



Phytobiomes Convening Event Summary

Introduction

On July 29, 2016, the Foundation for Food and Agriculture Research and the American Phytopathological Society (APS) co-hosted the Phytobiomes Convening Event, with generous sponsorship from The BioAg Alliance. The meeting brought together representatives from academia, industry, nonprofit organizations and the government to scope a potential FFAR funding opportunity in phytobiomes. Event hosts asked participants to identify the pre-competitive space where collective efforts in phytobiomes research could benefit a broad swath of the agricultural community. Specifically, participants focused on knowledge gaps and technology needs for accelerating our ability to understand and manipulate the phytobiome. The following is a summary of the broad areas of consensus coming out of the two working sessions in the afternoon (see Appendix 1 for full agenda).

Session Summary

Industry Panel

The Convening Event included a robust industry panel (see Appendix 1 for participants). The companies and commodity board represented a range of investment in microbiome research and a breadth of strategies to improve crop protection and crop efficiency through manipulation of the microbiome. Asked to identify research topics in the pre-competitive space, panelists repeatedly touched on the need to understand the functional groups in the microbiome to better understand community assembly. While several companies maintain large, private microbe libraries, there is still considerable work to be done in identifying microbes and classifying them by function. Some companies are currently working with academic partners to open up these private libraries and databases with certain intellectual property protections. There is opportunity for similar partnerships moving forward.

Once microbes are identified and classified, formulating inoculants that are deployable and effective in the field is another major task. There are opportunities in the pre-competitive space for research in microbiome establishment and dynamics. Companies want to understand the relationship between plant genotype and the microbial community, and public germplasm libraries could play a key role in understanding these dynamics. Additionally, it will be important to understand how interchangeable functional types are in inoculant formulations: do native and non-native species of the same functional type perform very differently, or is there potential for inoculant formulations to perform well across broad geographies?

Lastly, there is a great need for students trained in root biology and capable of working in the team environment of private industry.

Identifying Knowledge Gaps

Broad, Long-Term Projects

The working groups concluded that large-scale, long-term collaborative research projects on a handful of distinct cropping systems would provide the greatest insight into how phytobiomes assemble, how they change over space and time, and how producers can manipulate them to enhance crop quality and productivity. Cropping systems to consider are annual row crops, annual specialty crops, and perennial specialty crops. Most research on the phytobiomes has occurred with young, annual crops, so work with perennial crops or later-stage crops could be particularly illuminating. Additionally, the effects of the legacy of land use on the phytobiome are unknown. Each project team should consist of diverse experts and stakeholders, including scientists from academia, the government, nonprofits and private industry, as well as growers. Each project would include:

Field studies: To understand the phytobiome in the complex biotic and abiotic environment of working lands.

Hypothesis-driven reductionist studies: To complement the field studies by disentangling the multiple interacting biotic and abiotic components of the phytobiome and move toward a mechanistic understanding.

Formal Iterative Tests Between (1) and (2): To make reductionist studies relevant to field conditions and identify the common denominators between lab results and field outcomes.

Integration and Synthesis: To bring together data across research questions, field sites and production systems, capitalizing on pre-existing data as well as designing projects to produce complementary datasets.

There is opportunity for a research coordination network (RCN) to ensure that these studies and their data are designed to be integrated. It could also be valuable to use USDA's Long Term Agricultural Research (LTAR) sites as a basis for these studies to capitalize on large datasets and infrastructure in place at these sites.

In addition to the large-scale, long-term collaborative projects, the working groups suggested a separate, smaller line of uncommitted funding attached to each project that is reserved for researchers not already involved in the project who want to perform additional research and/or analyses in the targeted cropping system (bringing new depth and insight) or to perform some component of parallel research in a different cropping system (to provide insight on generalizability of phenomena across systems).

Focused, Short-Term Projects

While the phytobiome encompasses plants, their environment, and their associated communities of organisms, the plant and soil microbiomes, in particular, emerged as key areas of mutual interest between the public and private sectors. Participants identified "drivers of microbiome assembly" as an appropriate umbrella for a variety of near-term projects on the phytobiome. Many aspects of microbiome assembly are of interest to the private sector, including inoculate establishment dynamics, microbiome resilience and management, the impact of plant genetics on the microbiome, and development of reproducible "model" microbiomes for use across systems. In particular, participants emphasized the need to understand the functional groups in the phytobiome that are critical to productivity, because even if species differ across systems, there is likely to be more consistency in the functional groups that enhance or suppress productivity. Crosscutting all of these themes is the impact of abiotic and biotic conditions in space and time. For longer-lived and perennial crops, the impact of time is particularly under-researched. Attendees

suggested that research projects involving academic scientists and industry partners would be most fruitful, and that an annual meeting would be highly beneficial to synthesizing information. The diverse group of attendees also stressed the need to understand the impacts of the phytobiome on post-harvest metrics: including animal and human pathogens, nutritional quality, and probiotics.

With the phytobiome community just beginning together, there is also a need for shared resources. Establishing a shared vocabulary for the community could greatly facilitate collaboration across disciplines and the time is ripe with the launch of the *Phytobiomes* journal. A new generation of taxonomists will be in demand to identify microbial community members. The community can also benefit from collective efforts in genome sequencing, sampling and statistical technologies, database standardization, and culture collection.

Technology Needs

The group also discussed broad technology goals for studying the phytobiome. Several major themes emerged:

Non-Destructive, Real-Time High-Throughput Phenotyping: High throughput phenotyping for canopy measurements, root structure and physiology, microbial metabolic products, and soil characteristics. Tools that help researchers build “topographical” maps of microbe distribution in the soil would be particularly valuable.

Precise Microclimate Characterization: Understanding phytobiome variation across a field will require a precise spatial analysis of microclimate (temperature, pH, salinity, humidity, etc.) in real time.

Smart Plants: Plants that have in situ sensors for various conditions. Sensors could derive from genetic manipulation or from inoculation with endophytic microbes.



Phytobiome Convening Meeting

July 29, 2016 | Salon IV, Marriott | Tampa, FL

Open Community Input Session

- 8:30-8:40 **Opening Remarks**, *Dr. Sally Rockey (Executive Director, FFAR)*
- 8:40-8:45 **Opening Remarks**, *Dr. Sally Miller (President, APS)*
- 8:45-10:00 **Lightning Talks** (5 minutes each)
- Tapping into the phytobiome of switchgrass to enhance establishment and productivity, *Kelly Craven*
 - Harnessing the power of the microbiome of perennial plants to manage vascular plant diseases, *Caroline Roper*
 - The role of microbial predators in the phytobiome, *Carolee Bull*
 - Plant surface microbiota, *Johan Leveau*
 - Linking weather and climate to the phytobiome, *Andrew Jones*
 - Microbiomes of hemipteran plant pests, *Andy Michel*
 - Phytobiome and food safety, *Jeffrey LeJeune*
 - Quantitative microbial ecology for phytobiome research, *Bruce Hungate*
 - Microbiome profiling of Soybean SDS-suppressive soils, *Ali Srour*
 - Do foliar microbes mediate composition of the rhizosphere microbiome?, *JP Dundore-Arias*
 - The potential and challenges of phytobiome breeding, *Terrence Bell*
 - Engineering rhizobiomes through biostimulation of quorum quenching bacterial populations, *Kashif Riaz*
 - Managing indigenous populations of *Dactylella oviparasitica* to suppress the sugarbeet cyst nematode, *James Borneman*

- Elevated surface ozone and phytobiomes: Challenges and opportunities, *Alsayed M. Mashaheet*

10:05-10:20 **Brief Overview of the Phytobiome Roadmap**, *Dr. Gwyn Beattie*

10:20-10:35 Break

10:35-11:35 **Managing the Phytobiomes in the Field: Private Sector Perspective**

Moderator: Kellye Eversole; Speakers: Matthew DiLeo (Novozymes), Kelly Whiting (United Soybean Board/SmithBucklin), Lakshmi Praba Manavalan (Bayer), Virginia Ursin (Indigo Ag), Renée Rioux (New Leaf Symbiotics), Avi Alcalá (Valent)

11:35-11:40 **Brief FFAR remarks on the direction of Phytobiome programming at FFAR**
Sally Rockety

11:40 Open Community Input Session Adjourns

Invitation-Only Session

11:40-12:40 Lunch (Salon V, Marriott)

12:40-12:50 **FFAR sets up goals for session**
Tawny Mata (Scientific Program Director, FFAR)

12:50-3:20 **Prioritization of phytobiome knowledge gaps for funding**
Moderators: Linda Kinkel and Steve Lindow

3:20-3:40 Break

3:40-5:10 **Identification of Fundable Technology for Phytobiomes**
Moderators: Carolee T. Bull and Andrew Jones

5:10-5:30 Summarize and Next Steps

***FFAR and APS would like to thank The BioAg Alliance
for their generous sponsorship of this event.***

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