Osmotic adjustment, abscisic acid accumulation, and a decrease in photosynthetic efficiency are the key consequences of low temperature influence on sorghum seedlings

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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 **low temperature** and possible seedling damage caused by cold spells occurring in April and May. However, thanks to very broad genetic variability of this trait in the sorghum species, it should be possible to breed new hybrids aiming at higher chilling tolerance.

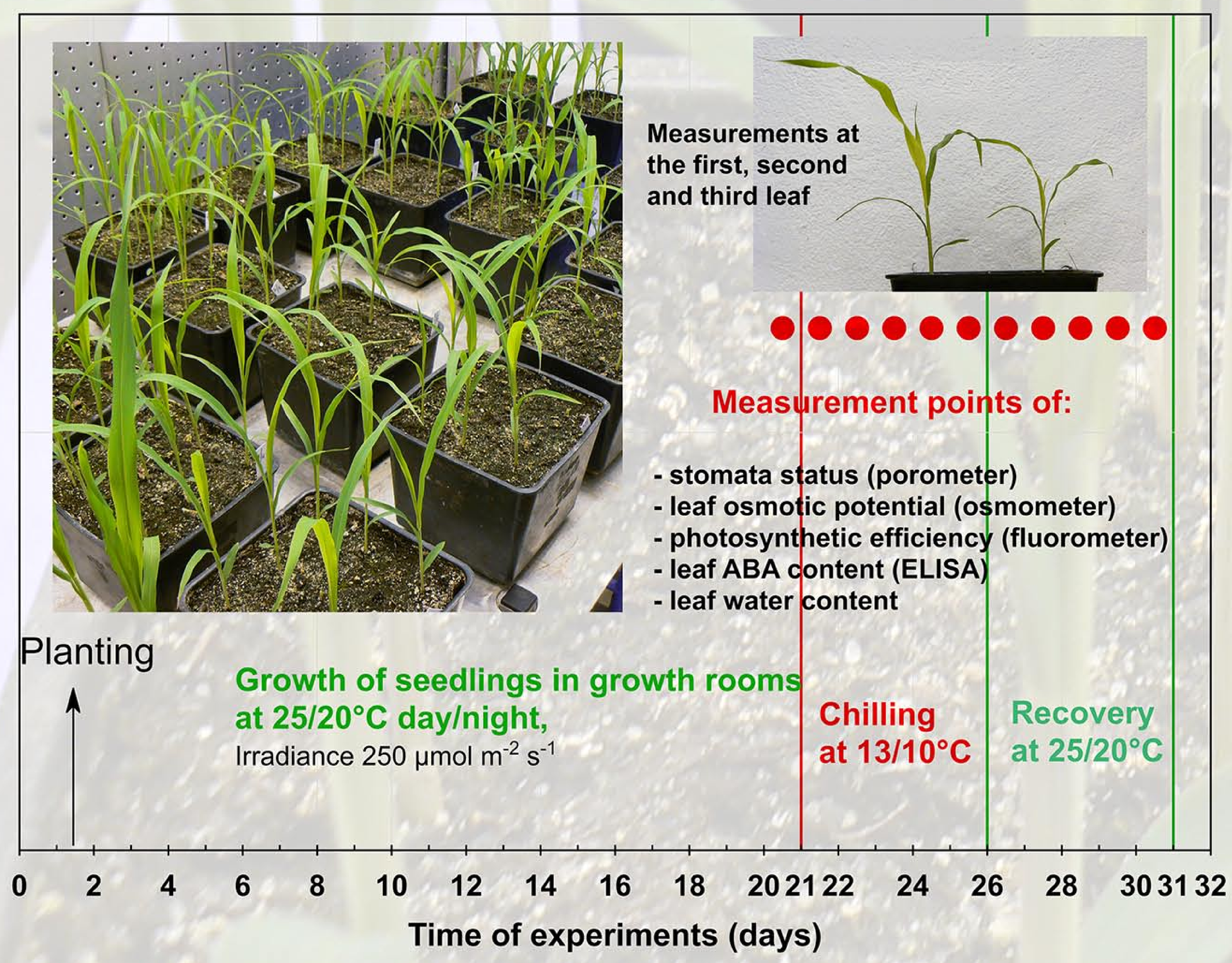
The **aim** of the presented research was to clarify the physiological mechanisms in sorghum seedlings under low temperature conditions and to identify the potential traits differentiating the genotypes' responses to low temperature stress.

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). In the course of chilling the parameter decreased further with significant differences among the genotypes studied. These genotypic differences were particularly pronounced after five-day recovery – M71 and Ji2731 recovered almost fully while SS79, Keller, and Btx623 only recovered to a very limited degree. The reason for the PE decrease under low temperature conditions was **not stomatal limitation** – stomata partly closed as late as the fifth chilling or first recovery day (Fig. 1B). After nine hours of chilling treatment there was a peak in the degree of stomata opening but they closed to the control level after 29 h of chilling, which was accompanied by a significant but transient **increase in abscisic acid (ABA)** content (Fig. 1C). During the whole chilling treatment there was no significant water deficit in leaves (measured as leaf water content, data not shown). Interestingly, however, a **drop in leaf osmotic potential** (OP) was observed in all genotypes starting from 52 h of chilling, though this phenomenon was very pronounced only in M71 and Ji2731 (Fig. 1D). During seedling recovery OP returned to the control level.

Conclusions

- **The presented results show that the fast and significant drop in PE 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.**
- **Stomata opening at the beginning of chilling stress seems to be caused by low temperature itself and not by chilling-induced leaf water deficit, and stomata closure – by an increase in leaf ABA content.**
- **The most pronounced genotypic differences in the reaction of sorghum seedlings to chilling stress were in the extent of osmotic adjustment and the capability for PE recovery after chilling treatment.**



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.

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, stomata status by porometr AP4 Delta T, photosynthetic efficiency measured as chlorophyll *a* fluorescence by PAM 2000 (Waltz), leaf ABA content by ELISA, and osmotic potential by osmometer (OSMOMAT 030, Gonotec GmbH) were measured for the first three leaves.

Poster shown during **10th International Plant Cold Hardiness Seminar** (10th IPCHS), August 17-21, 2014, Kórnik-Poznań, Poland.

Acknowledgments: This research was supported by the National Centre for Research and Development (NCBR), Warsaw, Poland, in the frame of the program ERANET Bioenergy, Project No. ERA-NET-BIOENERGY-3/2013.

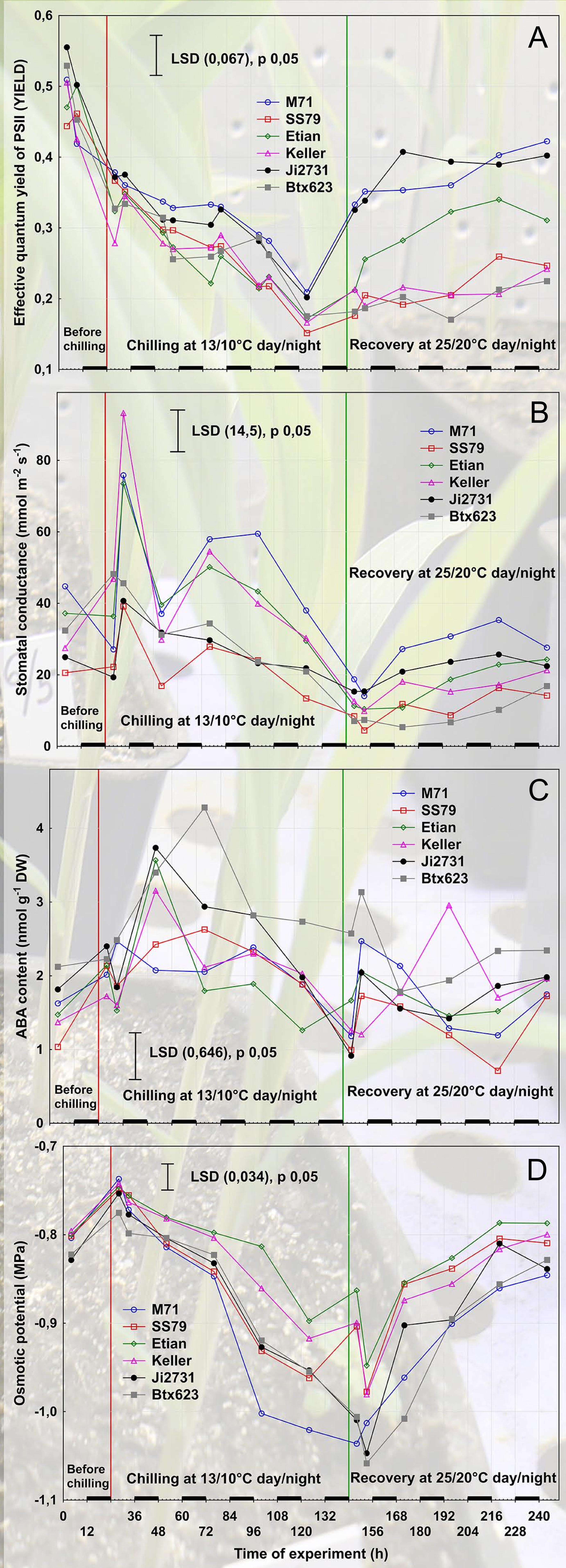


Fig. 1. **Photosynthetic efficiency** measured as chlorophyll *a* fluorescence parameter effective quantum yield of PSII electron transport (YIELD, A), **stomatal conductance** (B), **ABA content** (C), and **osmotic potential** (D) for the first three leaves of six sorghum genotypes before and during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