How to improve Fruit Quality and Plant Resistance ?
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Impacts of Deficit Irrigation at the Plant and Fruit Scales

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- Axe 1 : Analyse des impacts
- Axe 2a : Analyse de l'élaboration de la qualité initiale
- Axe 2b : Analyse des effets des procédés
- Axe 3 : Effets biologiques – Evaluation de la « valeur-santé »
- Axe 4 : Valorisation des signes de qualité

Introduction

To face the increasing pressure on water resources, alternative irrigation practices, such as deficit irrigation, are needed. In horticulture, controlled deficit irrigation might be a good alternative to reduce water use. Deficit irrigation is known for improving fruit quality but with reduction of yield (Barbagallo et al 2013). However, if response mechanisms to deficit irrigation are better understood and quantified it would be possible to find compromise between quality and yield. The proposed approach is essentially an experimental approach without a priori that intends to identify key features of the response to deficit irrigation at the scale of plant and fruit, and on resistance to pathogen.

Material & Methods

Different tomato genotypes were chose according to their specific sensibility :
- Sensibility to deficit irrigation : Plovdiv XXIVa (+) and LA1420 (-)
- Sensibility to pathogen : Momor (-) and Monalbo (+)

Monitoring of deficit irrigation :
- Measures of water potential were realized on fully expanded leaves with a pressure chamber at predawn
- Soil humidity was measured with a WCM Control (Grodan)
- Performance index of Strasser was evaluated by fluorescence measure with a Handy-Pea (Hansatech)
- Fruit water potential was measured with a WP4C (Decagon) by cutting slices of fruits (pericarp + gel)
- Fruit osmotic potential was realized on fruits stored at -20°C, sap was extracted with a syringe filtered with cotton, and the dew point potential was evaluated with a Vapro5520 (Wescor)

Infection with pathogen :
- One strain of *Botrytis cinerea* (BC1) was used
- A slice of gel with mycelium was placed on cut leaves placed in a box with moistened paper
- Infected surface area was measured after 3 days

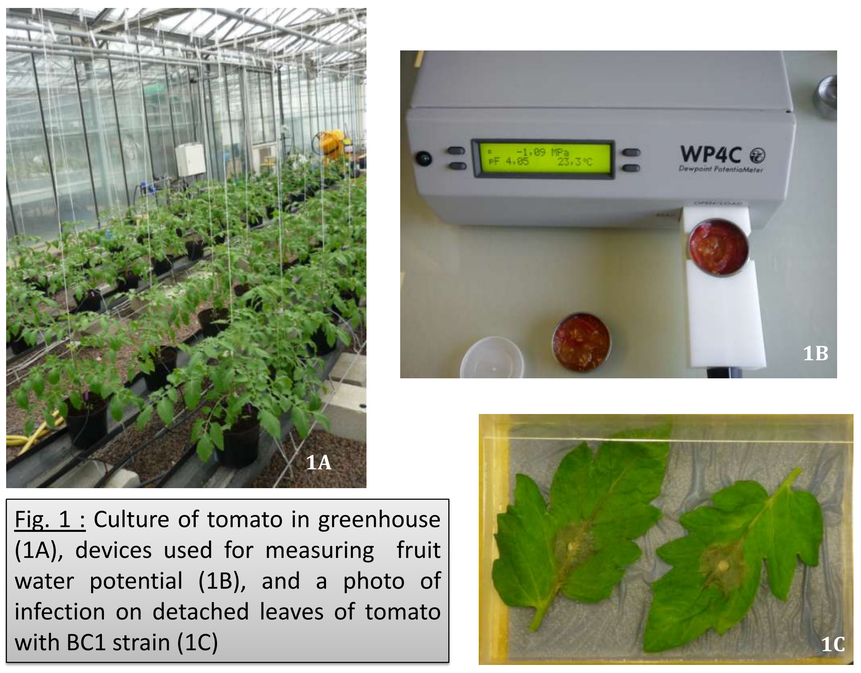
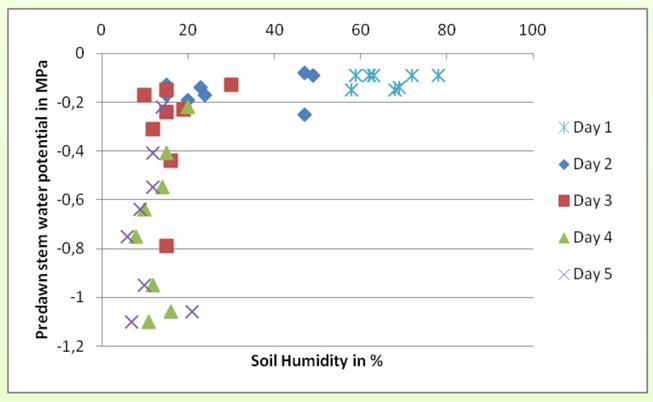
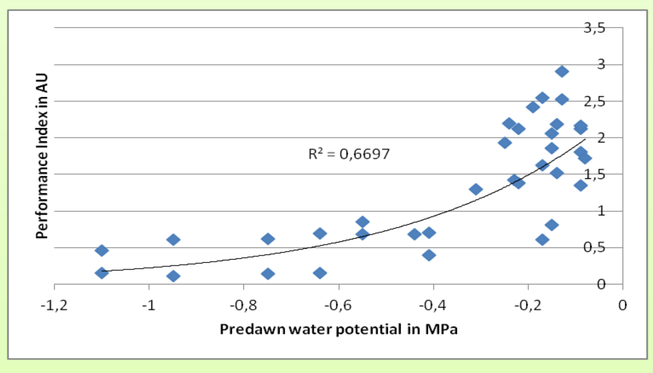


Fig. 1 : Culture of tomato in greenhouse (1A), devices used for measuring fruit water potential (1B), and a photo of infection on detached leaves of tomato with BC1 strain (1C)

Results

Soil Drying – Plant scale

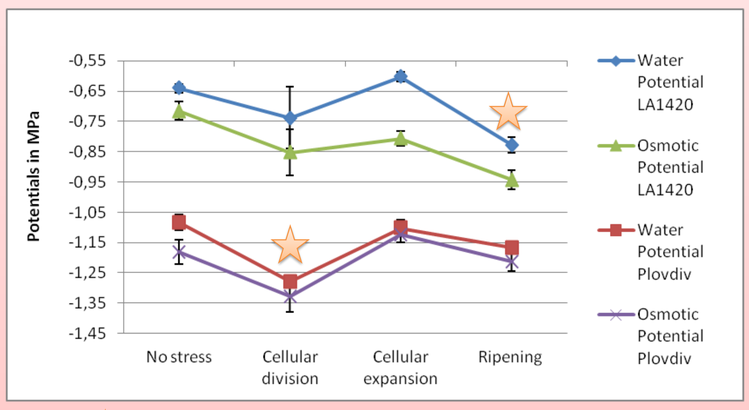




Nb: the soil drying was realized in a climatic chamber in order to permit a slow and progressive drying (on plants grown in greenhouse)

Fig. 2 : Predawn leaf water potential related to soil humidity during complete soil drying, and predawn leaf water potential related to Performance Index of Strasser (Plant vigor), mean values for LA1420 and Plovdiv genotypes (no significant difference between genotypes, Anova on R)

Deficit irrigation impact at Fruit scale



Significant difference p-value<0.01 (Anova, R)

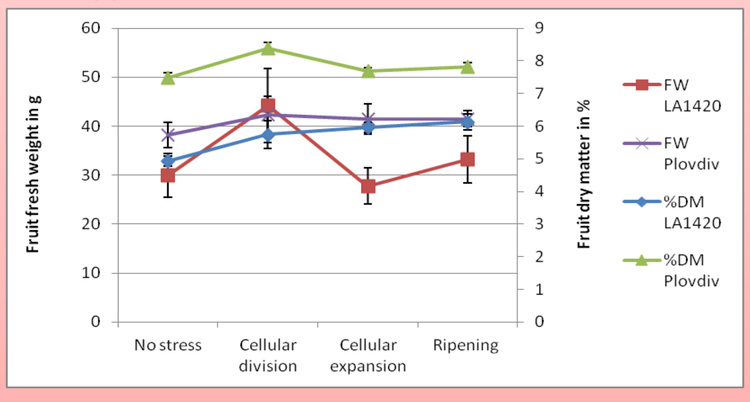
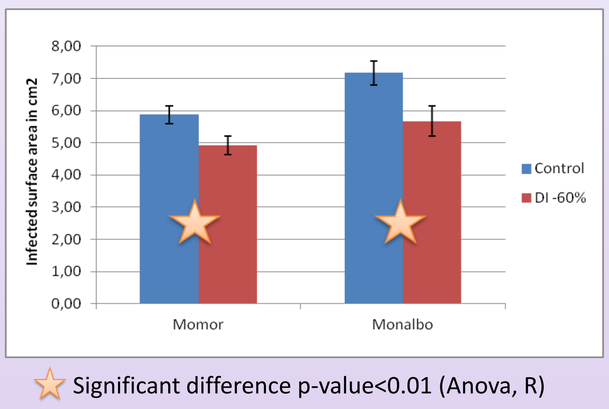


Fig. 3 : Osmotic and water potentials (5 repetitions per treatments), and fresh fruit weight (FW) with dry matter (DM) content (10 repetitions per treatments), fruits harvested at red stage ; deficit irrigation (60% less than control) was applied at different developmental stage (cellular division and expansion, and ripening)

Deficit irrigation alone and in Interaction with *B. cinerea*



Significant difference p-value<0.01 (Anova, R)

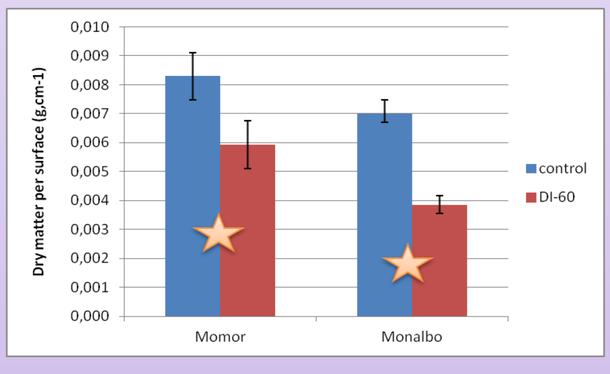


Fig. 4 : Infected surface area after 3 days of infection by *B. cinerea* on cut leaves for control and deficit irrigation (60% less than control during 3 weeks) and dry matter per surface area for this two treatments (5 repetitions per treatments)

Part I : Soil humidity decreased after the third day of soil drying. Predawn leaf water potential is better correlated to water potential (as resumed by Jones (2004)). The response curve to soil drying showed an increasing intensity of water stress after the third day. The decrease in leaf water potential was also correlated with plant vigor (Performance Index of Strasser et al. 2004), which strongly decreased after when the potential was lower than -0.2 MPa as humidity fell below 20%. Performance index on absorption basis is a product of terms expressing energy bifurcation in PSII (see review Strasser et al., 2000).

Part II : Genotypes responded differently to water restriction depending to the period of application. LA1420 was more sensible during fruit ripening stage for water and osmotic potentials. On the contrary, Plovdiv was more sensitive when the stress occurred during the cellular division (significant difference $p<0.01$ for osmotic and water potential both, Anova on R). Fruit fresh weight was not significantly different among all treatments. Fruit dry matter increased with deficit irrigation, differences were significative for cellular expansion and ripening for LA1420 and cellular division for Plovdiv. So, this type of water restriction could permit to increase the molarity of fruit relied to an accumulation of solutes (increased dry matter, biochemical analysis are planned) without a reduction in yield (expressed by fruit fresh weight).

Part III : interaction between abiotic and biotic stress factors could have a positive or negative impact on plant health. Here, the interaction between *B. cinerea* and water restriction (after 3 weeks of stress) have a positive effect on infection of cut leaves for two genotypes, like it was observed by Achuo et al. (2006) in another experiment. Contrary to Calcagno et al (2011), deficit irrigation had a different impact on dry mass per leaf area with an elongation of leaves and a reduction in thickness. This experiment will be repeated soon.

Conclusion

On their whole, results indicate that deficit irrigation permits to reduce water consumption, to improve fruit content in metabolites see with the increase in dry matter content for specific stress dependant of the genotype, and plant defense status by natural pathway.

References

Achuo, E. A., Prinsen, E., & Hofte, M. (2006). Influence of drought, salt stress and abscisic acid on the resistance of tomato to *Botrytis cinerea* and *Oidium neolycopersici*. *Plant Pathology, 55(2), 178-186.*

Barbagallo, R. N., Silvestro, I. d., & Patane, C. (2013). Yield, physicochemical traits, antioxidant pattern, polyphenol oxidase activity and total visual quality of field-grown processing tomato cv. Brigade as affected by water stress in Mediterranean climate. *Journal of the Science of Food and Agriculture, 93(6), 1449-1457.*

Calcagno, A. M., Rivas, M., & Castrillo, M. (2011). Structural, physiological and metabolic integrated responses of two tomato (*Solanum lycopersicum* L.) cultivars during leaf rehydration. *Australian Journal of Crop Science, 5(6), 695-701.*

Jones H.G. (2004) Irrigation scheduling: advantages and pitfalls of plant-based methods. *Journal of Experimental Botany, 55, 2427-2436.*

Strasser R., Tsimilli-Michael M., Srivastava A. (2004) Analysis of the Chlorophyll a Fluorescence Transient, in: G. Papageorgiou and Govindjee (Eds.), Chlorophyll a Fluorescence, *Springer Netherlands. pp. 321-362.*

Strasser, R. J., Srivastava, A., & Tsimilli-Michael, M. (2000). The fluorescence transient as a tool to characterize and screen photosynthetic samples. In M. Yunus, U. Pathre & P. Mohanty (Eds.), *Probing Photosynthesis: Mechanism, Regulation and Adaptation, (pp. 445-483). London: Taylor and Francis.*