Metabolic limitations to photosynthetic efficiency of sorghum seedling leaves at low temperature

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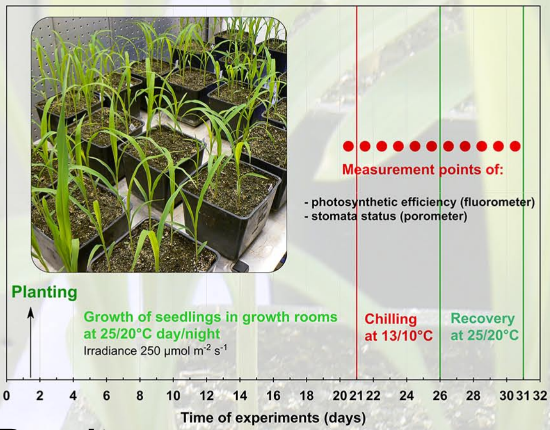
Introduction

In view of the effects of global climate changes on plant growth conditions in Europe, specific traits of sorghum (Sorghum *bicolor* (L.) Moench) make some of its cultivars (sweet sorghum) a promising candidate for a future bioenergy crop in this region. The main limiting factor seems to be low tolerance of sorghum seedlings to chilling temperature and possible seedling damage caused by cold spells occurring in April and May.

The aim of the presented research was to clarify the physiological mechanisms underlying the drop in photosynthetic efficiency in sorghum seedlings under low temperature conditions, and to investigate the role of stomata status in this stress response.

Materials and methods

Seedlings of six sorghum genotypes (M71, SS79, Etian, Keller, Ji2731, Btx623) at third-leaf stage were exposed to five-day chilling (13/10°C, day/night) in a growth chamber and then recovered for five days at control temperature (25/20°C, Scheme 1). Before and during chilling treatment as well as during recovery, the following measurements were performed for the first three leaves: photosynthetic efficiency measured as chlorophyll *a* fluorescence by PAM 2000 (Walz) and stomata status by porometer AP4 Delta T.



Scheme 1. Scheme of the experiments. Before chilling treatment seedlings were grown in growth chambers for ca. 20 days until the third leaf was fully developed. The seedlings were then subjected to five-day low temperature (13/10°C day/night) treatment and afterwards recovered for five days in control conditions (25/20°C, day/night).

Results

As early as after 4 h of chilling, there was a significant drop in photosynthetic efficiency (PE) measured as chlorophyll *a* fluorescence parameter effective quantum yield of PSII electron transport (YIELD, Fig. 1A), which decreased further in the course of chilling with significant differences among the genotypes studied. These differences were particularly pronounced after five-day recovery – M71 and Ji2731 recovered almost fully while SS79, Keller, and Btx623 only to a very limited degree. In these susceptible lines (S, Fig. 1B) a significantly bigger drop in PE was observed for the first (oldest) leaf compared to the third (youngest) one, whereas in the tolerant lines (T, Fig. 1C) these differences were not significant. All genotypes exhibited stomata closure as late as the fifth chilling or first recovery day (Fig. 1D).

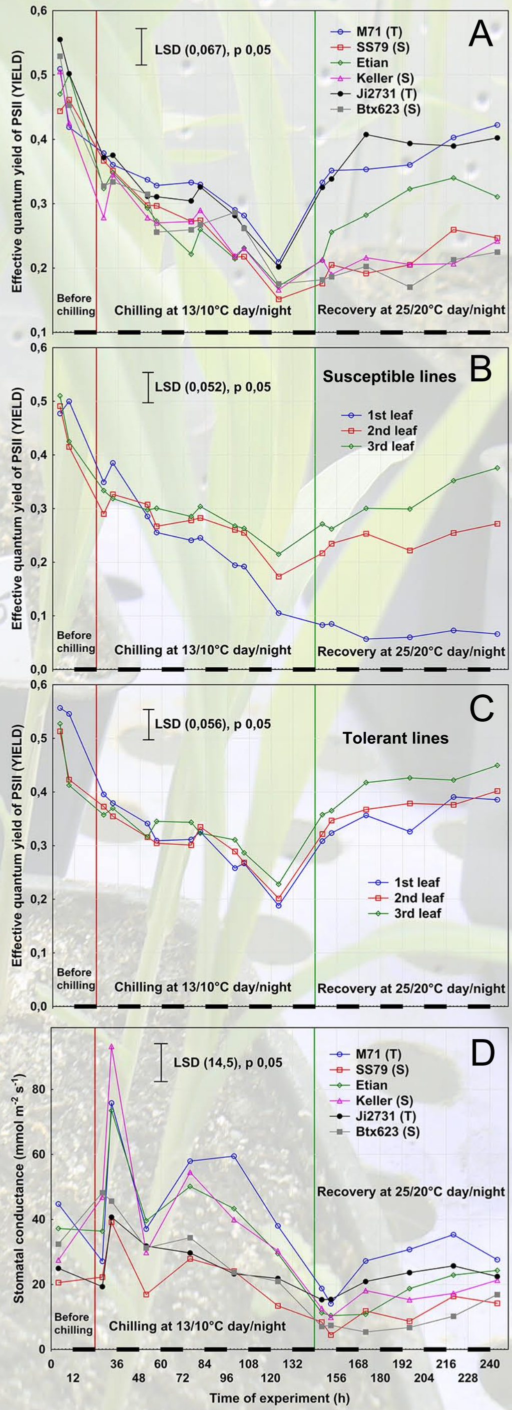


Fig. 1. Photosynthetic efficiency measured as chlorophyll *a* fluorescence parameter effective quantum yield of PSII electron transport (YIELD) for the first three leaves of six sorghum genotypes (A), separately for the first, second and third leaf of three susceptible lines (B) and of two tolerant lines (C); stomatal conductance for the first three leaves of six sorghum genotypes (D) before and during five-day low temperature (13/10°C day/night) treatment and five-day recovery. n=9 (A, B); n=6 (C, D). Black boxes on the x-axis indicate dark periods.

Conclusions

• The fast and significant drop in photosynthetic efficiency of sorghum seedlings under chilling conditions is caused by metabolic (non-stomatal) limitations during exposure to low temperature and by stomatal limitations after the cessation of the exposure.

• The most pronounced genotypic difference in the reaction of sorghum seedlings to chilling stress was in the enormous drop in photosynthetic efficiency in the oldest leaves of the susceptible lines in the later stages of chilling and during recovery.

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