PHYTOBIOMES



Dan Dinelli, CGCS North Shore Country Club

The entire system of factors that affect or are affected by plants, including: microbial communities (microbiomes) of the plants and soils. Animals, insects, nematodes, other plants, soil, weather and environment. _{Globalsoildiversity.org}

An ecosystem is a community of living organisms in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system. These biotic and abiotic components are regarded as linked together through nutrient cycles and energy flows. As ecosystems are defined by the network of interactions among organisms, and between organisms and their environment

Phytobiome...Plants Ecosystem

Wordsmithing

Phyto & phyte – meaning "plant" as in phytobiome.
Biome – the ecological community where something lives.
Micro – meaning "small" as in microorganism or microbiome.
Rhizo – meaning "root" as in rhizosphere.
Sperm – meaning "seed" as in spermosphere
Sphere – the environment where something lives.
Phyllo – meaning "leaf" as in phyllosphere or phylloplane (leaf as a habitat).
Endo – meaning "within" as in endophyte (fungas living in a plant) or EndoMycorrhizae living in the root. (grass)
Ecto – meaning "outer" as in ectomycorrhizae meaning lives outside on the root.

Phylo – combining form. **Symbiosis** – living together as in **PHYLOSYMBIOSIS** meaning the <u>host genetics</u> plus the <u>community of organisms</u> that defines, influence functions and responsible for host existence **Human microbiome** study started in 2008, developed tools and methods to study microbes, mainly bacteria. Broader use and technology have also drove the costs down to study microbes.

Found...over half of our cells are microbial

30 trillion human cells vs 39 trillion microbial cells

DNA... 1% of our human cells makeup the total DNA

20,000 – 25,000 human genes

vs 2-20 million microbial genes

Leads to a systems approach in human health. Rob Knight

Teaspoon of soil contains 100 million - 1 billion bacteria, about a ton of bacteria per acre. Elain Ingham.

The rhizosphere has approximately 10 times the population of the bulk soil around it.

Many of the relationships are specific to the plant and their exudates...**networking!**

Types of Microorganisms

Decomposers of carbon compounds i.e. root exudates, plant and animal litter

Mutualists, microbes that form relationships with plants

<u>Pathogens</u>, microbes that cause disease i.e. death or dysfunction. Some microbes can be in both categories, i.e.. *Rhizoctonia* both a decomposer and pathogen.

Lithotrophs or chemoautotrophs, microbes that get their energy from non-carbon sources, i.e. minerals, iron

Nasal

Oral



Gastrointestinal

Urogenital

Some of the Microbiomes of the Human Body. (Credit: National Human Genome Research Institute

PLANTS HAVE MICROBIOMES, TOO

Every part of a plant hosts distinct microbial communities, from leaves to roots and in the soil that surrounds them

Many microbes benefit their hosts by boosting plant immunity, helping plants absorb nutrients, or protecting against drought conditions

Nematodes video



Challenges in studying the phytobiome/microbiome...

- First, who are the players, identify the microbes. DNA
- Study what they are capable of.
- Understand their role within the community.
- How does the plant and its ecology effect their function.
- Develop a systems approach to soil quality & plant fitness with targeted outcomes

For example... Bioject, Pseudomonas aureofaciens (strain Tx-1 discovered by Dr. Joe Vargas @ MSU). A bacteria that produced an antibiotic (phenazine – 1 carboxylic acid 'PCA') when cell density got high enough in the lab near 10 to the eighth cfu/ml. It was clear "what" this microbe was capable of. But not clear on how to get it to function in a natural setting. Consistent and predictable







IREATMENT	GREEN TISSUE ² (%)	2	
UNINOCULATED CONTROL	98.9a	in the second se	
CURED-RS-CREN	95.2a	W	
RS-CREN (WILD TYPE)	4.4c	£ 4-	
RESTORED-RS-CREN	26.6b	NBU 3-	
¹ Plants were assessed after 21 days incubation at 28°C with a 16h photoperiod		EAA 1	C, (45.35a)
² Digital image analysis - values with same letter are not significantly different at $P < 0.05$			Cured-Rs-Cren

Fig. 4. Assessment for phenotypic differences of fungal strains. **A**, Disease symptoms of (i) mock-inoculated, (ii) cured-Rs-Cren, (iii) Rs-Cren, and (iv) restored-Rs-Cren pathogenicity on creeping bentgrass cultivar Crenshaw at 21 days post inoculation and incubation under high relative humidity (>90%), at 30°C and 13 h photoperiod. **B**, Virulence assay based on percentage of green tissue within a 3×3 cm² area in inoculated pots, estimated by analysis of digital images with SigmaScan Pro version 5.0 software, was significantly higher for the no inoculated (mock) control and cured-Rs-Cren compared with Rs-Cren and restored-Rs-Cren. **C**, Phenylacetic acid production by cured-Rs-Cren, Rs-Cren, and restored-Rs-Cren, with standard error bars, respectively, following incubation in complete media at room temperature for 21 days in the dark. Values followed by the same letter are not statistically different ($P \le 0.05$). Values in parentheses represent average mycelia dry weight (milligrams) from two independent experiments with three replicates each.

B, (32.52b)

Restored-Rs-Cren

Rs-Cren

Strain

A Dimorphic and Virulence-Enhancing Endosymbiont Bacterium Discovered in *Rhizoctonia solani*

Ken Obasa and Frank F. White, Department of Plant Pathology, University of Florida

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The rhizosphere



- The zone of soil that is significantly influenced by living roots
- Usually extends about 2mm out from the root surface
- The rhizosphere is enriched in organic material due to root exudates and sloughed off root cells.
- Microbial activity in the rhizosphere may be 2 - 10 greater than in the bulk soil.



Plot plan for Fairway #8

Composted Poultry Yardwaste/Biosolid **Blend (1:1) Composted** earthworm **Castingsted** Poultry litter (0.5) **Composted steer** manure **Fertilizer** Fertilizer + Fungicide-Spring only - Fall only Spring and Fall













Example of Mutualism...

Response of creeping bentgrass (Pennlinks) after 4 months to PHC- TurfSaver applied after aeration (May thru August, 1996) at North Shore Country Club

Treatment	%VAM Colonization	Root Depth (cm)
Control	34%	6.7
EndoMycorrhizae	a fair of the second second	
VAM TurfSaver	55%	10.3

Note: High P = less infection of VAM

In general grasses promote a bacteria dominated system relative to forest soils. Can we manage this system to include good fungi to better cycle thatch? (lignin, cellulose)

Just about everything we do effects the phytobiome, impacting the microbiome. Plants, their genetics, growth stage and growing condition in many ways drive the microbiome as exudates alter the communications and various energy sources. Some microbes alter the growth of plants in various ways including nutrient availability, protection, growth promoting biochemicals and soil health.

Its much to do with communication and networking ...

plant – microbe and microbe – microbe.

- Plant genetics... The plant drives much of the biology
- pH
- Moisture
- Soil gasses
- Temperature
- Nutrients, i.e. nitrogen, (ammonium vs. nitrate form), Fe, P etc.
- Mowing
- Hormones
- Organic matter, types, various proteins / amino acids, C/N ratio
- Chemicals, salinity
- Biology, impacts from other organisms and their byproducts
- Soil ecology
- Inputs and practices that effect signaling/communications etc. etc.

What can we expect with a better understanding of the phytobiome?

- Not just bugs in the jug, probiotics
- Plant breeding towards specific goals, i.e. improved Endophytic activity
- Inputs to manage exudates and guttation fluids
- Early indicators of problems before visual symptoms
- Insect activity, biochemical effects as pheromones etc.
- Weed control
- Nutrients. Improved or targeted cycling , nitrogen fixation, P availability
- Plant immune system bolstered
- Phytohormones i.e. auxins & GA drive plant response from microbes
- Drought tolerance
- Bioremediation
- Enzymes, proteins, amino acids, organic compounds,...many mechanisms and signaling compounds to tap into.
- Management practices and inputs that will drive a systems approach to soil & plant health.

PHYTOBIOMES—Integrating efforts spanning diverse components of agricultural systems

Everything we do impacts the phytobiome. I always ask myself, "am I impacting the health and function in a positive or negative way?"

A lot to look at... Support Research... Stay Engaged...

Joe Roberts Ph.D. @ University of Maryland, Cale Bigelow Ph.D. @ Purdue University, Koch Ph.D. @ University of Wisconsin, Jo Anne Crouch @ USDA, Lisa Beirn @ Rutgers Ruchi Verma @ USDA, and other turf scientists, agronomists, weed scientists, pathologists and entomologists.

As science learns more about the phytobiome, turf managers will have the practices & inputs to influence plant function, the environment and the community turf interacts with creating sustainable plant health and improved playability