Impact Objectives

- Produce or yield superior tomato genotypes that are better adapted to high temperature conditions
- Understand the factors behind high temperature tolerance
- Address the issue of yield stability in adverse environmental conditions such as high temperatures

A fruitful future

***Professor Mondher Bouzayen** of the **National Polytechnic Institute of Toulouse (INPT)** is the **Coordinator** of **TomGEM**, a cutting-edge Horizon 2020 initiative that seeks to improve fruit yield and quality in harsh environmental conditions. Here, he discusses the key objectives and challenges of the project and reveals what excites him most about the research*

Could you tell us a bit about yourself and how you became the Coordinator of TomGEM?

The scientific community is becoming increasingly sensitive to the issue of global climate warming and its potential impact on agricultural activities worldwide. In particular, the fast-growing world population combined with climate change raises fears of future quality food shortages. When I was Chair of the European COST Action FA 1106 'QualityFruit', these issues were widely discussed and the idea emerged of a project that would help to support research on fleshy fruits as part of a new European initiative. Indeed, fruit is the main source of vitamins and micronutrients in the human diet, and improving fruit yield and quality is highly relevant to the issue of ensuring sufficient amounts of high nutritional quality food. Thus, I invited several European groups to contribute to the establishment of an international network addressing the yield stability topic in the framework of Horizon 2020.

What are the main aims of the project and how will you work to achieve them?

The aim of TomGEM is to select superior genotypes with improved adaptability of fruit production to suboptimal environmental conditions. The initiative builds on a global research alliance bringing together 18 academic and non-academic partner institutions from three continents, including tomato breeders and growers. The yield stability issue in high temperature conditions is addressed using the tomato as a model crop for fruit and vegetables.

TomGEM uses a holistic approach addressing yield trait in unprecedented ways via an integrative multiscale strategy that implements the most advanced technologies and novel breeding strategies to improve yield and fruit quality. The outcome of the research is expected to translate into new breeding targets and novel management practices. In that regard, the final success of the project requires the setup of optimal management practices that can only be achieved upon the active involvement of tomato producers.

Why is it important for you to place a focus on the quality of the fruit produced? How will you go about ensuring high quality products for farmers?

Because enhancing yield can potentially result in nutritional and sensory quality losses, it is essential to evaluate the quality traits of the new cultivars that will be generated within the TomGEM project. The objective is to combine both yield and quality traits for tomato varieties adapted to high temperature conditions.

Since the project commenced in March 2016, have you encountered any challenges? If so, how have you sought to overcome them?

In the first phase of the TomGEM project, the focus has been on screening and phenotyping the available collection of tomato germplasm to select genotypes with the desired yield traits. Collecting genetic material from all over the world has its challenges, especially when dealing with non-EU countries. Nevertheless, so far the project has not encountered any deadlock situations.

What are you most looking forward to working on during the four years of the project and why?

TomGEM aims at identifying key molecular and genetic factors controlling various developmental processes that affect yield stability including fruit set, pollen fertility and flower initiation. I'm most excited by the fact that, if successful, this project will open new avenues towards designing innovative breeding strategies for the adaptation to higher temperatures.

Designing new tomato varieties in the face of climate change

One way in which climate change is negatively impacting our environment is through a decrease in crop yield and quality. To tackle this, the Horizon 2020 project ***TomGEM*** *is aiming to formulate new breeding and horticultural management strategies for harsher climates using the tomato as a reference point*

It is important for humans to consume fresh fruits and vegetables every day to obtain the vitamins, minerals, fibres and antioxidants needed to maintain a healthy diet. However, agricultural scientists are warning that growing produce will become more difficult as temperatures continue to rise, and may subsequently lead to a scarcity in food of nutritional value.

Fleshy fruits could be one such victim of climate change. These comprise many fruit types, including avocados, pears, apples, watermelons and tomatoes, and are major crops that are widely consumed across the world. The complex network of signalling pathways that coordinate the different stages of growth of fleshy fruit – including flower pollination, fertilisation and fruit set – are extremely sensitive to both hormonal and environmental cues. And, with regard to environmental factors, the successful development of fleshy fruit is heavily reliant on numerous aspects, including temperature, light and humidity, as well as insect pollinators. This means that as the Earth's weather conditions become harsher, it will be far more difficult for crops to bear fruit, leading to a decrease in yield.

To tackle this anticipated fall in fleshy fruit crops, agricultural scientists, policy makers and farmers are warning that new strategies need to be put in place to ensure that sufficient yields of fruits and vegetables can be maintained under adverse weather conditions.

NEW APPROACHES TO PRODUCING TOMATOES

TomGEM (A holistic multi-actor approach towards the design of new tomato varieties and management practices to improve yield and quality in the face of climate change) is one such endeavour that seeks to address these climate change-related issues for crops. Launched in March 2016 TomGEM concisely sets out the project's core aim. By using tomatoes, a common fleshy fruit crop, as a reference point, this research initiative will be working on the development of new approaches to maintaining a stable yield of fruits and vegetables grown in high temperatures, ensuring that society is well prepared as weather conditions continue to worsen.

The project is coordinated by fruit biotechnology expert Professor Mondher Bouzayen from the National Polytechnic Institute of Toulouse (INPT), France, and brings together 18 partner institutions from across Europe, as well as from Argentina and Taiwan. Extending the consortium to these latter countries is advantageous as it has enabled access to germplasm collections that are not obtainable in Europe. TomGEM's total budget over the next four years is €5.6 million, which is funded by the EU under Horizon 2020's Societal Challenges pillar in the Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research, and the Bioeconomy Work Programme.

What is particularly noteworthy about the project is that it is not only a multidisciplinary, collaborative effort among scientists, but also involves non-academic institutions such as SMEs. In fact, half of its partners comprise those who are actively breeding, growing and producing the tomato crops themselves. 'While TomGEM applies a multi-actor approach with a consortium of scientists contributing their complementary expertise, special emphasis is put on the active involvement of non-academic partners, including tomato breeders and growers,' states Bouzayen. 'This partnership is essential as it will facilitate the translation of the gained knowledge into innovative breeding strategies of tomatoes as well as into new cultural practices.'

IDEAL TEMPERATURES FOR TOMATO GROWTH

The successful growth of fleshy fruits is affected by environmental factors – and even what may be seemingly small changes in temperature or humidity can have a huge impact on many stages of the fruit development process, leading to decreased yield and quality of the crop. For tomatoes,

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Joining forces

A crucial ingredient for TomGEM's success is its connections with other European initiatives that focus on characterising natural diversity of tomato genotypes, such as TRADITOM (www.traditom.eu) and G2P-SOL (www.g2p-sol.eu), or the biology and quality of fleshy fruits, such as COST Action FA1106 'QualityFruit' (http://qualityfruit.inp-toulouse.fr/en/home.html). All projects involved benefit immensely from this collaborative approach through partners obtaining valuable information regarding the identification and characterisation of relevant genetic resources from each other.

the ideal temperature for optimum growing conditions ranges from 21°C to 29°C in the day and from 18°C to 21°C during the night. But with an increase of just 4°C in temperature, studies have shown a significant reduction in the amount of tomatoes produced. The TomGEM team will therefore be analysing a wide range of tomato varieties in order to select and breed those that are able to better deal with adverse weather conditions. 'TomGEM will select for and breed towards tomato cultivars with desired traits when growing under a temperature between 26°C and 32°C,' Bouzayen highlights. 'To achieve this, the consortium will implement innovative breeding and management strategies to ensure that the outcomes benefit all user communities including researchers, breeders, tomato producers and consumers.'

A QUEST TO FIND THE BEST TOMATO VARIETIES

To find the optimum varieties of tomatoes, a major activity of the project revolves around gathering germplasms from a diverse range of tomato genotypes and closely related species to be screened for lines that are more heat tolerant. It will simultaneously be looking to characterise loci/genes responsible for flower initiation, pollen fertility and fruit set. The assessment of these different germplasms will take place in hot countries, including Bulgaria, southern Italy, Spain and Argentina. And, once the most ideal loci/genes have been identified, the researchers will work on the development of new strategies for placing these optimal versions into genotypes to be used as a parent line for tomato breeding. The key areas TomGEM will be focusing on include high incidence of flowering and increased fruit set, as often in high temperatures the flowers on the tomato plant do not pollinate properly, or they do pollinate but then drop off early, so fruit doesn't grow. The TomGEM team will also assess fruit development and size, as well as post-harvest traits, such as the nutritional quality and length of shelf life at higher temperatures. It is important for the quality of the cultivated fruit to be analysed alongside yield because attempting to improve fruit growth via selective breeding can lead to an end product with less sensory and nutritional value.

A NEW HOPE FOR CROP PRODUCERS

What is particularly cutting-edge about this project is the innovative methods and technologies being used to carry out the research. 'TomGEM will implement the most advanced technologies, concepts and approaches including genome editing, genotyping by sequencing, and chromatin-immuno-precipitation with deep sequencing,' says Bouzayen. 'It will also tackle the epigenetic regulation of yield traits in relation to environmental factors in an unprecedented way.' Ultimately, through utilising these innovative practices, TomGEM hopes to offer tomato producers new breeding and horticultural management strategies for a variety of tomatoes that maintain a good level of both yield and quality in numerous environmental conditions across the world.

Project Insights

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PARTNERS

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CONTACT

Mondher Bouzayen
Project Coordinator

T: +33 5 34323871
E: bouzayen@ensat.fr
W: http://tomgem.eu/

PROJECT COORDINATOR BIO

Professor Mondher Bouzayen leads the Genomics and Biotechnology of Fruits (GBF) laboratory, a joint laboratory between the INRA and INPT. His present research deals with the multihormonal control of fleshy fruit development, with a major focus on the developmental transitions underlying fruit set and fruit ripening. Under his direction, GBF has contributed in recent years to the generation of generic tools and resources for the use of the tomato as a model species. Bouzayen has substantial experience in coordinating national and international programmes, including Chair of the COST Action 'QualityFruit' (July 2012–October 2016).

TomGEM