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Research Institute of Organic Agriculture FiBL
info.suisse@fibl.org | www.fibl.org

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Organic breeding as driver of agrobiodiversity in farming systems

Organics Europe Youth Event

01-09-2022, Frick and online from Brussels

CC BY SA

Mariateresa Lazzaro, Group Plant Breeding, FiBL

Martin Sommer, Policy Officer on GMOs, Patents and Seeds, IFOAM Organics Europe

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

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Everyone on the same page: plant breeding in short

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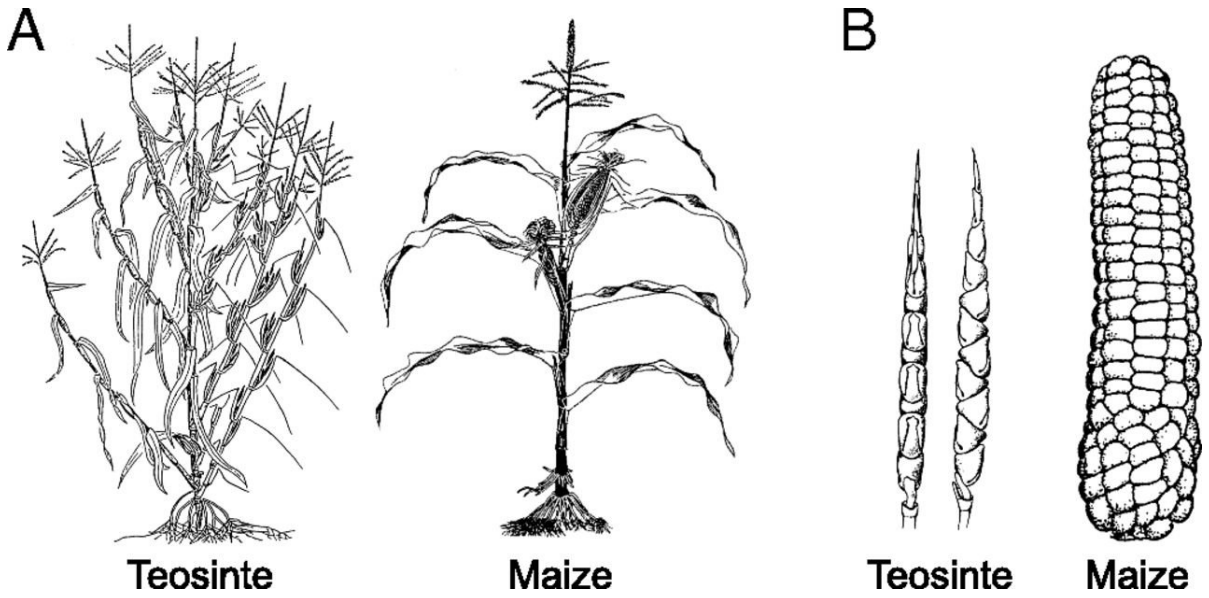
Domestication

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



https://www.pnas.org/doi/10.1073/pnas.1820997116

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

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Variety/ Cultivar development

Genetic Diversity

Natural
genetic diversity

Mutation &
Recombination of genes

Selection

Adaptation/Selection

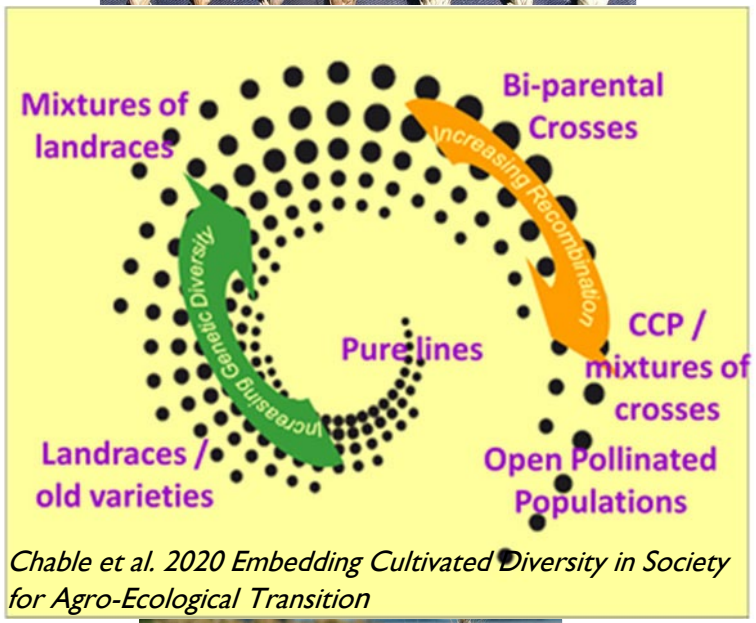
Selection of the best
Genotypes

Variety/Cultivar

Maintenance breeding

Seed propagation

Commercial cultivation



Chable et al. 2020 Embedding Cultivated Diversity in Society for Agro-Ecological Transition

New variability – start point for selection

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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?

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Why do we need ORGANIC BREEDING ?

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What is different in organic breeding?

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In what is organic breeding different from conventional breeding?

Methods and techniques used

….

Selection objectives

….

Breeding program governance structure

…

Actors in the breeding process

…

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Organic breeding as driver of functional agrobiodiversity in farming systems

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Breeding for functional agrobiodiversity- which levels of diversity?

landscape and habitat diversity

species and **management** diversity

genetic diversity

for diverse diets

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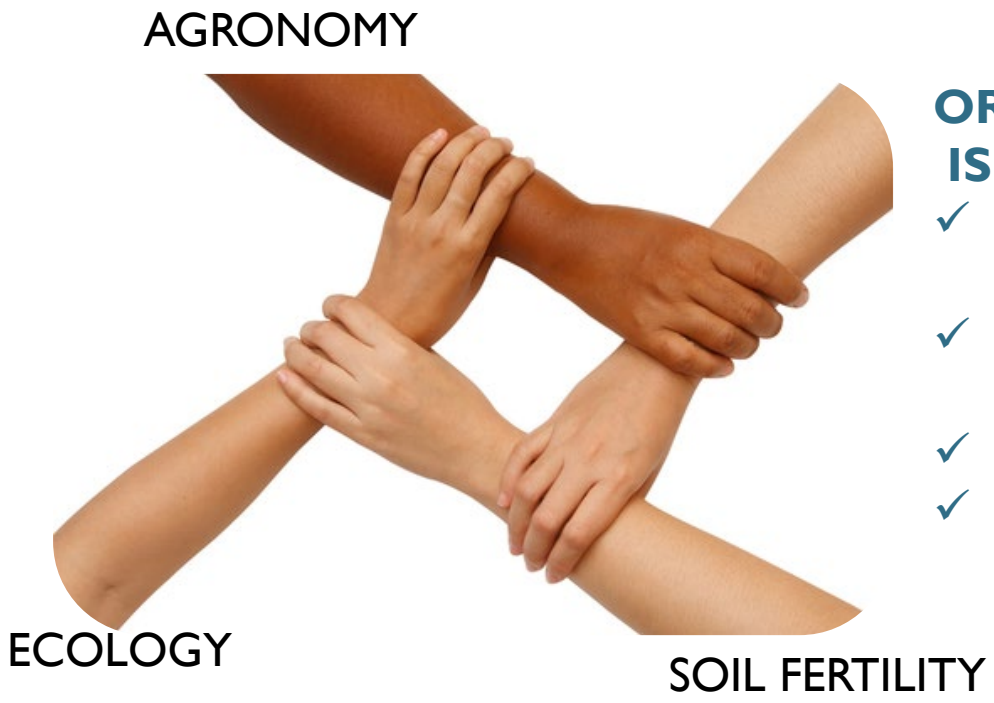
Breeding for functional agrobiodiversity-
unlock functional traits to provide agroecosystem services



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

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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
- …

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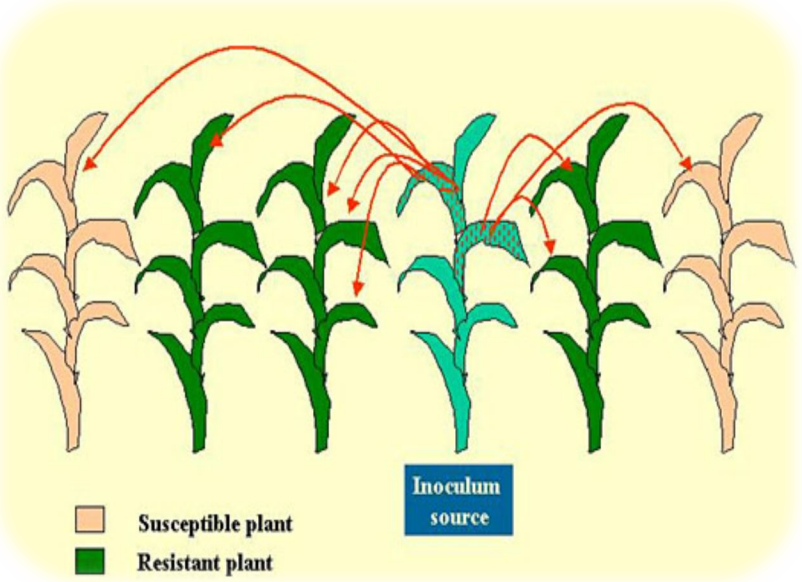
Breeding for functional agrobiodiversity- examples from genetic diversity level

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 adaped 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

1 variety

Mixture of components with different resistance genes

Frederik V. Larsen
@FredVLarsen

Wheat variety mixtures (sortsblandinger) are now grown on 20% of the DK wheat area for the upcoming 2021-22 season. That is huge and a great testimony to the adaptability of the modern DK farmer when supported by applied quality research & the confidence of the Agri supply chain.

Sort	Pct. af hvede-areal 2022	Meldug (0-4)	Septoria (0-4)	Gulrust (0-4)	Brunrust (0-4)
Pondus	21,0	2	1	0	3
Sortsblandinger	19,9	-	-	-	-
Informer	11,4	1	2	1	2
Heerup	10,2	1	2	2	2
Rembrandt	7,9	2	2	1	2
Kvium	6,7	1	2	1	3
KWS Extase	5,7	1	2	2	2
Momentum	5,3	1	2	0	2
RGT Saki	1,9	2	2	1	3
Graham	1,8	2	3	1	3

11:03 PM · Oct 20, 2021 · Twitter for iPhone

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Suggested reading:
Variety Mixtures in Theory and Practice: https://www.hutton.ac.uk/sites/default/files/files/rhynchosporium/Variety-Mixtures-in-Theory-and-Practice-booklet.pdf
Barot, S. et al. Designing mixtures of varieties for multifunctional agriculture with the help of ecology. A review. *Agron. Sustain. Dev.* **37**, 13 (2017)

Breeding for functional agrobiodiversity- examples from genetic diversity level

which variety traits are central in organic farming

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.

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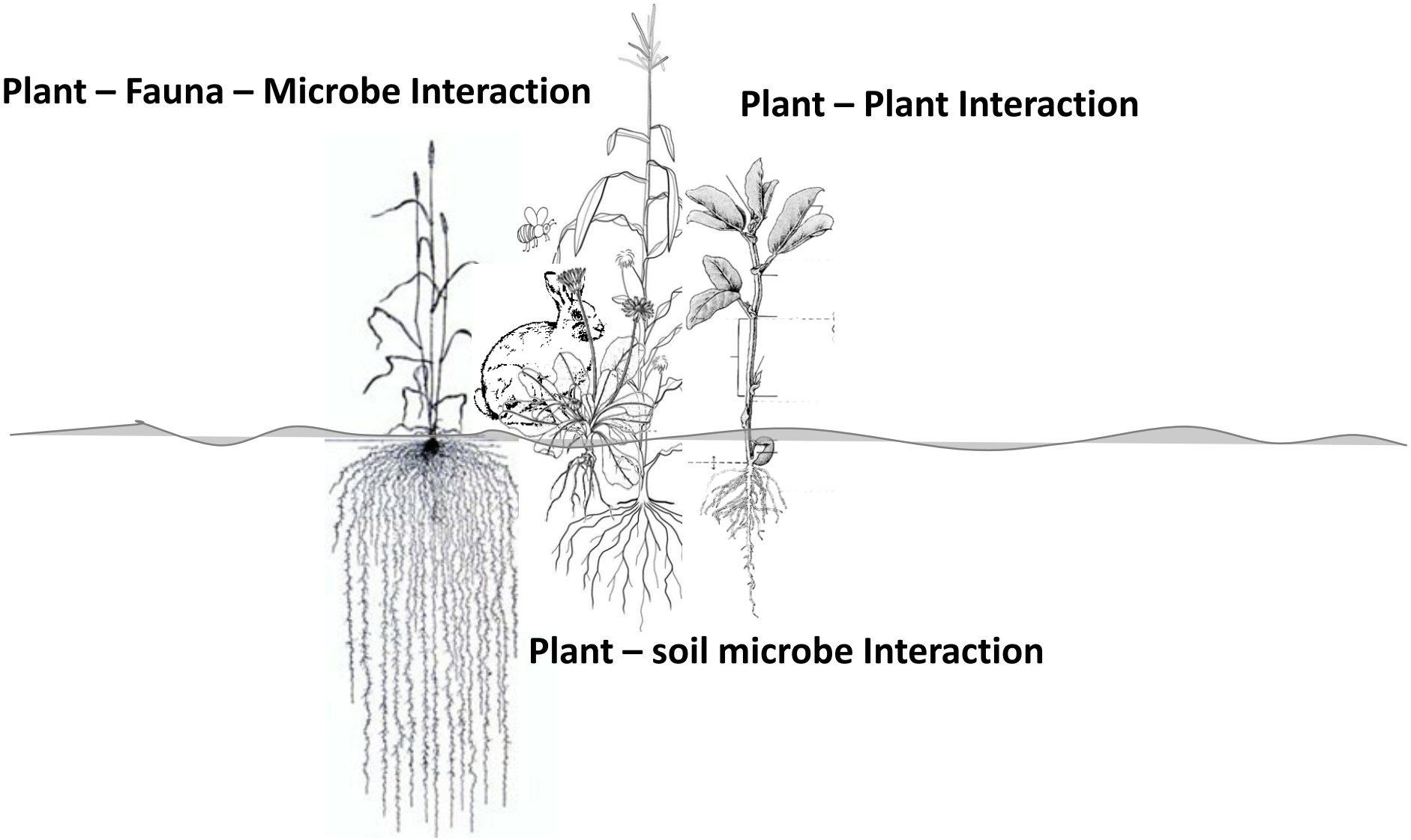
Further info at: https://www.liveseed.eu/wp-content/uploads/2020/01/LIVESEED_D2.8_heterogeneous_material_toolbox.pdf

Breding for functional agrobiodiversity- examples from species diversity level



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Breeding for functional agrobiodiversity- examples from species diversity level

Pea pure

Barley pure

Mixture

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Breeding for mixed cropping systems of pea and barley since 2017

Further reading: https://www.frontiersin.org/articles/10.3389/fpls.2020.620400/full

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

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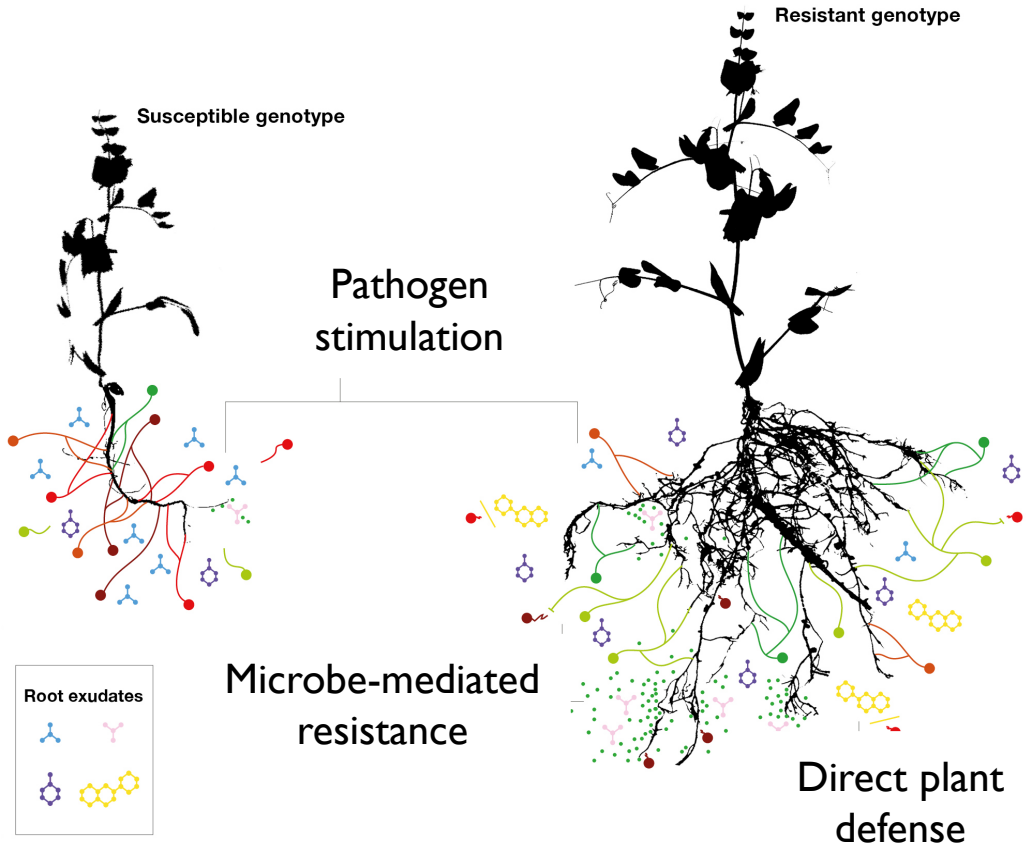
Breeding for microbiome-based resilience of pea

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

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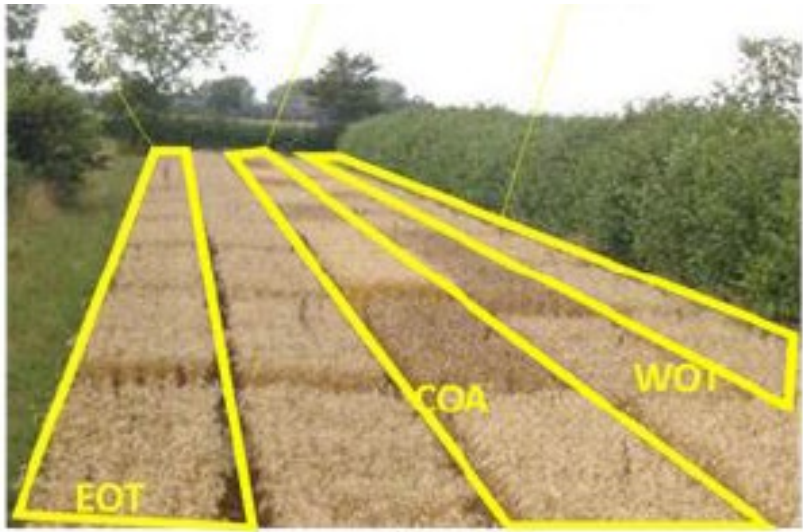
Pea tolerance towards complex root rot disease through improved plant-microbe interactions since 2016

Breeding for functional agrobiodiversity- examples from landscape level



H2020 LIVESEED – D3.6, agroforestry trial in the UK (Organic Research Centre)

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

Panozzo, A., Bernazeau, B. & Desclaux, D. Durum wheat in organic olive orchard: good deal for the farmers?. Agroforest Syst 94, 707–717 (2020). https://doi.org/10.1007/s10457-019-00441-0

- 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?

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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

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Field establishement of wheat (end of April)

Slower N mineralization in spring

Conventional **Organic**

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Direct vs Indirect Selection

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

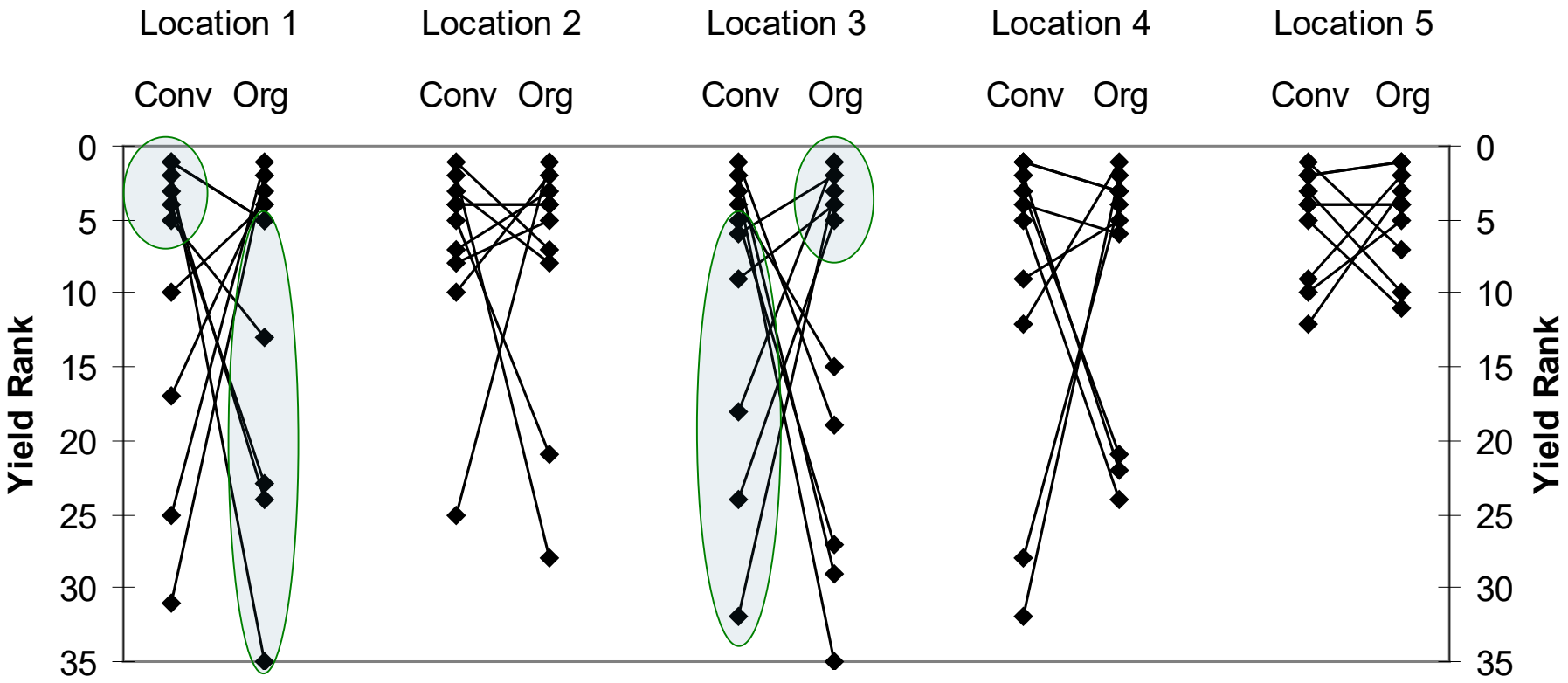


Fig. 1. Genotypic change in rank between organic and conventional wheat nurseries. The top five ranking genotypes for yield in both organic and conventional systems were compared at each location. Genotypes are ranked from 1 = highest yield to 35 = lowest yield

FiBL Evidence of varietal adaptation to organic farming systems. Murphy et al, Field Crops Research (2007).

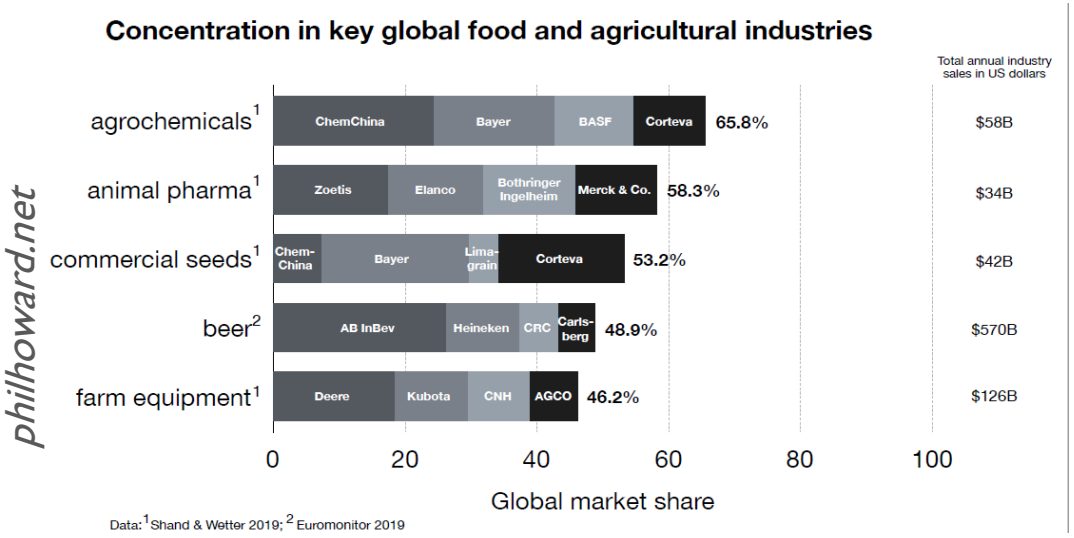
Socio-economic perspective: plant breeding and society today

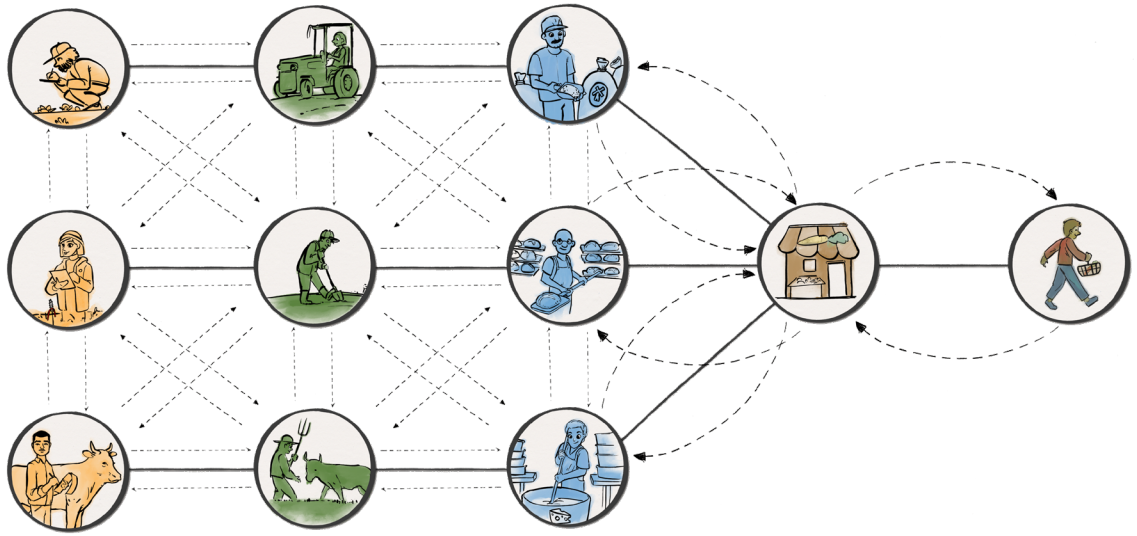
Breeding as a cultural achievement: service to the common good

- Free access to genetic resources

> NO PATENTS ON SEEDS!

- 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

which variety traits are central in organic farming

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

Participatory breeding and resilient seed systems (seed sovereignty)
Involvement of farmers in the selection process


Selection of candidate varieties

Single plant selection

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Organic cotton breeding and cultivar evalution 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

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More info:

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

https://www.fibl.org/fileadmin/documents/shop/1422-engagement-biobreeding.pdf

- **Map of organic breeders in Europe**

https://www.biobreeding.org/breeding.html

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

https://www.fibl.org/fileadmin/documents/shop/1202-plant-breeding.pdf

- **Association Bioverita (private label for organic varieties)**

https://bioverita.ch/

- **European Consortium for Organic Plant Breeding (ECO-PB)**

www.eco-pb.org

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