Exploring Phytobiome Systems: From Microbiomes to Next Generation Precision Agriculture

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A New Paradigm is Needed

Sustainably provide sufficient quantity of high quality food, feed, and fiber

Doubling global crop production by 2050 will require ~2.4% increase per year in yields

GLOBAL YIELD GROWTH RATES (%)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Maize</td>
<td>2.20</td>
<td>1.77</td>
</tr>
<tr>
<td>Wheat</td>
<td>2.95</td>
<td>0.52</td>
</tr>
<tr>
<td>Rice</td>
<td>2.19</td>
<td>0.96</td>
</tr>
<tr>
<td>Soybeans</td>
<td>1.79</td>
<td>1.08</td>
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Another Approach is Needed

• Reductionist approach to biology and agricultural science
• World is linear – understanding parts individually
• Reliance on partial knowledge - genetics or environmental factors, soil or plant, plant or microbe, microbe or community
• Reality - Complex, non-linear organization and regulation of biological systems
• New Paradigm - Phytobiomes
What Are Phytobiomes?

Micro- and Macroorganisms
- Viruses
- Archaea
- Bacteria
- Amoeba
- Oomycetes
- Algae
- Fungi
- Nematodes

Their environment

Plants

Arthropods, Other Animals and Plants
- Insects
- Arachnids
- Myriapods
- Worms
- Birds
- Rodents
- Ruminants
- Weeds

Soils

All of their associated organisms

Climate
Phytobiomes vs Plant Systems

• **Plant systems** focus on a specific, defined plant (e.g., maize) and interactions of that plant with other components.

• **Phytobiomes** focus on a plant ecosystem that may involve any number of different types of plants, organisms, and physical components.
  – Interactions of all these components will be used to identify the best crop/variety/management practices... for a given site and a given period.
**Why Now?**

- **‘Omics-enabling technologies**
  - high-throughput sequencing
  - computational biology & modeling

- **Systems-level approaches**

- **Advances in computational science**
  - Quantum computing
  - Machine learning
  - Analytics
  - Predictive analytics

- **Precision Agriculture**
  - Variable rate seeding & input
  - UAVs
  - Soil & weather sensors
How Do We Get There: Phytobiomes Roadmap for Research and Translation

A new vision for agriculture:

Achieve sustainable crop productivity through a systems-level understanding of diverse interacting components

www.phytobiomes.org
Developing a foundation of knowledge for:

- how phytobiome components influence or are influenced by plants or the plant environment – *in context!*

- how that information can be used to improve crop productivity, quality, nutrition, safety, and security

- includes knowledge and technology gaps
What genetic linkages connect phytobiome components?
→ Can we breed plants that select for beneficial communities?

What constitutes a “healthy phytobiome”?
→ Develop biologicals and predictors of crop and soil health
What are the mechanisms by which specific management practices promote ecosystem health?

→ Design novel or improved management practices

Can we exploit predictive and prescriptive analytics to design site-specific solutions to environmental challenges?

→ Can we incorporate biological information into precision agriculture technologies?
Outcomes of this new vision for agriculture

Managed or engineered phytobiomes that promote:

- Effective rehabilitation of degraded and depleted lands worldwide

*1.5 billion people depend on degraded lands for survival!*

Source: UNEP
Outcomes of this new vision for agriculture

Managed or engineered phytobiomes that promote:

- Increased resilience of our cropping systems to pests, pathogens, water and nutrient limitation
- Pest control practices that are best suited for sustainable productivity
- Full integration of biologicals into site-specific crop management (precision agriculture)
Outcomes of this new vision for agriculture

- Adaptive, **data-driven, on-farm systems** for managing phytobiomes for optimal productivity

- **Increased profitability** of sustainable food production to enable growers to meet demand

www.linkedin.com/pulse/foreign-affairs-precision-agriculture-revolution-ulrich-adam
International Alliance for Phytobiomes Research, Inc.

• A nonprofit, public-private organization
• Mission -- to establish a science and technology foundation for phytobiome-based, site-specific enhancement of the sustainable production of food, feed, and fiber

www.phytobiomesalliance.org
Phytobiomes Alliance: Activities

• Identify research & technology gaps and coordinate projects to address those gaps
• Establish national, international, and multi-national public-private projects and networks
• Coordinate and collaborate with existing initiatives internationally, e.g., soil health
• Establish standard protocols, reference collections, and reporting standards

Scientific Coordinating Committee (project leaders and financial sponsors): Establish scientific strategy, coordinate projects, establish working groups, ...

General Members: anyone with an interest in phytobiomes research
Standards

• Alliance-NIST (National Institute for Standards & Technology) Workshop on Standards for Phytobiomes, 12 August 2016
  – sample collection (how to avoid under- and over-sampling in the field)
  – sample storage
  – development of reference communities
  – minimizing plant macromolecule interference in microbiome/mycobiome/virome characterization
  – reference datasets for analytical tool development
Result: Phytobiome Enabled-Next Generation Precision Agriculture

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Join Us!

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