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Effect of Silixol granules on growth and yield of Rice

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A B S T R A C T

Field experiment was conducted at Annamalai University Experimental Farm, Annamalai Nagar, Tamil Nadu, India during Kharif 2014 to study the effect of silixol granules on growth and yield of rice. The treatments comprised of 100 % recommended dose of fertilizers (T_1), T_1 + Calcium silicate @ 2 t ha^{-1} (T_2), T_1 + 120 kg Si ha^{-1} through Fly Ash (T_3), T_1 + silixol granules @12.5 kg ha^{-1}(T_4), T_1 + silixol granules @ 25.0 kg ha^{-1} (T_5) and T_1 + silixol granules @ 37.5 kg ha^{-1} (T_6). The experiment was laid out in randomized block design with three replications. Among the different treatment imposed, 100 % recommended dose of fertilizers + silixol granules @ 37.5 kg ha^{-1} recorded higher values for growth (plant height, number of tillers plant^{-1}, root length, root volume, leaf area index and dry matter production), yield attributing (number of panicles m^{-2}, number of grains panicle^{-1} and test weight) characters and yield (grain and straw) of rice, respectively. Thus, it is concluded that soil application of silixol granules along with 100 % recommended dose of fertilizers holds immense potentiality to boost the productivity and profitability of rice.

Introduction

Rice (*Oryza sativa (L.)*) is one of the most important stable food crops in the world. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. In India, rice is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 44.6 m.ha with a production of 132 m.t of rice with average productivity of 2.96 t ha^{-1} (Yogendra *et al.*, 2014).

Among the rice growing countries of the world, India has the largest rice acreage and ranked second in production (Anonymous, 2006). The burgeoning population of our country may stabilize around 1.4 and 1.6 billion by 2025 and 2050, requiring annually 380 and 450 m.t of food grains respectively (Siddiq, 2000 and Yadav *et al.*, 2009). In Tamil Nadu, It is cultivated in an area of 1.79 m ha with the production of 5.04 mt and a productivity of 2.82 t ha^{-1}

(Anonymous, 2010). Rice yields are either decelerating/stagnating/declining in post green revolution era mainly due to imbalance in fertilizer use, soil degradation, type of cropping system practiced, lack of suitable rice genotypes for low moisture adaptability and disease resistance (Prakash, 2010).

Silicon (Si) is the second most abundant element of the earth's surface and plays a significant role in imparting biotic, abiotic stress resistance and enhancing crop productivity (Savant *et al.*, 1997, Korndorfer and Lepsch, 2001 and Jawahar and Vaiyapuri, 2010,). It is also crucial in preventing or minimizing lodging in cereal crops, a matter of great importance in agricultural productivity. Silicon addition increased the erectness of the leaves of rice; it strengthens the air canal, leading to more efficient oxygen supply to roots and to the limited loss of water by evapotranspiration. Silica is a structural element in diatoms and a cell wall component in rice and other grasses, which also occurs in vegetative tissues in lesser amounts, silica in plants contributes to the compression resistance and rigidity of cell walls, which in turn improve light interception and drought resistance and photosynthetic efficiency (Epstein, 1999).

It plays an important role in root formation, the secondary and tertiary root formation is controlled by monosilicic acid in the soil solution. Chanchareonsook *et al*. (2002) reported that application of NPK fertilizer in combination with Si increased the total number of tillers in rice. Application of silicon at 120 kg ha^{-1} through flyash along with S at 45 kg /ha significantly increased the plant height, leaf number, leaf area index, dry matter production, panicles m^{-2}, filled grains $panicle^{-1}$, test weight, grain, straw yield and benefit cost ratio of rice (Jawahar and Vaiyapuri, 2010 and 2013).

Silicon is the only element known that does not damage plants with excess accumulation. It has been has been demonstrated to be necessary for healthy growth and stable production.. Rice is a high Si accumulator plant and absorbs high amount of silicon, an average of 150-300 Kg of Si per hectare (Yoshida, 1975). For this reason, Si has been recognized as an "agronomically essential element" in Japan and silicate fertilizers have since then been applied to paddy soils (Ma *et al.,* 2001). Although silicon is the second largest element present in the soil but due to its presence in the amorphous form, it is not available for plants. Plants absorb silicon from the soil solution in the form of monosilicic acid, also called orthosilicic acid [H_4SiO_4] (Lewin and Reimann, 1969). This molecule is highly unstable and readily becomes into non available form i.e. polymeric silicic acid or forms complex with other compounds to form metasilicates. Upper 20 cm of soil contains an average of 0.1 to 1.6 kg Si ha^{-1} as monomeric silicic acid. Unstable nature of this molecule is not in many products which are available in market. Generally, the silicon is supplied as calcium or potassium silicates as fertilizers. However, their formulation contains the silicon in the form, which is not readily absorbed by plants. Privi Life Sciences, India has stabilized the Ortho Silicic Acid (OSA) through a patented technology. Now they are commercializing the formulation with a brand name *"Silixol"*. Present study has been carried out to study the efficacy of Silixol Granules, based on same technology on growth, yield attributes and yield of rice.

Materials and Methods

Experimental Site and Soil

The experiment was performed on a wetland field of Annamalai University Experimental

Farm, (11^{o} 24' N and 79^{o} 44' E with an altitude of + 5.7 m. m.s.l.), Annamalai Nagar, Tamil Nadu, India during Kharif 2014.The soil of the experimental field is low in available N, medium in available P, high in available K and medium in available Si and the soil is clay loam in texture with the pH of 7.6.

Season, Crop and Variety

Season	Crop	Variety	Pot size (m x m)
Kharif, 2014	Rice	ADT - 43	5 x 4

Treatment Details

The treatments comprised of 100 % Recommended dose of fertilizers (RDF) (T_1), T_1 + Calcium silicate @ 2 t ha^{-1} (T2), T_1 + 120 kg Si ha^{-1} through Fly Ash (T_3), T_1 + Silixol Granules @12.5 kg ha^{-1}(T_4), T_1 + Silixol Granules @ 25.0 kg ha^{-1} (T_5) and T_1 + Silixol Granules @ 37.5 kg ha^{-1} (T_6). The experiment was laid out in randomized block design with three replications. The Silixol Granules were obtained from *Privi Life Sciences Pvt. Ltd., India*.

Measurements

Growth Attributes

Plant height

Plant height was measured from ground level to the tip of the top most leaf at harvesting stages from ten randomly selected plants and the average was worked out and expressed in cm.

Number of tillers $hill^{-1}$

The number of tillers $hill^{-1}$ was recorded at active tillering stage and expressed as number of tillers $hill^{-1}$.

Root length

The entire rice plant was uprooted at flowering stage and roots were washed. The root length was measured from the base of the plant to the root tip individually and expressed in cm.

Root volume

Root volume was found out by placing the roots into a measuring cylinder containing a known volume of water. By measuring the increase in the water column, root volume was assessed at flowering stage of the crop and expressed in cm^3 (cubic centimeter).

Leaf area index

Leaf area index (LAI) of rice at flowering was worked out without removing the leaves by using the following formula as proposed by Palaniswamy and Gomez (1974)

$$LAI = \frac{L \times W \times K \times \text{Number of leaves hill}^{-1}}{\text{Spacing (cm}^2\text{)}}$$

Where,

L = Maximum length of 3^{rd} leaf blade from the top (cm)

W = maximum width of the same leaf (cm)

K = Adjustment factor (0.75)

Chlorophyll content

The total chlorophyll content of leaves was determined by using 80% acetone extraction suggested by Arnon (1949).

Dry Matter Production

Ten plants per plot from the destructive row, at harvest, were removed in all the experiments. These samples were first air-dried and then oven dried at 70°C till a constant weight obtained and the weight was recorded. The mean dry weight was expressed in kg ha^{-1}.

Yield attributes and Yield

Number of panicles m^{-2}

A quadrat of 0.25 m^2 size was placed at four places in each net plot and the total number of panicles were counted and expressed as number of panicles m^{-2}

Number of filled grains panicle $^{-1}$

Grains drawn from the panicles of the labeled sample plants in each net plot area were differentiated in to filled grains and chaffy. The mean value for the number of grains panicles^{-1} was recorded.

Thousand grain weight

Thousand filled grains were counted from the bulk of grains drawn at random in each plot and weighed at 14 per cent moisture level and expressed in gram (Yoshida *et al.*, 1976).

Grain yield

The grain yield was recorded from the net plot area and expressed in kg ha^{-1} at 14 per cent moisture level.

Straw yield

The straw yield of rice was recorded from the net plot area after enough sun drying and expressed in kg ha^{-1}.

Statistical analysis

The experimental data were analyzed as per the procedure outlined by Gomez and Gomez (1994). The critical difference was worked out as five percent probability level for significant results.

Results and Discussion

Silixol Granules significantly influenced the growth and yield of rice. Application of Silixol Granules @ 37.5 kg ha^{-1} along with 100 % recommended dose of fertilizers recorded higher values for plant height, number of tillers hill^{-1}, root length, root volume, LAI, chlorophyll content and DMP of rice. This was followed by Silixol Granules @ 25.0 kg ha^{-1} along with 100 % recommended dose of fertilizers which was on par with Silixol Granules @ 12.5 kg ha^{-1} along with 100 % recommended dose of fertilizers (Table 1). The beneficial effect of Silixol Granules in all cases seemed to be the results of low initial status of silicon in soil and silixol granules @ 37.5 kg ha^{-1} along with 100 % recommended dose of fertilizers to rice crop could be more advantageous for profuse root and shoot growth which enhanced the absorption of NPK and Si from the soil and may improved metabolic activity in the plant system.

Further, increase in plant height might owe to increased cell division, elongation and expansion caused by silicon. This was in agreement with the findings of Yavarzadeh.*et al.* (2008) who reported that increase in plant height could be due to deposition of silica on the plant tissues causing erectness of leaves and stem. Tillering is the production of expanding auxiliary bud which is clearly associated with nutritional condition of the mother clump because tillers receive carbohydrate and nutrients from the mother clump during early growth period and this was improved by silicon application (Liang *et al.*, 1994). The highest LAI and chlorophyll content of rice at flowering stage was due to erectness of leaves and synthesis of chloroplast resulted in higher concentration of chlorophyll per unit area of leaf tissue. This was in agreement with the findings of Adatia and Besford (1986). The maximum DMP under Silixol Granules @ 37.5 kg ha^{-1} along with 100 % recommended dose of fertilizers could be due to the maintenance of high photosynthetic activity and efficient utilization of light and translocation of assimilated products to sink (Rani *et al.*, 1997). Larger leaf area and high chlorophyll content might have accumulated more photosynthates and produce higher biological yield (DMP). This is in conformity with the reports of Jawahar and Vaiyapuri (2010). In addition, Si improves high interception of light by keeping leaves erect there by stimulating canopy photosynthesis in rice. Similar reports were earlier outlined by Singh *et al.*, (2005).

The same treatment Silixol Granules @ 37.5 kg ha^{-1} along with 100 % recommended dose of fertilizers) registered its superiority over others and recorded higher number of panicles m^{-2}, no. of filled grains $panicle^{-1}$, test weight and grain and straw yield of rice (Table 2). It might be due to readily available form and sustained supply of silicon in the form of ortho silicic acid to the crop and its synergistic effect with other nutrients which ultimately lead to better photosynthetic activity by the crop and resulted in higher yield attributes and yield. In addition, panicle formation is directly related with the number of productive tillers, which resulted in higher number of panicles per unit area. Increased filled grain number was due to better assimilation of carbohydrate in panicles. Higher test weight was attributed to better availability and translocation of nutrients as well as photosynthates from source to sink. The adequate silicon supply might have improved the photosynthetic activity enabled the rice plant to accumulate sufficient photosynthates, which resulted in increased dry matter production. These factors coupled with efficient translocation of photosynthates resulted in more number of filled grains and increased test weight which ultimately led to higher grain and straw yield. This is in agreement with the findings of Rani and Narayanan (1994) and Jawahar and Vaiyapuri (2010, 2011 and 2013). In the light of above said facts, it can be concluded that the conjoint application of Silixol Granules @ 37.5 kg ha^{-1} along with 100 % recommended dose of fertilizers holds immense potentiality to boost the productivity and profitability of rice.

Table.1 Effect of Silixol Granules on growth attributes of rice

Treatments	Plant height at harvest (cm)	No. of tillers $hill^{-1}$	Root length (cm)	Root volume (cc)	LAI	Chlorophyll content (mg/g)	DMP at harvest (Kg ha^{-1})
T1	47.85	6.29	16.65	17.02	5.19	3.13	9930
T2	50.81	7.74	19.02	19.95	5.47	3.75	10790
T3	52.04	8.09	19.43	20.78	5.58	3.91	11130
T4	54.55	9.36	20.92	22.93	5.95	4.22	11580
T5	55.95	9.95	21.86	23.84	6.09	4.39	11970
T6	58.03	11.38	23.57	25.12	6.31	4.68	12530
CD(P=0.05)	1.89	1.21	0.98	1.16	0.18	0.25	410

Table.2 Effect of Silixol Granules on yield attributes and yields of rice

Treatments	No. of panicles (per sq m)	No. of filled grains/panicle	1000 grain weight(g)	Yield (Kg ha^{-1})		
				Grain	% increase over RDF	Straw
T1	455.08	68.67	15.45	4290	-	6820
T2	489.15	71.53	15.48	4865	13.40	7680
T3	497.03	72.05	15.49	4995	16.43	7845
T4	546.40	73.88	1551	5375	25.29	8350
T5	554.66	75.05	15.52	5470	27.51	8480
T6	580.02	76.68	15.60	5690	32.63	8785
CD(P=0.05)	18.72	1.55	NS	159	-	284

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