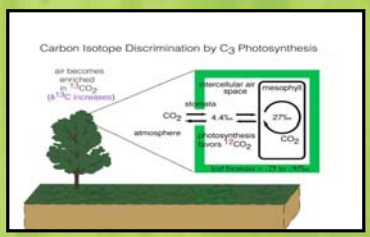
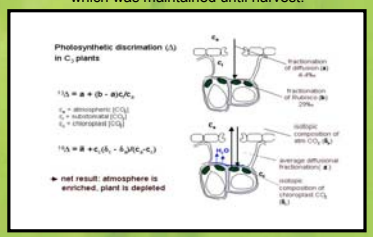
Carbon Isotope Discrimination Screening of Salinity Tolerance at the Seedling and Reproductive Stage in Rice

Rice is considered the most important cereal crop in the world. It is particularly sensitive to salt stress at early vegetative stage and during reproduction. Screening for salinity tolerance in rice is conducted using controlled environment facilities and solution cultures. However, this approach may not be practical for large-scale breeding programs and may pose serious problems in the field because of climatic factors and field heterogeneity. Alternative strategies such as carbon isotope discrimination (Δ), which uses differences in the 13C/12C isotopes to measure the photosynthetic responses of plants to various environmental stresses could be more effective in screening and can potentially be applied under field conditions.

One plant per pot across 3 replications were grown for a month then salinized at 3 dSM-1, gradually increased to 6 dSM-1 over 10 days which was maintained until harvest.





MATERIALS AND METHOD

Eighty rice lines and varieties were used for this experiment, including 46 breeding lines and 34 varieties and landraces. SES scores were taken when plants were approximately 90 days old; plants were harvested for salt uptake. measurements and 13C analysis. Flag leaves and harvested grain samples were analyzed for δ13C composition at IRRI Analytical Service Lab (ASL).

A number of morphological traits and yield components were also measured to compare reproductive stage responses of these diverse genotypes under the control and salt-stress conditions and to test the association between Δ and reproductive stage tolerance.

RESULTS

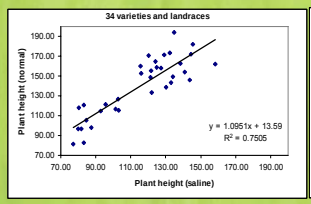
An analysis of the trait correlations between grain yield (total grain weight per plant) with grain number, Δ of flag leaves with that of the grains both under normal and salt stress conditions. Δ of flag leaves also correlated negatively with visual SES scores under salt stress. Grain yield per plant correlated strongly and positively with grain number but not with fertility under salt stress, suggesting that salinity damage is probably more serious during spikelet formation than during pollination and fertilization (Table 1 and 2).

Table1. Correlation coefficients for the associations of Δ, Na/K ratio, SES, and yield components of rice plants grown to maturity under salt stress of 6 dS m^{-1} using 80 diverse genotypes.

	Height	*Fertility*	*Yield*	*Grain number*	*Na/K Ratio*	*Delta flag leaf*	*Delta grains*	*SES*
Height	1.00							
Fertility	0.18	1.00						
Yield	-0.14	0.14	1.00					
Grain number	-0.07	0.19	0.72	1.00				
Na/K Ratio	0.01	0.07	0.21	0.11	1.00			
Delta flag leaf	-0.68	-0.08	0.54	0.46	0.06	1.00		
Delta grains	-0.59	-0.10	0.50	0.43	0.13	0.87	1.00	
SES	0.09	0.10	-0.53	-0.51	-0.25	-0.26	-0.27	1.00

Table 2. Correlation coefficients for the associations of Δ, Na/K ratio, and yield components of rice plants grown to maturity under normal (non-stress) conditions using 80 diverse genotypes.

	Height	*Fertility*	*Yield*	*Grain number*	*Na/K Ratio*	*Delta flag leaf*	*Delta grains*
Height	1.00						
Fertility	-0.39	1.00					
Yield	-0.44	0.71	1.00				
Grain number	-0.17	0.60	0.60	1.00			
Na/K Ratio	0.04	-0.03	0.06	-0.15	1.00		
Delta flag leaf	-0.52	0.46	0.51	0.34	0.14	1.00	
Delta grains	-0.57	0.32	0.41	0.31	0.09	0.83	1.00



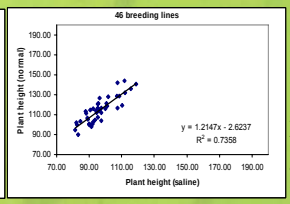
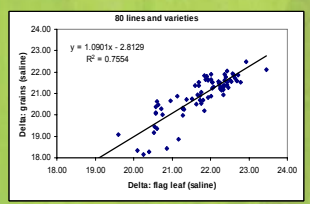
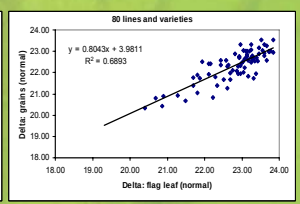
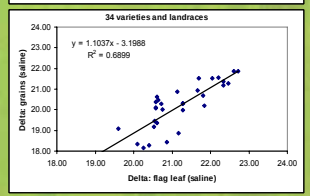


Fig 1A and B. Associations between plant height under normal conditions compared to plant height under salt stress when grown to maturity. Graph A is the subset of 34 varieties and landraces, and B is the set of 46 IRRI breeding lines.

When analyzed separately, the two subsets of varieties show clear differences in plant types, with 34 varieties and landraces showing a larger range of plant height at maturity compared with shorter and more uniform set of 46 mostly semi-dwarf breeding lines, under both saline and normal conditions (Fig 1 A and B).







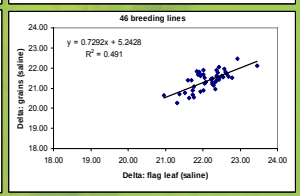
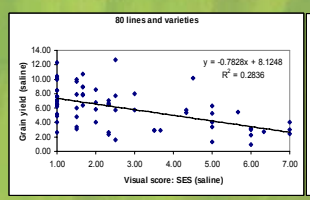


Fig 2 A, B, C and D. Associations of Δ values from the flag leaves with the values from the grains. A) the entire set of 80 lines and varieties under salt stress, B) the 80 lines under normal conditions, C) the subset of 34 varieties and landraces under salt stress, and D) the set of 46 breeding lines under salt stress

This technique had a high sensitivity to differentiate between rice genotypes based on their yield potential and also the more diverse set of varieties and landraces showed greater variability in ability to maintain their gas exchange than the more uniform set of breeding lines



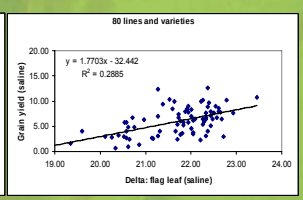


Fig 3 A and B. Under saline conditions, the association of the SES scores with grain yield shows a negative correlation, while the relationship between Δ values from the flag leaves with the grain yield shows a positive correlation.

CONCLUSIONS

The Δ values from flag leaves correlated well with values obtained from the grains, and both correlated positively with grain yield of single plants, suggesting that Δ can potentially be used to select for salinity tolerance during reproductive stage based on values obtained from flag leaves.

The widely different results seed between our two sets of germplasm (34 diverse varieties compared with the 46 more uniform breeding lines) suggests that future experiments to study the correlation between Δ and salinity tolerance should always include both germplasm groups during the initial study.

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