Holobiont-based plant breeding

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Microorganisms – a solution to maintain yields with reduced inputs

Theis et al. 2016

FiBL

Theis et al. 2016
Plant genetics of plant-microbe interactions

Is genotypic variation exploitable for breeding?

2019 keynote discussions:

- **Jos Raaijmakers**: Beneficial plant-associated microbiomes were indirectly co-selected throughout the history of breeding

- **Richard Jefferson**: Plant genome-focussed breeding has neglected agile trait contributions from the microbiome

- 5-10% of variation of microbiome composition explained by plant genotype
Plant genetics of plant-microbe interactions

Genotypic variation of plant responsiveness to micro(biome)es

- Colonisation success of symbionts
- Recruitment of microbes under stress situations
- Microbe-mediated disease resistance
- Priming effects (readiness of plant to respond to (a)biotic stresses)

Genetic marker (QTL)

- Plant microbiome composition
- Recruitment of specific microbial taxa
- Microbe-induced leaf rust resistance

Horton et al. 2014
Breeding for plant-microbe interactions

Disentangling the environmental effect:

From $G \times E$ to $G \times E' \times MB$

$G$: Host genotype

$E'$: climate and physicochemical soil environment

$MB$: Soil and/or plant microbiome

- Disentangling $MB$ from $E$ due to its dynamic and evolving nature
- Useful framework to capture ecological interactions
- Enhancing the predictability of microbe-assisted plant breeding

Oyserman et al. 2020
Opportunities for breeding

- Yield stability and productivity (reduced inputs)
- **Tools:** High-throughput phenotyping, machine learning and modelling, seed treatments, genetic markers, gene editing
- Monitoring and decision tools for genotype selection, but also for crop selection and agricultural practices
- From controlled conditions to field >> farmer participation
Advancing pea resistance breeding

Improving disease resistance of pea through selection at the plant-soil interface

Wille et al. 2018

Lukas Wille
Advancing pea resistance breeding

Pea is affected by a complex of fungal and oomycete pathogens, e.g.:

- *Aphanomyces euteiches*
- *Pythium ultimum*
- *Fusarium solani*
- *Rhizoctonia solani*
Advancing pea resistance breeding

Heritable variation for resistance against a root rot complex

Wille et al. 2020
Advancing pea resistance breeding

Heritable Variation in Pea for Resistance Against a Root Rot Complex

Validated in 6 field environments
Advancing pea resistance breeding

Heritable Variation in Pea for Resistance Against a Root Rot Complex

Screen implementation at

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Advancing pea resistance breeding

Verification of the complexity of pea root rot

Microbial markers for resistance breeding
Advancing pea resistance breeding

AGRI BIOME – Plant microbiome recruitment for superior agricultural systems

Three genome-wide association studies related to disease resistance:

1. Standard plant genetic markers based on disease phenotype
2. Advanced plant genetic markers for functional microbiome diversity and the recruitment of microbial key taxa
3. Holobiont genetic markers: combined action of plant+microbiome markers
Outlook

Main Research priority:
Identify genetic determinants that steer beneficial plant-microbiome interactions

Key targets:
- Bridge fundamental knowledge and application
- Understand functioning within complex microbial communities and holobiont interactions
- Improve efficacy predictions
- Link beneficial functions of indiv. microbes or entire microbiomes with plant traits
Thank you for your attention!