Variability of the genetic response of tomato during soil drying and repeated cycles of water deficit and recovery

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VARIABILITY OF THE GENETIC RESPONSE OF TOMATO DURING SOIL DRYING AND REPEATED CYCLES OF WATER DEFICIT AND RECOVERY

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Introduction

In horticulture, controlled deficit irrigation may be a good alternative to reduce water use in the context of global climate change. Reduction of growth is one of the most current adaptive response to deficit irrigation for tomato (Chaves *et al.*, 2003) but it can be partially compensated for during a recovery period (Xu *et al.*, 2010). We tested here the potential of alternating periods of deficit irrigation (DI) of increasing intensity followed by recovery periods (RP), in order to test the hypothesis that a better quantification of plant response to water deficit during the reproductive period may help finding trade-off between plant growth and water saving. A kinetic drying treatment was performed in parallel to compare the responses of genotypes in more stressful conditions. The study investigated the 8 parents of the MAGIC TOM (Multi-Parent Advanced Generation Inter-Cross) population (Ranc, 2010).

Materials & Methods

Plant Material: Cervil, Criollo, Ferum, LA0147, LA1420, Levovil, Plovdiv XXIVa and Stupicke Polni Rane (the 8 parents of the MAGIC TOM population). Plants were grown until the tenth truss.

Treatments were applied on reproductive plant:
- Control plants: irrigation was based on plant evapotranspiration per day, measured twice daily
- "Alternative treatment" (AT) (Figure 1): consisted of **three 15-days periods of deficit irrigation (DI) of increasing intensity, interrupted by two 15-days periods of recovery (RP)**
  - DI1 : -38% of water supply
  - DI2 : -45% of water supply
  - DI3 : -55% of water supply
  - RP: same irrigation as in control plants
- "Kinetic drying": no water was supplied to the plants until the permanent wilting point; realized in a climatic chamber in order to permit a slow and progressive soil drying on 4 genotypes (Cervil, Levovil, Plovdiv and LA1420) selected for their contrasted responses to water deficit in order to compare their response under extreme conditions

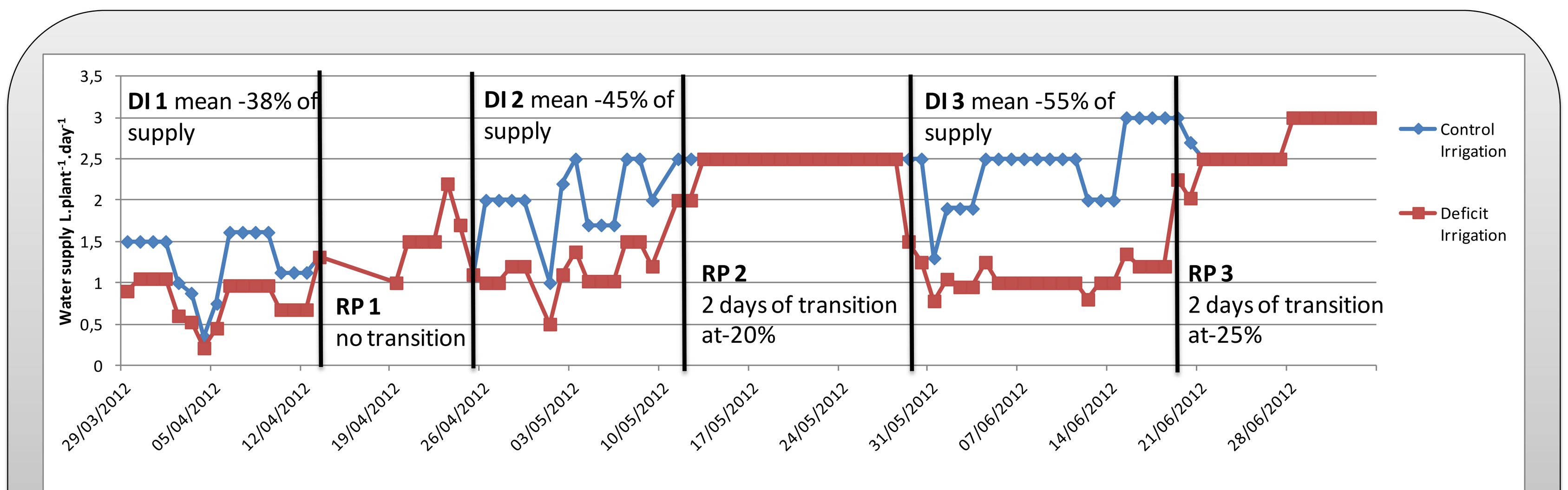


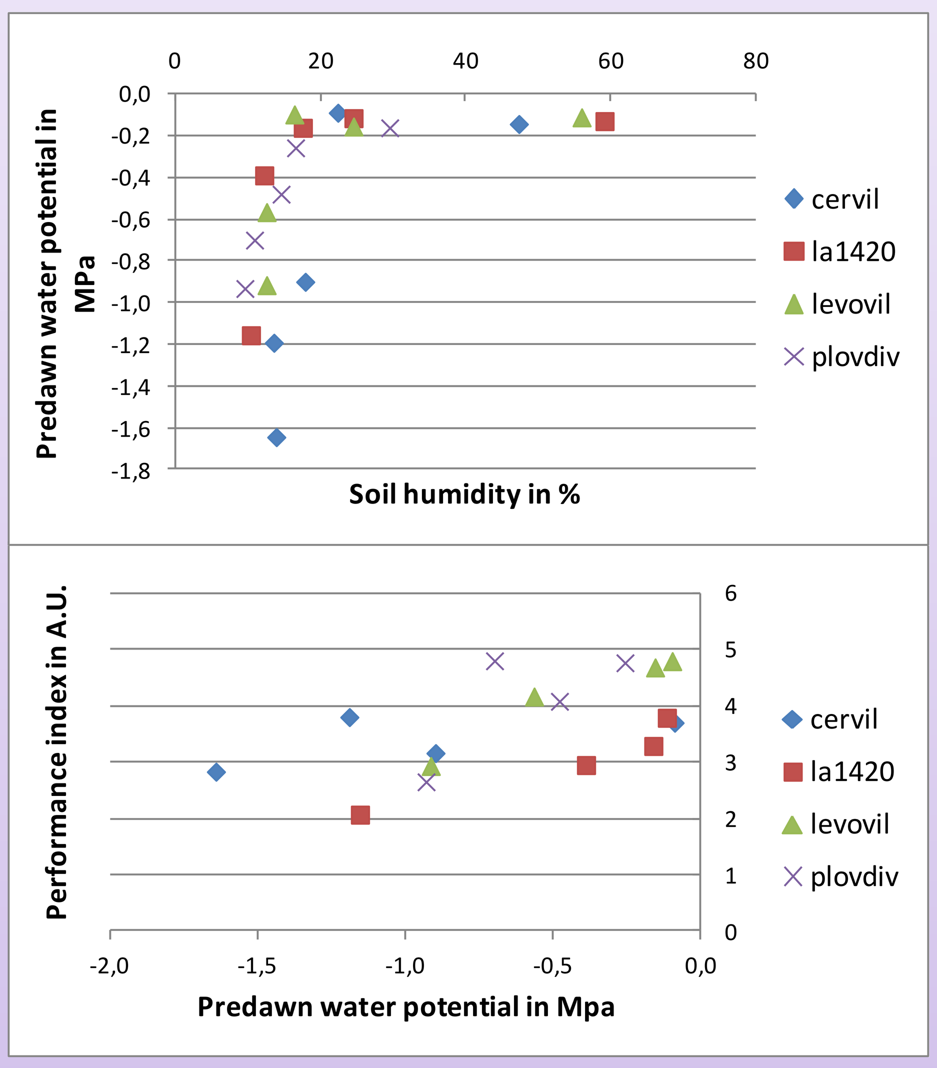
Fig. 1: Treatments scheduling of deficit irrigation (DI) and recovery periods (RP).
Kinetic drying was not represented on this figure because of the lack of visibility

Measurements:
- **Soil humidity** was measured using a tensiometer (WCM Control, Grodan©)
- **Plant growth** was assessed by multiplying leaf size by the number of leaves per plant at the end of each period of DI and recovery
- **Stem water potential** was measured using a pressure chamber on bagged mature leaves (SAM Précis 2000 Gradignan, France)
- **The performance index** (PI) (Strasser *et al.*, 2000) was measured using a chlorophyll fluorimeter (Handy-PEA, Hansatech©)
- To assess the long term effects of the alternative treatment we compared the areas under the curves for the parameters measured at the end of each DI and RP periods for stressed and control plants.

Statistical analysis on R 3.1.0:
- The areas under the curve called "total AUDPC", were compared using the H test (Scheirer-Ray-Hare, 1976) for non parametric data, completed by a multi-comparison test for details on differences between treatments.

Results

Relationships between the parameters measured during the kinetic drying experiment

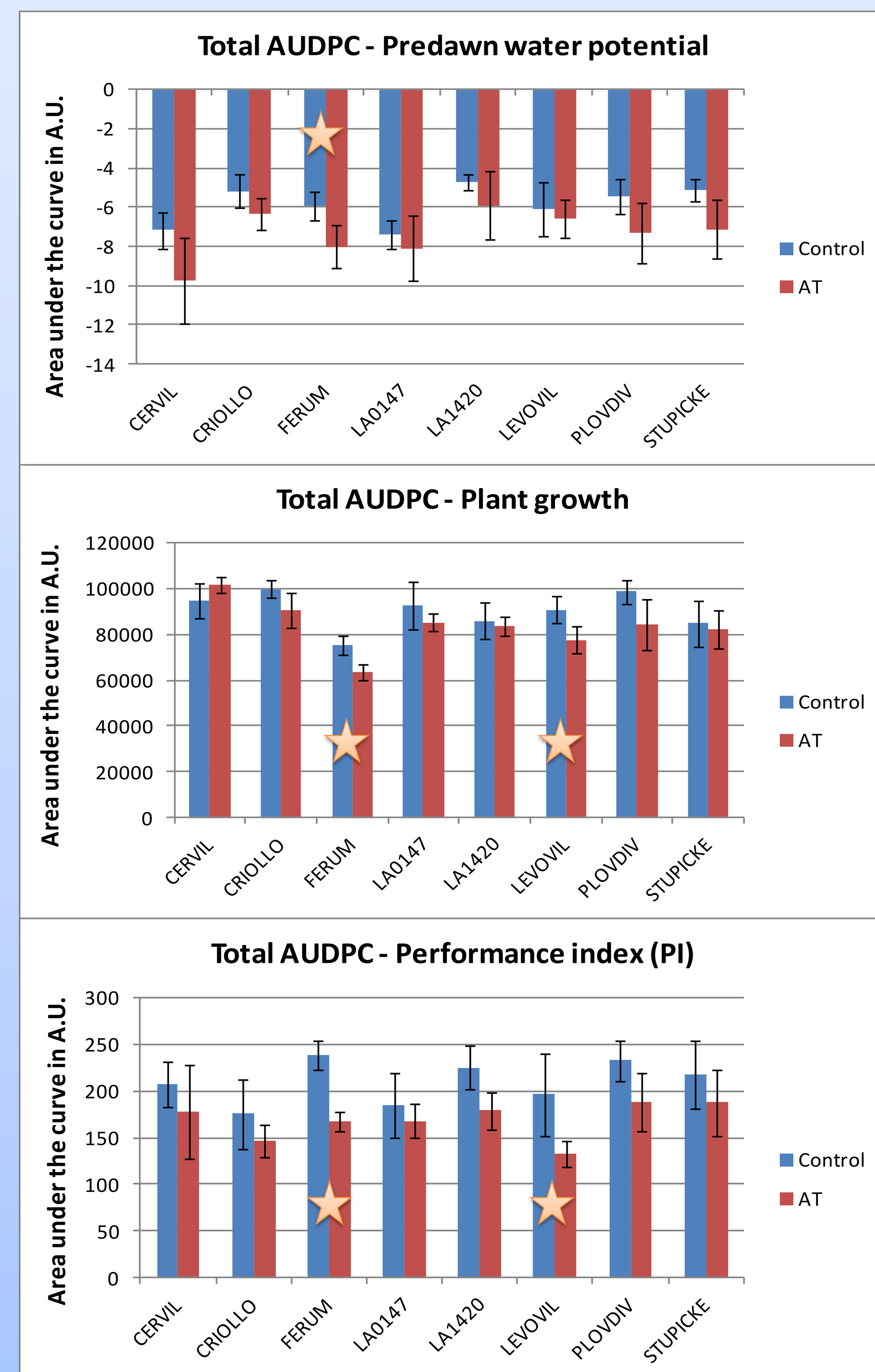


- All genotypes responded in a similar way during "kinetic drying"
- Plant water status decreased exponentially during soil drying, with a threshold around 20% soil moisture below which the plant water status declined rapidly.
- This water status also caused a decline in the plant performance index, except for Cervil which seemed to be less sensitive
- Below the threshold of -0.2MPa predawn water potential, plant survival seemed to be endangered

Fig. 2 : Predawn water potential related to soil humidity during kinetic drying, and performance index related to predawn water potential, for genotypes Cervil, Levovil, LA1420 and PlovdivXXIVa (each point is the mean of 6 repetitions, n=6)

Long term effects of the alternative treatment in comparison to control irrigation for the 8 genotypes

- Ferum, Levovil and Cervil showed the most extreme responses to the "alternative treatment". Ferum and Levovil were the most sensitive to stress, whereas the growth of Cervil was not affected by stress.
- AUDPC of predawn water potential for the 8 genotypes was on average 25% lower in the alternative treatment compared to the control
- AUDPC of plant growth for the 8 genotypes was on average 8% lower in the alternative treatment than in the control
- AUDPC of PI for the 8 genotypes was reduced by 20% in the alternative treatment compared to the control
- Globally, water relationship, plant growth and photosynthetic machinery were negatively affected by the alternative treatment but some genotypes (Ferum and Levovil) were more sensitive.



Significant differences between treatments

Fig. 3 : Total AUDPC for predawn water potential, plant growth and performance index for "AT" and control plants (n=5)

Conclusion & Perspectives

The alternative treatment helped reducing the use of water by 25% compared to the control. This irrigation strategy might be interesting despite an average loss of 8% in terms of plant growth. On their whole the results suggest that accurately monitoring irrigation to maintain soil humidity above critical thresholds and selecting genotypes for their tolerance, may be a good strategy to reduce water input in horticultural crops.

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