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Effect of silicon sources on silicon uptake and blast incidence in low land rice

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Abstract
Field experiments were conducted during Navarai (January to April 2017) and Samba (September 2017-January 2018) seasons at Annamalai University Experimental Farm, Annamalai Nagar, Tamilnadu, India to study the effect of silicon sources on blast incidence in low land rice. The treatments comprised of 100 % Recommended Dose of Fertilizers (RDF) (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 @ 25 kg ha^{-1}(T_4), T_1 + Silixol granules @ 50 kg ha^{-1} (T_5), T_1 + Foliar application of Silixol plus @ 500 ml ha^{-1} on 20, 40 and 60 DAT (T_6), 75 % Recommended Dose of Fertilizers (RDF) (T_7), T_7 + Calcium silicate @ 2 t ha^{-1} (T_8), T_7 + 120 kg Si ha^{-1} through Fly ash (T_9), T_7 + Silixol granules @ 25 kg ha^{-1} (T_{10}), T_7 + Silixol granules @ 50 kg ha^{-1} (T_{11}), T_7 + Foliar application of Silixol plus @ 500 ml ha^{-1} on 20, 40 and 60 DAT (T_{12}). The experiments were laid out in randomized block design with three replications. Among the treatments tried, T_5 (100% RDF + Silixol granules @ 50 kg ha^{-1}) considerably reduced the blast incidence (0.40, 1.44 and 0.36, 1.15) in rice at tillering and flowering stages in both seasons. While, T_7 (75 % RDF alone) had least defense on rice leaf blast which recorded higher per cent incidence in both seasons. Thus it can be concluded that soil application of silixol granules @ 50 kg ha^{-1} along with 100% NPK and recommended plant protection measures holds immense potentiality to reduce the blast incidence at tillering and flowering stages in low land rice.

Keywords: Silicon sources, leaf blast, incidence, leaf damage, low land rice

Introduction
Rice is one of the world's most important crops and a primary source of food for more than half of the world's human population. More than 90% of the world's rice is grown and consumed in Asia. Rice is widely cultivated in China followed by India, Indonesia, Bangladesh, Vietnam, Thailand, and Myanmar. The crop occupies about 165.2 mha worldwide, with an annual production of 740.9 mt and a productivity of 4485.87 kg ha^{-1} (Yashaswini *et al.*, 2017) [21]. Rice is a rich source of protein, carbohydrate, dietary fiber, minerals and vitamins. It is one of the important food security crops of India and provides 43 per cent of calorie requirement for more than 70.0 per cent of the Indian population of the world. In India, rice is cultivated in almost all part of the country in an area of 43.39 mha with a production of 104.32 mt having average productivity of 2.40 t ha^{-1}. In India, the productivity of rice is less than those in agriculturally advanced countries. This is attributed to the poor agronomic practices and partially due to biotic and abiotic stresses. Rice crop is frequently affected by about 50 diseases which include 6 bacterial, 21 fungal, 4 nematodes, 12 viral and 7 other diseases and disorders (Hollier *et al.*, 1993) [5] However, major diseases are rice blast, brown spot, bacterial leaf blight, sheath blight, sheath rot, Bakanae, stem rot, tungro, false smut and post-harvest diseases (Sharma and Bambawale, 2008) [18].

Rice blast is among the most significant diseases affecting rice cultivation, since it is prevalent in most rice growing regions and causes serious yield losses. The disease is widely distributed in 85 countries (Gilbert *et al.*, 2004) [3] and under favorable environmental conditions it can be very disastrous. This disease generally causes yield loss of 10-20 per cent but in severe cases yield loss may reach up to 80 per cent (Koutroubas *et al.*, 2009) [9]. Applying fungicide to control the disease is neither economical nor environmentally friendly. Furthermore, rice blast spreads very fast and the use of resistant varieties is considered as a short term remedy. Hence there is a need to induce plant resistance by alternate methods to reduce blast incidence. One of the strategies is enrichment of silicon in rice shoot.

Silicon is the second element which is found in abundance in the earth's crust and is a main component of plant tissues as well as cell walls, despite the fact that it is not considered as an essential nutrient for terrestrial plants (Epstein, 1999) [2]. Silicon is also considered as an Environmentally-friendly element in relation to soils, fertilizers and plant nutrition.

Rice is known as a Si-accumulator and accumulation of Si in leaves and tissues in addition to conferring resistance against fungal diseases and insect pests, can improve erectness of leaves, increase yield and alleviate water stress, salinity stress and nutrient deficiency or toxicity stresses (Ma and Takahashi, 2002) [10]. Silicon is accumulated at levels equal to or greater than essential nutrients in plant species belonging to the families Poaceae and Cyperaceae. In rice, for example, Si accumulation is about 108% greater than that of nitrogen. It is estimated that a rice crop producing a total grain yield of 5000 kg/ha will remove Si at 230 to 470 kg/ha from the soil (Savant *et al.*,1997) [16]. Supply of soluble silicon in plants provides stronger, tougher cell walls which serve as a mechanical barrier against sucking and piercing insects (Jawahar *et al.*, 2015) [6]. Also silicon can be deposited by the plants at the infection site thus inhibiting the penetration of cell walls by the attacking fungus. Low silicon uptake has been proved to increase the susceptibility of rice to diseases such as rice blast, leaf blight of rice, brown spot, stem rot and grain discoloration (Massey and Hartley, 2006) [13]. This element can be absorbed from soil in significant amount and it is taken up by plants in the form of mono silicic acid or ortho silicic acid. This plant available form of silicon is not available in many of the traditional fertilizers. As far as ortho silicic acid formulations concerns, a few researches have been conducted on rice in particular on rice diseases. Therefore, field experiments were conducted to study the blast incidence due to ortho silicic acid formulations in low land rice along with traditional silicon sources.

Materials and Methods

Field experiments were conducted at Field No A4 of wet land (January – April 2017) and 11 D (September 2017 – January 2018) of the garden land, Department of Agronomy, Faculty of Agriculture, Annamalai university, Annamalai nagar, Tamil Nadu, India to study the effect of silicon sources on blast incidence in low land rice. The treatments consisted of 100% NPK (T_1), T_1 + soil application of calcium silicate at 2 t ha^{-1} (T_2), T_1 + soil application of silicon at 120 kg ha^{-1} through Fly ash (T_3), T_1 + soil application of 25 kg silixol granules ha^{-1}(T_4), T_1 + soil application of 50 kg Silixol granules ha^{-1} (T_5), T_1 + foliar spray of Silixol plus @ 1ml lit^{-1} on 20,40 and 60 days after transplanting (T_6), 75 % NPK (T_7), T_7 + soil application of calcium silicate at 2 t ha^{-1} (T_8), T_7 + soil application of silicon at 120 kg ha^{-1} through Fly ash (T_9), T_7 + soil application of 25 kg silixol granules ha^{-1} (T_{10}), T_7 + soil application of 50 kg Silixol granules ha^{-1} (T_{11}), T_7 + foliar spray of Silixol plus @ 1ml lit^{-1} on 20,40 and 60 days after transplanting (T_{12}). The experiments were laid out by adopting randomized block design and replicated thrice. The rice cultivar chosen for study is ADT 43 (Short duration) and ADT49 (Medium duration) respectively for both the seasons. The rice crop was fertilized with 120:40:40 kg of N, P_2O_5 and K_2O ha^{-1} in Navarai and 150:50:50 kg of N, P_2O_5 and K_2O ha^{-1} during Samba in the form of Urea (46 %), DAP (18% N and 46 % P_2O_5) and Muriate of Potash (60 % K_2O). The entire dose of P_2O_5 and 25% of N & K was applied as basal and remaining N and K was applied in three equal splits at active tillering, panicle primordial initiation and heading stages. Silixol granules and silixol plus sample investigated in this study were obtained as gift sample from Privi Life Sciences Pvt. Ltd., Navi Mumbai. It contains 1 and 2.05 % ortho silicic acid respectively. Inorganic fertilizers and silicon sources were applied as per the treatments. Recommended plant protection measures were carried out for controlling rice blast. The infected leaves and total leaves from 10 randomly selected hills were observed in each plot. The per cent incidence was calculated as follows and the individual leaf damage was calculated using a mobile application called Bio leaf (Machado and Rodrigues, 2016) [11].

Results and Discussion

Silicon sources favourably influence the uptake of silicon in rice and the higher silicon content was associated with application of silicon through silixol granules due to the supply of ortho silicic acid (Fig.1). This might be due to increase in root growth and enhanced soil silicon availability with silicon application. These findings are in agreement with the reports of Kalyan Singh *et al.* (2006) [8] and Hellal *et al*. (2012) [4]. Silicon fertilizers are silicon rich inorganic substances that increase the content of plant available silicon compounds (Monosilicic acid) in the soil. Under submerged conditions, monosilicic acid concentration was increase in the soil solution due to application of silicate fertilizer and it leads to such a concentration of mono silic acid in the soil solution to synthesise of poly silicic acids. Thus plant could uptake more silicon and this was in harmony with the findings of Malav *et al*. (2018) [12]. In addition Meunier *et al.* (2008) [14] reported that rice can remove more silicon than essential nutrients. Increase in silicon uptake at all stages is mainly due to consistent availability of sufficient quantity of plant available silicon in soil (Jawahar and Vaiyapuri, 2010) [7].

On perusal of the data furnished in the table 1and 2 indicated that the application of different sources of silicon along with graded levels of NPK significantly reduced the blast incidence of rice at tillering and flowering during navarai and samba seasons. Among the treatments, T_5 (100% RDF + Silixol granules @ 50 kg ha^{-1}) considerably reduced the blast incidence (0.40, 1.44 and 0.36, 1.15) in rice at tillering and flowering stages in both seasons while T_7 (75 % RDF alone) had the least defense on blast which recorded higher per cent incidence in both seasons. The per cent incidence of blast ranged from 0.41 to 8.95, 1.44 to 12.20 and 0.36 to 9.95, 1.15 to 11.06 at tillering and flowering stages in both seasons. Among the treatments, T_5 (100% RDF + Silixol granules @ 50 kg ha^{-1}) recorded least % damage $leaf^{-1}$ of 0.91, 1.75 and 0.65, 1.02 over 100% RDF at tillerring and flowering stages in both seasons. Soil application of silicon performed well at different levels of NPK over foliar spray of silicon at all the stages in both seasons. With reference to silicon sources at different levels of NPK, silixol granules did cause lesser damage over fly ash and calcium silicate. However when silicon was combined with NPK, it was noticed that T_5 was comparable with T_{11}.

The maximum resistance against blast may be due to the capacity of the silicic acid to form into a hard glass like coating of polymerized SiO_2 on the epidermal surfaces may physically block penetration by fungi (Winslow *et al.*, 1997). These findings are in harmony with the results of Aroubandi (2017) [20] who reported that a layer of silica approximately 2.5 μm thick beneath the cuticle of rice leaves impede the *Magnoporthea grisea* penetration and consequently decreases the number of blast lesions on the leaf blades (Rodrigues *et al*., 2001) [15]. In addition silicon produces a phenolic compound which acts as a barrier for pest and diseases. These results are in consonance with the findings of Seebold *et al.* (2000) [17] and Wattanapayapkul *et al*. (2011) [19]. Hence it can be concluded that conjoint application of 100% NPK + Silixol granules@50 kg ha^{-1} along with recommended fungicides is a viable practice to reduce the rice blast incidence in low land rice. The future research priorities are given to study the effect of ortho silicic acid formulations with graded levels fungicides on rice diseases.

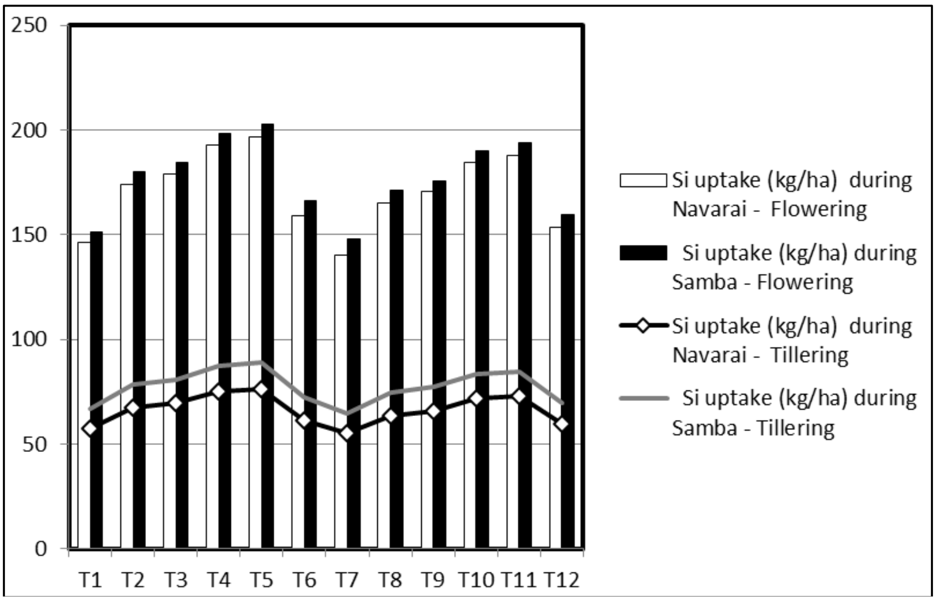

Fig 1: Effect of silicon sources on silicon uptake (kg ha^{-1}) of rice at Tillering and Flowering stages during Navarai and Samba Season

Table 1: Effect of silicon sources on blast incidence (%) in rice at tillering and flowering during Navarai season

Treatments	Tillering		Flowering	
	% incidence	% damage $leaf^{-1}$	% incidence	% damage $leaf^{-1}$
T_1 - 100 % Recommended Dose of Fertilizers (RDF)	8.22	5.85	9.16	6.22
T_2 - T_1 + Calcium silicate @ 2t ha^{-1}	3.43	3.32	3.82	4.01
T_3 - T_1 + 120 kg Si ha^{-1} through Fly ash	2.15	2.98	3.22	3.64
T_4 - T_1 + Silixol granules @ 25 kg ha^{-1}	0.55	1.20	1.74	2.06
T_5 - T_1 + Silixol granules @ 50 kg ha^{-1}	0.41	0.91	1.44	1.75
T_6 - T_1 + Foliar application of Silixol plus @ 500 ml ha^{-1} on 20,40 and 60 DAT	5.88	4.36	6.00	5.32
T_7 - 75 % Recommended Dose of Fertilizers (RDF)	8.95	6.18	12.20	7.26
T_8 - T_7 + Calcium silicate @ 2t ha^{-1}	5.03	3.72	5.50	5.01
T_9 - T_7 + 120 kg Si ha^{-1} through Fly ash	3.93	3.64	4.47	4.57
T_{10}- T_7 + Silixol granules @ 25 kg ha^{-1}	1.66	2.71	2.64	3.21
T_{11}- T_7 + Silixol granules @ 50 kg ha^{-1}	1.07	2.65	2.24	2.75
T_{12}- T_7 + Foliar application Silixol plus @ 500ml ha^{-1} on 20,40 and 60 DAT.	7.56	5.21	8.37	5.78
SEd	0.13	0.14	0.20	0.15
CD (P= 0.05)	0.27	0.31	0.42	0.33

Table 2: Effect of silicon sources on blast incidence (%) in rice at tillering and flowering during samba season

Treatments	Tillering		Flowering	
	% incidence	% damage $leaf^{-1}$	% incidence	% damage $leaf^{-1}$
T_1 - 100 % Recommended Dose of Fertilizers (RDF)	9.62	5.61	10.42	7.85
T_2 - T_1 + Calcium silicate @ 2t ha^{-1}	3.97	2.92	4.53	3.95
T_3 - T_1 + 120 kg Si ha^{-1} through Fly ash	2.81	2.64	3.42	3.40
T_4 - T_1 + Silixol granules @ 25 kg ha^{-1}	0.60	1.03	1.74	1.86
T_5 - T_1 + Silixol granules @ 50 kg ha^{-1}	0.36	0.65	1.15	1.02
T_6 - T_1 + Foliar application of Silixol plus @ 500 ml ha^{-1} on 20,40 and 60 DAT	7.99	4.79	6.76	6.71
T_7 - 75 % Recommended Dose of Fertilizers (RDF)	9.95	5.70	11.06	8.56
T_8 - T_7 + Calcium silicate @ 2t ha^{-1}	6.30	3.62	5.63	5.35
T_9 - T_7 + 120 kg Si ha^{-1} through Fly ash	5.53	3.41	4.69	4.01
T_{10}- T_7 + Silixol granules @ 25 kg ha^{-1}	1.73	2.05	2.48	2.51
T_{11}- T_7 + Silixol granules @ 50 kg ha^{-1}	1.11	1.77	2.10	2.25
T_{12}- T_7 + Foliar application Silixol plus @ 500ml ha^{-1} on 20,40 and 60 DAT.	8.32	4.68	10.05	7.02
SEd	0.12	0.18	0.28	0.40
CD (P= 0.05)	0.25	0.38	0.59	0.85

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