Tópicos em Biotecnologia de Plantas – Turma 2020

Disciplina do Programa de PG em Genética e Melhoramento de Plantas – ESALQ/USP

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Discussion on the Review article:

"Domestication and Breeding of Tomatoes"

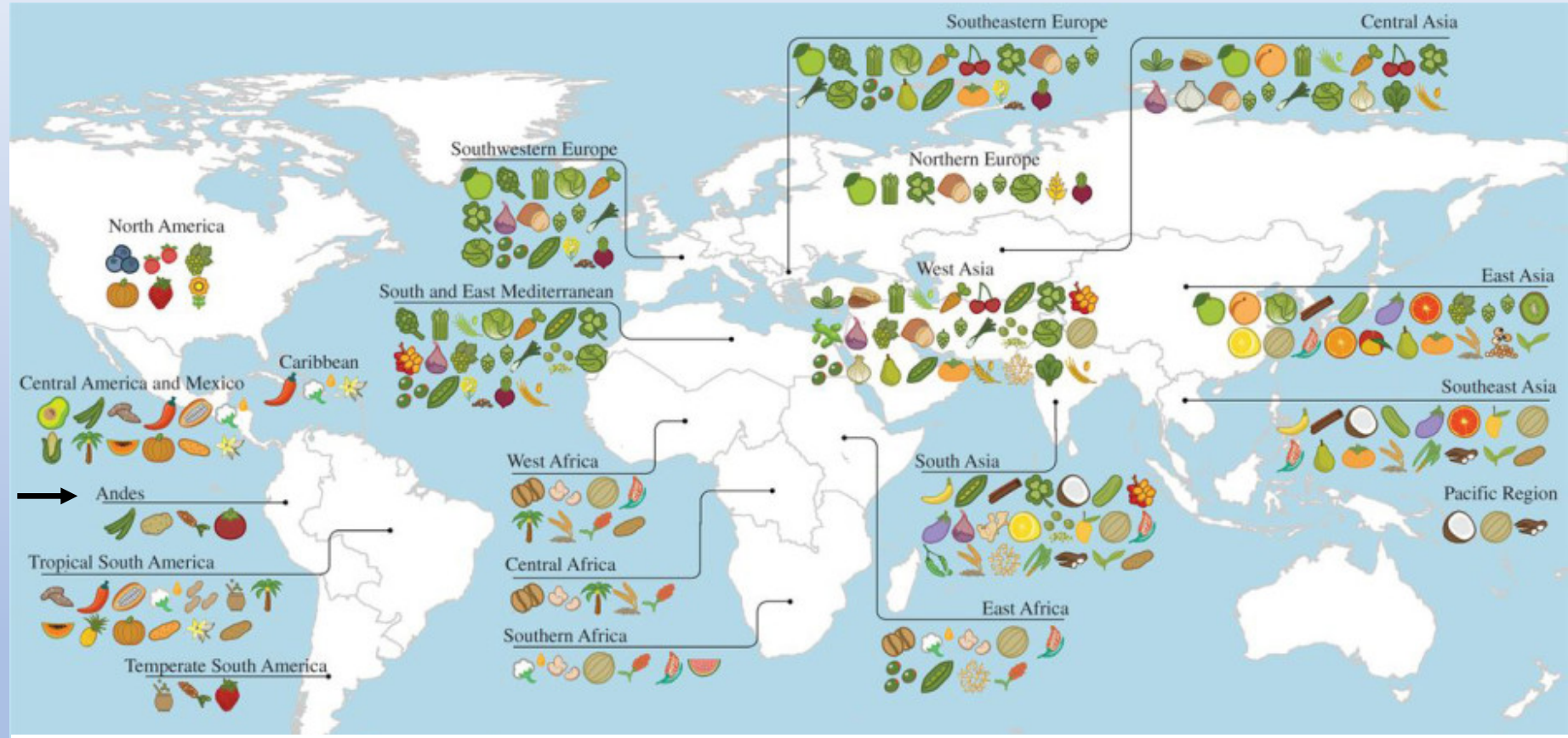
Bai & Lindhout, *Annals of Botany* (2007) **100**: 1085–1094

☼ Tópicos em Biotecnologia de Plantas

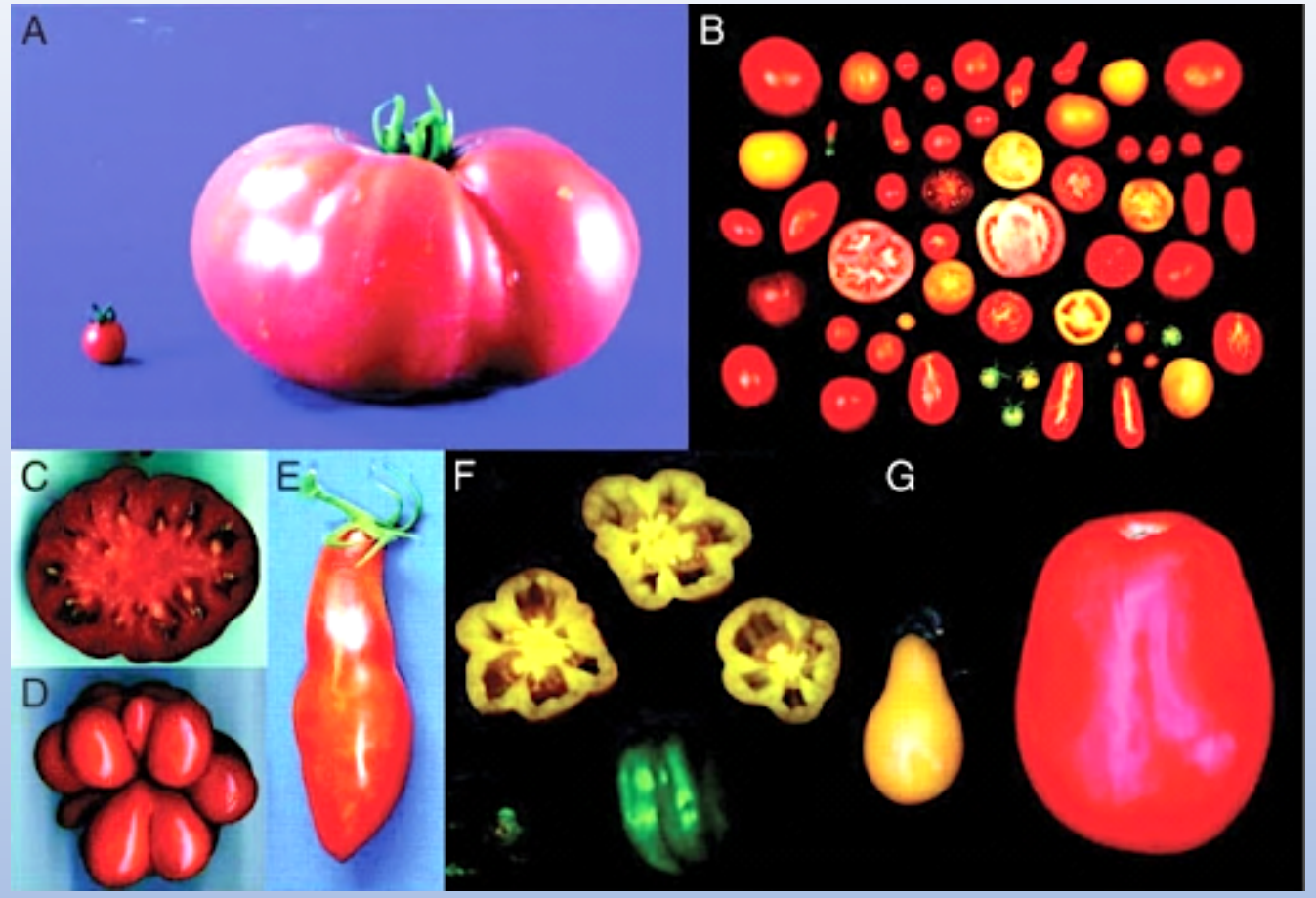
1ª semana

- Conceito de Biotecnologia
- Exemplos em diversas áreas
- Biotecnologia e ciências de apoio
- Objetivos e finalidades
- Biotecnologia e melhoramento de plantas

Primary regions of diversity of major agricultural crops worldwide



The tomato had reached a fairly advanced stage of domestication before being taken to Europe in the 15th century. Domestication on a much more intense level occurred throughout Europe in the 18th and 19th centuries



20th century: huge array of morphologically different cultivars and forms from a single species *Solanum lycopersicum* via classical plant breeding

☼ Genetic diversity and domestication

- *Solanum* section *Lycopersicum* includes the cultivated tomato and 12 wild species (genepool)
- Self-incompatible species, *S. chilense* and *S. peruvianum:* more genetic diversity variation revealed by **molecular markers** was observed within a single accession of these species than in all accessions of any self-compatible species ←
- Rich reservoir in wild species (exploited by breeders) comparatively to the variation in the cultivated species: few polymorphisms due to a bottleneck of the crop that was carried out to Central America (15th century) and from there to Europe (18 and 19th centuries)

- *S. lycopersicum* is an inbreeding species (self-fertilized), and genetic variation tend to decrease with selection;
- Selection was done on a single plant basis and with a small number of selected plants;
- Genetic drift is a major process reducing variation;
- Novel genetic variation was obtained via interspecific crosses in the 20th century
- Collection and preservation: **Tomato Genetics Resources Center** (California, Davis): natural collections from Andes and monogenic **mutants**;
- **Netherlands**: *ex situ* plant collections

- 13 000 M2 families derived from EMS and fast-neutron **mutagenesis** ←
- Isogenic lines to exploit gene functions (http://zamir.sgn.cornell.edu/mutants/)

- *In situ* conservation: **a large collection of wild tomatoes** (Ecuador)

- *Domestication syndrome*: Mendelian traits

- Mexico is presumed to be the most probable region of domestication, with Peru as the centre of diversity for wild relatives

- Domestication has triggered a wide range of morphological and physiological traits that distinguish domesticated crops from their wild ancestors

Tomato: selection for improving growth habit, fruit size and shape, fruit color and morphology

- Later Validation

- 6 **QTLs** transforming the small berries of wild tomatoes to extremely large fruits of cultivated tomato ←
- Constructing the respective molecular linkage maps, phenotyping the same populations and mapping the QTLs
- 2 quantitative loci: 2.2 (*fw2.2*) that changes fruit weight by up to 30% (lower total transcript level)
- **Cloning** the QTL: natural mutation in the promoter ←
- Allelic variation

At the end of the 19th century: because tomatoes do not naturally outcross very often, seeds produce plants resembling the parent. Then, earlier tomato cultivars were selected and inherited in a family or community, thus earning the name “heirloom” tomatoes. These cultivars could be considered as landraces or products of early breeding.

“Heirloom Tomatoes are a Pure Gift of Nature”

☼ Modern cultivars: objectives

- Breeders are continuously improving their breeding lines
- Breeders prefer to develop F_1 hybrids, not only for heterosis, but also for their uniformity and protection
- Breeders use naturally occurring recombination to produce cultivars that combine favorable traits
- New traits are **rarely introduced from wild germplasm** as it may take many generations to remove the deleterious genes that go along with the introduced genes due to linkage drag
- Resistance to biotic and abiotic stress
- Breeding for fruit quality

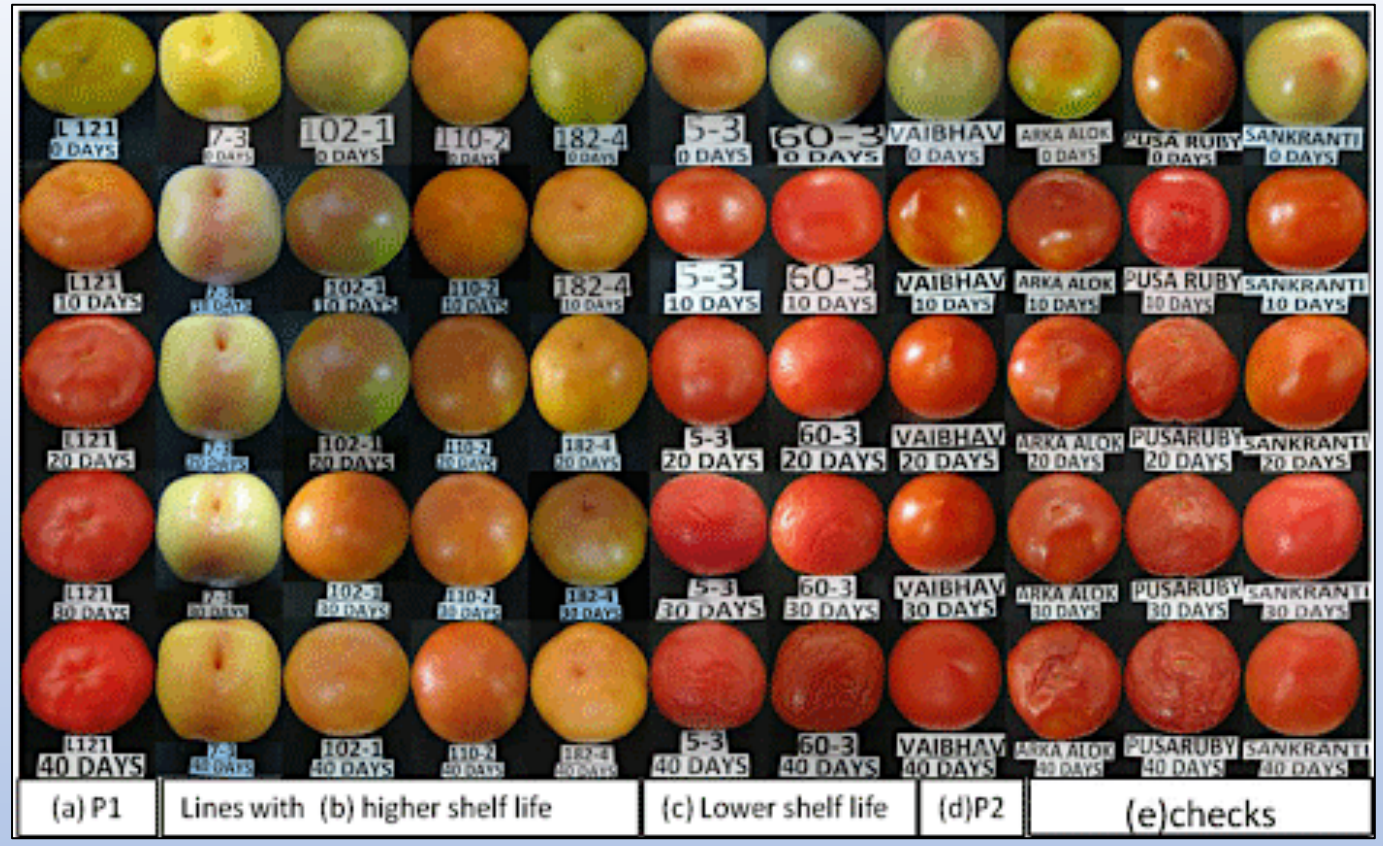
☼ Breeding in the 20th century

- Most of the cultivars require open pollination and the propagation was done by the farmers and growers who could easily obtain seeds from the fruits for the next generation
- However, seed companies have shifted open-pollinated cultivars to hybrids and dominate crop research and seed commercialization
- S*ingle cross*, the first hybrid; Fixed lines (F_4 to F_6) ➔ hybrids
- Seed companies: turnover time of a cultivar is 5 years
- Yield, shelf-life, taste and nutritional quality are the main traits

A utilização de híbridos está consolidada, atende todos os mercados para a produção de tomate, principalmente dos dois grandes grupos, tomates para a indústria e tomates de mesa. As cultivares de tomate destinadas ao consumo in natura podem ser divididas em quatro grandes grupo: Cereja, Italiano, Salada e Santa Cruz.

Visite: (https://www.embrapa.br/hortalicas/tomate-de-mesa/cultivares2).

http://tomatocultivation.com/tomato-hybrid-seeds-Companies.html

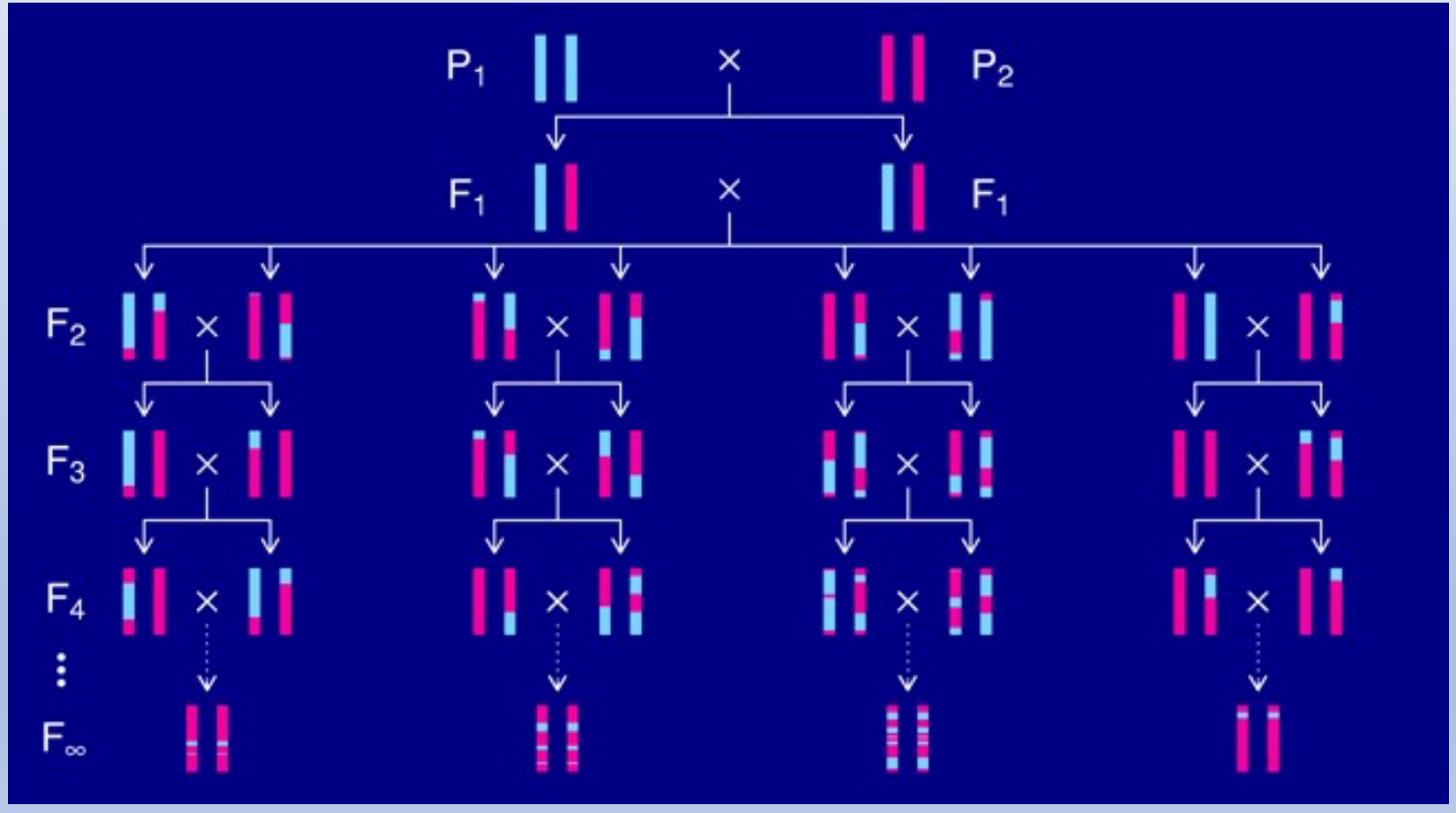


Recombinant inbred lines (RILs): F_7 lines, derived from crossing between *L121 and Vaibhav.* Note the gradual change in the fruit after harvesting: the lines with high shelf life remain intact even after 40 days (b), whereas lines with low shelf life shriveled even at the 20th day (c). Commercial checks (e).

Sinha et al. Austin J Biotechnol. Bioengineering. (2014), 1(3): 4.

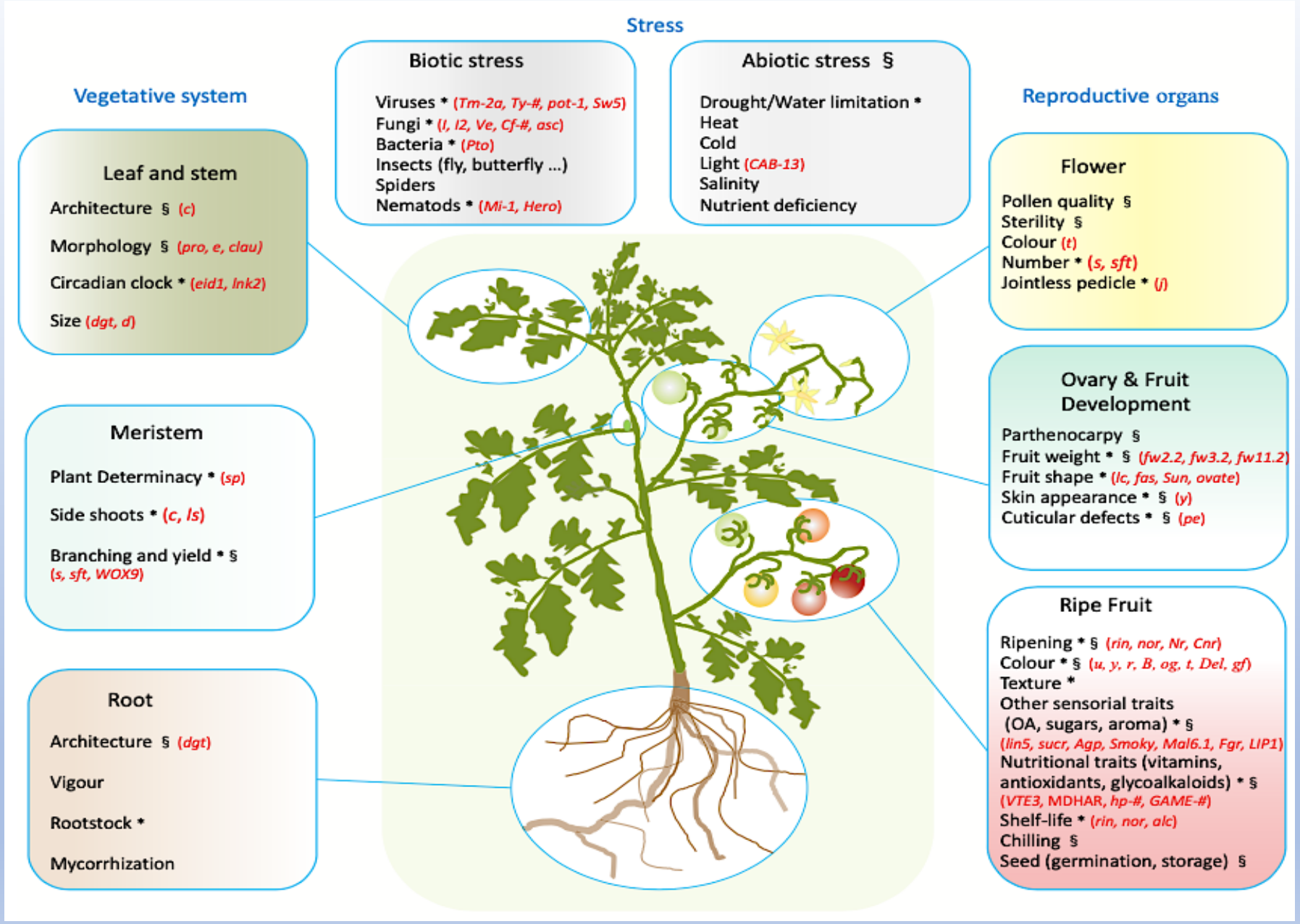
RILs (Recombinant Inbred Lines) produced by *sibling mating*

Recombinant inbred lines (RILs) are a collection used to map quantitative trait loci. Parent crosses and F_1 crosses are performed to create an F_2 population. Advanced intercrossing may be implemented to increase mapping resolution through the accumulation of additional meiotic crossover events. Finally, lines are inbred to create genetically stable recombinant lines



P_1 and P_2 are phenotypically contrasting and homozygotic lines

Main phenotypic traits studied in tomato



Rothan et al. Trait discovery and editing in tomato. The Plant Journal (2019) 97, 73–90

☼ Biotechnological approaches

- ✓ *In vitro culture*: in vitro techniques to regenerate plants from tissue or single cells, embryo-rescue
- ✓ Molecular markers (several applications)
- ✓ Marker-assisted breeding for qualitative traits
- ✓ QTL mapping to determine the genetic architecture of complex traits
- ✓ Transgenesis and GMOs
- ✓ SNPs: Diversity studies, GBS, GWAS
- ✓ Genomics and other omics: functional assays, candidate genes controlling tomato metabolism
- ✓ Gene editing