TOMRES

A novel and integrated approach to increase multiple and combined stress tolerance in plants using tomato as a model

Programme and Book of Abstracts

TOMRES Online Workshops
5 & 15 March, 2021

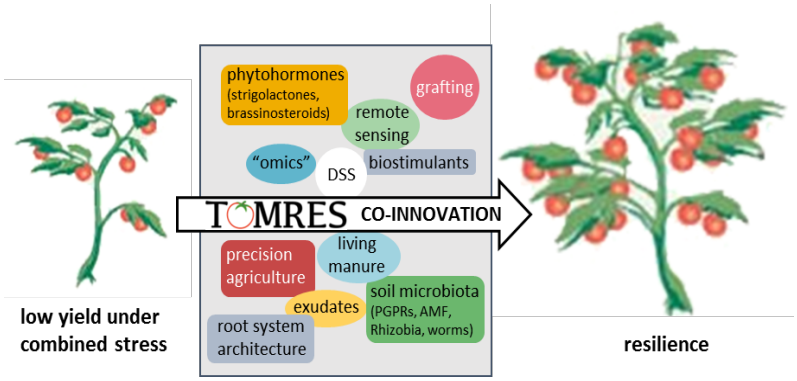
v1.0 – 4 February 2021

TOMRES has received funding by the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No.727929

Introduction

Tomato is a main EU agricultural commodity, cultivated all over Europe in open and protected field and in glasshouses, representing a biological and agronomical model crop. Combined water and nutrient stress is a major problem for tomato farmers and solutions are needed to safeguard yields, while preserving the environment.

The overall goal of TOMRES is to enhance resilience to combined water and nutrient stress in tomato and to maximize water (WUE) and nutrient use efficiency (NUE) by designing and testing in the field (open and protected) novel combinations of genotypes and management practices reducing the environmental impact of agricultural activities.



To this aim, TOMRES will select, among over 10,000 available accessions, rootstocks and scions tolerating combined stress, while retaining fruit quality and yield, taking advantage of innovative screening approaches. Novel traits, in particular belowground, to be exploited in breeding, will be identified. The role of selected hormones (strigolactones and brassinosteroids) will be studied to identify further resilience traits. TOMRES will test and optimize sustainable crop management strategies such as legume intercropping, precision fertilization and irrigation techniques, manipulation of symbiotic microorganisms, and the use of rootstocks more suited to water and nutrient uptake from the soil.

Novel genotypes X management strategies will be developed with the goal of reducing N and P application by at least 20%, water input by 40%, while granting environmental sustainability and economic viability of the solutions proposed. Testing will be integrated with analysis of environmental (greenhouse emissions, water quality), and of socio-economic impact. Agronomical, environmental, and economical data will be processed to construction of models and of a Decision Support System.

Demonstration and dissemination activities will follow the whole course of the project, and will transfer the results to different environments and other cropping systems, thus ensuring the widest impact of the gained knowledge on the EU economy. Trans-disciplinary knowledge transfer among farmers, breeders, industries, associations and scientists will be granted by a solid multi-actor approach since the planning stage.

The two TOMRES online Workshops are part of this strategy.

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Preliminary Programme

Workshop I: TOMRES contributions to basic plant biology

Date: Friday 5 March 2021, 10:00-12:30 CET

The workshop will be moderated by Hannah Jaenicke and Simone Röhlen-Schmittgen

Time	Topic	Speaker
10:00 – 10:10	Welcome & Introduction	A. Schubert, H. Jaenicke
10:10 – 10:30	Drought tolerance in tomato	D. Zamir
10:30 – 10:50	A tale of plant hormones: how strigolactones shape water use efficiency and reproduction in tomato	F. Cardinale
10:50 – 10:55	Comfort Break	
10:55 – 11:15	Quantifying root traits in Tomato using 3D X-ray imaging	C. Sturrock
11:15 – 11:35	The effect of the arbuscular mycorrhizal symbiosis on tomato and wild relatives and stress resilience	L. Lanfranco
11:35 – 11:55	High-throughput phenotyping of the TOBC collection under combined stress: identification of the most resilient genotypes	M. Fullana
11:55 – 12:00	Comfort Break	
12:00 – 12:30	Discussion & Wrap-up	Chair: H. Jaenicke

Please register via:

https://uni-bonn.zoom.us/meeting/register/tJYrdu6przItHgJY3Azv7oHBJvU5XpAVRvKo

Further information how to participate at the meeting will be sent upon registration.

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Workshop II: Implementation of TOMRES research in the praxis

Date: Monday 15 March 2021, 14:00-16:00 CET

The workshop will be moderated by Hannah Jaenicke and Simone Röhlen-Schmittgen

Time	Topic	Speaker
14:00 – 14:10	Welcome & Introduction	A. Schubert, H. Jaenicke
14:10 – 14:30	The systematic mapping of methods used to assess crop yield-maintenance under reduced inputs of water-, nitrogen and/or phosphorous: field grown tomato as a model	P. Ianetta
14:30 – 14:50	What can a tomato farmer do in the field to reduce water and fertilizer application?	P. Kalozoumis
14:50 – 14:55	Comfort Break	
14:55 – 15:15	Managing the environmental stress of tomato production requires digitization and the use of artificial intelligence methods	M. Debeljak
15:15 – 15:25	Contribution by SHG/AB member (requested)	tbd
15:25 – 15:30	Comfort Break	
15:30 – 16:00	Discussion & Wrap-up	Chair: H. Jaenicke

Please register via:

https://uni-bonn.zoom.us/meeting/register/tJAlcuqtqTwsG9YVsJn5Ymqlrfoe62RwP-hV

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Abstracts

Workshop I: TOMRES contributions to basic plant biology
Date: Friday 5 March 2021, 10:00-12:30 CET

Dani Zamir, Hebrew University of Jerusalem, Israel
"Drought tolerance in tomato"

Francesca Cardinale, University of Turin, Italy
"A tale of plant hormones: how strigolactones shape water use efficiency and reproduction in tomato"
Regulation of plant growth and reproduction must integrate with signals of environmental stress. Besides acting as ecological communicators with (micro)organisms in the rhizosphere, the phytohormones strigolactones (SLs) inhibit shoot branching, affect root morphology improving soil exploration, regulate reproductive development in certain species, and tune these effects to conditions of water and nutrient deprivation. During TOMRES, part of our work focussed on the roles of SLs on drought stress tolerance and on reproductive development in tomato. Such effects of SLs are often linked with perturbations of the abscisic acid (ABA) message, involving both changes in ABA concentrations and sensitivity but also of ABA transmembrane fluxes; and affect the "memory" of stress in the plant. Possible downstream mediators of the SL effects under stress have been identified, and will be shortly introduced; the identification of further mediators and the elucidation of their mechanistic integration are our next challenge.

Craig Sturrock, University of Nottingham, United Kingdom
"Quantifying root traits in Tomato using 3D X-ray imaging"
The root system of plants is of key importance for the acquisition of water and essential nutrients to support their growth. The depth, width, degree of branching, surface area and angle of a root system are regulated by a complex interplay between the genetic and environmental factors. Understanding how plant roots respond to unfavourable environmental conditions may have benefits to crop breeding programmes by selection of adaptive root traits that can confer stress resilience. However, visualising how roots grow in soil is challenging. Not only is the soil opaque, making it impossible to see how they are growing, but digging them up intact is very difficult and key shape information is often lost (e.g. root angle). Over the last 10 years, the application of X-ray Computed Tomography imaging (originally developed for diagnostic medicine) has enabled the non-destructive measurement of root systems grown in soil under a range of environmental conditions. The technology allows detailed information of the 3D shape of the roots systems and how the develop over time to stress with the goal to discover resilience traits for the plant. In the TOMRES project, we have used the technique to quantify the root system architecture of a selected number of lines to determine if root traits can be identified that confer greater resilience to combined water and nutrient stress. This seminar will present a background to the technique and a summary of the key results.

Luisa Lanfranco, University of Turin, Italy
"The effect of the arbuscular mycorrhizal symbiosis on tomato and wild relatives and stress resilience"

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The root-associated microbiota can protect plants against biotic and abiotic stresses. A role in plant resilience to nutrients limitation and drought, major issues for crop productivity in modern agriculture, has been attributed to arbuscular mycorrhizal (AM) fungi that establish a mutualistic symbiosis with most land plants, including tomato (*Solanum lycopersicum*). Within the TOMRES project we have been testing a number of tomato accessions, including commercial genotypes and wild relative species, for their susceptibility and responsiveness to the AM symbiosis looking at root colonization and growth effect under water and nutrient combined stress. Plant's ability to be colonized by an AM fungus is a rather constant trait in tomato accessions. However, the amount of mycorrhizal colonization and the effect on plant growth vary significantly across genotypes. Unexpectedly the wild species *S. pennellii*, of large interest in tomato breeding, shows a strongly reduced colonization. An RNA-seq analysis, that was used to elucidate the molecular mechanisms underpinning the peculiar phenotype, is pointing to a possible role of strigolactones. In the whole the study is providing insights on plant adaptation to the AM symbiosis and on its effect on responses to stress conditions.

Jeroni Galmes and Mateu Fullana, University of the Baleares, Spain
"High-throughput phenotyping of the TOBC collection under combined stress: identification of the most resilient genotypes"
In the frame of the Work Package 1, the UIB in collaboration with Agroilla drove an experiment to screen the TOBC collection to identify those genotypes with an increased resilience to combined stress. To do so, 165 lines were cultivated under well-watered and combined stress conditions, and leaf morphology, isotopic composition, leaf gas-exchange, fruit production and fruit quality related traits and remote sensing parameters were measured. The obtained results were not only useful to detect the most resilient genotypes, but also to test the use of high-throughput measurements to phenotype large tomato collections.

Workshop II: Implementation of TOMRES research in the praxis
Date: Monday 15 March 2021, 14:00-16:00 CET

Fanny Tran, Jonathan E. Holland, Nora Quesada, Mark Young, Damian Bienkowski, Dimitrios Savvas, Andrea Schubert, Georgia Ntatsi, Philip J. White, Graham S. Begg, Pietro P. M. Iannetta, James Hutton Institute, United Kingdom
"The systematic mapping of methods used to assess crop yield-maintenance under reduced inputs of water-, nitrogen and/or phosphorous: field grown tomato as a model"
Increasingly, the scientific community is asked how crop yields may be maintained, or increased, with lower inputs. However, it is very challenging to achieve food security goals whilst reducing agricultural inputs and agriculture's environmental footprint. Therefore, we selected tomato as a model crop species to study such apparent trade-offs: since high tomato yields are associated with large inputs of water, plus nitrogen- and phosphorus-fertilisers. Also, tomatoes are of significant commercial importance being the most consumed fruit globally, and the crop has been the subject of intense research scrutiny for many years, even centuries. We assessed the published literature as an evidence base to identify approaches which can maintain yields of field grown tomatoes. Using a systematic map protocol, we screened 19,829 studies which could potentially answer

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our research question. Of these, only 221 reports were suitable, and so a significant void was identified in the available literature on how we may practically address the maintenance of crop-yield under conditions of lowered inputs. The results highlight the weak evidence base which is available to guide value chain stakeholders and policy makers in their quest for sustainable intensification. More positively, the insights also identify future crop-research priorities - at least for tomatoes.

Panagiotis Kalozoumis, Georgia Ntatsi and Dimitrios Savvas, Agricultural University of Athens, Greece
"What can a tomato farmer do in the field to reduce water and fertilizer application?"
Farmers are willing to reduce the amounts water and fertilizers they are using by practical and effective management practices. The practices should require small effort, little scientific knowledge and simple directives. At the same time, production should be maintained at an acceptable level. During the TOMRES project, Agricultural University of Athens tested many different sustainable crop management practices suited to improve water and nutrient resource efficiency (W/NUE) upon combined stress in organic and conventional tomato production systems. Basic precondition was that tested management practices should be practical in order to be easily adopted by farmers. Some of the tested management practises were i) the use of legumes as green manure, ii) application of earth worms and iii) inoculation of plants with Plant Growth Promoting Rhizobacteria (PGPR). Three years' experiments on AUA facilities and on experiments conducted in Preveza revealed some interesting management practices, while other did not prove to be significantly effective. Reduction of water and fertilizers will be feasible when novel methods are organized and applied properly.

Aneta Trajanov and Marko Debeljak, Josef Stefan Institute, Slovenia
"Managing the environmental stress of tomato production requires digitization and the use of artificial intelligence methods"
Agronomy is obliged to meet the objectives of several sustainable development goals and must provide a wide range of ecosystem services. This requires quick and correct decisions. Thus, decision-making in agronomy has become an extremely complex process that can be improved using objective scientific approaches. Due to the intensive digitalization of agronomy, both data and existing knowledge increase rapidly. Decision analysis has made significant progress in solving complex problems with data and knowledge-based decision models developed by various methods of artificial intelligence (AI). In the TomRes project, we applied data mining on data from the digitized monitoring of tomato production in greenhouses and fields. We discovered new patterns that allow a very reliable interpretation and prediction of the responses of tomato varieties to different stress combinations caused by reduced water and nutrient supply. In addition, we developed a decision support system (DSS) that will help farmers select management measures for the production of tomatoes exposed to environmental stress. It is based on decision analysis that is supported by AI. The digitalization of agronomy and the use of advanced artificial intelligence methods have enormous potential to facilitate progress in producing sufficient quantities of healthy food in a sustainable and environmentally friendly way.

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