GROW YOUR TOMATOES: PILLS OF CITIZEN SCIENCE

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Harnesstom European Project

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THE HARNESSTOM PROJECT AND THE CITIZEN SCIENCE

"Harnesstom: harnessing the value of tomato genetic resources for now and the future" is a European Union project about all the aspect of tomato breeding, like resistance to abiotic and biotic stress, fruit quality and speeding up of breeding programs.

The project, coordinated by Dr. Antonio Granell at the Consejo Superior de Investigaciones Científicas, (IBM CP-CSIC) counts 22 partners belonging to seven different countries, including universities, private companies, and non-profit associations.

In the Work Package 8 (WP8), which concerns Participatory Plant Breeding and Citizen Science, researchers from Bulgaria, Italy and Spain are involved.

WP8 tasks aim to involve citizens and farmers in research activities, to disseminate scientific principles and procedures, and to increase consumer awareness towards food production and quality.

Thus, citizens/consumers and farmers/growers from Spain, Italy and Bulgaria have been involved in scientific activities, including growing plants, measure phenotypes, express preferences and at last in evaluating new breeding material by giving a score to their productivity, appearance, and taste.

PILLS OF CITIZEN SCIENCE

THE FLOWERING TIME

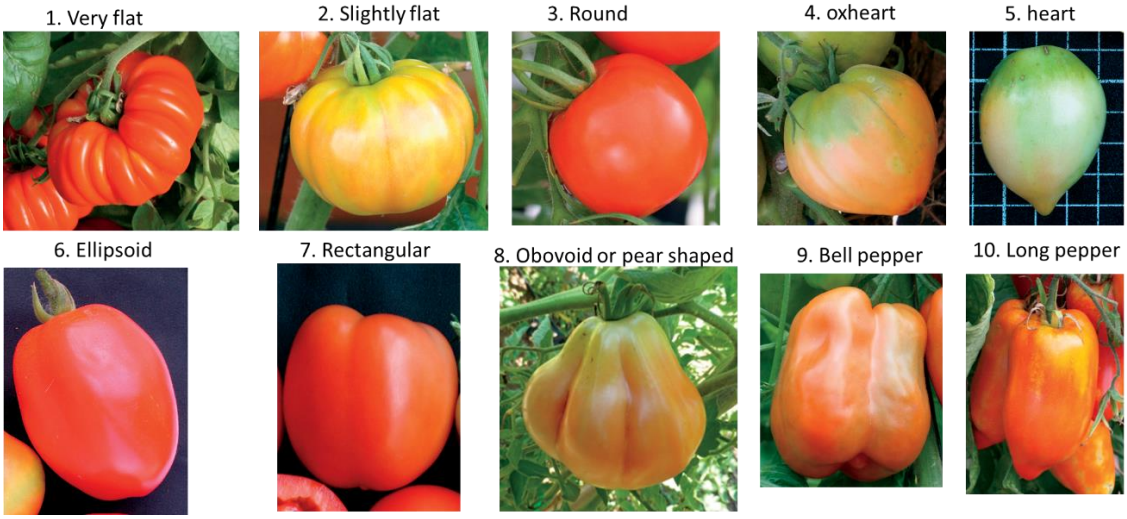
Unlike animals, baby plants do not bear reproductive organs. Their reproductive organs, stamens, and pistils, are developed after flowering is induced and, since plants do not move (they are "sessile"), it is very important that the flowering induction is finely tuned in the most suitable season.

Thus, plants flower in response to environmental stimuli, such as daylength (photoperiod) or cold temperatures (vernalization), or to internal clocks that measure their "juvenile" period. Our tomato belongs to the latter case; it does not check photoperiod (it is "day neutral") nor the cold season. It's adulthood (18th birthday) usually arrives after the 8th true leaf, when the first inflorescence is produced. However, many minor genes affect this timing and different tomato types may greatly differ in flowering date.

THE GREEN SHOULDER

Many tomato varieties produce uniformly light green fruits before ripening, a characteristic that facilitates maturity determinations and promotes even ripening at the stem end. There are also certain tomato varieties that ripen the bottom two thirds of the fruit quickly, but leave the top third green, this is called "green shoulder" and it is represented in the fruits on the right of the above pictures, while the tomatoes of the picture on the left are "uniform".

The "green shoulder" is genetically determined (and the responsible gene is called *Uniform*) but also the environment has a strong effect on its intensity. Thus, high temperatures and strong sunlight during ripening produces the retention of chlorophyll (green pigment) around the stem area, and the shoulder becomes hard and darker.



THE FRUIT SHAPE

At the beginning tomatoes were all round. Geometrically the sphere is the most optimum shape – it has least surface area and at the same time, a most volume in it, which means less energy for the plant to create the protective skin around the fruit. Moreover, when spherical fruit falls on the ground there is more chance of bouncing and rolling to a different area where it can germinate. The domestication process, the long-term selection, and targeted breeding more recently, resulted in a variably shaped fruits of tomato. In other words, the preference of the nature is small and round, while the preference of humans is big and variably shaped. *Sun, Ovate, Fas, Lc* are the known genes that control the shape of the tomato fruit.

This is just like the members of your family are different because of their genes. The shape of tomato fruit is a defining feature that distinguish one variety from another and also largely determines our perception. Besides, this trait is very important for the processing industry where elongated and rectangular shapes are preferred since they will not roll on conveyor belts. The tomato fruit shape is genetically determined, but the growing conditions can alter it resulting in unusual deformities. We know that you take a good care of your plants supplying them with optimal water, nutrients, and sun. If so, do not expect to find weird shapes. But in case that you see a catfacing fruits that means that your plants felt cold during fruit development; tomato with a "nose" means too hot, cracked tomatoes – too much water. Pay attention to what the plants are telling you!

THE FRUIT WEIGHT

Go back 8,000 years and try to prepare a tomato salad… it would be very tiring! You should pick, one by one, about 300 fruits of 1.5 grams each, because this is the weight of the fruit produced by the wild species from which the tomato was domesticated (aka *Solanum pimpinellifolium*)! Fortunately, for over 500 generations, farmers made a good job, and selected, step by step, varieties with higher fruit weight, till the Guinness-champion variety that produced in 2022 a fruit weighing 5.3 kg alone! Thus, from 0.0015 to 5.3 kg there is a huge diversity for fruit weight in tomato.

And we are happy with this, because it gives us an interesting diversity for playing in the kitchen. To add complexity, all the fruits of the same plant can have very different weights. Thus, to understand the average fruit weight of a variety, we need to weight different fruits from different plants, ideally as many as possible.

THE FRUIT COLOR

Have you ever wondered what causes the amazing spectrum of colors in the plant kingdom? The answer is pigments. Plant pigments are organic compounds that not only give color, but have essential role for photosynthesis, growth, and development of plants; they also protect plant from damages caused by UV radiation and attract animals for pollination and seed dispersion. In the case of tomato there are thousands of varieties all over the world with a wide range of colors - from pink to purple, yellow to white, even as dark as black. Tomato fruits can be uniform in color, bi-colored or even striped. When unripe, all tomatoes are green because of the green pigment called chlorophyll. Later, they become colored and that's for a purpose – to spread the seeds.

The color serves as an attractant for many leaving creatures who are tempted to taste the delicious fruits and give a ride of the seeds. So, chlorophylls break down and carotenoids and other secondary metabolites are synthesized. This is just like how the leaves change the color in autumn. A combination between chlorophylls, carotenoids, and flavonoids determines the color of ripened tomato fruit. The red color is due to the accumulation of lycopene, orange – of beta-carotene, yellow – of lutein, etc. When consumed, these pigments act as antioxidants to protect human and animal cells. The research also shows that tomato color relates to tomato flavor. When you prepare your salad, put as many colors of tomato as possible in order to have "all-inclusive" of these treasures. But do not expect to find more than one color on one plant. So, you will need different varieties, since the fruit color is genetically determined.

THE SKIN COLOR

Do you know that Japanese consumers prefer mostly pink tomatoes, while in Europe we tend to prefer intense red ones? This slight difference in the external fruit color can be very important for consumers and is mainly related to the composition of the outer layer of the fruit. This layer is also called the "skin of the tomato" and can be highly perceived when chewing the fruit. During the ripening of the fruit the red varieties accumulate a chemical compound called "naringenin chalcone", which pigments the skin yellow, while the pink tomatoes do not accumulate this compound, resulting in a transparent skin.

Thus, we can say that pink tomatoes are "nude tomatoes", as the transparent skin allows us to see the flesh of the fruit, while red tomatoes are dressed in yellow skin, and the color we see is the result of combining yellow skin + pink flesh. This difference is related to a single change in the genome of the tomato, so just observing which type of peel we have in our tomato we can guess how the sequence of the DNA for this gene is.

THE LOCULE NUMBER

Everybody, at least once in his life, made the game of love predictions pulling the petals off a daisy and repeating "he/she loves me, he/she loves me not". So, counting petal number is a common knowledge. Counting sepals is also easy; turn the flower upside-down and see the green elements of the calix. Counting stamens, the male flower organs, is still easy in many species (in tomato not so, because single stamens are tied together to form a cone). But few people know that also the innermost female organ (the pistil) is made of single parts, called carpels, that fuse together to form a unique structure.

In some species, there is just one carpel (e.g., in bean) that folds to form the fruit. In other fruits carpels are many; think to an orange, where every slice corresponds to a carpel. In tomato, carpels can be recognized by the number of cavities (locule) that are still visible in the ripe fruit. In the wild types, carpels were regularly two. During domestication, the man has selected those mutations that led to an increase in carpel number, which also corresponded to an increased fruit weight. The most striking of such mutations, called fasciated (*fas*), is the variant responsible of big flattened-ribbed tomatoes were loculescan be up to 15!

THE YIELD

The production of a tomato plant (grams of tomato per plant) varies greatly from one variety to another and is one of the most important characteristics for farmers and producers of this vegetable. The total production depends on several components, for example, the number of fruits per truss, the weight of each fruit and also the number of trusses that we harvest. To have an idea of the yield it is possible to count the fruits on the three first trusses and multiply that number by the weight of a representative fruit of the plant.

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