) and lodging percentage (5.97%) over other treatments. This might be due to foliar spray of potassium silicate helps in increases plant resistance by stimulating defense reaction mechanism(s) and decreasing damage from insects and pest due to the fortification of the plant by better uptake of mineral nutrients particularly major, macro and micro nutrients absorption to plants which helps to plant develop more resistance to pest infestation and lodging. It has been reported that silicon suppresses insect pest such as stem borers, brown plant hopper, white backed plant hopper, and non insect pests such as spider mites (Ma and Takahashi, 2002).

Table 3: Pest incidence and lodging percentage of kharif rice as influenced by foliar spray of silicon (Pooled data of three year)

Treatments	Sheath mite infestation (%)	Stem bore infestation (%)	Lodging percentage (%)
T_1	5.68 (13.77)	10.59(19.04)	5.97 (14.12)
T_2	4.93 (12.80)	8.87 (17.52)	3.00 (9.92)
T_3	4.50 (12.22)	7.13(15.46)	2.53(9.12)
T_4	4.03 (11.56)	6.38 (14.56)	2.77(9.49)
T_5	3.57(10.86)	5.00 (12.29)	2.43(8.94)
T_6	3.23(10.32)	3.35(10.15)	1.68(7.43)
T_7	2.40 (8.86)	1.37(5.99)	0.85 (5.23)
S.Em. ±	0.13 (0.11)	0.39 (0.42)	0.14 (0.17)
C. D. at 5%	0.37 (0.30)	1.10 (1.20)	0.40(0.48)
C.V. %	11.19 (6.64)	22.11 (11.67)	18.01 (6.86)

**Figures outside the parenthesis are original value, while parentheses are arcsine transformed value*

Economics

Among the different foliar application of potassium silicate, 1.5% potassium silicate at tillering, PI stages and grain formation stage recorded maximum total cost of cultivation (Rs. 44585 ha^{-1}). However, maximum gross income (Rs. 90124 ha^{-1}), net income (Rs. 46514 ha^{-1}) and B: C ratio (2.07) was incurred under the foliar spray of 1.0 % potassium silicate at tillering, PI and grain formation stage. The increase in income and cost benefit ration under the application of potassium silicate may be due to increase the grain and straw yield under the same treatment.

From the study it can be concluded that foliar application of 1.0 % potassium silicate at tillering, panicle initiation and grain formation stage recorded maximum yield, net income as well as benefit cost ratio. The practices may be recommended for enhancing the productivity of rice under South Gujarat region.

REFERENCES

Ahmad, A., Afzal, M., Ahaad, A. U. H. and Tahir, A. (2013) Effect of foliar application of silicon on yield and quality of rice (*Oryza sativa* L.) *Cercetari Agronomic in Moldova* **155** (3): 21-28.

Ahmad, F., Rahatullah, Aziz. T., Maqsood, M. A., Tahir, M. A. and Kanwal, S. (2007) Effect of silicon application on wheat (*Triticum asetivum* L.) growth under water deficiency stress. *Emirates Journal of Food Agriculture* **19** (2): 01-7.

Brunings, A. M., Datnoff, L. E., Ma, J. F., Mitani, N., Nagamura, Y., Rathinosabapathi, B. and Kirst M. (2009) Differential gene expression of rice in response to silicon and rise blast fungus *Magnaporthe oryzae*. *Annals of Applied Biology* **155**: 161-70.

Gomez, K.A. and Gomez A.A.(1984). Statistical Procedure for Agricultural Research. Jhon Wiely and Sons, New York, pp: 139-264.

Liang, Y.C., Sun, W.C., Si, J. and Romheld, V. (2005) Effect of foliar and root applied silicon on the enhancement of induced resistance to powdery mildew in *Cucumis sativus. Plant Pathology* **554**: 678-85.

Malidareh, A.G. (2011) Silicon application and nitrogen on yield and yield component in rice in two irrigation systems. *Academy of Science Engineering and Technology* **78**: 88-95.

Ma, J.F. and Takahashi, E. (2002) Soil fertilizer and plant silicon research in Japan. *Elsevier Science, Amsterdam.*

Ma, J.F., Tamai, K., Yamaji, N., Mitani, N., Konishi, S., Katsuhara, M., Fujiwara, T. and Yano, M. (2007) An efflux transporter of silicon in rice. *NATURE* 448: 5964.

Mobasser, H.R., Malidarh, G.A. and Sedghi, H. (2008) Effect of silicon application to nitrogen rate and splitting on agronomic characteristics of rice (*Oryza sativa* L.). Silicon in Agriculture: 4th International Conference 26-31 Oct., South Africa: **76**.

Prakash, N.B., Chandrashekar, N., Mahendra, C., Patil, S.U., Thippeshappa, G.N. and Laane, H. M. (2011) Effect of foliar spray of soluble silicic acid on growth and yield parameters of wetland rice in hilly and coastal zone soils of Karnataka. *Journal of Plant Nutrition* **34**: 1883-93.

Shashidhar, H.E., Chandrashekhar, N., Narayanaswamy, C., Mehendra, A.C. and Prakash, N.B. (2008) Calcium Silicate as silicon source and its interaction with nitrogen in aerobic rice. Silicon in Agriculture: 4th International Conference 26-31 Oct., South Africa, 93.

Surapornpiboom, P., Julsrigival, S., Senthong, C. and Karladee, D. (2008) Effect of silicon on upland rice under drought condition. *Journal of Natural Science* **7** (1): 163-71.