Response of Transplanted Paddy to Foliar Spray of Silicon in South Gujarat, India

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A B S T R A C T

A field experiment was conducted for three consecutive years at NAU, Navsari, during the year 2015-16, 2016-17 and 2017-18 to study the effect of foliar spray of potassium silicate on growth and yield of paddy. Seven treatment of potassium silicate as a foliar spray (T₁: control, T₂: 0.5% potassium silicate at tillering and PI, T₃: 0.5% potassium silicate at tillering, PI and grain formation stage, T₄: 1.0% potassium silicate at tillering, PI and grain formation stage, T₅: 1.0% potassium silicate at tillering, PI and grain formation stage, T₆: 1.5% potassium silicate at tillering and PI and grain formation stage) were tested in complete randomize design with four replication. The various growth and yield attributes viz., panicle length, panicle weight, number of grain per panicle and weight of grain per panicle, grain and straw yield, as well as gross return, net return and BC ratio were recorded significantly superior over control. under the foliar spray of potassium silicate @ 1.0 percent at tillering, panicle initiation and grain formation stage.

K e y w o r d s
Silicon, Rice, Grain yield, Potassium silicate

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 concerned. 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, however its concentrations in soil solutions range from 0.1 to 0.6 mM (Joseph, 2009). Its concentrations in different plants range from 0.1% (similar to P and S) to more than 10% of whole plant dry matter (Epstein, 1999). 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 in 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 (Epstein, 1999; Richmond and Sussman, 2003; Ma et al., 2004). 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). Foliar fertilization or foliar feeding entails the application of nutrients via spraying to plant leaves and stems and their absorption at those sites. Foliar fertilizers are usually applied along with agricultural pesticides to lower the cost of application. Although few studies have been confirm the benefits of the use of silicon as amendments through foliar applications. There is no user friendly commercial product of silicon for foliar applications and very limited information is available on yield parameters and uptake of nutrient elements, particularly in rice.

Under changing socio-economic conditions all around the world, reduction in paddy yield is not affordable by the agricultural system. Applications of major nutrients are already in practice at optimum level but yield gap is still present. Therefore, present study was designed to study the effect of foliar application of different concentrations of silicon on rice yield under the south Gujarat conditions. The main objective was to evaluate the effect of foliar application of silicon on yield of rice.

Materials and Methods

The Field experiment was conducted at Krishi Vigyan Kendra Farm, Navsari Agricultural University, Navsari for the south Gujarat region during kharif season of three consecutive year 2015-16, 2016-17 and 2017-18. The experimental site is located at 20. 94-76° N latitude and 72. 95-20° E longitudes with an altitude of 9 m mean sea level. The soil of the experimental plots was clay in texture having medium to poor drainage, alkaline in reaction (pH=7.86), low in available nitrogen (512 kg/ha) and medium in available phosphorus (49 kg/ha) and potash (268 kg/ha). Total seven treatments consisting of T1 : control, T2 : 0.5 % potassium silicate at tillering and panicle initiation stage (PI), T3 : 0.5 % potassium silicate at tillering, PI and grain formation stage, T4 : 1.0% potassium silicate at tillering and PI, T5 : 1.0% potassium silicate at tillering, PI and grain formation
stage, T6: 1.5 % potassium silicate at tillering and PI and T7: 1.5 % potassium silicate at tillering, PI and grain formation stage were tested in complete randomize design with four replication. Paddy variety “GNR-3” seeds were used for the raising the nursery. Twenty five days old seeding was transplanted at a distance of 20 x 15 cm in previously puddle field in the third week of July during all the three years.

The recommended dose of 10 t FYM/ha was applied at the time of land preparation and entire dose of phosphorus (30 kg P2O5/ha) and 40 per cent dose of nitrogen (40 kg N/ha) applied as a basal application just before transplanting and remaining 40 per cent (40 kg N/ha) and 20 per cent (20 kg N/ha) 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 die 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 annual rainfall of 1209, 1430 and 1318 mm were received throughout the crop growth period during the year 2015-16, 2016-17 and 2017-18, respectively. The results were analysis statistically to draw suitable interference as per the standard ANOVA techniques suggested by Gomez and Gomez (1984).

Results and Discussion

Effect on growth and yield attributes

The data show in Table-1 clearly indicated that there was none significant difference found in growth parameter due to varying levels of foliar application of potassium silicate at different crop growth stages. The growth attributes viz. plant height (cm) and effective tillers/m² were found numerically maximum with the foliar spray of 1.0 and 1.5 per cent potassium silicate at tillering, panicle initiation (PI) and grain formation stage, respectively. There were 5.15 and 9.65 per cent increase in plant height and effective tillers/m² under the foliar application of 1.0 and 1.5 per cent potassium silicate at tillering, PI and grain formation stage. Similar types of results were also reported by Singh and Singh (2005), Ahmad et al., (2013).

Yield attributing characters viz, panicle length, panicle weight, number of grain per panicle and weight of grain per panicle were significantly influenced by different levels of potassium silicate foliar spray. Foliar spray of potassium silicate @ 1.0 percent at tillering, PI and grain formation stages was recorded remarkably higher panicle length (24.03 cm) and number of grain per panicle (154.42) over the control and 0.5% potassium silicate at tillering and PI stages. These finding are in accordance with Rodriguez et al., (2003) and Mobasser et al., (2008).

Panicle weight (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 the highest weight of grain per panicle (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 T5 and T6.

The increase in panicle weight and grain weight per panicle 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).
Effects on yield

The variation in grain yield (Table-2) and straw yield (Table-3) were found to be significant due to foliar spray of potassium silicate in all the individual years and in pooled analysis. Significantly higher grain yield of 4819, 4706, 4615 and 4713 kg/ha were produced during the year 2015-16, 2016-17, 2017-18 and in pooled results, respectively, due to foliar spray of potassium silicate @ 1.0 per cent at tillering, PI and grain formation stage over control and it was remain at par with the foliar spray of potassium silicate at 1.5% at tillering and PI stand as well as potassium silicate @1.5 at tillering, PI and grain formation stages. The percentage increase in grain yield under the different foliar spray treatment up to the tune of 18.06, 15.88 and 16.91 per cent under the treatments T_5, T_6 and T_7 over control on pooled bases, respectively. The increase in grain yield may be attributed to the reduction in per cent spikelet sterility, increase the rate of photosynthesis and thereby increased the growth and yield attributes 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 potassium silicate @ 1.5 percent at tillering, PI and grain formation stages recorded remarkably higher straw yield of 6505, 6559, 6419 and 6495 kg/ha over rest of the treatments during the year 2015-16, 2016-17, 2017-18 and in pooled respectively, except control and treatment T_2 (0.5% potassium silicate at tillering and PI stages) in all the individual year and in pooled analysis.

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/m² | Panicle length (cm) | Panicle weight (g) | No. of grain/panicle | Wt. of grain/panicle (g) |
|------------------------------------------------|-------------------|-----------------------|---------------------|--------------------|----------------------|--------------------------|
| T_1: Control (No spray)                        | 120.22            | 169.51                | 21.49               | 4.80               | 127.50               | 4.17                     |
| T_2: 0.5 % potassium silicate at Tillering and PI stage | 121.71            | 178.06                | 22.21               | 5.00               | 132.25               | 4.30                     |
| T_3: 0.5 % potassium silicate at Tillering, PI and grain formation stage | 123.69            | 179.17                | 22.80               | 5.22               | 132.17               | 4.48                     |
| T_4: 1.0 % potassium silicate at Tillering and PI stage | 124.02            | 181.83                | 23.62               | 5.43               | 135.75               | 4.75                     |
| T_5: 1.0 % potassium silicate at Tillering, PI and grain formation stage | 126.42            | 184.55                | 24.03               | 5.86               | 154.42               | 5.09                     |
| T_6: 1.5 % potassium silicate at Tillering and PI stage | 125.63            | 180.82                | 23.60               | 5.87               | 153.42               | 5.17                     |
| T_7: 1.5 % potassium silicate at Tillering, PI and grain formation stage | 126.27            | 185.86                | 23.85               | 5.84               | 150.92               | 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                     |
| YxT                                          | NS                | NS                    | NS                  | NS                 | NS                   | NS                       |
### Table 2 Grain yield of kharif rice as influenced by foliar spray of potassium silicate

| Treatments                                      | Grain Yield (kg/ha) | 2015-16 | 2016-17 | 2017-18 | Pooled |
|------------------------------------------------|---------------------|---------|---------|---------|--------|
| T<sub>1</sub>: Control (No spray)               | 4034                | 4072    | 3868    | 3992    |        |
| T<sub>2</sub>: 0.5 % potassium silicate at Tillering and PI stage | 4259                | 4280    | 3981    | 4173    |        |
| T<sub>3</sub>: 0.5 % potassium silicate at Tillering, PI and grain formation stage | 4275                | 4396    | 4187    | 4286    |        |
| T<sub>4</sub>: 1.0 % potassium silicate at Tillering and PI stage | 4451                | 4429    | 4292    | 4391    |        |
| T<sub>5</sub>: 1.0 % potassium silicate at Tillering, PI and grain formation stage | 4819                | 4706    | 4615    | 4713    |        |
| T<sub>6</sub>: 1.5 % potassium silicate at Tillering and PI stage | 4683                | 4630    | 4565    | 4626    |        |
| T<sub>7</sub>: 1.5 % potassium silicate at Tillering, PI and grain formation stage | 4743                | 4683    | 4577    | 4667    |        |

S. Em. ± 150 137 166 87
C. D. at 5% 447 407 493 245
C.V. % 6.73 6.15 7.71 6.81
YxT NS NS NS NS

### Table 3 Straw yield of kharif rice as influenced by foliar spray of potassium silicate

| Treatments                                      | Straw Yield (kg/ha) | 2015-16 | 2016-17 | 2017-18 | Pooled |
|------------------------------------------------|---------------------|---------|---------|---------|--------|
| T<sub>1</sub>: Control (No spray)               | 5576                | 5611    | 5159    | 5449    |        |
| T<sub>2</sub>: 0.5 % potassium silicate at Tillering and PI stage | 5926                | 5949    | 5541    | 5805    |        |
| T<sub>3</sub>: 0.5 % potassium silicate at Tillering, PI and grain formation stage | 6102                | 6101    | 5826    | 6013    |        |
| T<sub>4</sub>: 1.0 % potassium silicate at Tillering and PI stage | 6229                | 6256    | 5970    | 6152    |        |
| T<sub>5</sub>: 1.0 % potassium silicate at Tillering, PI and grain formation stage | 6491                | 6491    | 6444    | 6475    |        |
| T<sub>6</sub>: 1.5 % potassium silicate at Tillering and PI stage | 6434                | 6511    | 6418    | 6454    |        |
| T<sub>7</sub>: 1.5 % potassium silicate at Tillering, PI and grain formation stage | 6505                | 6559    | 6419    | 6495    |        |

S. Em. ± 181 201 235 117
C. D. at 5% 537 596 698 329
C.V. % 5.85 6.46 7.87 6.60
YxT NS NS NS NS
Table 4 Effect of foliar spray of potassium silicate on economics of different treatments (av. of three year)

| Treatments | Grain yield (kg/ha) | Straw yield (kg/ha) | Total cost of cultivation (Rs./ha) | Gross income (Rs./ha) | Net income (Rs./ha) | BCR |
|------------|--------------------|--------------------|-----------------------------------|-----------------------|---------------------|-----|
| T1: Control | 3992               | 5449               | 40700                            | 76220                 | 35520               | 1.87|
| T2: 0.5 % potassium silicate at Tillering and PI stage | 4173               | 5805               | 41990                            | 80011                 | 38021               | 1.91|
| T3: 0.5 % potassium silicate at Tillering, PI and grain formation stage | 4286               | 6013               | 42635                            | 82326                 | 39691               | 1.93|
| T4: 1.0 % potassium silicate at Tillering and PI stage | 4391               | 6152               | 42640                            | 84315                 | 41675               | 1.98|
| T5: 1.0 % potassium silicate at Tillering, PI and grain formation stage | 4713               | 6475               | 43610                            | 90124                 | 46514               | 2.07|
| T6: 1.5 % potassium silicate at Tillering and PI stage | 4626               | 6454               | 43290                            | 88751                 | 45461               | 2.05|
| T7: 1.5 % potassium silicate at Tillering, PI and grain formation stage | 4667               | 6495               | 44585                            | 89495                 | 44910               | 2.01|

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

Straw yield of rice increase up to the tune of 18.83, 18.44 and 19.20 per cent under the treatment T5, T6 and T7, respectively. The improvement in straw yield of rice may be because of silicon is responsible to control stomatal activity, photosynthesis and water use efficiency which ultimately results in better vegetative growth and straw yield. This is in confirmation with the finding of Ahmad et al., (2007) and Surapornpiboom et al., (2008).

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) followed by treatment T5 (Rs. 43610/ha) and T6 (Rs. 43290/ha). However, maximum gross income (Rs. 90124/ha), net income (Rs. 46514/ha) and B: C ratio (2.07) was incurred under the foliar spray of potassium silicate 1.0 % at tillering, PI and grain formation stage, which was followed by treatments T5 and T7. The increase in income and cost benefit ratio under the application of potassium silicate may be due to increase the grain and straw yield under the same treatment.

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

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