System-Level Knowledge of Phytobiomes Will lead to More Environmentally Friendly Agricultural Production and Healthier Food, Feed, and Fiber

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Global challenges

Expanding population

Declining productivity

World Population: 1950-2050

Source: U.S. Census Bureau, International Data Base, August 2016 Update.
Simplicity to complexity

Traditional Agricultural Sciences

• Reductionism

• World is linear – understanding parts individually
  – Soils
  – Plant genetics
  – Microbiomes or
  – Weather and environment

Real World Situation

• Complex system, non-linear organization

• Governed by multiple nonlinear interactions and multiple environmental variables

We need a global approach to elucidate, quantify, model, and potentially reverse engineer biological processes & mechanisms for their geophysical context

Decipher Phytobiomes
Phytobiomes

Climate

Micro- and Macro-organisms
- Viruses
- Archaea
- Bacteria
- Amoeba
- Oomycetes
- Algae
- Fungi
- Nematode

Plants

Soils

Site specific environment

Associated organisms

Arthropods, Other Animals and Plants
- Insects
- Arachnids
- Myriapods
- Worms
- Birds
- Rodents
- Ruminants
- Weeds
Holy grail of phytobiomics

To understand, predict, and control emergent phenotypes for sustainable production of food, feed, and fiber on a given farm.

How?
The International Alliance for Phytobiomes Research
A nonprofit Alliance of industry and academic partners
All growers have the ability to use predictive and prescriptive analytics to choose the best combination of crop/variety, management practices, and inputs for a specific field in a given year taking into consideration all physical (climate, soil…) and biological conditions (microbes, pests, disease, weeds, animals….).
Strategy and implementation

- Industry leadership in identifying research, resource, and technology gaps (e.g., model development)
- Focus on pre-competitive science
- Facilitate linkages within and between industry and academia
- Coordinate projects to address gaps
- Empower industry growth and profitability in the phytobiomes space – connecting site specific biological and physical information for agriculture
Initial priorities

- Develop, validate, and optimize accurate models that include all physical & biological components and their interactions

- Enable simple, simulation models that are functionally accurate to real world complex conditions – e.g., greenhouse studies that reflect field conditions

- Design systems level predictive and prescriptive analytics for on-farm/site implementation

- Create databases of near real-time environmental and biological data
Immediate needs

• Farm, field, orchard, grassland, or forest specific weather measurements linked to plant productivity, environment, and management practices

• Temporal or spatial models of phytobiome that quantify environmental differences and measure stress (e.g., drought..)

• Site specific environmental timing and episodic intensity measurements

• Identification of minimum instrumentation necessary for accurate predictions of microclimates on small, medium, and large tracts
  - 100 acre apple orchard, 400 acre corn or 800 acre wheat farm, or 2,500 acre ranch

• Instrumentation cheap enough for wide scale deployment

• Phytobiomes network within weather community
• Scientific Coordinating Committee

✓ Alliance sponsors

✓ Project leaders

• Alliance working groups (weather, data, standards….)

✓ Overall topical leader

✓ Involved in projects aimed at filling gaps in knowledge, resources, or tools
Acknowledgements

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