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Harnessing Microbes for Sustainable Food Production

Sustainable Agriculture Research & Education (SARE)

Our objective:

The goal of this project is to conduct an education program on the essential roles of microbes in sustainable agriculture. Topics discussed include microbes that are involved in mineralization of nitrogen and phosphorus, root associated beneficial microbes (mycorrhizal fungi and rhizobium), and microbes that are involved in anaerobic digestion and the composting of farm waste, which can be used for soil amendments. This education program will allow farmers to learn methods to sustainably fertilize and improve soils using naturally occurring materials and processes, the concept that over fertilization or irrigation may pollute groundwater or watersheds, and skills about waste conversion into renewable energy and biofertilizer, which make farmer operations more sustainable.

(about page)

About Us

"Harnessing Microbes for Sustainable Food Production" is a USDA Sustainable Agriculture Research & Education (SARE) program funded research and education project. Our practices include education and training about basic knowledge on beneficial microbes in soils, and methods to improve soil health through enrichment of soil microbes.

In order to make food production sustainable, farming practices and operations must be sustainable. Soil nutrients, leachate water quality, and farm waste need to be managed efficiently to mitigate negative environmental impacts of farming. Microorganisms are essential and play important roles in agriculture by facilitating growth of plants via symbiotic interactions, maintaining the water quality of receiving water bodies, and converting farm waste into renewable energy and nutrient-rich biofertilizer. The microbial processes are natural rather than synthetic, mediating long-lasting interactions between nutrients, plants, and soils.

This project consists of an education program on the crucial roles of microbes in sustainable agriculture. Topics covered include microbes involved in the nitrogen cycle, the phosphorus cycle, mycorrhizal fungi, and microbes that are involved in anaerobic digestion and composting of farm waste. This education program will allow farmers to learn methods to sustainably fertilize and improve soils using naturally occurring materials and processes, the concept that over fertilization or irrigation may pollute groundwater or reservoirs, and skills about waste conversion into renewable energy and biofertilizer, which make farming operations more sustainable.

(literature page)
pdf's pf each article will be linked in this section

Literature

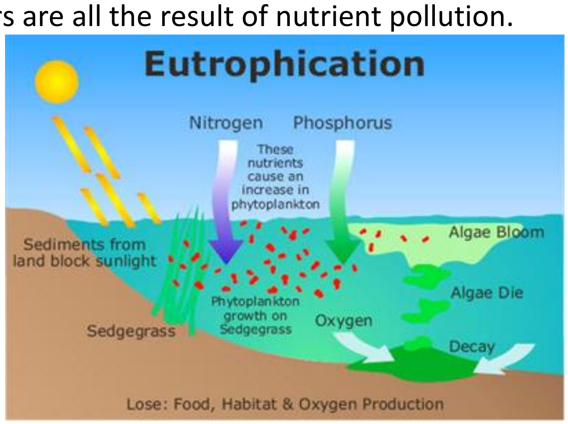
The articles and summaries in this section provide insight to the following key topics that are relevant to the SARE project: Agricultural Practices and Water Quality, Agroecosystem Concepts, Anaerobic Digestion by Microbes, Beneficial Soil Microbes, Compost Microbes, Plant Disease & Soil Disinfection, & Disease Suppression by Soil Amendment, Soil Amendment Biosolids Safety, Soil Health Concept & Indicators, Soil Management Practices, Sustainable Agriculture Practice & Microbes, and Sustainable Waste Management

<u>Agricultural Practices & Water Quality</u>

Agriculture is one of the top consumers of water in the world. Water, unlike other resources, is renewable so long as the resource is not overused to the point of depletion. This means that when water is used in any setting, it continues to flow through the water cycle to other aspects of the ecosystem.

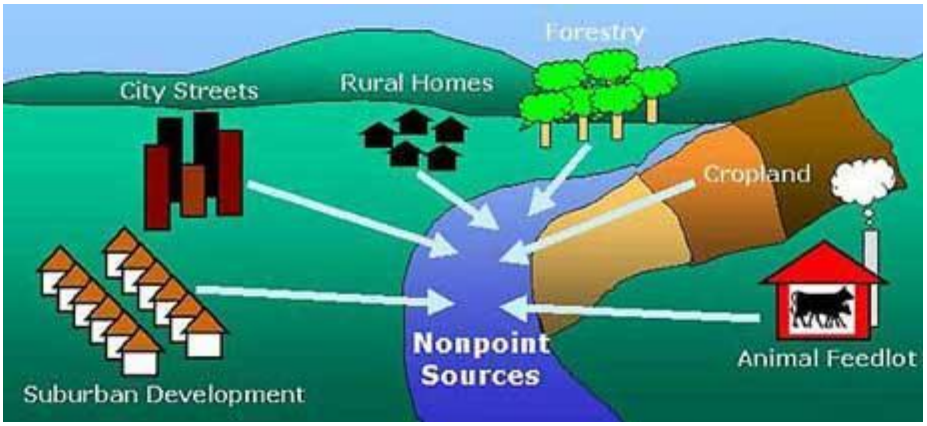
Water that are applied to farm lands can evaporate into atmosphere or flow into watersheds or aquifer through soils. Excess amount of nutrients that are placed on farmlands through the use of fertilizer can leach from soil to watersheds, which may add nutrients into aquatic waterbodies such as lakes, wetlands, streams and aquifer.

Eutrophication is the term for excessive productivity and algae growth in water due to an influx of nutrients. Eutrophication, harmful algae blooms, and nitrate issues in springs and aquifers are all the result of nutrient pollution.



An example of eutrophication and the resulting algae growth, from https://onlinesciencenotes.com/eutrophication-causes-effects-and-controlling-measures/

Nutrients that are released from farmlands are referred to as one of non-point source pollutions. Eutrophication, mentioned previously, is a common example of nonpoint source pollution. Nonpoint source pollution is a great example of how communities must work together to ensure the good health and upkeep of their watershed.



An example of "nonpoint source pollution" from https://oceanservice.noaa.gov/education/kits/pollution/04nonpointsource.html

The nature of water makes it especially good at carrying nutrients and other pollutants after they have been dissolved, so the best way to manage harmful impacts on watersheds is to demonstrate proper foresight when dealing with nutrients and chemicals that may be washed away or have direct contact with a shared water source. Expect water to travel through the environment carrying any contaminants gathered along the way until they reach to adjacent waterbodies. Pesticides and herbicides entering the water have detrimental effects to the wildlife they come into contact with!

Agricultural practices that help maintain water quality include:

- Do not excessively till the land. This loosens the soil and makes it more likely to wash away, while also giving the water more access to the nutrients below the outer layer for leeching.
- Account for all nutrients present in the soil. Keep record of the nutrients applied, amount remaining in the soil, and those lost to plant growth. These levels should not exceed the amount necessary for the crop being grown, as this may lead to movement of nutrients (leaching),
- Vary pest management practices. By keeping the pest management practices varied (ex. Trapcrop, crop rotation, intercropping, etc), pesticides may only become necessary in dire situations while also minimizing the pollution.
- Implement conservation buffers. Placing a buffer plant (such as thick grass) at the edge of an agricultural area can capture some pollutants before they are able to runoff into the waterways.

(for more suggestions, please visit https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=1362)

Agroecosystem Concept

It is easy to imagine a divide between agricultural land and a natural ecosystem. Especially in instances where cash crops are not native, monoculture is practiced, or the soil is constantly being altered, it is easy to lose sight of the true relationship between farmland and the natural ecosystem. Adoption of agroecosystem concepts allows us to see farms as a part of natural ecosystems. While cultivating lands for food production, farms can also help increase and maintain wildlife diversity. By taking advantage of natural resources (such as predators), farmers could control pests and create a healthier environment for increased yield and a healthier environment.

Due to the relationship between farmland and the surrounding wildlife, farms are truly part of a regional ecosystem and actively impact the environment surrounding them. The key principles of agroecology are:

- Enhancing species and genetic diversification of the agro-ecosystem
- Enhancing beneficial biological interactions and synergies among components of agro-biodiversity and the surroundings, thus promoting key ecological processes and functions.

(Taken from https://www.oxfamamerica.org/static/media/files/ib-building-new-agricultural-future-agroecology-280414-en.pdf)

Agroecology favors the incorporation of more genetic diversity and improving biological interactions between surroundings. These points have notable overlap, as polyculture has been shown to reduce pest populations and slow the spread of disease, while genetic diversity is further enabled by the presence of unrelated and diverse wildlife outside of the farm. Genetic diversity is also crucial in crops themselves, since a variety of different plants will be more resistant to disease and infestation than a monoculture, thus providing greater security and ensuring plants remain healthy.

Plant Disease & Soil Disinfection & Disease Suppression by Soil Amendment

The realm of the rhizosphere is flush with a diverse array of microorganisms. Plant disease can be suppressed by an overwhelming population of other microbes, specifically ones that act antagonistically. There is a difference between suppression of a disease and eradication of disease. In most cases, disease severity is not extreme enough to call for eradication methods like soil solarization and fumigation. These practices of eradication are extremely effective in elimination of undesirable organisms like predatory nematodes, insects of economic concern and plant pathogens, but act indiscriminately and eliminate beneficial soil dwelling organisms as well. When a soil is “wiped clean” with such a practice, it becomes free real estate for any organism, beneficial or pathogenic alike.

Compost has been shown to be able to suppress disease incidence, but it’s not quite that simple. Suppression of pathogens is not guaranteed, and the presence of certain microbes are responsible for the suppressive effect. Some organisms, like Trichoderma species have been found to be mycoparasite of Sclerotium rolfsii, an economically significant fungal plant pathogen. Antagonistic microorganisms can be found in mature composts, and they tend to repopulate the edges of compost piles that did not experience a high rise in temperature. Overmatured composts tend to have lower capacity for disease suppression likely related to the loss of biological activity. The use of conservation practices like green manures, organic amendments, crop rotation, minimal tillage practice also are effective at increasing soil biodiversity which can contribute to disease suppression.

There are five identified mechanisms of disease suppression. Each mechanism may bring the same result, pathogen suppression, but are differ in the way that causes the suppression. Competition is related to essential food for microbes, carbon and nutrient sources. Antibiotics may be produced which are toxic to other microorganisms. Pathogens may be consumed by predatory microbes or may be parasitized. Disease resistant genes related to a plant's induced resistance may be activated by microorganisms in compost. And lastly, certain microbes may improve plant nutrition which leads to enhanced plant disease resistance. The first three mechanisms (competition, antibiosis, and predation) interact directly with pathogenic organism and the final two mechanisms interact indirectly with the pathogen.

More research on this subject is required to determine exactly what organisms are responsible for suppressing specific diseases. An understanding for the complex relationships that exist within soil is possible with additional research on soil meta genomics.

Sustainable Waste Management

When producing organic materials, waste is inevitably harvested alongside the desired product. Whether this is rotten produce or animal byproducts, the waste must be carefully contained to avoid contamination of nearby areas. Some waste can even be utilized and recycled to provide additional nutrients or energy.

1. Compost

Compost provides a stable and nutrient rich amendment to the soil, formed from the decomposition of organic material under controlled conditions. While these nutrients are incredibly beneficial to plants, it is worth noting that the long term effects on soil structure, microbiome, and chemistry provide even greater long-term benefits.

2. Biogas

Utilizing the “wet” wastes such as manure and food processing byproducts in combination with bacteria creates methane gas in anaerobic (oxygen-free) conditions. This biogas can be utilized for heat and energy, while the remaining materials include nutrient-rich wastewater and fibrous solids that can be used as an organic fertilizer.

More coming!!

Anaerobic Digestion Microbes

Beneficial Soil Microbes

Compost Microbes

Soil Amendment

Soil Health Concept and Indicators

Soil Management Practices

Sustainable Agricultural Practices & Microbes

(Researchers page)

Research

The USDA SARE project consists of educating on the role of microbes for sustainable agriculture for famers. Dr. Masanori Fujimoto is the PI of the project and Dr. Ann Wilkie is the co-PI. Four undergraduate research assistants work on the project as well.

Principal Investigators

Masanori Fujimoto: PI

Research Assistant Professor, Microbial Ecology, Soil and Water Sciences Department, University of Florida. Dr. Fujimoto obtained a dual Ph.D. degree in Microbiology / Ecology, Evolutionary Biology and Behavior at Michigan State University in 2012. He has a strong passion in understanding fundamental ecological processes and applying it to solutions of pressing issues.

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Ann Wilkie: Co-PI

Research Professor, Bioenergy and Sustainable Technology, Soil and Water Sciences Department, University of Florida. Dr. Wilkie investigates and develops sustainable resources management techniques for agricultural and industrial wastes, with emphasis on utilization of naturally occurring microbes. Current focus includes farm waste management technology for energy production, nutrient recovery and water quality improvement.
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Undergraduate Research Assistants

Philip Daly: Research Assistant

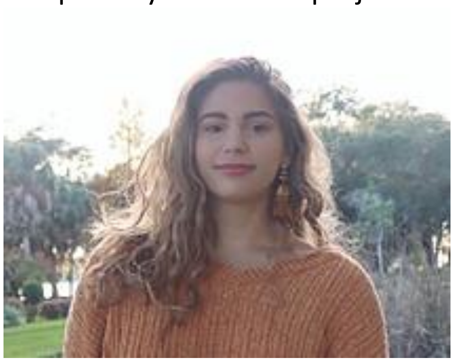
Philip Daly is a senior undergraduate student at the University of Florida pursuing a Bachelors of Science degree in Plant Sciences. While attending the University, Philip has taken an interest in plant pathogens, soils and composting. Philip has worked part time as a lab assistant at the UF Plant Diagnostic Center for two years. He is interested in organic systems and soil management. Philip is an avid outdoors person and enjoys all outdoor recreation activities. He has worked as a wilderness canoe guide for four summers and in his spare time enjoys bicycling, hiking, and climbing.

Madeline Lynch: Research Assistant

Madeline Lynch is a biochemistry and plant science (breeding and genetics) dual major. Her primary roles in the project are plant maintenance and research. A fun fact about Madeline is that she plays flute in a music organization on campus.

Kelsey Orr: Research Assistant

Kelsey Orr is a senior undergraduate student at the University of Florida pursuing a Bachelors of Science degree in Environmental Science and minoring in Materials Science and Engineering. Her primary role in this project is science communication. She loves the outdoors and hiking.



Danielle McManamon: Research Assistant

Danielle McManamon is currently working towards a degree in Environmental Science with minors in Religion and Agricultural and Natural Resource Law. Her primary role in this project is assisting in education and outreach. She loves learning new things about sustainability and what we can do to make a positive difference on the environment.

(blog page)

Workshops

((this page will consist of picture and video content from workshops and will be updated throughout the course of the project))

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