10 Questions and Answers about EU-SOL

1. What is EU-SOL?

In 2006 an extensive network of plant scientists from universities, research institutes and industry joined in a project focusing on the development of high quality and healthy tomato and potato varieties with improved consumer-, processor- and producer-directed traits. The consortium brings together expertise across a wide variety of disciplines, from taxonomy to molecular biology to consumer integration. The members come from across the EU, Bulgaria, Israel, Palestinian Terrirtories , Argentina, Brazil and South-Africa.

Strategic objectives addressed by EU-SOL

EU-SOL has five strategic objectives:

1. To extract the under-exploited natural biodiversity present in Solanaceae to improve consumer-driven and environmentally-directed quality of tomato fruits and potato tubers;
2. To map, isolate and characterise genes responsible for quality traits and to dissect the molecular mechanisms underlying these traits by application of state-of-the-art knowledge and innovative technologies;
3. To assemble these genes within new genotypes to boost our knowledge and provide a blueprint for novel high quality varieties to be developed by EU breeding companies;
4. To coordinate and integrate breeding research for quality traits, to provide training in innovative technologies, to disseminate the results and to transfer knowledge and technologies to industry;
5. To participate in the international tomato genome sequencing initiative that will tie European Solanaceae research and innovation into the full global activities in this area.

2. Why focus on potato and tomato?

Tomato fruits and potato tubers, both belonging to the Nightshade family (Solanaceae), are the two most important non-cereal products in the EU, both from an economical and nutritional perspective. Also in China, the USA, India and other parts of the world, both crops account for an essential part of agricultural production and human nutrition. Production, processing and trade in tomato and potato products is a multi billion Euro business that provides an income for a vast number of people in the breeding industry, agriculture, processing industry, and trade.

3. What makes potato and tomato important in nutrition?

In 2008, several organizations cited the potato's potential derived from its status as a cheap and plentiful crop, which can be grown in a wide variety of climates and locales. In addition, potato is an important source of starch, which has chemical properties that has specific food and industrial uses. The United Nations Food and Agriculture Organization (FAO) reports that the annual diet of an average global citizen in the first decade of the twenty-first century would include about 33 kg of potato, ranging from as much as 172 consumed by the average Belarus to less than 10 kg in a large number of developing countries.

Tomatoes are an important part of the diet, especially in Mediterranean countries and the Middle East. The average citizen in the European Union consumes 28.8 kg of tomatoes annually. Tomatoes are a rich source of vitamin C, but also contain significant amounts of vitamin A, vitamins B - including niacin and riboflavin-, magnesium, phosphorous and calcium. In recent years particular nutrients found in abundance in tomatoes, lycopene, flavonoids and chlorogenic acids, have made headlines for its disease fighting abilities. These nutrients are powerful antioxidants and as such help to protect the cells in our bodies from damage caused by cancer or degenerative, age-related diseases.

Tomato production

Thousands of tomato cultivars have been selected. There is a huge variety in size - from cherry tomatoes 1- 2 cm in diameter to beefsteak tomatoes as big as 10 cm or more in diameter-, shape, fruit colour, taste, texture and plant architecture. Apart from tomatoes grown for direct consumption, there is an extensive amount of processing tomatoes grown for canning, paste, sauce or juice. According to the FAO, world-wide tomato production amounts to almost 130 million tonnes (2008), grown in the open field as well as in greenhouses. The major tomato producer is China (33.8 million tonnes in 2008). This country produces more than twice the amount of tomatoes produced in the European Union and the United States (in particular in California). Also Turkey is a major tomato producer. In the European Union, most tomatoes are produced in the southern member states, Italy, Greece, Spain and Portugal, followed by The Netherlands and France. Tomatoes are also very popular among home growers and small subsistence farmers.

On average, tomato growers yield 400 tonnes/ha or even more in the greenhouses in North Western Europe, 50-70 tonnes/ha in Southern Europe and the United States, and 10 tonnes/ha or even less in most developing countries.

Potato production

There are close to 4,000 varieties of potato. There is russets, reds, whites, yellows, and purples. Floury, or mealy (baking) potatoes have more starch than waxy (boiling) potatoes. According to the FAO, world-wide potato production amounts to 314 million tonnes (2008).The major potato producer is the European Union (61.5 million tonnes in 2008), followed by China, India and the Russian Federation. Potato production is concentrated in North Western Europe (Poland, Germany, The Netherlands, France and the United Kingdom).

Average yields are as high as 45 – 50 tonnes/ha in New Zealand, The Netherlands and the USA, 20 tonnes/ha or less in Eastern Europe and about 10 tonnes/ha in most developing countries.

4. Why is there a need for new traits?

The market for tomatoes and potatoes is highly dynamic. Both consumers and producers demand products with new characteristics.

Consumers demand better taste for a reasonable price. Quality and wholesomeness of food are two issues addressed prominently in society and consumers in industrialised countries increasingly prefer 'regional' and 'niche' food specialties.

Agriculture is an important economic activity, but under pressure from many sides. Globalisation, environmental issues, price competition, land shortage, plant pests, changing consumer preferences: they all in their own right demand adaptation of the agricultural system. Therefore, growers need crops that harvest sufficient yield with less labour, less pesticides, and less energy. The industry demands fruits and tubers that need less processing and produce high quality products for their customers.

Such demands require permanent breeding for crops with adapted characteristics.

5. What type of traits are of interest?

EU-SOL particularly focuses on mapping, isolation and characterisation of genes responsible for traits that are important for consumers and processers, and unravels the mechanisms underlying these traits.

Traits of interest for consumers are the presence of health components, nutrition, aroma, fragrance, texture, colour, shelf-life, and starch and chipping quality. Examples of traits important for producers are plant architecture (long/short plants, branching), fruit set and conservation, tuberisation and cold tolerance.

Apart from the specific needs of consumers and producers, there is a general need to develop crops better adjusted to a changing climate, including traits for improved yield on poorly fertile soil and for tolerance to situations of reduced water availability or increased salinity. There is also a need for crops with improved yields that will enable us to feed an increasing world population.

6. Is conventional breeding no longer needed?

Conventional plant breeding, based on selection of plant material with desired characteristics, crossing of varieties with different characteristics, selection for the additional characteristics and backcrossing of selected crossings with the parent variety, has contributed to a large number of modern varieties. In the last three decades several sophisticated molecular techniques have been developed that seem to have transformed plant breeding in a revolutionary sense. Nonetheless, the use of those techniques speeds up breeding process and reduces the number of plants to analyse, but always results in a single event, a kind of prototype plant, which is subsequently

used for crossing into commercial cultivars with conventional breeding methods. Moreover, the existing tomato and potato species still hold a wealth of genetic diversity that can be simply tapped by applying conventional breeding methods. Therefore, all plant breeders still use those conventional plant breeding methods, which involves a great deal of craftsmanship

7. What does EU-SOL add to existing breeding practices?

Although conventional plant breeding is still successful and indispensable, it is a time consuming process. It usually takes several cycles of back crossing, collection of seeds or seedlings, and growing new plants for further selection. To develop a new tomato variety takes, on average, five to seven years, and to develop a new potato variety can even take more than fifteen years. New tools, based on detailed knowledge of the factors that control fruit and tuber quality will help to improve and speed up the breeding process.

X-omics

X-omics is the ensemble of four technologies that is used for large scale collection of data about the characteristics and functions of cells:

1. **Genomics**, the study of the genome (DNA) of cells, includes the sequencing of the four building bricks (DNA) of genomes, A,T.C and G, so we can compare the genetic make-up of different varieties or species;
2. **Transcriptomics**, the study of the activity of genes. Transcription of genes, the first step that leads to gene expression, occurs by synthesis of an equivalent RNA copy of a sequence of DNA. So the presence of RNA tells us about gene activity;
3. **Proteomics**, the study of gene products (proteins). Cells translate the RNA copies in proteins;
4. **Metabolomics**, the study of metabolic pathways or the chemical fingerprint of cells at a certain moment.

Whereas the *genes* tell us about the *potential* of cells, the *RNA* tells us which genes are *active,* the *proteome* tells us which *proteins* are present, and the *metabolite composition* tells us about the *amount of specific molecules* at a certain moment.

EU-SOL scientists analyse consumer preferences for quality traits and attempt to dissect the genetic and molecular components that control these quality traits. The knowledge about the plant genome, the translation of genes in proteins, and the role of those proteins in plant metabolism (X-omics; see box), the biochemical processes that result in compounds that define characteristics such as fruit shape, colour and taste, is increasing rapidly. This knowledge can help us to determine the biochemical and genetic processes in plants that affect consumer-driven and environmentally-directed quality of potato and tomato. Technologies that support and build upon this knowledge, such as rapid DNA sequencing techniques and genetic engineering, are important tools that help us to discover traits of interest and the genetic factors responsible for the expression of those traits in cultivars (commercial varieties), traditional landraces and wild relatives of tomato and potato, so the natural biodiversity can be exploited more effectively. Genes that are considered candidates for controlling traits of interest are identified and experiments are done with those genes assembled in new genotypes, so their effects can be studied. Thus, step by step we can boost our knowledge of the factors that control quality.

To date companies have been slow to pick up on proteomics and metabolomics. It thus falls to public sector science to develop these.

8. How will the results be used?

Ultimately, EU-SOL is meant to provide tools for novel high quality varieties to be developed by EU breeding companies using efficient and rational breeding strategies. One of these tools is the use of DNA markers for selection of conventional crossings (Marker Assisted Selection; see Box). The results will also enable plant breeders to apply genetic engineering that exclusively use genes of the same plant species (cisgenesis) but most breeders are reluctant to use this technology because of public aversion.

The project focuses on tomato, potato and, to lesser extent, other Solanaceous crops such as peppers and eggplant. Nevertheless, the initiators also intended to create a model for how world-wide scientific collaboration can lead to innovative research that contributes to improvement of global food security related to a wide variety of other crop plants.

What is Marker Assisted Selection (MAS)?

Marker Assisted Selection is a technology that makes it possible to detect desired characteristics in plant crossings at an early stage of development, for instance in the seeds or seedlings, by looking at specific DNA sequences. By linking specific plant characteristics to a certain string of DNA in their genome, it is possible to know whether crossings have inherited these characteristics. Sets of such well-defined DNA strings or markers have been, and still are developed. They can be easily detected with DNA analysis tools, thus enabling plant breeders to test for the associated characteristics.

9. What is the advantage of Marker-Assisted Selection?

The application of MAS in conventional breeding programmes has four main advantages:

1. You do not need to wait until the crossing has matured far enough to observe the phenotypic character in question, for instance an increased sugar level or improved cold tolerance. Selection can be thus be performed at a much earlier phase of development and in series with sequencing (determining the DNA sequence), thus saving a lot of time.
2. Breeders want to keep all the favourable characteristics of the original variety and add only the desired characteristic of the plant they are crossing with. They certainly do not want to add undesired characteristics. With DNA markers they can more easily check which seeds are closest to the original variety and still possess the new characteristics. Breeders can also save a lot of time here because they require fewer generations of plants to remove genes encoding undesired characteristics.
3. Breeders can more easily check for hidden characteristics since they can trace back the best characteristics in crosses, even those that are not immediately visible. Thus, breeders can start using plants which are far removed from the commercial cultivar in terms of phenotype, such as wild relatives that contain genes for many desired characteristics that the domesticated plants no longer have in their genepool.
4. Molecular markers make it easier to check for traits that require complex and expensive assessment of a very large number of plants. For instance, markers for specific aromas and sugar content allow to make a pre-selection of a large progeny before tasting the fruits.

10. Who decides what we need?

In the end, breeders will try to create cultivars which correspond to what we need based on the requests and requirements of each stakeholder in the supply chains (growers, processors, retailers) and also on consumers expectations.

The scientists and breeders involved in EU-Sol are aware of the fact that modern plant biotechnology as it has developed in the last three decades, has been a regular source of contention. The use of genetic modification has led to fierce debates in society, especially in Europe, but also in other parts of the world. Apart from the safety issues, these debates tend to focus on the question which goals and whose interests new powerful biotechnologies should serve. In the case of EU-SOL: which targets should be set out for genomics research and to what problems should these targets relate? How do different stakeholders define 'better quality '? More fruits? Healthier food? Robust plants? Grown with less pesticides and fossil energy? Sweeter tomatoes. Potatoes that take up less fat while frying? And how do they think about the acceptability of different technologies in relation to these targets? Is Marker Assisted Selection more acceptable than mutagenesis or genetic engineering?

EU –SOL attempts to get feed back on these questions in several ways. We use taste panels with consumers and professionals to investigate consumer preferences for different types of tomato. In order to widen the range of inputs beyond the direct partners of EU-SOL, we actively disseminate information about the project and backgrounds of tomato and potato breeding and we ask external stakeholders for feed back: Growers, environmentalists, food manufacturers, retailers, consumers etc.etc. This feedback is collected by means of interviews for the EU-SOL newsletter, a page with several discussion items and a blog on the EU-SOL website (www.eu-sol.net).

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