



European Plant Science Organisation
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Annex to the report

EPSO Workshop Implementing a Plants and Microbiomes Strategy in Europe Cologne, October 2018

Brussels, 18.10.2019

The 'Report with recommendations' as well as this 'Annex to the report' are available at <https://epsoweb.org/working-groups/plants-and-microbiomes/>.

Annex I - Breakout group reports

Group 1 Report

Participants: Corné Pieterse (chair), Soledad Sacristan (rapporteur), Paul Schulze-Lefert, Karin Metzclaff, Carmen Bianco, Sofie Thijs, Pascal Falter-Braun

The discussion was focused mainly on recommendations for standardization and also some points about the study of mechanisms were addressed.

Standardisation, reference plants:

R16-Standards - best practices in plant microbiome research need to be implemented

Technology is not yet enough standardized:

- *In first place, a precise definition of terms used is necessary in order to achieve a controlled vocabulary that allows an unambiguous communication between the members of the research community.*
- *In order to be able to compare different studies, it is necessary to define correctly which plant compartments are being sampled (leaf epiphytes, leaf endophytes, mycorrhizosphere, rhizosphere, rhizoplane, root endophytes, bulk soil). Methods to separate the different compartments, and thus define them, should be agreed. (MIAME standard)*
- *The research community will benefit from the use of the same primer sets to sequence and identify the different microorganisms in the microbiota. Bacterial and fungal primers are generally well established, but for other microorganisms (oomycetes and other protists) there is still work to be done in optimising the best regions to sequence. Another pending issue is to find the way to be able to include viruses as part of the microbiome, since the methods for the analysis of these microorganisms are different.*
- *Statistical and bioinformatics analysis should use approaches that are comparable between different studies. For example, pipelines should include standardized tools.*
- *Raw data deposition should be encouraged when publishing results. In general, a minimum information for microbiome experiments should be established.*

R15-Open access databases integrating (plant) microbiome and meta-data are required

Methodology should follow the FAIR principles: Findable, Accessible, Interoperable, and Reusable

R17-European infrastructure recommended for plant microbiome research

Isolate collections should contain defined metadata (place of sampling, plant associated species, compartment, etc) and ideally genome sequence.

- *At this respect, we have considered the expediency of establishing a European Culture Collection, which would have several advantages, such as:*
- *Preservation of microbial diversity. It would be necessary to define well which microorganisms to include, covering contrasting environments.*
- *Providing defined ensembles of microbes to researchers. Thus, the philosophy of this collection would be different than the existing culture collections that focus on and provide individual cultures with a price that makes unaffordable the deposit and ordering of the high number of microorganisms to test microbiomes.*
- *However, it would be a very expensive facility, specially concerning the maintenance of the isolates, and the long-term funding should be guaranteed. Another alternative could be that, instead of investing in one installation, the EU provides funds for guarantee the maintenance of different collections that may exist already.*
- *It may be good devoting a special session in next workshop addressing this issue, including representatives of research communities in environmental and animal microbiota.*

Reconstitution experiments should be subject to a minimum experimental standardization. It is necessary to standardize the obtaining of germ-free plants. It is also necessary to precisely describe the microbial communities used. In this sense, having defined community assemblies from an European Culture Collection would be useful.

R6 - Proposed reference plants for Europe include barley, potato, tomato, pea and strawberry

A discussion was established about whether it is necessary to define particular plants that are preferred as model systems to study microbiomes. EU prefers that research is focused on relevant targets, but it is also necessary that recommended model plants cover the whole diversity within the plant kingdom. Arabidopsis is the best studied model plant, but model crops should also be included. Tomato and barley are clearly good studied model crops. It is important also to include Fabaceae, although it is not yet clear which one. We must not forget trees. The best studied model for trees is poplar.

R3 - Moving from correlation to causation under lab, greenhouse and field conditions

Studies about functions should be encouraged, moving from descriptive works that uncover correlations to mechanistic studies that elucidate functions of the microbiomes.

One understudied aspect is the mechanisms that determine the persistence of applied microbiomes in the environment, which traits improve the competence or persistence of bio inoculants. In this respect, the plant research community should exchange experience and learn from the medical field, that is steps forward in the understanding of the persistence of microbiotas (for example, microbiome trans

Group 2 Report

Participants: Michael Schlöter (chair), Simona Radutiou (rapporteur), Stijn Spaepen, Isabel Vercauteren, Leo van Overbeek, Christophe Mougel, Anouk Zancarini

Standardisation, reference plants:

R2 - The term plant microbiome / plant microbiota comprises all microorganisms being associated with the plant including human/animal/plant pathogens

We agreed that the current term for microbiome/microbiota is well defined and there is no need for further adjustments.

R6 - Proposed reference plants for Europe include barley, potato, tomato, pea and strawberry

We discussed the various plants and the need of microbiome studies in model plants where the genetic resources are in place. Rapeseed was suggested to be added to the list of the above reference plants. In addition to model plants, research on the above-mentioned species is highly relevant for the economy of Europe, but advances in sequencing and genome editing might enlarge the panel. See point R1 below on the Research strategy and policy.

Research strategy and policy:

R1 - Diverse crops with diverse microbiomes for diverse diets for human and animal health and resilient production systems

We discussed that in the current context of large and rapid developments in sequencing and genome editing, and with the increased demand for diversity of raw material for food production, the diversity matters. Therefore, research covering microbiome of diverse crops should be welcomed.

R7 - Precompetitive research should address the identification of microbiome-based plant health and resilience indicators and microbiome understanding needed by the industry

We discussed the necessity of tailoring the projects according to purpose. It is difficult to define what a “good microbiome” actually is, and that depends on the purpose. Projects that target a specific feature in the agricultural practice can be tailored by the demands of industry, however projects that target mechanistic understanding would not necessarily require a demand from the industry.

R10 - International (beyond Europe) cooperation is highly recommended

We discussed that international research programmes exist but these are scattered and driven by independent research initiatives. Examples are the programmes on rice endophytes, N2 Africa, Back to roots. It has been suggested that programmes like Phytobiomes-Alliance-initiated by the US represent interesting opening initiatives for establishing and further developing of international collaborative projects. However, the issue of funding has been raised, as currently, only a very limited possibility for funding non-EU partners exists from EU-funded projects. This limits greatly the involvement and the possibility for international programmes. There is a great interest for aligning EU with national programs at a global level.

R14 - Public programmes should focus on the lower TRLs, leaving the differentiation to companies themselves

We discussed that the level of the applicability needs to be realistic. Currently, the H2020 programmes are too ambitious in this respect, and impedes industry and academia in joining projects that are too far apart in terms of translation. We acknowledged that there is a “death valley” for funding and no link of basic knowledge to applicative programmes currently exists. Such programmes need financial support to enable translation of knowledge from model species to crops, from laboratory to field, from small scale to large scale production.

R17-European infrastructure recommended for plant microbiome research

We discussed that large glasshouse facilities that comply to biosafety requirements are in great need to enable large, high-throughput tests and screenings.

We questioned whether the large phenotyping infrastructures are amenable for repeating microbiome studies based on the knowledge that working with microbes requires specific conditions where the sterility of the system from one experiment to another is a requirement and problems with cross-contamination may occur. We suggested that simpler, mobile and less costly equipment are in great need and will enable research in several laboratories.

Culture collections require financial support from EU. Current format is very good for storage and handling of the large collections but not suitable for the individual labs since the costs of handling and distributing are high. We suggest that EU financial support for the unit handling and maintaining the collection is needed and in this way the costs for the individual laboratories will be reduced.

Data collection- we discussed the high priority of developments at EU level of data collection portals.

Group 3 Report

Participants: Ton Bisseling (chair), Davide Bulgarelli (rapporteur), Angela Sessitsch, Juan Imperial, Ernest Aliche, Maria Saarela

Dissemination and Legislation:

R11 - Early and wide communication of plant and microbiome science and applications is recommended

The group unanimously recognises the importance of engaging with a broad range of beneficiaries of plant microbiome research and innovation to ensure that a fact-informed public can capitalise on translational applications of this discipline. At the moment, the general perception is that plant microbiome do not face a strong opposition from the public as other innovations in the agro-food sector have been encountered almost since their inception (e.g., genetically modified organisms). We therefore advocate the establishment of a dialogue between academia and non-governmental organisations (and other stakeholders) as early as a potential translational application is identified. We recognise this interaction as pivotal towards the acceptance of innovations in agriculture and we recommend the establishment of a dedicated post(s), to be filled with professionals in the disciplines of social media and communication. This post will be within the European Commission and in charge of gathering and disseminating information regarding both general aspects of the microbiome science and specific details of individual funded projects. We propose temporary appointments (e.g., the duration of a framework programme) to be evaluated in term of achieved impact.

R12 - The industry needs personnel trained in classical microbiology and modern microbiome skills

A wider application of agricultural biologicals will likely trigger a surge in the demand of skilled personnel from the expanding plant microbiome industrial sector. At the moment, Universities across Europe appear ill-equipped to meet this demand due to the lack of 'dedicated' microbiome curricula. However, the group recognise that individual companies may well be keen on the training of their own personnel. Notwithstanding, the group identifies the importance of removing "boundaries" existing between experimental and computational biology curricula. Specifically, the group recognise that having perspective experimental scientists with a broader understanding of bioinformatics and data analysis will benefit both future academics and employability in the industrial sector. We therefore recommend a wider use of existing platforms (e.g., ERASMUS plus, COST actions...) to strengthen relationships

among Universities and provide more focussed education and training in plant microbiome research.

R13 - Regulation of microbial products requires improvement to support European bioeconomy and make best use of the plant microbiomes potential

The process of registering microbiome-derived products remain too long and complex: no significant changes have been noticed in the last year. We therefore recommend to streamline the current procedure and we further underline the need to act upon the points outlined in the former report.

Post-meeting note: Remains disharmonized: While the new [Fertilising Products Regulation \(FPR\) \(EU\) 2019/1009](#) recognises plant biostimulants as a distinct category of agricultural inputs, and thus will likely expedite their development, commercialization and application, a similar regulatory framework is lacking for plant protection products.

Annex II Workshop participants and programme

Workshop participants *company representatives

Ernest Aliche, Univ of Amsterdam, NL	Group 3
Gabriele Berg, Graz Univ. of Technol., AT	apologies
Carmen Bianco, CNR, IT	Group 1
Ton Bisseling, WUR, NL	Group 3 chair
Davide Bulgarelli, Univ Dundee, UK	Group 3 rapporteur
Pascal Falter-Braun, Helmholtz Munich, DE	Group 1
Rene Geurts, Wageningen Univ, NL	Group
Juan Imperial, Univ. Polit. de Madrid, INIA / CSIC, ES	Group 3
Karin Metzloff, EPSO	Group1; co-chair workshop
Christophe Mougel, INRA – Centre de Rennes, FR	Group 2
Greta Noelke, IME Aachen. DE	Group
Corne Pieterse, Utrecht Univ, NL	Group 1 chair
Simona Radutoiu, Aarhus, DK	Group 2 rapporteur
Maria Saarela, VTT, FI	Group 3
Soledad Sacristan, UPM-INIA, Madrid, ES	Group 1 rapporteur
Michael Schlöter, Helmholtz Munich, DE	Group 2 chair
Paul Schulze-Lefert, MPIZ, DE	Group 1; co-chair workshop
Angela Sessitsch, AIT, AT	Group 3; co-chair workshop
Stijn Spaepen, KU Leuven, BE	Group 2; co-chair workshop
Sofie Thijs, Uni. Hasselt, BE	Group 1
Leo van Overbeek, WUR, NL	Group 2
*Isabel Vercauteren, AphaBio, BE	Group 2
Michelle Watt, Julich Research Centre, DE	apologies
Anouk Zancarini, Univ Amsterdam, NL	Group 2

Workshop programme

- 10:30 Welcome (Paul Schulze-Lefert)
- 10:45 Recommendations from the first workshop (Angela Sessitsch /Stijn Spaepen)
- 11:00 EPSO and FP9 (EC proposal, EPSO position & mission ideas, actions) (Karin Metzloff)
- 11:15 Pitches (**à 4 min**) main actions and which recommendations from the 1st workshop these address:

Mechanistic insights

- DECrypT (Paul Schulze-Lefert)
- RECONSTRUCT (Paul Schulze-Lefert)
- Barley genetic control (Davide Bulgarelli)
- Viroplant (Soledad Sacristan)
- Back2Roots (Corne Pieterse)
- Root microbiome and plant immunity (Corne Pieterse)

Towards translational microbiomes

- MICRO4PLANT (Carmen Bianco)
- CIRCLES (Davide Bulgarelli)
- MASTER (Angela Sessitsch)
- BIOFRESH (Sofie Thijs)

- EcoCities (Sofie Thijs)
- 12:15 Break
- 12:25 Infrastructure & Databases / open access
 NL Plant-Eco Phenotyping Center (Corne Pieterse)
 DD-DeCaF (Soledad Sacristan)
- Networking, dissemination & policy
 HUPLANT (Leo van Overbeek)
 Plant Biological Network (Simona Radutoiu)
 Centre of Excellence Severo Ochoa (Soledad Sacristan)
 MICROBIOMESUPPORT (Angela Sessitsch)
- 13:00 Lunch
- 13:45 Breakout groups to discuss recommendations based on 1st workshop*
- Group 1: Standardization; Mechanisms; Research strategy & policy;
 Dissemination & legislation (Rapporteur: Davide Bulgarelli)
- Group 2: Research strategy & policy; Standardization;
 Dissemination & legislation; Mechanisms (Rapporteur: Simona Radutoiu)
- Group 3: Dissemination & legislation; Standardization;
 Research strategy & policy; Mechanisms (Rapporteur: Soledad Sacristan)
- 15:20 Break – rapporteurs to prepare first feedback
- 15:30 Presentation of group outcome and plenary discussion
- 16:00 Next steps (Angela Sessitsch / Karin Metzloff)
- 16:30 Closure