Combining deficit irrigation and recovery periods can save water and maintain yield and fruit quality in tomato

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Combining Deficit Irrigation And Recovery Periods Can Save Water And Maintain Yield And Fruit Quality In Tomato

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Abstract

Climate change has a significant and increasing impact on water resources. Water deficit could negatively impact plant growth and yield. Increased interest to control deficit irrigation to save water seems to be a good alternative to current practices. The innovative strategy of alternating deficit irrigation periods of increasing intensity and recovery periods permits to save water, to maintain plant growth without any negative impact on fruit quality and yield.

Introduction

In the future, plants will experience more repeated cycles of water deficit, which could negatively impact on yield (Farooq *et al.*, 2009). However, water deficit is also known to improve fruit quality under certain conditions of application (Ripoll *et al.*, 2014). It is interesting to exploit water deficit to increase fruit quality while maintaining yield? Diminution of growth is one of the most current adaptive response to deficit irrigation for tomatoes (Chaves *et al.*, 2003) but it could be partially compensated during a recovery (Xu *et al.*, 2010). Also a slight stress could improve the tolerance to further stress (Stoeva *et al.*, 2010). We test here the potential of alternating periods of deficit irrigation (DI) of increasing intensity and recovery periods (RP). We include in our study the genetic influence factor by using the 8 parents of the MAGIC TOM (Multi-Parent Advanced Generation Inter-Cross) population (Ranc, 2010).

Materials & Methods

Plant Material: see the description of the 8 parents of MAGIC TOM populations in table 1.
In all plants, trusses were pruned to a given number of fruits for truss to avoid competition effects
Treatments:
- Control plants: irrigation was based on plant evapotranspiration per day, measured twice daily
- Stressed plants: the treatment consisted in **alternating three 15-days periods of deficit irrigation (DI) interrupted by two 15-days periods of recovery (RP)**
  - DI1 : -38% of water supply in comparison with control irrigation
  - DI2 : -45% of water supply
  - DI3 : -55% of water supply
  - RP: same irrigation as in control plants

Genotype	Species	Ripe Fruit weight	Fruit cellular division period in days	Fruit cellular expansion period in days	Fruit maturation period in days
Cervil	*S.l.cerasiforme*	< 5g	14	25	10
Criollo	*S.l.cerasiforme*	< 15g	21	24	10
Ferum	*S.l.esculentum*	< 130g	20	25	10
LA0147	*S.l.esculentum*	< 130g	21	24	10
LA1420	*S.l.cerasiforme*	< 50g	21	24	10
Levovil	*S.l.esculentum*	< 130g	25	25	10
Plovdiv XXIVa	*S.l.cerasiforme*	< 50g	25	25	10
Stupicke Polni Rane	*S.l.esculentum*	< 70g	25	26	10

Table 1: Fruit and phenological data of the 8 parents of the MAGIC TOM population

Measurements:
- **Leaf surface** was estimated by multiplying leaf size and the number of leaf 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
- **Fv/Fm** was measured using a fluorimeter (Handy-PEA, Hansatech©)
- **Fruit fresh weight**
- Fruit quality was assessed by measuring the **percentage of dry matter** and the contents in **total soluble sugar and total organic acid** by HPLC

Statistical analysis:
- Correlation among plant phenotyping data, measured at the end of DI3, was evaluated by an **ACP correlation circle** realized with R (2.13, package FactoMine R).
- Effect of treatments on fruit parameters were analyzed with R (2.13) by the non parametric test of **Kruskal-Wallis with post-hoc analysis** from the package "pgirmess"

Results

Irrigation treatment permitted **a reduction of 25% of water supply for the whole culture period** in the stress treatment

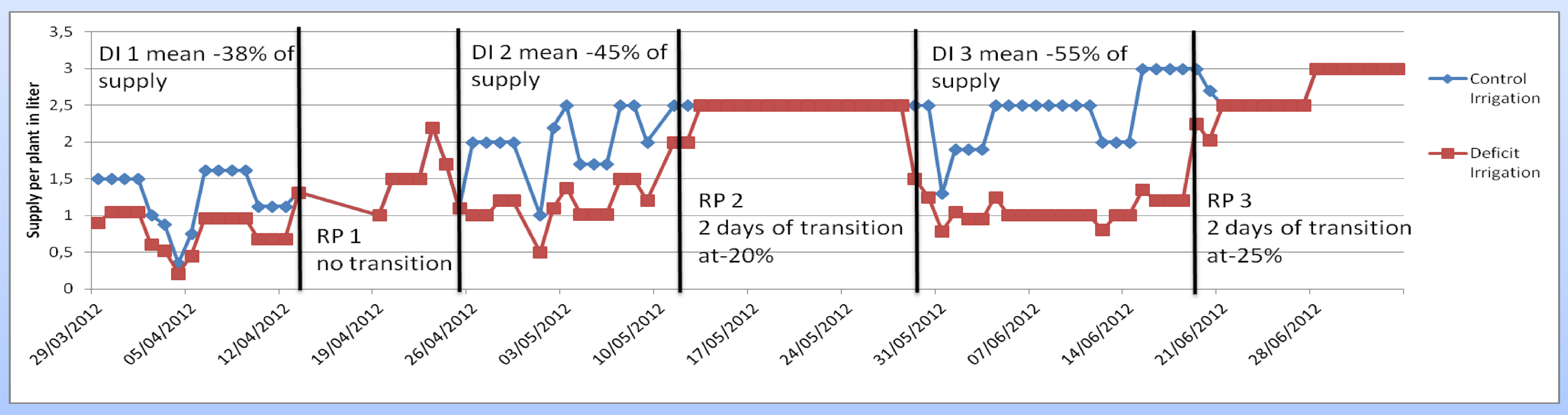

Fig. 1: Treatments time table of deficit irrigation (DI) and recovery periods (RP)

Dry matter and total soluble sugar and organic acid contents were not negatively affected by the water stress treatment

- Dry matter content of the fruits of the water stress treatment was increased (p=0.1)
- Total soluble sugar and total organic acid contents were both increased in the water stress treatment (p=0.1),with exception of total organic acid in Criollo and Plovdiv fruits
- The sugar increase seems to be mostly due to a dilution effect

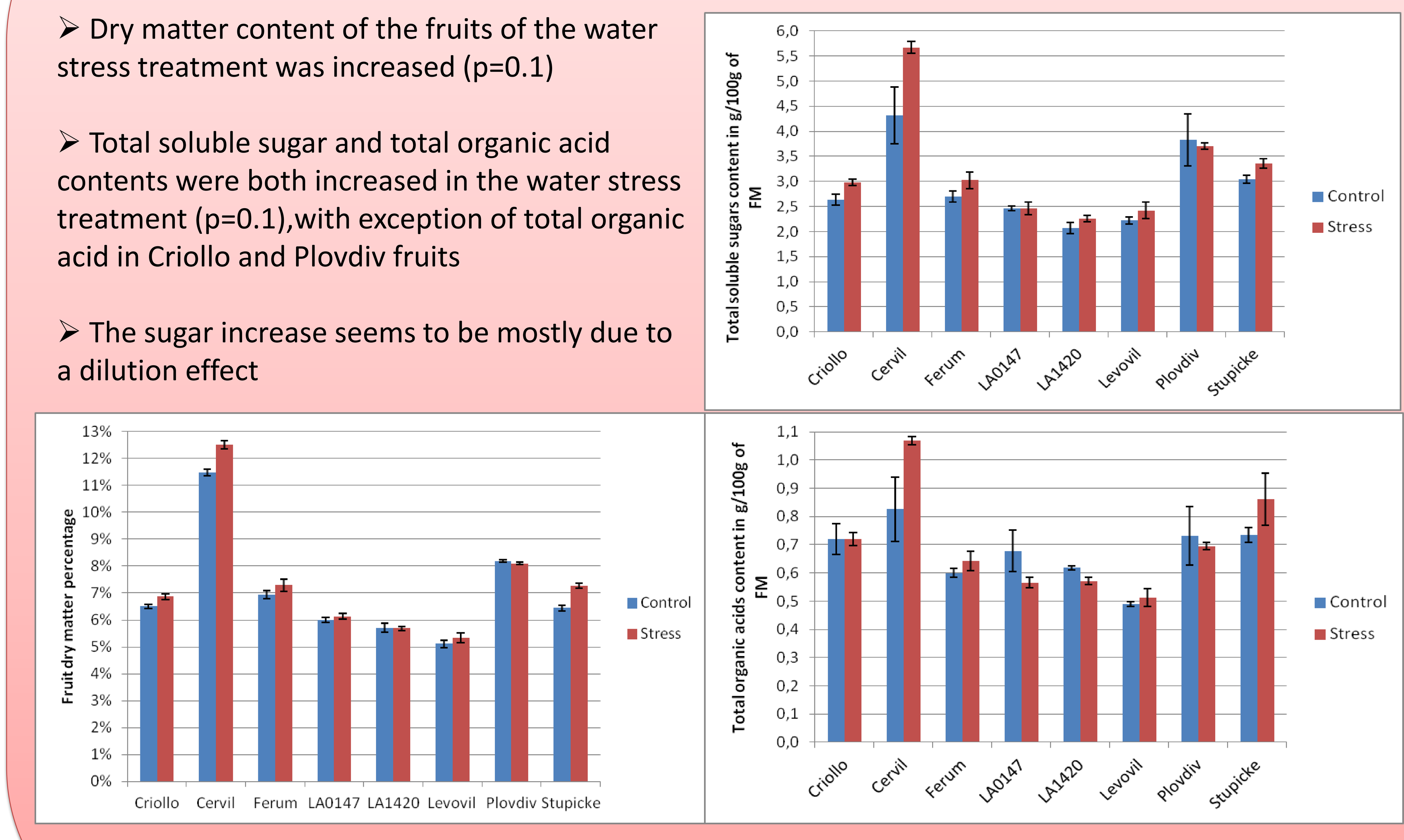

Fig. 4: Fruit dry matter content and total soluble sugar and total organic acid content in g/100g of fresh matter, for control and stressed fruits of each genotype (10 to 20 repetitions per treatment)

Effect of the water stress treatments at the end of DI3

- Axis 1 (24.55%): treatment effect
- Axis 2 (16.15%): genotype effect
- Parameters most correlated to axis 1: percentage of dry matter in leaves, stem water potential at predawn and midday, and Fv/Fm.
- Plant performance (Fv/Fm) was slightly reduced by the DI3 but not significantly (N.S.)
- Leaf surface was best correlated with the genotype axis because of differences among genotypes (N.S. for irrigation treatment)

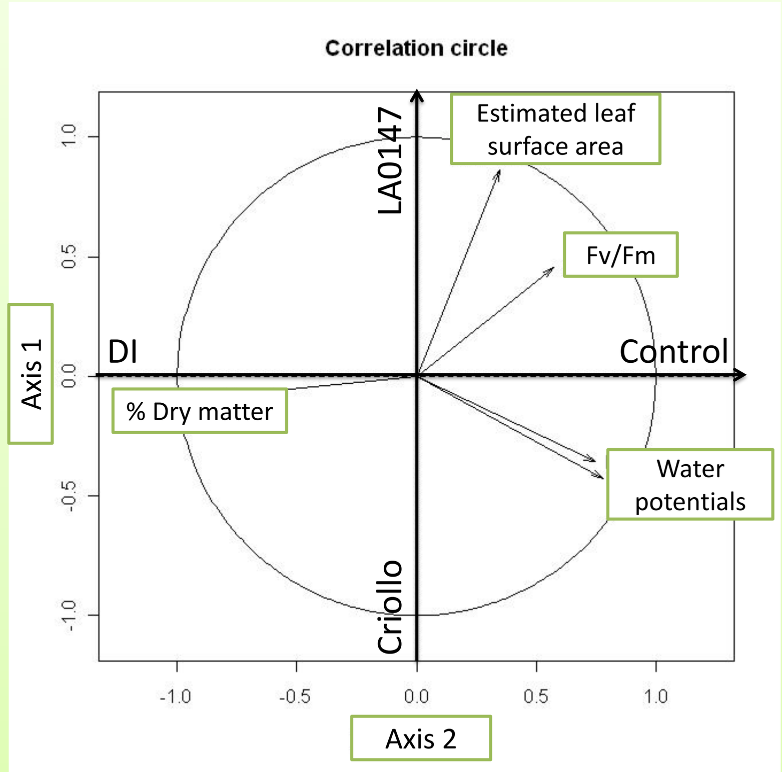

Fig.2: Correlation circle of ACP analysis, at the end of DI3, for each genotype in comparison to control plants (5 repetitions per treatment)

Fruit fresh weight was slightly impacted by the water stress treatment

- Fruit fresh weight was slightly reduced for all stressed genotypes
- No statistical treatment effects on fruit diameter and fresh weight were found (at p<0.05), so yield was maintained in the water stress treatment

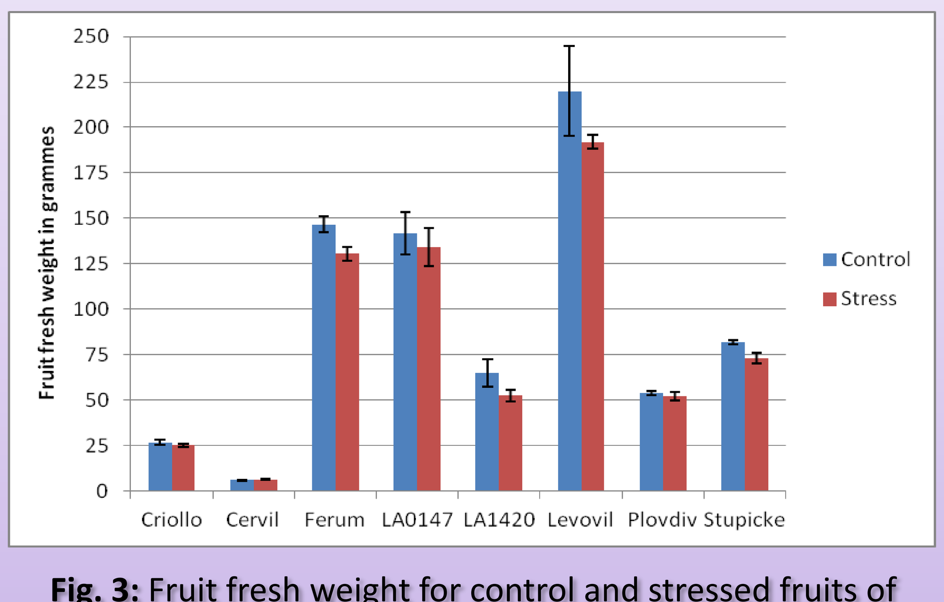

Fig. 3: Fruit fresh weight for control and stressed fruits of each genotype (10 to 20 repetitions per treatment)

Conclusion & Perspectives

Taken globally, our observations indicate that alternating deficit irrigation periods of increasing intensity and recovery periods permits to globally maintain plant growth without any negative impact on fruit quality and yield. Despite a large genetic variability in the fruit traits which were measured, an homogeneous response to the treatment could be observed concerning the fruit fresh weight, dry matter content, and sugar content. More contrasted response was measured regarding the acid content.
The water stress treatment saved 25% of water in comparison to control irrigation. This strategy may be exploited to save water without any negative effect on yield.

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