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Effect of Ortho silicic acid formulation (Silixol granules) on milling and cooking quality of Rice

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Abstract
An experiment was conducted at Department of Agronomy, Annamalai University, Annamalai Nagar, Tamil Nadu during June to September, 2014 to study the effect of ortho silicic acid formulation (silixol granules) on milling and cooking quality of rice. The experiment consisted of six treatments *viz.*, 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 @ 12.5 kg ha^{-1} (T_4), T_1 + Silixol granules @ 25 kg ha^{-1} (T_5), T_1 + Silixol granules @ 37.5 kg ha^{-1} (T_6). The experiment was laid out in randomized block design with four replications. The results of the experiment revealed that application of Silixol granules @ 37.5 kg ha^{-1} along with RDF recorded higher values for milling and head rice recovery of raw rice. The same treatment registered maximum length and breadth ratio and amylose content in cooked rice over others. This was closely followed by T_5 and was on par with T_4. Among the traditional sources of silicon, Calcium silicate performed well than Fly Ash. The least milling and cooking quality of rice was observed under recommended dose of fertilizers. Therefore, this study shows that enrichment of silicon in paddy grains through silixol granules enhanced the milling and cooking quality of rice.

Keywords: Silixol granules, rice, milling, cooking quality

Introduction
Agricultural commodities produced on the farm fields have to undergo a series of operations such as harvesting, threshing, winnowing, bagging, transportation, storage, processing and exchange before they reach the consumer, and there are appreciable losses in crop output at all these stages. A recent estimate by the Ministry of Food and Civil Supplies, Government of India, puts the total preventable post-harvest losses of food grains at 10 per cent of the total production or about 20 Mt, which is equivalent to the total food grains produced in Australia annually. Rice 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 43.39 mha with a production of 104.32 mt with average productivity of 2.40 t ha^{-1}. In the recent years, with the growth of population, more pressure on the arable land has been made and this in turn, the need for higher productivity of crops was felt in the country. At the same time, large quantity of food grain was reported to be lost due to inefficient milling processes in the country (Komol Singha, 2013) [5]. It has been reported that about 9 per cent of paddy is lost due to use of old and outdated methods of drying and milling.

Milling is a crucial step in post-production of rice. The basic objective of a rice milling system is to remove the husk and the bran layers, and produce an edible, white rice kernel that is sufficiently milled and free of impurities. Depending on the requirements of the customer, the rice should have a minimum number of broken kernels. Hence it is imperative to minimize the loss of rice kernels during processing to enhance the yield of milled rice, improve its quality and market value. These unavoidable milling losses can be reduced by enrichments of silicon in rice.

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 (Aroubandi, 2017) [1, 2]. It is also crucial in preventing or minimizing lodging in cereal crops, a matter of great importance in agricultural productivity. Silicon is the only element known that does not damage plants with excess accumulation. In recent years Si has been regarded as a quasi essential element and increases crop production and enhance soil fertility. It is required for the development of strong leaves, stems and roots. The formation of a thick silicate epidermal cell layer reduces the susceptibility of rice to insect pests (Subramanian and Gopalswamy (1991) [7].

Si offers resistance against rice blast due to the capacity of the silicic acid to form a hard glass like coating of polymerized SiO_2 on the epidermal surfaces which physically block the penetration by fungi (Winslow *et al.*, 1997) [8]. Generally silicon is absorbed by the plants as ortho silicic acid (OSA) also called mono silicic acid from the soil solution for its normal growth and development (Lewin and Reimann, 1969) [6]. As far as OSA is concerned a very few works has been done on quality of rice and especially nil with ortho silicic acid formulation. Therefore the present investigation was programmed to study the effect of ortho silicic acid formulation (silixol granules) on milling and cooking quality of rice.

Materials and Methods

The field experiment was conducted at the field No C2 of the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu (India) during Kharif 2014 (June to September) to study the effect of silicon on milling and cooking quality of rice. The experimental farm is located at 11°24'N latitude and 79°44' E longitude at an altitude of + 5.79 m above mean sea level in the southern part of India. The soil of the experimental farm is deep clay, low in available N and medium in available P_2O_5, high in available K_2O and medium in available Si. The treatments consisted of 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 @ 12.5 kg ha^{-1}(T_4),T_1+ Silixol granules @ 25 kg ha^{-1}(T_5), T_1+ Silixol granules @ 37.5 kg ha^{-1}(T_6). The experiment was laid out in randomized block design with four replications. The paddy variety ADT 43 was chosen for this study. The rice crop was fertilized with 120:38:38 kg of N, P_2O_5 and K_2O ha^{-1} in the form of urea (46% N), DAP (18% N and 46% P_2O_5) and muriate of potash (60% K_2O). The entire dose of P_2O_5, K_2O and half of the dose of N was applied as basal. The remaining half of N top dressed in two equal splits at active tillering and panicle primordial initiation stage. The amount of applied K was adjusted according to the nutrients content of fly ash. Half of the dose of Silixol Granule was applied as basal. The remaining half was top dressed in two equal splits at active tillering and panicle primordial initiation stage. The experimental crop was harvested plot wise leaving the border rows to avoid border effect. Grains were separated by hand threshing, cleaned and sun dried to bring the moisture content to14 per cent. The cleaned grains were used for milling and cooking quality analysis. The parameters of milling process were calculated by using the following equations

$$\text{Milling Recovery (\%)} = \frac{\text{Weight of milled rice (g)}}{\text{Weight of sample paddy (g)}} \times 100$$

$$\text{Head Rice Recovery (\%)} = \frac{\text{Weight of milled head rice (g)}}{\text{Weight of milled rice (g)}} \times 100$$

The elongation ratio of cooked rice was worked out by using procedure as suggested by Juliano and Perez (1984) [4] and the amylose content was estimated as per the procedure of Gomez (1979) [3].

Results and Discussion

Silicon sources favourably influenced the milling and cooking quality of rice. Among the different sources, Silixol Granules registered its superiority over traditional sources viz., Calcium silicate and Fly ash (Table 1). Among the treatments tested, the higher milling recovery of 69.49 per cent was recorded in the treatment T_6 (100 % RDF + Silixol Granules @ 37.5 kg ha^{-1}). The same treatment registered higher head rice recovery (63.07 %) of raw rice, which was 14.63 %, increased over 100% RDF. This treatment was closely followed by T_5 and was on par with T_4**.** The maximum milling and head rice recovery with T_1 + Silixol Granules @ 37.5 kg ha^{-1} could be due to higher accumulation silicon on the seed coat may favoured easy removal of husk and reduced the breakage of white rice during milling process. These results are agreement with findings of Zhang *et al.* (2007) [9] who reported that application silicon increased the milling and eating qualities of rice. The minimum values for milling and head rice recovery was observed under 100 % recommended dose of fertilizers (T_1).

The cooking qualities viz., Length and breadth ratio and amylose content of raw rice were greatly improved by silicon application (Table 1). Among the various treatments tried, application of 100 % RDF + Silixol Granules @ 37.5 kg ha^{-1} (T_6) recorded higher values of L/B ratio (2.92) in cooked rice. The higher amylose content of 18.83 per cent in cooked rice was also noticed under T_6, which were 58.37 % increased over control. This was followed by treatments T_5 and T_4 and was at par with each other. Higher water intake by raw rice may be the reason for better L/B ratio of cooked rice. A greater value on amylose content due to silicon is unknown. The lesser values for cooking qualities were recorded fewer than 100% RDF. This study shows that application of 100 % RDF + Silixol Granules @ 37.5 kg ha^{-1} enhanced the milling and head rice recovery of raw rice and L/B ratio and amylose content in cooked rice. Further researches are needed on milling and cooking qualities of rice due to silicon application.

Table 1: Effect of Silixol Granules on milling and cooking quality of raw rice

Treatments	Milling qualities		Cooking qualities							
			L/B ratio							
	Milling recovery (%)	Head rice recovery (%)	Un cooked rice			Cooked rice			Amylose Content (%)	% increase over RDF
			L (mm)	B (mm)	L/B ratio	L (mm)	W (mm)	L/B ratio		
T_1	67.70	55.02	5.5	2.0	2.75	6.15	2.24	2.75	11.89	-
T_2	68.44	58.94	5.5	2.0	2.75	6.36	2.30	2.77	14.90	25.32
T_3	68.52	59.98	5.5	2.0	2.75	6.42	2.31	2.78	15.58	31.03
T_4	68.87	61.26	5.5	2.0	2.75	6.63	2.34	2.83	17.15	44.24
T_5	69.05	61.64	5.5	2.0	2.75	6.76	2.36	2.86	17.64	48.36
T_6	69.49	63.07	5.5	2.0	2.75	7.30	2.50	2.92	18.83	58.37
S.Ed	0.11	0.60	-	-	-	0.09	0.06	0.02	0.47	-
CD (P=0.05)	0.22	1.20	NS	NS	NS	0.18	0.12	0.04	0.94	-

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