**PhD DISSERTATION PROJECTS**

**Use of genetic and genomic resources to improve nutritional quality and shelf-life in pepper.**

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This PhD thesis project aims at the preparation of experimental mapping populations including recombinant crossing populations to be used for the dissection of the genetic bases of complex traits responsible for pepper quality. Shelf-life and content of antioxidant compounds will be the focus traits to be investigated. The project aims not only to provide tools for basic research but also for qualitative and quantitative genetic improvement by bridging the gap that currently exists with respect to other agricultural crops (e.g., cereals, tomatoes).

**Utilizzo di risorse genetiche e genomiche per migliorare la qualità nutrizionale e la *shelf-life* in peperone.**

Questo progetto di tesi di dottorato basato mira allo sviluppo di popolazioni sperimentali quai collezioni “*core”* di germoplasma e di popolazioni ricombinanti ottenute mediante attività di inter-incrocio da utilizzare per lo studio delle basi genetiche di caratteri complessi responsabili della qualità in peperone. *Shelf-life* e contenuto in sostanze antiossidanti saranno i principali caratteri da studiare Il progetto mira non solo a fornire strumenti per la ricerca di base ma anche per il miglioramento genetico quali-quantitativo colmando il divario ad oggi esistente rispetto altre colture agrarie (es. cereali, pomodoro).

# State-of-the-Art

Climate change and its consequences are emerging as one of the main challenges to deal in the near future. Agriculture is the sector most affected by these changes, therefore, the increase in agricultural production together with the stability of production and the quality of products represent the crucial objective for the economy and food security of all countries. Pepper (*Capsicum* spp.) is an important member of the Solanaceae family, it is a main vegetable and spice crop originated in the American tropics and today cultivated all over the world for fresh, dried, and processing products (Patel et al., 2019). According to recent estimates there are more than 35 pepper species grouped in 11 clades (or complexes), three of which (Annum, Baccatum and Pubescens) encompass domesticated and wilds relevant in terms of nutritional and economic importance and widely used for genetic improvement. Around the genus *Capsicum* there is an increasing interest and fascination due to the considerable variation for several traits, which makes this crop extremely versatile and suitable for innumerable uses as food and non-food products. *Capsicum* fruits are highly rich in pharmacological compounds such as carotenoids (provitamin A), vitamin C and E, flavonoids and the distinct metabolite alkaloid complex known as capsaicinoids which impart pungency to its fruits. In recent years, several genomes of domesticated and wild *Capsicum* species have been sequenced, which provided a basic infrastructure for subsequent genomic studies (Ziv et al.,2022). High yield, early flowering, biotic and abiotic stress tolerance, enriched metabolite content, desired fruit size and shape and reduced postharvest water loss have been major targets for pepper improvement mostly by classical breeding efforts. Marker-assisted selection and genome-wide association studies for the useful exploitation of resistance genes and QTLs have offered considerable advantages over the conventional plant breeding approaches for the improvement of *Capsicum* in terms of accuracy, specificity, and duration (Uffelmann et al., 2021). Furthermore, the next-generation sequencing technologies have proven breakthroughs in the field of identification of the genomic regions responsible for stress tolerance, evasion and responses which could be employed for future *Capsicum* breeding programs.

In pepper it is estimated that there are over 30 thousand accessions available in the network of international gene banks (Barchenger et al., 2022); the existing germplasm represents an important source of characteristics of interest for agriculture, which, however, at present is still little used for genetic improvement. The innovation of the project concerns the development of advanced germplasm resources through breeding and selection activities and the enrichment with genomic information obtained through latest generation sequencing technologies and phenomic characterizations for the main characteristics required by the market and consumers. These activities allow to define potential germplasm platforms to be used for the discovery of new key genes.

# PhD Thesis Objectives and Milestones

The PhD thesis project, within the general objective mentioned above, can be divided into the following phases according to the Gantt diagram given in Table 1:

A1) **Development of experimental populations** including F2 and Backcrosses derived from intra- and inter-specific crosses and core germplasm set.

A2) **Application of *next generation sequencing* for genomic characterization** through ddRAD-seq (Double digest restriction-site associated sequencing).

A3) **Phenotyping** for shelf life an main metabolites underlying pepper quality (vitamin C, flavonoids, carotenoids).

A4) S**canning genomic regions underlying phenotypes** through *quantitative trait loci**mapping* **(QTL***)* and genome wide association approaches.

A5) **Development of functional genomic markers**, developed for precision breeding and assisted selection of target genes.

A6) **Writing and Editing** of the PhD thesis, scientific papers and oral and/or poster communications.

**Table 1:** Gantt diagram for this PhD thesis project.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Activity Trimester | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| A1) | Mapping populations |  |  |  |  |  |  |  |  |  |  |  |  |
| A2) | Genomic characterization |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Nucleic acid isolation |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) ddRAD sequencing |  |  |  |  |  |  |  |  |  |  |  |  |
| A3) | Phenotyping |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Shelf life |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Metabolic compounds |  |  |  |  |  |  |  |  |  |  |  |  |
| A4) | Gene mapping |  |  |  |  |  |  |  |  |  |  |  |  |
| A5) | Functional markers |  |  |  |  |  |  |  |  |  |  |  |  |
| A5) | Thesis and Paper Preparation |  |  |  |  |  |  |  |  |  |  |  |  |

# References

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