Assessing the Contribution of Chlorophyll Fluorescence Parameters for Studying Environmental Stress Tolerance in Maize

F.O.M. Duraes[1,2], W.K. Russell[3], J.F. Shanahan[4], and P.C. Magalhães[1]

[1]Researcher, Embrapa-Brazil (www.embrapa.br), email: fduraes@cnpms.embrapa.br
[2]Visiting Scientist, UNL; USDA-ARS
[3]Professor, University of Nebraska, Lincoln, NE USA
[4]Research Agronomist, USDA-ARS and UNL.

Introduction

Plant production is driven by photosynthetic processes, and these processes are sensitive to environmental stresses. Among photosynthetic processes, Photosystem II (PSII) evaluated by chlorophyll fluorescence technique is believed to be the most sensitive to stress (Goedheer 1972; and others). Response to drought and nitrogen (N) stresses involves morphological, physiological and metabolic processes. Understanding these processes may improve the efficiency of selection for drought stress. But an important key is finding precise measures of these processes that are relatively easy and quick to take. The goals of this research were to demonstrate that apparent electron transport rate, as measured by chlorophyll fluorescence, can be used as a measure to discriminate among maize (*Zea mays* L.) genotypes and to determine if the response to drought- and N-induced stresses differed between a set of older hybrids compared to current, elite hybrids.

Methods

We carried out greenhouse experiments with maize to evaluate the response of eight single-cross hybrids grown under inadequate and adequate regimes of water and N. The hybrids included four old hybrids, including B73 x Mo17, and four current commercial hybrids. We assessed their photosynthetic performance by measuring both CO_2 assimilation rate (A, in µmoles $CO_2/m^2/s$) and the chlorophyll fluorescence parameter of electron transport rate (ETR, in µmoles$/m^2/s$) under low and high light conditions and varying concentrations of intercellular CO_2 (Ci) at V6, V8 and flowering stages of growth. These genotypes were previously grown under drought and N stress in the field, and were shown to exhibit contrasting responses to these stresses (Figure 1).

Results

A strong linear relationship between ETR and A was observed (r=0.873) across all eight hybrids (Figure 2), indicating that chlorophyll fluorescence parameters are good estimates of A. We observed contrasting responses to ETR and A between the older and current hybrids. The measures of ETR and A were lower for both groups of hybrids under low N conditions compared to high N (Figure 2); however, under low N the older hybrids exhibited higher A and ETR values than the current hybrids, whereas under high N the current hybrids had the higher A and ETR values. A similar contrasting response between older and current hybrids was observed for water stress (data not shown).

Conclusions

Both ETR, as measured by chlorophyll fluorescence, and A characterized the responses of eight hybrids to drought and N stress in a similar fashion, and the correlation between these two measures was high. The contrasting responses of the older and current hybrids suggest they would be suitable candidates for further research focusing on the understanding of water stress and nitrogen metabolism in maize, where physiological and molecular biology approaches may be appropriate.

References

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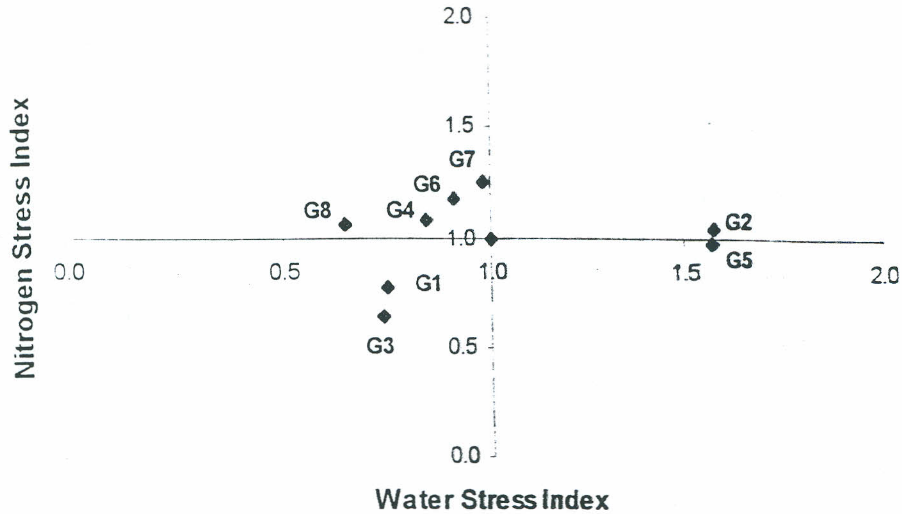

Figure 1. Environment Stress (Nitrogen, NSI and Water, WSI) Indexes (ESI) [$ESI = (Y_{Full\ Factor} - Y_{Factor\ stressed}) / (Y_{Avg\ Full\ Factor} - Y_{Avg\ Factor\ stressed})$] calculated as the average grain yield (mg/ha) of each genotype grown under both factors vs. yield of each genotype grown under varying water and nitrogen regimes in the field for four years in Shelton, NE USA. (Calculated from J.F. Shanahan et al. 2003. Data unpublished.).

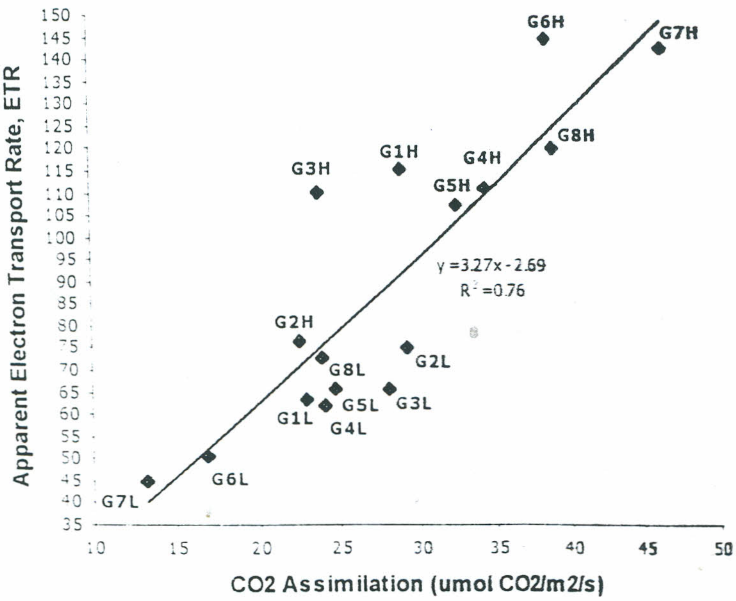

Figure 2. Correlation between CO_2 assimilation rate and the electron transport rate (ETR) in leaves of eight maize genotypes at flowering, under high (HN) and low (LN) N-levels.