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Influence of silicon fertilization on the incidence of rice insect pests and diseases in Telangana

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Abstract
Most of the pest and disease control measures used by farmers affect the soil fertility and plant resistance, which together leads to high control costs and make the rice cultivation unfeasible. To address this, an experiment was carried out in two phases. In the first phase of the experiment, Si content is accessed in the rice index leaves by utilizing 133 varieties with a mean value of 2.50, 2.48, 2.51 and 2.43% at Jagtial, Warangal, Rajendranagar and Rudrur varietal rice display plots of Telangana. For the second phase of field experiment, one with high Si (JGL-3855) and another with low Si (RNR-2354) content genotypes were selected with sixteen treatmental combinations of Si and Nin strip plot design. Conjunctive application of N and Si to both genotypes, JGL-3855 recorded significantly higher grain and straw yields compared to RNR-2354, and among the different combinations of Si and N, application 160 kg N + 600 kg Si ha^{-1} recorded significantly higher grain and straw yields (7180 and 9693 kg ha^{-1}) over control (5622 and 7197 kg ha^{-1}). The incidence of pests and diseases was significantly higher with the application of increased N levels by 0, 80, 120 and160 kg ha^{-1}alone when compared to the conjunctive use of N and Si. However, significant scaling down of menace was noticed in treatments wherever increased Si doses (0, 200, 400 and 600 kg ha^{-1}) included.

Keywords: Silicon, nitrogen, rice genotypes, pest and disease incidence, soil fertility

Introduction
Rice (*Oryza sativa* L.) is the main staple food of around half of the world's population and is provides 21 and 15% per capita of dietary energy and protein (Maclean *et al.* 2002) [14]. One of the main yield-limiting factors is the attack of different kinds of insect pests and diseases and the application of various pesticides and fungicide to control the menace is neither economical nor environmentally friendly. Silicon is the second most abundant element in the earth's crust (Datnoff *et al.* 1997) [4] and rice is known as a Si-accumulator (Mitani and Ma, 2005) [16] crop. Supply of soluble silicon in plants provides stronger and tougher cell walls which serve as a mechanical barrier against sucking and piercing insects and deposited silicon in the various plant parts inhibit the penetration of cell walls by the attacking fungus. In addition to conferring resistance against fungal diseases and insect pests, silicon can improve erectness of leaves, increase yield and alleviate water and salinity stress and nutrient imbalances as well (Ma and Tamai, 2002) [13]. Therefore, this study aims to evaluate the effect of silicon and nitrogen rates on grain yield and its impact on major pests and diseases of rice crops.

Materials and Methods
First phase of the experiment was carried out 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 and Rice Research Station (RS & RRS) Rudrur of Telangana region. From the selected plots, index leaf samples *i.e,* 3rd or 4th leaves were collected at the tillering stage and were analyzed for plant Si concentration as per procedure given by Saito *et al*. (2005) [20]. To know the available silicon status of different rice-growing soils, representative soil samples were also collected from the same locations and were estimated as per standard procedure given by Korndorfer *et al*. (2001) [10]. As well as, grain yield in display plots were recorded at harvest and correlated with silica content in rice index leaves. Of the 133 genotypes analyzed during the first phase of experiment, two promising varieties one with high and another with low Si content were selected for next phase field trial with four levels of Nitrogen and Silicon consisting of sixteen treatments, replicated

thrice in strip plot design. Recommended doses of phosphorus and potassium (60 and 40 kg ha^{-1}) were applied uniformly to all treatments in the form of single super phosphate (SSP) and muriate of potash (MOP) as basal. Nitrogen @ 0, 80, 120 and 160 kg ha^{-1} was applied as per the treatments as scheduled in the form of urea in 3 equal splits (1/3 basal, 1/3 at active tillering stage and 1/3 at panicle initiation stage). Silicon @ 0, 200, 400 and 600 kg ha^{-1} was applied in the form of silica gel as basal as per the treatments and it contains 99.71, 0.02, 0.03, 0.1, 0.09, 0.01 and 0.02 per cent of SiO_2, Na_2O, Fe_2O_3, Al_2O_3, TiO_2, CaO and ZrO_2 respectively. The observations on various pest *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 (Anonymous, 2007b) [1]. 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) recorded at harvest of the rice crop in accordance with standard evaluation system by adopting 0-9 scale (IRRI, 1979) [8] and calculated per cent disease intensity (PDI) by Wheeler (1969) [25]. Total phenols were extracted and estimated following the method described by Malik and Singh (1980) [12]. The analysis of variance for grain and straw yield, pest and diseases were worked out by feeding the replicated data into the INDOSTAT software.

Results and Discussion

Among the various locations of the study area, the Si content in the index leaf of the promising varieties at tillering ranged from 1.50 to 3.20 (mean value of 2.50) per cent at RARS, Jagtial, 1.60 to 3.15 (mean value of 2.47) per cent at RARS, Warangal, 1.49 to 3.20 (mean value of 2.51) per cent at ARI, Rajendranagar and 1.55 to 3.06 (mean value of 2.43) per cent at RS & RRS, Rudrur (Table 1). Whereas the rice grain yields ranged from 2886 to 7198 kg ha^{-1} at RARS, Jagtial, 2693 to 6831 kg ha^{-1} at RARS, Warangal, 2653 to 6860 kg ha^{-1} at ARI, Rajendranagar and 4399 to 5950 kg ha^{-1} at RS & RRS, Rudrur and both parameters showed a positive and significant correlation (r = 0.55**). The variation in Si concentration in plant species was due to the difference in the efficiency of plant roots for Si acquisition (Takahashi and Hino, 1978) [23]. All the index leaf samples of selected display plots of four rice growing areas were found to be deficient in Si concentration when a critical value is less than 5 percent to considered as critical value suggested by Shivay and Dinesh kumar (2009) [21]. It could be also noticed that there was not much variation in mean Si content of index leaves at different places. This indifference among the cultivars at various locations could be due to the dissolution of Si from the soil matrix in the root zone of the crop itself. The wide variation among the cultivars was observed with respect to rice grains and yield at four locations with a range of 2653 to 7198 kg ha^{-1}. The variation in yields among the varieties could be due to the reason that certain genotypes are more efficient than others in the accumulation of Si as revealed by Deren *et al.* 1992 and Winslow, (1992).

Conjunctive application of N and Si to both genotypes, JGL-3855 recorded significantly higher grain and straw yields (6779 and 8949 kg ha^{-1}) compared to RNR-2354 with grain yield of 6460 kg ha^{-1} and straw yield of 8530 kg ha^{-1} (Fig 1), which could be due to the high efficiency of JGL-3855, probably might be due to prevention of excessive transpiration with the application of Si and genotypic characteristics put forth more yield attributes like number of productive tillers, number of grains per panicle and test weight (Ghanbari, 2011 and Liang *et al.*1994) [6, 11].

The yield response to the application of Si and N was more in low Si content variety RNR-2354 (20.4%) when compared to high Si content variety (17.4%). Among the different combinations of Si and N, application of 160 kg N + 600 kg Si ha^{-1} recorded significantly higher grain and straw yields (7180 and 9693 kg ha^{-1}) over control (5622 and 7197 kg ha^{-1}) and was on par with (N_{160} + Si_{400}), (N_{160} + Si_{200}), (N_{120} + Si_{600}), (N_{120} + Si_{400}) and (N_{120} + Si_{200}) with their respective grain and straw yields of 7169 and 9607, 7172 and 9601, 7172 and 9611, 7165 and 9597, 7155 and 9594 kg ha^{-1} by the synergistic effect of Si and N in decreasing per cent spikelet sterility. Si fertilization increases N use efficiency by efficient use solar radiation (Shivay and Dinesh Kumar, 2009) [21]. Similar results were also noticed with the application of calcium silicate in soils of Brazil. The yield component is dependent on pollen grain meiosis, anthesis, pollination, fertilization and carbohydrate translocation and influenced by Si fertilization along with N application (Munir *et al.* 2003) [17]. The lower yields registered in the no Si fertilized plots, this might be due to leaching and fixation loss of native silicon in submerged conditions and inadequate in meeting the Si requirement by the crop for producing higher grain yields (Narayanaswamy C and Prakash N B, 2010) [18].

The variety, RNR-2354 recorded a higher incidence of both pests and diseases compared to the JGL-3855. Among the fertility levels, the treatments which received higher dose of Si @ 600 kg ha^{-1} 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. 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 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 same above-mentioned diseases were -0.91, -0.89, -0.91 and -0.90 (Table 2). Pest and disease intensity was significantly influenced by the formation of a physical barrier in epidermal cells by Si deposition contributes to plant resistance against pests and diseases (Datnoff *et al.* 2001) [3]. As well as occurrence of major pests and pathogens were negatively correlated with silica content in both the varieties and this was in confirmation with the findings of Korndorfer *et al.* (2004) [9]. On the other hand, pesticides and fungicides currently perceived to be potentially harmful to the environment, particularly to soil and water could be alternated with the use of Si fertilization which offers an enhancement of resistance to host plant against all these stresses (Aziz *et al.* 2002) [2].

Higher Si concentration was recorded by JGL-3855 (3.01, 4.05, 4.29 and 1.26%) compared to lower Si concentration (2.96, 4.01, 4.25 and 1.23%) obtained by RNR-2354 at active tillering, panicle initiation, and harvest stage of crop growth respectively (Fig. 2). Silicon concentration significantly influenced by both varieties as well as the different levels and combinations of nitrogen and silicon at all the stages of crop growth stages and this was mainly attributed to additional supplement of Si fertilizer and enhanced the characters like biomass production, root bearing ability. The results are in agreement with the findings of Inanaga *et al.* (2002) [7].

Conjunctive use of N and Si with N_{160}+Si_{600} recorded higher leaf Si concentration of 3.12, 4.34, 4.39 and 1.35 per cent at active tillering, panicle initiation, harvest and in grain of rice crop respectively and were found to be significantly superior over control (2.76, 3.09, 3.56 and 1.07%) and it was at par with N_{160} + Si_{400}, N_{160} + Si_{200}, N_{120} + Si_{600}, N_{120} + Si_{400} and N_{120} + Si_{200} with their respective Si contents of 3.11, 4.32, 4.38 and 1.34; 3.10, 4.30, 4.35 and 1.34; 3.11, 4.33, 4.38 and 1.34; 3.10, 4.31, 4.36 and 1.33; 3.10, 4.28, 4.34 and 1.33 per cent.Mean Si concentration in straw was higher than the grain, because Si linked in shoot and straw and Si content obviously increased with increase in Si application, Yoshida (1978) [24]. The accumulation of Si in the straw may be related to a number of factors such as transpiration, growth duration, growth rate Malidareh *et al.* (2009) [15].

With an increase in the level of N application from 0 to 80, 120 and 160 kg ha^{-1} across Si levels for the two varieties increased the meantotal phenolsduring various crop growth stages from 1.71 to 1.67 and 2.75 to 2.70 ppm respectively. Si induced accumulation of total phenol compounds, played a primary role in rice defense mechanisam. Dallagnol *et al.* (2011) [3] found that the concentrations of soluble phenolics, lignin and activities of peroxidase and chitinase were higher in Si-treated rice leaves infected by *Bipolaris oryzae*, which contributed to rice resistance. The combined application of N and Si doses, the highest total phenols were obtained with N_{160} + Si_{600} treatment, which was at par with the other treatment combinations of: N_{160} + Si_{400} > N_{160} + Si_{200}>N_{120} + Si_{600}> N_{120} + Si_{400}> N_{120} + Si_{200}. Other reports suggest that after inoculation with *M. grisea*, Si-treated rice plants significantly increased the activities of pathogenesis-related proteins (PRs) in leaves, such as peroxidase (POD), polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL), and catalase (CAT) Therefore, Si-enhanced plant disease resistance plus the role of Si as physical barrier as suggested by Rodrigues *et al.* (2003) [19] and Shen *et al.* (2010) [22].

Table 1: Mean values of Si content in index leaves and Yield at rice varietal display plots of Telangana

Location	No. of Varieties	Yield (kg ha^{-1})		Silica (%)	
		Range	Mean	Range	Mean
RARS (Jagtial)	41	2886-7198	5845	1.50-3.20	2.50
RARS (Warangal)	33	2693-6831	5871	1.60-3.15	2.47
ARI (Rajendranagar)	47	2653-6860	5646	1.49-3.20	2.51
RS&RRS (Rudrur)	12	4399-5950	5069	1.55-3.06	2.43
Mean	133	3157-6709	4933	1.54-3.15	2.34

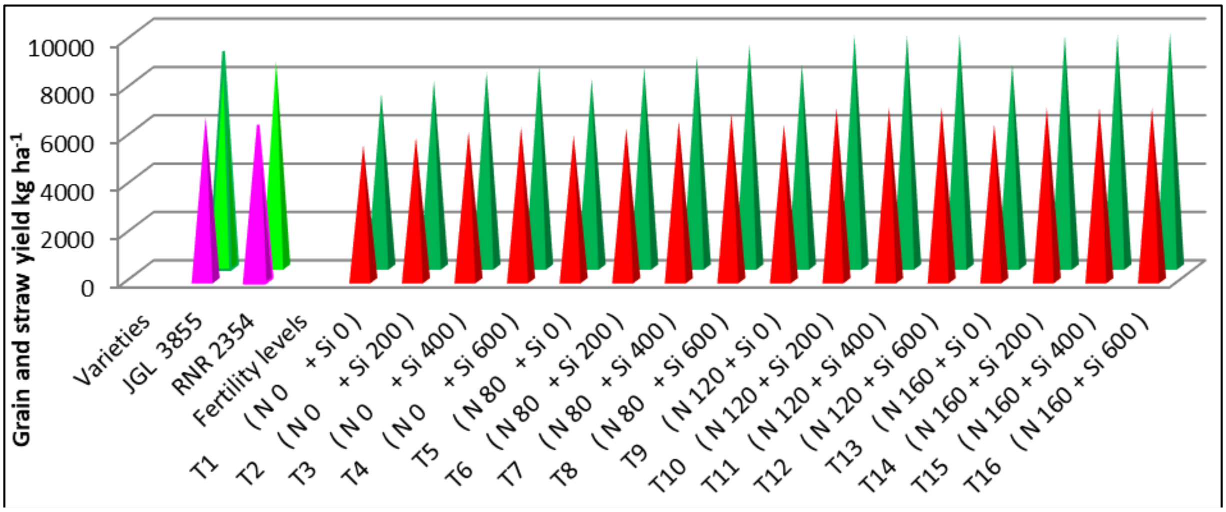

Fig 1: Silica and Nitrogen nutrition on grain and straw yields of two differentrice genotypes

Table 2: Correlation coefficients of Si concentration with Dead Hearts and Galls in JGL-3855 and RNR-2354

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

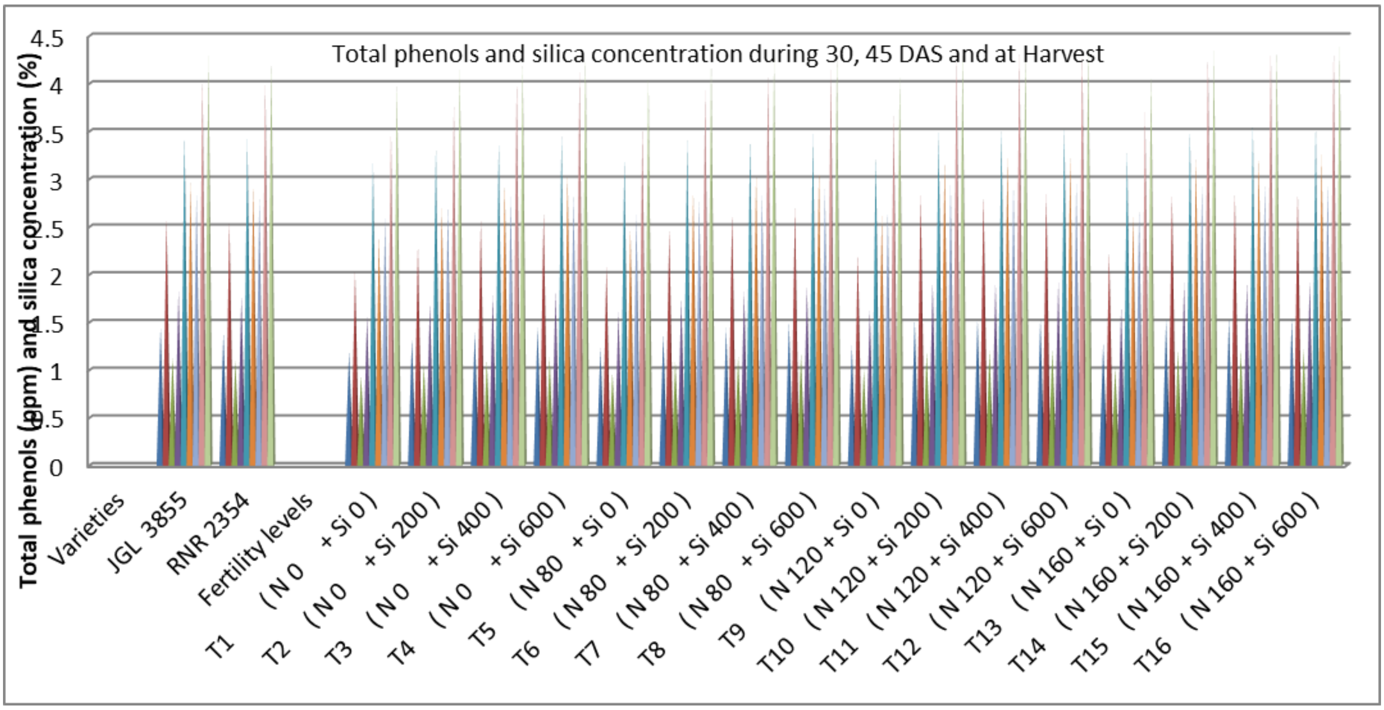

Fig 2: Silica and Nitrogen nutrition on Si and total phenols of two different rice genotypes

References

1. Anonymous. Directorate of Rice Research. Hyderabad, Annual Report. 2007; 2:2.59-2.60.
2. Aziz T, Gill MA, Rahmatullah. Silicon nutrition and crop production: A review. Pak. J Agril. Sci. 2002; 39:181-187.
3. Dallagnol LJ, Rodrigues FA, DaMatta FM, Mielli MV, Pereira SC. Deficiency in silicon uptake affects cytological, physiological, and biochemical events in the rice-Bipolaris oryzae interaction. Phytopathology. 2011; 101(1):92-104.
4. Datnoff LE, Snyder GH, Korndorfer GH. The use of silicon for integrated disease management: reducing fungicide application and enhancing host plant resistance. Studies in Plant Sci. 8, Silicon in Agriculture. 2001; 10:171-182.
5. Deren CW, Datnoff LE, Snyder GH. Variable silicon content of rice cultivars grown on Everglades Histosols. J Plant Nutri. 1992; 15:2363-2368.
6. Ghanbari-Malidareh. Silicon application and nitrogen on yield and yield components in rice (*Oryza sativa* L.) in two irrigation systems. World Academy of Science, Engineering and Technology. 2011; 50:88-95.
7. Inanaga S, Higuchi Y, Chishaki N. Effect of silicon 632 c.c. MA *et al*. application on reproductive growth of rice plant. Soil Sci. Plant Nutri'. 2002; 48:341-345
8. IRRI, Los Banos, Philippines. Report of Brown planthoppers: threat to rice production in Asia. International Rice Research Institute., 1979, 369..
9. Korndorfer AP, Cherry R, Nagata R. Effect of calcium silicate on feeding and development of tropical sod webworms. Florida Entomologist. 2004; 87:393-395.
10. Korndorfer GH, Snyder GH, Ulloa M, Datnoff LE. Calibration of soil and plant silicon for rice production. J Plant Nutri. 2001; 24:1071-1084.
11. Liang YC, Ma TS, Li FJ, Feng YJ. Silicon availability and response of rice and wheat to silicon in calcareous soils. Comm. Soil Sci. Plant Anal. 1994; 25:2285-2297.
12. Malik EP, Singh MB. Plant Enzymology and Hittoenzymology (1st Edn.) Kalyani Publishers: New Delhi, 1980, 286.
13. Ma JF, Tamai K. Characterization of silicon uptake by rice roots. II Silicon in Agriculture Conference. 2002, 111-113.
14. Maclean JL, Dawe DC, Hardy B, Hettel GP. Rice Almanac (3rd edition). CABI Publishing, Wallingford, 2002, 253.
15. Malidareh Ghanbari A, Kashani A, Nourmohammadi HR, Mobasser, Alavi V. Effect of silicon application and nitrogen rates on N and Si content and yield of rice (*Oryzae sativa* L.,) in two water systems in north of Iran. World Appl. Sci. J. 2009; 6:719-727.
16. Mitani N, Ma JF. Uptake system of silicon in different plant species. J Exp. Bot. 2005; 56:1255-1261
17. Munir M, Carlos ACC, Heilo GF, Juliano CC. Nitrogen and silicon fertilization of upland rice. *Scintia Agricola*. 2003; 60:1-10.
18. Narayanaswamy C, Prakash NB. Evaluation of Selected Extractants for Plant-Available Silicon in Rice Soils of Southern India. Comm. Soil Sci. Plant Anal. 2010; 41:977-989.
19. Rodrigues FA, Vale FXR, Datnoff LE, Prabhu AS, Korndorfer GH. Effect of rice growth stages and silicon on sheath blight development. Phytopath. 2003; 93:256-261.
20. Saito K, Yamamoto A, Sa T, Saigusa M. Rapid, Micro-Methods to Estimate Plant Silicon Content by Dilute Hydrofluoric Acid Extraction and Spectrometric Molybdenum Method. Soil Sci. Plant Nutr. 2005; 51:29-36.
21. Shivay YS, Dinesh kumar. Importance and management of silicon deficiency in rice. Indian farming, 2009, 34-36.
22. Shen XF, Li XW, Li ZH, Li JM, Duan LS, Eneji AE. Growth, physiological attributes and antioxidant enzyme activities in soybean seedlings treated with or without Si under UV-B radiation stress. Journal of Agronomy Crop Sciences. 2010; 196:431-439.

23. Takahashi E, Hino K. Effect of different Si forms on silicic acid uptake. Japanese J Soil Sci. Manure. 1978; 33:453-455.
24. Yoshida S. Tropical climate and its influence on rice. IRRI Research Paper Series 20, IRRI, Los Banos, Philippines, 1978.
25. Wheeler BEJ. Anintrodnctionto plant diseases. John Wiley and Sons, London, 1969.
26. Winslow MD. Silicon, disease resistance and yield of rice genotypes under upland cultural conditions. Crop Sci. 1992; 32:1208-213.