Quantitative Assessment of Leaf Color Change in Response to Phosphate Deficiency Tolerance in Rice

Y.C. Aluwihare, R. Lelwala, M. Ishan, S.D.S.S. Sooriyapathirana
Department of Molecular Biology and Biotechnology, Faculty of Science, University of Peradeniya, Sri Lanka

and

D.N. Sirisena, W.L.G. Samarasinghe
Rice Research and Development Institute, Bathalagoda, Sri Lanka

Introduction

Phosphate deficiency tolerance (PDT) is one of the important traits in improving rice varieties. Annual expenditure on phosphate fertilizers for rice is Rs.1158.4 millions in Sri Lanka. Application of phosphate fertilizers also causes many other environmental and health problems (Wickramasinghe *et al*., 2009). If PDT rice varieties can be developed, they can be grown with reduced fertilizer applications, higher profit margin, and minimum negative effects of phosphate applications (Wissua and Ae, 2001). Because of the phosphate deficiency, the leaf color is changed. If the color differences in leaves can be quantitatively measured, it can be used to assess the PDT of different rice varieties (Fageria *et al*., 1988). The present study was conducted to screen selected traditional and improved rice varieties developed by Rice Research and Development Institute (RRDI), Batalagoda (Bg) for PDT using the leaf color change measurements in a quantitative approach.

Methodology

A total of 10 rice genotypes (nine varieties: Bg 358, H 10, H4, Bg 360, Bg 403, Bg 379-2, Bg 352, H 7 and MAS and the landrace: Suduheenati) were grown in a field at RRDI, Bathalagoda where no fertilizer has been applied for last 30 years. Plants were maintained with standard management practices except no phosphate application.

The leaf color measurements; L*, a* and b* were recorded in four replicates per plant on the sixth week after planting using a spectrophotometer (CR-10, Konika Minolta, Tokyo, Japan). L* measured the darkness/lightness range of the visual color from black (-L*) to white (+L*), a* measured the range from green (-a*) to red (+a*) while b* measured the range from blue (-b*) to yellow (+b*). The quantitative estimates, C* (chroma; estimate of dullness/sharpness of the visual color) and H* (hue angle; estimate of the overall visual color) were calculated using the following equations (Melgosa, 2000).

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The overall performance of the varieties and landraces were tested by observing the general plant growth and yield. Means for L*, a* b*, chroma and hue angle were calculated for each plant and subjected to cluster analysisusing the statistical software package, Minitab 14.

Results and Discussion

The tested rice genotypes showed variability in leaf color development due to phosphate deficiency (PD) in the soil (Figure 1). The variety *MAS* showed maximum dissimilarity to other varieties and clustered separately. Basically, three clusters could be observed in leaf color for tested varieties under PD. This indicates that the rice varieties show variable responses to PD in terms of leaf color development. However, these color changes cannot be quantified precisely with naked eye and therefore quantitative measurements are important.

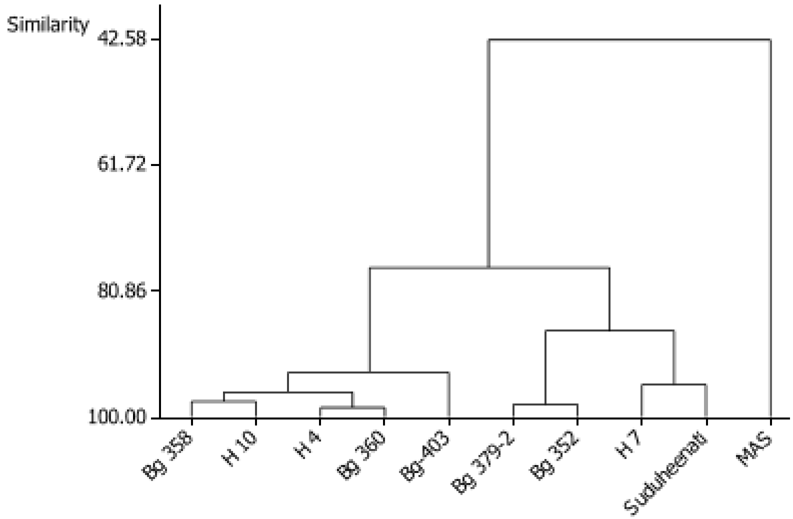

Figure 1. A dendrogram showing variability of leaf color in rice varieties due to phosphate starvation.

The rice variety *MAS* showed the minimum dark coloration (highest L*) and the varieties H7, Bg 352 and the landrace *Suduheenati* also showed less dark coloration compared to that in Bg varieties (Figure 2A). MAS, H7 and *Suduheenati* also showed the highest overall performance compared to other varieties (data are not shown) under PD.In green coloration (-a*), the varieties H4, H7, H10, Bg 360 and *Suduheenati* showed minimum changes compared to other genotypes tested. But overall a* was not really correlated with the plant performance under PD compared to L* (Figure 2B). The same pattern was also observed in the dullness of color (chroma) (Figure 2C) and in yellow coloration (+b*) (Figure 2D) where no correlation of the overall performance of different genotypes grown under PD with chroma and b*. The hue angle (actual color perceived by human eye) was observed highest in *MAS* and lowest in H4 but again not correlated with the PDT of each genotype.

Conclusions

The darkening of color is indicated by –L* and was correlated with overall performance of the variety. The varieties MAS, H7 and *Suduheenati* showed highest overall performance under PD conditions. Therefore, L* could be used as an effective indicator in measuring the PD and PDT. However, further studies are required to develop an empirical equation to model the correlation between L* and amount of phosphate present in the soil. Such an equation will be immensely important to decide the amount and precise timing of phosphate fertilizer application to rice fieldsin order to minimize the negative effects of unnecessary applications of phosphate fertilizers and to reduce the cost of production for profitable rice farming.

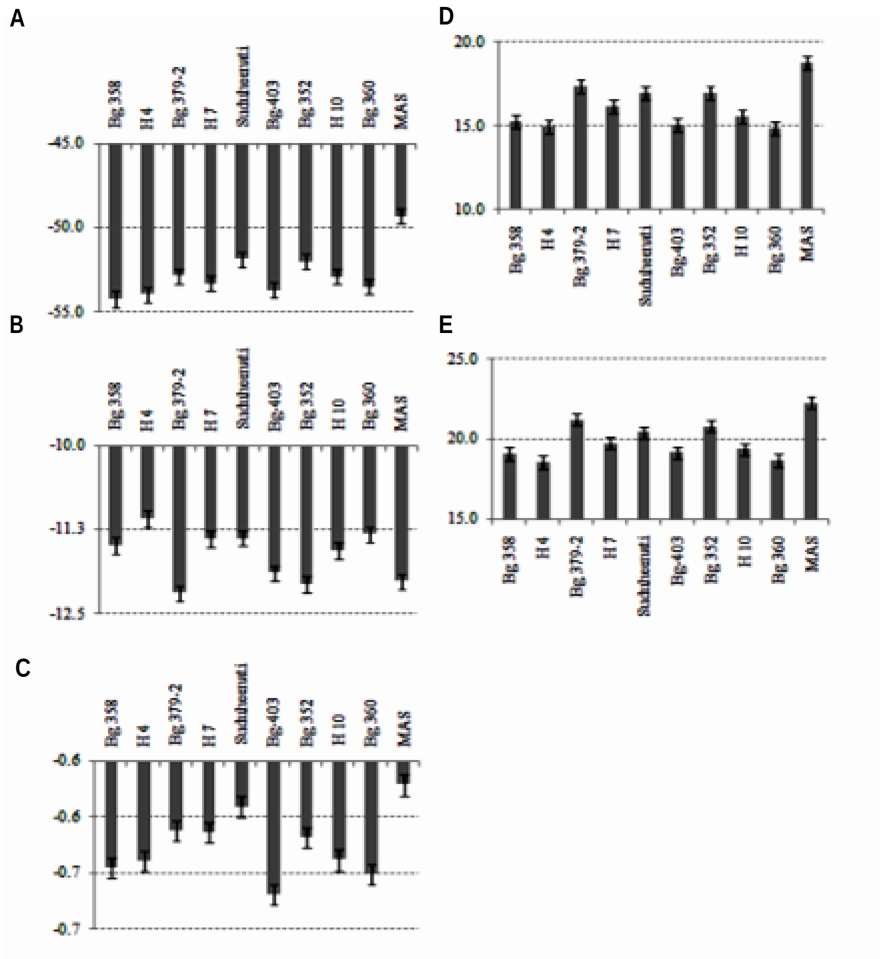

Figure 2. The changes of color metrics in rice genotypes grown under deficient phosphate conditions A: L*, B: a*, C: chroma, D: b* and E: hue angle. X axis in all the graphs represent rice genotypes and Y axis represent respective color metric.

References

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