Organic breeding as driver of agrobiodiversity in farming systems
Organics Europe Youth Event
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Outline

• 9:30 – 9:45 /Intro to the workshop
• 9:45 – 10:00 /Everyone on the same page: plant breeding in short
• 10:00-10:40 /Why organic plant breeding?
• 10:40 – 11:00 /Organic breeding as driver of functional agrobiodiversity in farming systems
• 11:00 -11:15 /Break
• 11:15 – 11:30 /Summary: reasons for independent organic plant breeding
• 11:30 – 12:00 /Why plant breeding keeps the EU busy?
• 12:00 – 12:15 /Discussion
Everyone on the same page: plant breeding in short
Domestication

Selective process [from genetic variability] that leads plants to adapt to growing conditions

It is a process, by the first farmers (and breeders!) in history, in which people actively interfere and direct the natural evolution of the plant species (to become a crop). The beginning of breeding coincides with the beginning of agriculture.

https://www.pnas.org/doi/10.1073/pnas.1820997116
Variety/ Cultivar development

- Genetic Diversity
  - Natural genetic diversity
  - Mutation & Recombination of genes
- Adaptation/Selection
  - Selection of the best Genotypes
- Variety/Cultivar Maintenance breeding
- Seed propagation
- Commercial cultivation

New variability – start point for selection

Variety > UPOV definition > DUS & VCU (arable crops) > registration > plant variety rights
Cultivar (broader definition) : landraces, genetically diverse populations, open pollinated varieties, ....
Why do we need breeding programs specifically dedicated to organic farming?
Why do we need ORGANIC BREEDING?

Economy
Market

Environment

Specific needs of organic farming

Society
What is different in organic breeding?
In what is organic breeding different from conventional breeding?

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Organic breeding as driver of functional agrobiodiversity in farming systems
Breeding for functional agrobiodiversity—
which levels of diversity?

- landscape and habitat diversity
- species and management diversity
- for diverse diets
- genetic diversity
Breeding for functional agrobiodiversity - unlock functional traits to provide agroecosystem services

ORGANIC BREEDING IS AN ASSET:
- Provide cultivars that allow to optimise sustainable agronomic practices
- Provide cultivars that allow to implement innovative management strategies
- Climate change adaptation
- Improved resilience of the farming system
Breeding for functional agrobiodiversity-examples from genetic diversity level

Select for traits specifically relevant for organic crop production – FUNCTIONAL IDENTITY

Example of organic breeding research:
- Weed competitive ability
- Resistance to seed/soil born diseases
- Robust resistance to pest/diseases
- Nutrient-use efficiency
- …
Breeding for functional agrobiodiversity-examples from genetic diversity level

Resistance breeding of white lupine

@ FiBL Lupin breeding for anthracnose tolerance since 2014
Breeding for functional agrobiodiversity—examples from genetic diversity level

Develop concepts for optimized cultivar mixtures—FUNCTIONAL COMPOSITION

Example of organic breeding research:
- selection of cultivars best adapted to be grown in mixtures
- Study relationship between benefits achieved and increased mixture diversity (n of components)
  planning mixture to achieve several agroecosystem services at the same time

Suggested reading:
Breeding for functional agrobiodiversity - examples from genetic diversity level

Develop high diversity cultivars: composite cross populations (derived from crosses) and dynamic populations (derived from mixtures) that can adapt to multiple stresses

Example of organic breeding research:
- Increase diversity in cultivated fields
- adaptation to local conditions
- adaptation to changing climatic conditions


- **Composite Cross Populations (CCPs):** the result of targeted crosses that are then left to evolve together under natural conditions. The moment of putting the progenies together can be decided upon by the breeder depending on crop type and breeding goal. This category is different from synthetic varieties/populations which are reconstructed to be stable.

- **Dynamic Populations:** developed from a mixture of large numbers of breeding lines and cultivars (understood in a broader sense than officially released varieties, landraces, less homogeneous populations, niche varieties...) in the case of selfing crops, and a smaller number of breeding lines and cultivars in the case of outcrossing crops, cultivated together and seed saved. After a few generations, the mixtures outcross and adapt to local conditions. When applicable, the breeder does artificial selection for particular traits (plant architecture, disease tolerance, etc) The process is important for the definition.

which variety traits are central in organic farming
Breding for functional agrobiodiversity-examples from species diversity level

Plant – Fauna – Microbe Interaction

Plant – Plant Interaction

Plant – soil microbe Interaction
Breeding for functional agrobiodiversity - examples from species diversity level

Breeding for mixed cropping systems of pea and barley since 2017

Resistance breeding of Pea
Breeding for microbiome-based resilience of pea

Complex of pathogen caused root rot, soil fatigue, e.g.

- Aphanomyces euteiches
- Pythium ultimum
- Fusarium solani
- Rhizoctonia solani
Breeding for microbiome-based resilience of pea

Improving disease resistance through selection at the plant-soil microbiome boundary

Expected outcome

- Identify new resistance resources
- Identify key pathogens and antagonists
- Develop plant and microbial markers for disease resistance
Breeding for functional agrobiodiversity-examples from landscape level

diversified in-field landscape composed of many environments (e.g., close to the tree, far from the trees, different tree species, seminatural elements, etc.)

- Can agroforestry systems offer opportunities for the breeding of sustainable and resilient crops thanks to their inherent spatial diversification?
- Can agroforestry systems offer new solutions for more effective variety testing for low-input systems?

Environmental approach:

• Organic selection environment
Organic farming: working with the environment

- Stronger influence of location factors (soil, crop rotation, climate)
- Local or temporary low nutrient availability (e.g. Slow mineralization of nitrogen in the spring)
- Weeds
- Insects & Microbes
- Diversified cropping systems
Field establishment of wheat (end of April)

Conventional Organic

Slower N mineralization in spring
Direct vs Indirect Selection

Spring Wheat: Ranking of the Top 10 Conv. vs. Organic

Fig. 1. Genotypic change in rank between organic and conventional wheat nurseries. The top five ranking genotypes for yield in both organic and conventional systems were compared at each location. Genotypes are ranked from 1 = highest yield to 35 = lowest yield.

Socio-economic perspective: plant breeding and society today
Breeding as a cultural achievement: service to the common good

• Free access to genetic resources

• New concepts for the ownership of cultivars and their financing

Embedding diversity into food systems

• Involving all stakeholders (farmer, value chain and community driven breeding)

• Nutritionally valuable and tasty > diet diversification

• Suitability for soft processing without additives

Engagement of the organic value chain to support Organic Breeding in Europe. Governance and financing models.

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which variety traits are central in organic farming
Participatory breeding and resilient seed systems (seed sovereignty)

Involvement of farmers in the selection process

Selection of candidate varieties

Single plant selection

Organic cotton breeding and cultivar evaluation in India (2012-2023)

CROPS4HD underutilized crops in Tanzania, Chad, Niger, India (2021 onwards)
Summary: reasons for independent organic plant breeding
Summary: reasons for independent organic plant breeding

Technical reasons:
- Organic-specific breeding objectives (becoming more important also for conv. farming and strong reduction of pesticide inputs)
- More diverse crops and cultivar types needed for broad crop rotation incl. legumes for N-fixation, market demands and local adaptation
- Higher breeding efficiency if selection takes place in target environment

Socio-economic and ethical reasons:
- Preservation of the diversity of crops, varieties and breeding programs
- More holistic systems-based breeding including also socio-economic aspects
- Decentralized, participatory projects as an alternative to monopolization
- Ethical principles
  - Cell integrity
  - Respect for crossing barriers
  - Ensuring the ability to reproduce
  - Possibility for farm saved seed
  - Possibility for further breeding
More info:

• **Brochure: Visiting friends of agrobiodiversity in Europe**

• **Map of organic breeders in Europe**
  https://www.biobreeding.org/breeding.html

• **FiBL dossier: Plant Breeding Techniques: an assessment for organic farming**

• **Association Bioverita (private label for organic varieties)**
  https://bioverita.ch/

• **European Consortium for Organic Plant Breeding (ECO-PB)**
  www.eco-pb.org