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Effect of Silicon and Nitrogen Nutrition on Pest and Disease Intensity in Rice

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Abstract: Nutrition management is the most important for high yield production but it may affect the response of rice plants to pest and diseases due to the change of microclimate under rice plant canopy. The knowledge of nutrition management and its relation with pest and diseases are basis for setting up a high yield production system. Most of the pest and disease control procedures used by farmers can be considered as soil fertility management and these nutrition practices can have impact on the physiological susceptibility of crop plants to pest and diseases by affecting the plant resistance. Silicon content of plants is particularly effective against pest and diseases in rice and certain rice genotypes are more efficient accumulators of silicon, thus making them more resistant. In the absence of natural heritable resistance in rice varieties, resistance could be induced by alternate strategies to suppress certain pest and pathogens. Hence experiments were carried out in two stages during kharif 2010 and 2011 to assess the concentration of silicon in the index leaves of rice plant utilizing 133 varieties in four locations. The silica content of promising varieties ranged from 1.50% to 3.20%, 1.60% to 3.15%, 1.49% to 3.20% and 1.55% to 3.06% with a mean values of 2.50%, 2.48%, 2.51% and 2.43% at Jagtial, Warangal, Rajendranagar and Rudrur centres of Telangana region and not much variation in mean silica content in index leaves at different places. The overall yield from four locations ranged from 2,653 kg/ha to 6,860 kg/ha with a mean of 5,624 kg/ha. The yields recorded at Jagtial, Warangal, Rajendranagar and Rudrur centres ranged from 2,886 to 7,198, 2,653 to 6,831, 2,653 to 6,860 and 4,399 to 5,950 kg/ha, respectively. The lowest mean yield 5,069 kg/ha was noticed at Rudrur and the highest yield 5,940 kg/ha was found at Warangal. The variations in yields might be due to genotypic variations and also due to variations in climatic conditions of different locations.

Key words: Nutrition management, conventional rice, silicon, rice genotypes, pest and diseases.

1. Introduction

Nutrition management is the most important for high yield production but the response of rice plants to pest and diseases due to the change of microclimate under rice plant canopy may be affected. Information on nutrition management and its relation with pest and diseases are essential for setting up a high yield production system. The pest and disease control procedures adopted by farmers can be considered as soil fertility management and these nutrition practices can affect the physiological susceptibility of crop plants to pest and diseases by affecting the resistance. Soils with high organic matter and active soil biological activity generally exhibit good soil fertility. Studies have shown that the shift from organic soil management to chemical fertilizers has increased the potential of certain pest and diseases causing economic losses. Ramesh et al. [1] reported that organic crops are more tolerant to insect attacks and organic rice is reported to have thicker cell wall and lower levels of amino acid than conventional rice. Silicon is particularly effective against pest and diseases in rice and certain rice genotypes are more efficient accumulators of silicon, thus making them more resistant [2]. In the absence of natural heritable

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resistance in rice varieties, resistance could be induced by alternate strategies to suppress certain pest and pathogens. Hence the present studies are taken up during 2010 and 2011 to study the induced resistance and its impact on major pest and diseases of rice.

2. Materials and Methods

The experiments were carried out in two stages during *kharif* 2010 and 2011, to assess the concentration of silicon in the index leaves of rice plants from varietal display plots at Agricultural Research Institute (ARI) Rajendranagar, Regional Agricultural Research Station (RARS) Jagtial, Regional Agricultural Research Station (RARS), Warangal and Regional Sugarcane & Rice Research Station (RS & RRS) Rudrur of Telangana regions of Andhra Pradesh during 2010 *kharif*. From the selected plots, the index leaf samples, i.e., 3rd or 4th leaves from top of the plant were collected at tillering stage and were analyzed for plant Si concentration as per procedure given by Saito et al. [3]. To know the available silicon status of different rice growing soils, representative soil samples were also collected from same locations and were estimated as per standard procedure given by Korndorfer et al. [4]. Grain yields were recorded at harvest and correlated with silica content in rice index leaves. Of the 133 genotypes analyzed during 2010 *kharif*, two promising varieties (one with high and another with low Si content) were selected for field experiment with four levels of nitrogen and silicon consisting of 16 treatments, replicated thrice in STRIP plot design. Recommended doses of phosphorus and potassium (60 kg/ha and 40 kg/ha) were applied uniformly to all treatments in the form of single super phosphate (SSP) and muriate of potash (MOP) as basal. Nitrogen was applied as per the treatments as scheduled in the form of urea in three equal splits (1/3 basal, 1/3 at active tillering stage and 1/3 at panicle initiation stage). Silica applied in the form of silica gel as basal as per the treatment composition and it formulated as 99.71%, 0.02%, 0.03%, 0.1%, 0.09%, 0.01% and 0.02 % of SiO_2, Na_2O, Fe_2O_3, Al_2O_3, TiO_2 CaO and ZrO_2. The observations on various pests *viz*., yellow stem borer (*Scirpophaga incertulas*), gall midge (*Orseolia oryzae*), brown plant hopper (*Nilaparvata lugens*) and green leaf hopper (*Nephotetticx virescens*) were recorded during tillering vegetative and reproductive phases by following standard procedures. The disease incidence was assessed by recording severity of sheath blight (*Rhizoctonia solani*) and brown spot (*Helminthosporium oryzae*) during boot leaf, tillering and at harvest stage, whereas, sheath rot (*Sarocladium oryzae*) and grain discoloration (complex disease caused by fungi and bacteria) were recorded at harvest of the rice crop in accordance with standard evaluation system by adopting 0-9 scale and calculated percent disease intensity (PDI) as Per Wheeler [5]. The analysis of variance for grain and straw yield, pest and diseases were worked out by feeding the replicated data into the INDOSTAT software.

3. Results and Discussion

3.1 Silica Content in Index Leaf Samples and Grain Yields of Promising Varieties

Different genotypes were evaluated for silica accumulation in index leaves at tillering stage at different locations (Table 1) which showed the mean silica content in index leaves ranging from 1.50% to 3.20%. The silica content of promising varieties ranged from 1.50% to 3.20%, 1.60% to 3.15%, 1.49% to 3.20% and 1.55% to 3.06% with mean values of 2.50%, 2.48%, 2.51% and 2.43% at RARS (Jagtial), RARS (Warangal), ARI (Rajendranagar) and RS & RRS (Rudrur) centres, respectively. There was not much variation in mean Si content in index leaves at different places and it was slightly more (2.50%) at Rajendranagar followed by Jagtial (2.50%), Warangal (2.48%) and Rudrur (2.43%). Similar results were obtained by Narayana and Prakash [6] for South Indian soils. The variation in Si concentration in plant species was largely due to efficiency of plant

Table 1 Mean values of Si content in index leaves and yield at different locations.

Location	No. of varities	Yield (kg/ha)		Silica (%)	
		Range	Mean	Range	Mean
RARS (Jagtial)	41	2,886-7,198	5,845	1.50-3.20	2.50
RARS (Warangal)	33	2,693-6,831	5,871	1.60-3.15	2.47
ARI (Rajendranagar)	47	2,653-6,860	5,646	1.49-3.20	2.51
RS & RRS (Rudrur)	12	4,399-5,950	5,069	1.55-3.06	2.43
Mean	133	3,157-6,709	4,933	1.54-3.15	2.34

roots for Si acquisition [7]. The yields of selected promising rice varieties at four different rice growing areas of Telangana region presented in Table 1 show that the overall yield from four locations ranged from 2,653 kg/ha to 6,860 kg/ha with a mean of 5,624 kg/ha with yields recorded at Jagtial, Warangal, Rajendranagar and Rudrur of Telangana region ranging from 2,886 to 7,198, 2,653 to 6,831, 2,653 to 6,860 and 4,399 to 5,950 kg/ha, respectively. The lowest mean yield of 5,069 kg/ha was noticed at Rudrur and the highest yield 5,940 kg/ha was found at Warangal. The variations in yields might be due to genotypic variations and also due to variations in climatic conditions of different locations.

3.2 Correlation of Yields with Si Content in the Index Leaf

Correlation coefficients between different genotypes silica concentration in index leaves and their yields (kg/ha) are positive and significant correlation (r = 0.55) existed between rice grown in display plots and their silica concentration. The soils in which they were grown at different locations are clay to sandy clay loam in texture, contained enough quantities of available Si and hence had a good Si supplying power to rice crop.

3.3 Available Silica in Rice Grown in Display Plots

The available Si content of different rice grown soils ranged from 79.06 to 94.19, 80.73 to 96.41 and 73.62 to 77.53 kg/ha at different crop growth stages (Table 2). The Si content in soils was the highest at Rajendranagar and the lowest at Rudrur at initial, tillering and post harvest stages (94.19, 96.41, 87.53, 79.06, 80.73 and 73.62, respectively). The soils of various research stations are low in available silica content. With the lowest Si recorded at Rudrur followed by Warangal and highest was recorded at Rajendranagar. The

Table 2 Silica and nitrogen nutrition on grain and straw yields of two rice genotypes.

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)
Varieties		
JGL 3855	6,779	8,949
RNR 2354	6,460	8,530
S.Em ±	8.53	10.66
C.D (0.05)	36.73	45.89
Fertility levels		
T_1 (N 0 + Si 0)	5,622	7,197
T_2 (N 0 + Si 200)	5,937	7,719
T_3 (N 0 + Si 400)	6,167	8,079
T_4 (N 0 + Si 600)	6,360	8,331
T_5 (N 80 + Si 0)	6,027	7,775
T_6 (N 80 + Si 200)	6,305	8,259
T_7 (N 80 + Si 400)	6,609	8,724
T_8 (N 80 + Si 600)	6,927	9,213
T_9 (N 120 + Si 0)	6,466	8,406
T_{10} (N 120 + Si 200)	7,155	9,594
T_{11} (N 120 + Si 400)	7,165	9,597
T_{12} (N 120 + Si 600)	7,172	9,611
T_{13} (N 160 + Si 0)	6,477	8,420
T_{14} (N 160 + Si 200)	7,172	9,601
T_{15} (N 160 + Si 400)	7,169	9,607
T_{16} (N 160 + Si 600)	7,180	9,693
S.Em ±	36.88	176.40
CD (0.05)	75.24	356.34
Varieties at same level of fertility levels		
S.Em ±	135.02	176.40
C.D (0.05)	296.51	356.34
Fertility levels at same level of varieties		
S.Em ±	17.80	23.39
C.D (0.05)	55.01	72.07

variation in available Si content among the soils is mainly attributed to the clay content, amount of rainfall and organic matter content of the particular location [8]. Among the different locations, soils of Rudrur contained lowest organic carbon and clay content compared to other locations. The soils studied from three different agro climatic zones of Telangana region have low to medium Si (Table 1). This could be attributed to the depletion of available Si due to continuous rice cultivation, low solubility and/or slow dissolution kinetics of soil Silica Lindsay [9], high uptake of Si by rice crops to an extent of 250 kg/ha for producing grain yield of 5 t/ha [10].

3.4 Grain and Straw Yields

It is observed that both the varieties as well as the nutrient levels showed a significant influence on rice grain and straw yields (Fig. 1). Among the varieties, JGL-3855 showed significantly higher grain (6,779 kg/ha) and straw yields (8,949 kg/ha) compared to RNR-2354 with grain yield of 6,460 kg/ha and straw yield of 8,530 kg/ha (Fig. 2). Among different silica and nitrogen levels, N_{160} + Si_{600} recorded highest grain yield of 7,180 kg/ha and was at par with other treatments which received N @ 120 and 160 kg/ha along with silica levels. Even among these treatments, the treatments which did not receive any silica along with N @ 120 and 160 kg/ha recorded lower grain yields of 6,466 kg/ha and 6,467 kg/ha compared to the treatments which received silica along with nitrogen. This might be attributed to the reason that application of silicon causes increase in growth and yield in cereals, because of the high phosphate uptake in rice with the application of silica [11].

But in case of treatments which received no nitrogen and nitrogen 80 kg/ha, the average yields were observed to be less than the treatments which received N 120 kg/ha and 160 kg/ha. This may be due to influence of conjunctive application of Si and N, thus it decreases percent spikelet sterility with increased Si levels [12]. Application of silica increased rice yield on Histosols mainly due to the supply of plant available Si and not due to supply of other nutrients [13]. Similar to grain yields, the results revealed a significant influence of fertility levels as well as their interactions on rice straw yields. This higher straw yield could also be attributed to increased number of tillers per hill and plant height. The dry matter production increased significantly with each increment in N and Si fertility level due to increased chlorophyll formation which ultimately improved photosynthesis [14] in different rice soils of India.

3.5 Incidence of Pest and Diseases

The data from Figs. 3 and 4 revealed a significant influence of different N and Si levels during various crop growth stages on pest and disease incidence, while the varieties and the interaction effects between the varieties and different N and Si levels are not statistically significant. However, among the varieties, RNR-2354 recorded higher incidence of both pest and diseases. Among the fertility levels, the plot which did not receive any fertilizer doses, i.e., (N_0 + Si_0) recorded the highest incidence of pest and disease incidence compared to other treatments which received both N and Si. Even among these treatment combinations, the treatments which received higher dose of Si 600 kg/ha in combination with N recorded the lower incidence of pest and diseases compared to the treatments which received low Si content in combination with N. On the other hand, with increase in N by 160 kg/ha in combination with various levels of Si, a decrease in the incidence of pests and diseases was observed at various growth stages respectively. Formation of a physical barrier in epidermal cells by Si deposition contributes to plant resistance against pests and diseases [15]. On the other hand, pesticides which are currently perceived to be potentially harmful to the environment, particularly to soil and water [16] could be alternated with use of Si fertilization which offers an enhancement of resistance to host plant against all these stresses [17, 18].

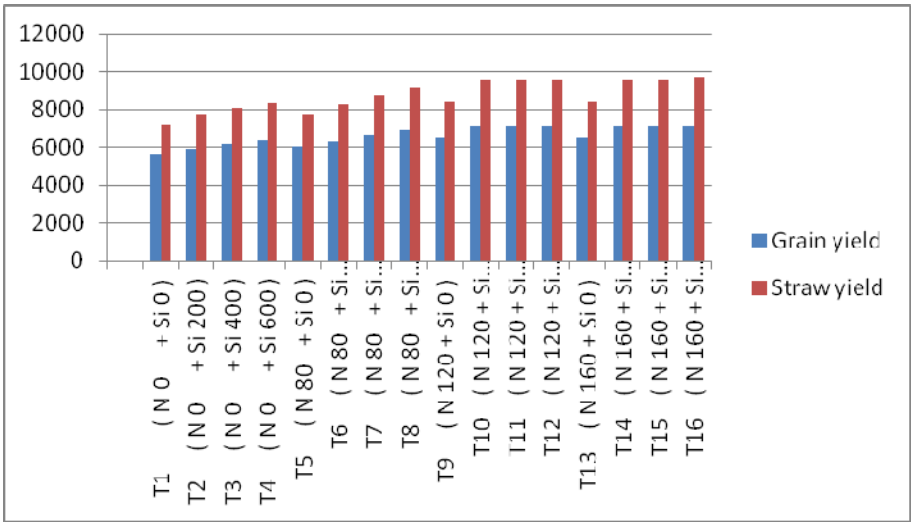

Fig. 1 Silica and nitrogen nutrition on grain and straw yields of two rice varieties.

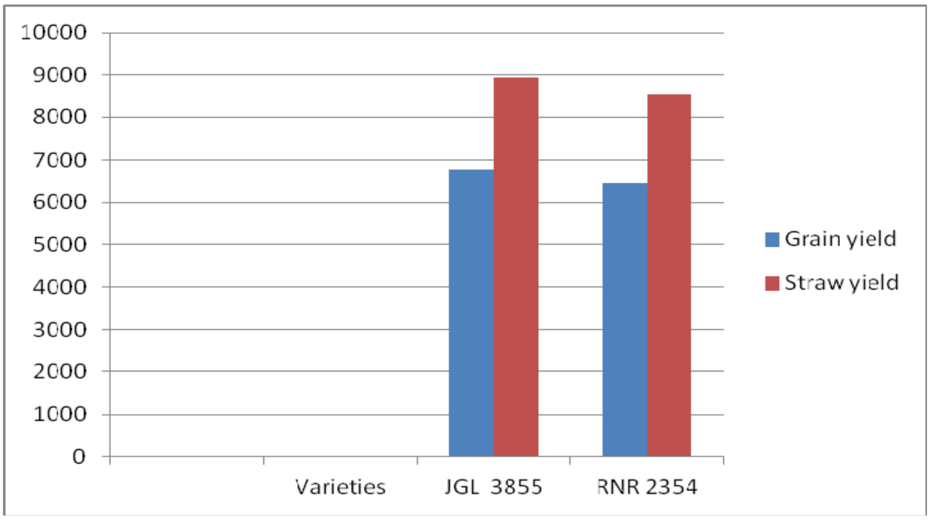

Fig. 2 Silica and nitrogen nutrition on grain and straw yield (kg/ha) of two rice varieties.

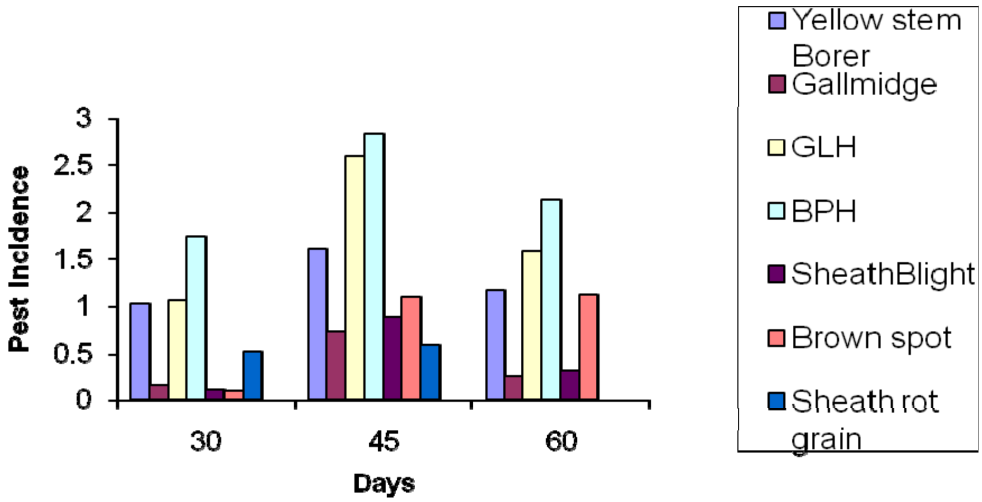

Fig. 3 Percent pest and diseases incidence in JGL 3855 varities.

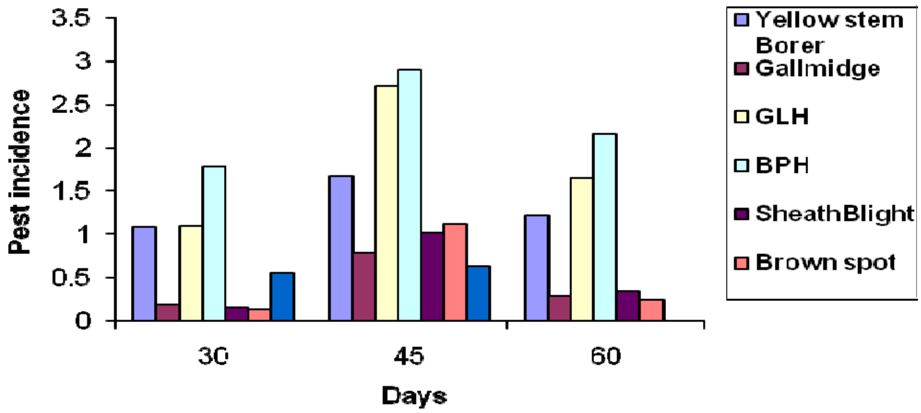

Fig. 4 Percent pest and diseases incidence in RNR 2354 varities.

Table 3 Correlation coefficients of Si concentration with dead hearts, galls rice diseases in JGL-3855 and RNR-2354.

Parameters JGL-3855	Si (%)	Dead hearts	Galls	Sheath rot	Sheath blight	Grain discoloration	Brown spot
Si (%)	1.00	-0.84	-0.84	-0.88	-0.88	-0.88	-0.87
Dead hearts		1.00	0.99	1.00	0.97	0.98	0.97
Galls			1.00		1.00	0.97	0.96
RNR-2354						1.00	0.95
Si (%)	1.00	-0.90	-0.90				1.00
Dead hearts		1.00	0.99				
Galls			1.00	-0.91	-0.89	-0.91	-0.90
				1.00	0.97	0.98	0.98
					1.00	0.97	0.97
						1.00	0.96
							1.00

3.6 Correlation of Pest and Diseases with Silica

From the results in Table 3 and Figs. 3 and 4, it is observed that the occurrence of major pests and pathogens were negatively correlated with silica content in both the varieties. Correlation values of JGL-3855 and RNR-2354 existed as -0.84 and -0.90 for stem borer and -0.84 and -0.90 for gall midge. Similarly, the presence of high silica content is negatively correlated with the incidence of diseases by JGL-3855 which was -0.88 for sheath rot, -0.88 for sheath blight, -0.88 for grain discoloration and -0.87 for brown spot and also with RNR-2354, correlation values for the above mentioned diseases were -0.91, -0.89, -0.91 and -0.90. This was in confirmation with the findings of Kajimura [19]. Special attention is needed to find the appropriate method of control which in addition to being efficient and cost-effective does not cause any harm to the environment. Silicon application is a method that is consistent with environmental friendly strategies for pest and disease management. However, finding of more efficient silicon sources is important and also extension of knowledge on silicon to farmers and rice growers will help the agriculture industry in the management and control of rice pest and diseases with respect to producing safe food and environmental protection.

4. Conclusions

Two genotypes evaluated for silica accumulation in index leaves at tillering have shown silica content at

1.5% to 3.2% and there was a positive correlation between silica content and yields. There was variation in silica based on the soils the rice crop was grown where in Rajendranagar soils recorded 94.19, 96.41 and 87.53 at initial, tillering and post harvesting stages. The nitrogen and silica have shown significant impact on the pest and disease incidence with higher doses reducing the incidence.

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