From Simple to Complex – Phytobiomes and the 2050 Vision for Agriculture

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Global challenges

World Population: 1950-2050

Year

Population (billions)


3 Billion 4 Billion 5 Billion 6 Billion 7 Billion 8 Billion 9 Billion

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

Arable land per caput (ha in use per person)


0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70

Developed countries

Developing countries

Global economy

The Economist

How to feed the world
Declining Productivity

THE GLOBAL AGRICULTURAL PRODUCTIVITY (GAP) INDEX™

Source: Food Demand Index is from Global Harvest Initiative (GHI) 2013.
Agricultural Output from TFP Growth is from USDA Economic Research Service (2013).
Crop Improvement Is Complex

- Increase yield
- Adapt to changing climate
- Achieve durable resistance to abiotic and biotic stresses
- Maintain consistent quality & yield
- Ensure sustainability
- Meet contextual situation
Simplicity to Complexity

Traditional Agricultural Sciences

- Isaac Newton - nature is exceedingly simple
- Reductionism
- World is linear – understanding parts individually
- Rely on partial knowledge – genetics, soils, microbiomes, animals, environment
- Linear, deterministic assumption that genes are causes and organismic fitness is effect

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

Crop plants, their environment, and their associated micro- and macro-organisms.

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

“Biome” - Site specific environment

Plants

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

Soils

Associated organisms

Climate
“Phytobiome”? 

- “Phyto-” related to plants, crop plants
- “Biome” distinct geographical area, e.g., site specific, farm
- Phytobiome ≠ “plant microbiome”
- Phytobiomes ≠ “plant systems”
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
Who We Are

An international, nonprofit Alliance of industry, academic, and governmental partners
All farmers 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
• 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 implementation

• Create databases of near real-time environmental and biological data
Alliance Priorities

• A whole genome sequence database for microbes that includes geospatial data
• Accessible, curated strain repository for all agriculturally relevant microbes with back-up at ARS genetic resources preservation labs
• Multidisciplinary phytobiomes research coordination networks
• Standards development – sampling, storage, reference communities, reference datasets for analytical tool development
• Research linking site-specific and temporal physical & biological data for crops, forests, and grasslands
• Science to support the regulations that may exist for agricultural biologicals, including biopesticides and permitting
Working Groups

- Ag Data – physical & biological
- Standards
- Regulatory
- Climate/Weather
How to become involved

Scientific Coordinating Committee

✓ Alliance sponsors

✓ Project leaders

Alliance working groups

✓ Overall topical leader

✓ Involved in projects aimed at filling gaps in knowledge, resources, or tools
• Omics-enabling technologies
  – high-throughput sequencing
  – computational biology & modeling

• Systems-level methods

• Advances in computational science
  – Quantum computing
  – Machine learning
  – Analytics
  – Predictive analytics

• Precision Agriculture
  – Variable rate seeding & input
  – UASs
  – Soil & weather sensors
Agricultural Biologicals

2016-2022 CAGR = 12.76%

Market equals $11.35 Billion in 2022

Source: Markets and Markets, 2017
Growing Agricultural Investments

The Growing Pace of Global Investment in Agriculture

Investor interest in the agricultural sector is heating up...

And there's still room for investment to grow. Agriculture makes up nearly 7% of global GDP.

Major agtech subsectors that received funding in 2015 include:

- Irrigation & Water ($673 million),
- Drones & Robotics ($383 million),
- Soil & Crop Technology ($168 million),
- Sustainable Protein ($160 million), and
- Indoor Agriculture ($77 million).

In 2006-2010, new funds raised an average of $1.24 billion a year to invest in agriculture. The same figure more than doubled for 2011-2015 to $3.08 billion a year.

However, agtech investment made up less than 3.5% of total venture funding in 2015.

Sources: AgFunder, Peqin, CIA World Factbook, Gro
Now is the time to
Join Us!
Acknowledgements

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