

**Soil Microbiology:**  
Using Soil Biology to Grow Better Plants, Trees and Turf

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GO GREEN • SAVE MONEY • GROW BETTER PLANTS  
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**Outline**

- I. The Relationship of Plants and Microorganisms
- II. The Benefits of Probiotics:
  - a. Providing & Cycling Carbon, Thatch, Detoxification
  - b. Reducing Fertilizer Use & Pollution
  - c. Disease & Pest Control Using Biologicals
  - d. Water Retention & Savings
  - e. Transplant & Up-Plant Survival Increases
  - f. Hormone Production, Germination & Yield Increases
- III. Probiotic Results: Soil Food Web Study
- IV. Strategies For Integrating Biologicals

**What? Why? How?**

**Report Proposes Microbiology's Grand Challenge to Help Feed the World**  
Aug. 17, 2012 — A greater focus on the role of soil microbiology in agriculture could help mitigate powerful food shortages associated with rising population pressures, according to a new report from the American Academy of Microbiology.

**Bacteria Enhance Growth of Fruit Trees Up to 40 Percent**  
Sep. 19, 2012 — Implemented in reforestation and agriculture is possible thanks to the work of scientists in the Center of Research and Advanced Studies (CIRAD) who use different strains of fungi and bacteria to promote development and health in trees, which have enabled them to accelerate growth of different species up to 40 percent.

**Soil Biodiversity Will Be Crucial to Future Land Management and Response to Climate Change**  
Aug. 12, 2012 — Research by a consortium at the University of Massachusetts Lowell and other institutions is leading soil biologists to suggest that increased focus on soil biodiversity and management, especially in the reforestation and land management communities, could benefit forest health and productivity, published in the latest edition of the journal Soil. It raised the understanding about the forest soil microbial biodiversity.

**The Recent Rise of Underground Microbes: Plant Root Microbiomes Rule the World**  
Sep. 18, 2012 — The soil grows what we eat, see, and yet organisms below the soil's surface play a role in its plant function and microbial wellbeing. These organisms can enhance or reduce plant growth. In the field, plants in microbiomes with other plants. A new study, "Plants in a Special Section in the Journal of Botany on Microbiomes" explains the soil microbiomes, explains how root microbiomes affect plants, and how multiple microbes, from bacteria to fungi, and other plant roots to community and ecology.

**Research on the benefits of using soil microbiology in growing practices is absolutely exploding right now!**

**Probiotics As A Tool:**  
**The Relationship of Plants, Trees and Turf with Microorganisms**

**The Relationship of Plants & Microorganisms**

**What is soil and how do we supplement it?**

Minerals & Nutrients      Water      Gas      Organic Matter & Microbes

**Traditional growing practices largely ignore supplementing biology in the soil. Many chemicals that are used are actually detrimental to microbes.**

**The Relationship of Plants & Microorganisms**

**We all know the benefits of probiotics for human health and digestion...**

## The Relationship of Plants & Microorganisms

Plants also have a digestive system – soil.  
 The microbes in the soil are as vital or more so for plant nutritional needs as for human digestion.  
 Biologicals are "yogurt" for plants, trees & turf!

## The Relationship of Plants & Microorganisms

**Facts about soil microorganisms:**

- 1 gram of soil contains:
  - 1 million ( $1 \times 10^6$ ) fungi.
  - 1 billion ( $1 \times 10^9$ ) bacteria.
- 1 ton of bacteria per acre (2 cows).
- Between 4,000 to 10,000 species of bacteria in a gram of soil.
- Estimates are that there are between 1 million and 100 million species of bacteria; only 0.5% to 0.005% are likely described in detail.
- 90%-95% of the cells on or in the human body are bacteria.

## The Relationship of Plants & Microorganisms

<p><b>Bacteria</b> 0.5-5 <math>\mu\text{M}</math></p>	<p><b>Fungi</b> 2-10 <math>\mu\text{M}</math></p>
Size:	Size:
Cell Type:	Cell Type:
Trophic Level:	Trophic Level:
Function:	Function:

## The Relationship of Plants & Microorganisms

**Pathogens**

*Parasitic Relationship* – One member (parasite) benefits from the relationship while the host is harmed or killed.

vs.

**Beneficials**

*Commensal Relationship* – One member benefits from the relationship while the other is neither harmed or benefits.

*Mutualistic Relationship* – Both members benefit from the relationship.

**All are technically symbiotic relationships.**

## The Relationship of Plants & Microorganisms Building the Soil Food Web

**Build your soil from the bottom up to help reduce disease, fertilizer and pesticide use, compaction and costs and maintenance.**

## The Relationship of Plants & Microorganisms Building the Soil Food Web

**FACT SHEET**  
Agriculture and Natural Resources

SAG 13-11

### The Role of Soil Bacteria

James J. Hoorman  
Cover Crops and Water Quality  
Assistant Professor and Extension Educator  
Ohio State University Extension

**"Diverse microbial populations with fungus, protozoa, and nematodes keep nutrients recycling and disease causing organisms in check."**

## The Relationship of Plants & Microorganisms Building the Soil Food Web



First Trophic Level

Second & Third Trophic Level

Fourth & Fifth Trophic Level

## Probiotics As A Tool:

### Soil Food Web Case Study: Florida Orange Grove

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## Probiotics As A Tool: Soil Food Web Study Design

### Florida Orange Grove Remediation:

**Background:** This orange grove had what was essentially "dead" soil due to excess chemical use and poor soil practices. Yields were down significantly, increased disease pressures (especially citrus greening) were having a large economical impact.

#### Methods:

Samples were collected before and after probiotic treatments. No other treatments in the grove were changed.

Day 0 – Collect soil sample, treat with beneficial bacteria.

Day 14 – Treat with beneficial bacteria.

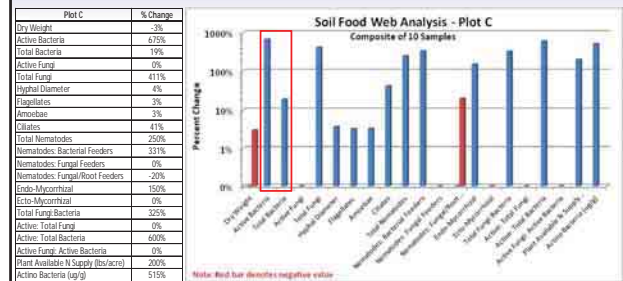
Day 90 – Treat with beneficial bacteria.

Day 180 – Treat with beneficial bacteria.

Day 198 – Samples Collected.

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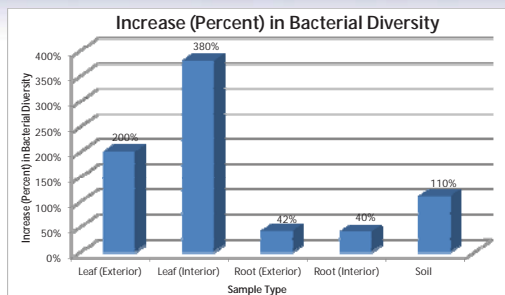
## Probiotics As A Tool: Soil Food Web Study Results



**Beneficial organisms in the soil increased as much as 675%.**

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## Probiotics As A Tool: Soil Food Web Study Results



Treatment with beneficial bacteria resulted in large increases in the number and diversity (species) of bacteria present in the soil food web.

**Yield went from 4438 boxes to 8120 boxes (83% Yield Increase)!!!**

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## Probiotics As A Tool:

### Providing & Cycling Carbon, Reducing Thatch & Compaction, Soil Detoxification

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## Probiotics As A Tool: Providing & Cycling Carbon



THATCH

COMPACTION  
& BLACK LAYER

Beneficial microbes break down higher carbon forms and nutrients into more useable forms that plants, trees or turf can utilize.

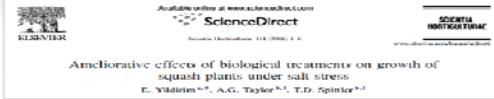
**Practices that promote or add beneficial microbes lower soil compaction and thatch buildup.**

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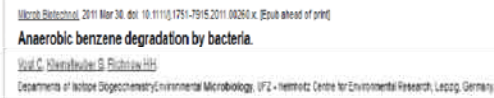
## Probiotics As A Tool: Detoxification of Soil

Beneficial microbes can help to remediate many types of toxins found in soils.

High Salts  
(Hurricane Damage)



Toxic Chemicals



Heavy Metals



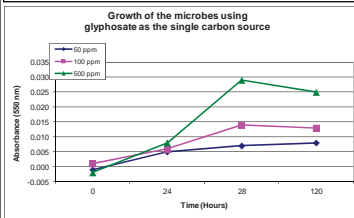
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## Probiotics As A Tool: Detoxification of Soil

APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Dec. 1988, p. 2953-2958  
0099-2240/88/122953-06\$02.00/0  
Copyright © 1988, American Society for Microbiology

Metabolism of Glyphosate in *Pseudomonas* sp. Strain L.Br  
GARY S. JACOB,<sup>1</sup>\* JOEL R. GARBOW,<sup>1</sup> LAURENCE E. HALLAS,<sup>2</sup> NANCEE M. KIMACK,<sup>1</sup>  
GANESH M. KISHORE,<sup>3</sup> AND JACOB SCHAEFER<sup>1</sup>  
<sup>1</sup>Physical Sciences Centre<sup>1</sup> and Monsanto Agricultural Product Research Department,<sup>2</sup> Monsanto Co., St. Louis, Missouri 63167, and Plant Molecular Biology Laboratory, Monsanto Co., St. Louis, Missouri 63199<sup>3</sup>

Received 27 April 1988/Accepted 15 September 1988



Beneficial bacteria break down pesticides such as RoundUp (glyphosate) and other man-made compounds commonly used in agriculture, turf care etc...

## Probiotics As A Tool: Detoxification of Soil

Beneficial bacteria break down oil and other hydrocarbons

**Oil Biodegradation and Bioremediation: A Tale of the Two Worst Spills in U.S. History**  
Ronald M. Atlas\*  
University of Louisville, Louisville Kentucky 40292, United States  
Terry C. Hazen  
Lawrence Berkeley National Laboratory, Berkeley, California 94720

**ABSTRACT:** The devastating environmental impacts of the Exxon Valdez spill in 1989 and its media notoriety made it a frequent companion to the BP (Exxon) oil spill in the popular press in 2010, even though the nature of the two spills and the environments impacted were vastly different. Fortunately, unlike the higher organisms that are adversely impacted by oil spills, microorganisms are able to consume petroleum hydrocarbons. These oil-degrading indigenous microorganisms played a significant role in reducing the even 8 environmental impact of both the Exxon Valdez and BP Deepwater Horizon oil spills.

Microorganisms are able to consume petroleum hydrocarbons...played a significant role in reducing the overall impact of the (oil spills).

## Probiotics As A Tool: Detoxification of Soil EnCana Reclamation Project - Parachute, Colorado



## Probiotics As A Tool: Detoxification of Soil EnCana Reclamation Project - Parachute, Colorado



Best Practice Soil Probiotics

Best Practice Soil Probiotics

# Probiotics As A Tool:

**Reducing Fertilizer Use & Cost  
Reducing Pollution & Run-Off**

## Probiotics As A Tool: Compliance With Laws

**Gloucester Times**  
August 21, 2012  
**Lawmakers OK new limits on fertilizer**  
From News and Staff Reports

**Westchester**  
Board Votes to Ban Phosphate Fertilizers

**NorthJersey.com**  
Phosphorus fertilizer ban goes statewide, predicted to boost compliance with West Milford law

**State Sets Hearing On Strict New Phosphorus Discharge Requirements**  
November 26, 2012 | By BILL LEUKARDT, wleukardt@courant.com, The Hartford Courant

At least 11 states now have some type of fertilizer ban or restriction in place (including MA, CT, VT, ME, NY, NJ) with more states pending.

## Probiotics As A Tool: Nutrient Retention & Delivery

**Retention**  
Beneficial organisms fix nutrients into their cell bodies and produce "sticky" biofilms that help retain vital elements and water in the soil and rhizosphere.

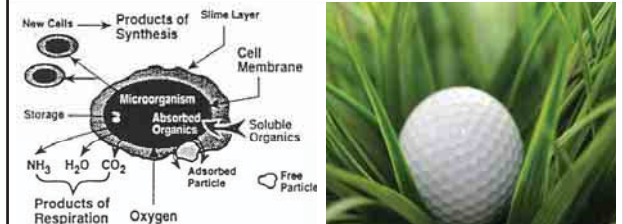
**Delivery**  
Microbes travel through the xylem and phloem and release nutrients as part of their normal life-cycle turn over.

Soil microbes help to retain, deliver and cycle nutrients.

**ScienceDaily**  
New research for the latest research news  
**Science News**  
**Some Trees 'Farm' Bacteria to Help Supply Nutrients**  
ScienceDaily (July 30, 2010) — Some trees growing in nutrient-poor forest soil may get what they need by cultivating specific root microbes to create compounds they require. These microbes are occasionally efficient at turning inorganic minerals into nutrients that the trees can use.

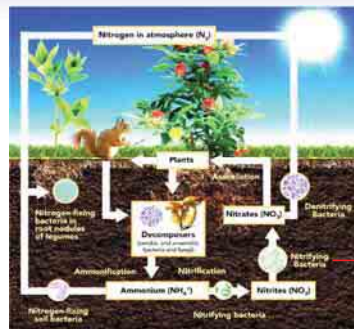
See Also:  
**Plants & Animals**  
• Acid Rain  
• Soil Types  
• Urogen  
**Soils & Structure**  
• Acid Rain  
• Fossils  
• Forest Ecosystems  
**Soilless**  
• Soil pH  
• The Growth of Soil  
• Plants  
• Soil

## Probiotics As A Tool: Nutrient Retention & Delivery

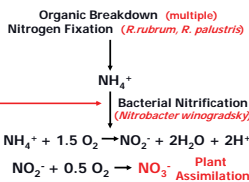


Think of the dimples on a golf ball as receptor sites on a microbe. Particles in the environment stick to the receptor sites and the microbe uses enzymes (keys) to unlock the particle and bring it inside the cell. The microbe divide to the level of the carbon, nutrients and water in the soil.

## Probiotics As A Tool: Nitrogen Fixation & Cycling



Beneficial microbes provide & process nitrogen both by "nitrogen fixation" from the air and by cycling higher (not useable) ammonium nitrogen to (useable) nitrates.



## Probiotics As A Tool: Phosphate Cycling & Delivery

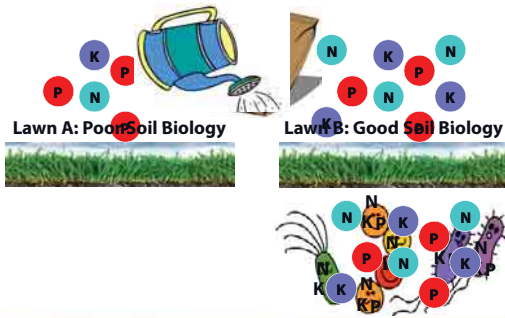
**PubMed**  
U.S. National Library of Medicine  
National Institutes of Health  
lett. Appl. Microbiol., 2009 Aug;49(2):222-8. Epub 2009 May 22.  
**Mechanism of insoluble phosphate solubilization by Pseudomonas fluorescens RAF15 isolated from ginseng rhizosphere and its plant growth-promoting activities.**  
Park KH, Lee CY, Son HJ.  
Department of Life Science and Environmental Biochemistry, Pusan National University, Miryang, Korea

**Applied Soil Ecology**  
Volume 34, Issue 1, November 2009, Pages 33-41  
**Phosphate solubilizing bacteria from subtropical soil and their tricalcium phosphate solubilizing abilities**  
Y.P. Chen\*, P.D. Rekha<sup>a</sup>, A.B. Arun<sup>a</sup>, F.T. Shen<sup>a</sup>, W.-A. Lai<sup>a</sup> and C.C. Young<sup>a, \*</sup>  
<sup>a</sup>Department of Soil and Environmental Sciences, National Chung Hsing University, 250, Kuo-Kuang Road, Taichung, Taiwan 402, ROC

Beneficial microbes solubilize phosphate in the soil therefore increasing the "P" value that is available to plants, trees & turf.

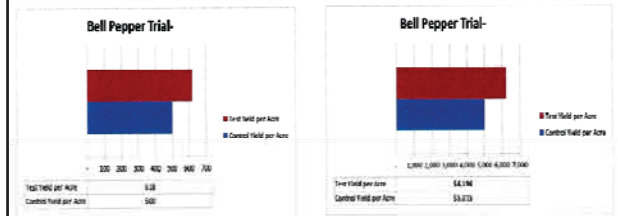
## Probiotics As A Tool: Nutrient Delivery

A TALE OF TWO SOILS.



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## Probiotics As A Tool: Higher Quality and Yields University Study



Rutgers University trial (Dr. Tom Orton) with beneficial bacteria:

**23% decrease in fertilizer use.**  
**24% increase in yield.**  
**30x Return On Investment (ROI)!!!**

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## Probiotics As A Tool: Reducing Excess Nitrogen

The use of excess fertilizer is actually counter-productive to healthy plant, tree and turf growth.

- Excess fertilizer and chemical use is actually harmful to plants and turf and can lead to turf burning, unhealthy growth etc. . .
- Artificially fast growth impairs the absorption of nutrients, leading to health issues.
- High phosphorous fertilizers are toxic to beneficial microbes.
- Excess nitrogen can stimulate the growth of pathogenic microbes and increase diseases in plants and turf.
- Plants and turf grown without chemicals and excess fertilizer are less prone to damage from pathogens and harmful insects.



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## Probiotics As A Tool: Reducing Excess Nitrogen

### Excess nitrogen raises nectarine susceptibility to disease and insects

Karl M. Daane □ R. Scott Johnson □ Thomas J. Michalides □ Carlos H. Cresoto  
 Jeff W. Dlott □ Hugo T. Ramirez □ Glenn Y. Yakola □ Dave P. Morgan

This multidisciplinary study examined the effects of nitrogen fertilization on nectarine yield, fruit quality, brown rot and moth pests.

Results indicate that excess nitrogen fertilization did not increase fruit yield or improve fruit quality; however, fruit on overfertilized trees were more susceptible to attack from brown rot, peach twig borer and oriental fruit moth.



Fruit from trees fertilized with excess nitrogen showed more damage from brown rot, peach twig borer and oriental fruit moth. Fruit from trees fertilized with excess nitrogen showed more damage from brown rot, peach twig borer and oriental fruit moth.

CALIFORNIA HORTICULTURE, JULY/AUGUST 1995 18

Only some of the added fertilizer reaches a plant, tree or turf. The remaining fertilizer feeds pests, pathogens and pollutes water.

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## Probiotics As A Tool: Disease & Pest Control Using Beneficial Organisms

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## Probiotics As A Tool: Disease Control

**“The Enemy of My Enemy is My Friend”**

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## Probiotics As A Tool: Compliance With Laws



**1. Why no pesticides?**

The Connecticut legislature passed a law (P.A. 09-56) banning lawn care pesticide applications on the grounds of day care centers, elementary and middle schools (grade 8 and lower) as a result of residents' concerns about children's health and the environment. This ban went into effect for day care centers on October 1, 2009 and for K-8 schools on July 1, 2010. Some Connecticut municipalities have gone beyond the requirements of the law and have stopped using pesticides to manage turfgrass on all their municipal properties.

**Pesticide use is now banned on school grounds and day care centers in the states of Connecticut (K-8) and New York. Chemical products are constantly being pulled off the market.**



**Pest Management for Schools, Day Care Centers and Parents**

**Pesticide Prohibition on Grounds at Schools and Day Care Centers**

**Emergency Pesticide Application Determinations:**

With the ban in place, you and your business can no longer use any pesticide on the grounds, except for an emergency application to treat an infestation or control a pest on the grounds. If you have an emergency, you must call the state's Department of Environmental Protection (DEP) at 860-418-7300. DEP will make determinations only for pesticide applications and giving specific field guidance. DEP will not make determinations about insecticide applications.

## Probiotics As A Tool: Disease Control

### Mechanism #1 – Microbes Produce Compounds That Target Pathogens

**Inhibitory effect against Akt of cyclic dipeptides isolated from *Bacillus* sp.**

Hong S. Moon, BH, Yong Y. Shim, SY, Lee, YH, Lim Y.

*Bioactive Information Center, Division of Biochemistry and Biotechnology, Korea University, Seoul 145-701, Korea*

**Abstract**

Among *Bacillus* strains of the genus *Bacillus* isolated from Spring-purified soil laboratory, a strain BA34 showing good antibiogram activity against *Phytophthora infestans* in a previous experiment was tested for the inhibitory effect against Akt protein kinase B. Since Akt is known to play an important role in conferring virulence, the metabolites can be used as potential apoptosis-inducing agents in the treatment of cancer. Two active compounds were isolated and their structures were determined. They have similar structures, despite showing different inhibitory effects. In order to elucidate the reasons for these different effects, three-dimensional studies were carried out.

PMID: 19427881 (PubMed - indexed for MEDLINE) [Free Article](#)

***Bacillus subtilis* and phenotypically similar strains producing hexaene antibiotics**

(Article in Russian)

Kudriashova EB, Vinokurova NG, Ariskina EV

**Abstract**

We studied metabolites synthesized by *Bacillus subtilis* strains, including the type strain of *B. subtilis* and phenotypically similar cultures. These metabolites were presented by polyene antibiotics with conjugated double bonds. Hexaenes from study strains inhibited the growth of phytopathogenic fungi *Fusarium culmorum*, *F. sporotrichiella*, *F. oxysporum*, *Botrytis soroliniana*, *Alternaria tenuis*, and *Phytophthora infestans*. The degree of growth inhibition depended on the leaf fungus.

PMID: 16246655 (PubMed - indexed for MEDLINE)

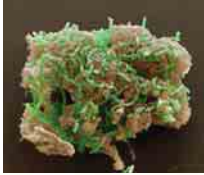
**Beneficial microbes produce compounds that can directly kill pathogens.**

## Probiotics As A Tool: Disease Control

### Mechanism #2 – Numbers Game, Beneficials Out-Compete Pathogens

#### Competitive Exclusion Principle (Gause's Law)

"two species competing for the same resources cannot stably coexist if other ecological factors are constant. One of the two competitors will always overcome the other, leading to either the extinction of this competitor or an evolutionary or behavioral shift towards a different ecological niche. The principle has been paraphrased into the maxim "complete competitors cannot coexist"."



- Bacteria and fungi compete for the same resources.
- Bacteria divide much faster than fungi and can out-compete them for limited resources.
- Can a lone coyote establish territory where there is already 100 wolves?


## Probiotics As A Tool: Disease Control

### Mechanism #3 – Healthier Plants Naturally Resist Pests & Pathogens

**Trophobiosis Theory:  
A Pest Starves on a Healthy Plant**

*By John Paul*  
Fenner School of Environment & Society, Australian National University, Canberra

Pests shun healthy plants. Pesticides weaken plants. Weakened plants open the door to pests and disease. Hence pesticides precipitate pest attack and disease susceptibility, and thus they induce a cycle of further pesticide use.



**Pathogens evolved eating dead or weakened plant material with simple amino acids and sugars. Healthy plants contain proteins and complex sugars that can not be digested by pests.**

## Probiotics As A Tool: Disease Control



**When Under Attack, Plants Can Signal Microbial Friends For Help**

ScienceDaily (Oct. 24, 2008) — Researchers at the University of Delaware have discovered that when the leaf of a plant is under attack by a pathogen, it can send out an SOS to the roots for help, and the roots will respond by secreting an acid that brings beneficial bacteria to the rescue.

- Plants "Farm" or "Signal" disease-suppressing beneficial bacteria when under attack by pathogens.
- It's important to maintain a diverse consortium of microbes.

## Probiotics As A Tool: Disease Control

### Late Blight (*Phytophthora infestans*) Disease Control



**Best Practice**

**Soil Probiotics**

## Beneficials As A Tool: Pest Control

### Beneficial Nematodes



- Most nematodes feed on fungi and bacteria and are harmless to plants.
- Some require root feeding to complete their life-cycle (parasitic).
- Can be used as Biological Control Agents: Enter insect larvae and release bacteria (*Xenorhabdus* sp. bacteria) that kills the pest within 24-48 hours.
- Very broad spectrum biological insect control agent.
- Timing of pest larval stages and specific soil temperatures needed makes nematodes more effective for indoor growing.

**A healthy soil food web stimulates beneficial nematodes.**

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## Beneficials As A Tool: Pest Control

### Beneficial Insects



Exploit the natural predators of pathogenic organisms:  
**"The enemy of my enemy is my friend"**

- Ladybugs (*Hypodamia convergens*)
  - Eat aphids, mites and other insects.
- Parasitic wasps (i.e. families Ichneumonidae, Braconidae, Chalcididae)
  - Lay eggs inside a large array of pathogenic insect hosts and kill them.
- Praying Mantises (*Stagmomantis carolina*):
  - Predators of a wide variety of insect pests.

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## Probiotics As A Tool: Pest Control

### Milky Spore (*Paenibacillus popilliae*)



- A harmless beneficial bacterium species that attacks the larvae of the Japanese Beetle (White Grubs).
- When attacked, the grubs turn milky white, causing "milky spore" disease in the grubs and thus death.
- Only attacks Japanese Beetle grubs, and is generally not effective in the Northeastern US due to soil temperatures or increased resistance.

UCONN IPM: <http://www.ladybug.uconn.edu/WhiteGrubs.htm>

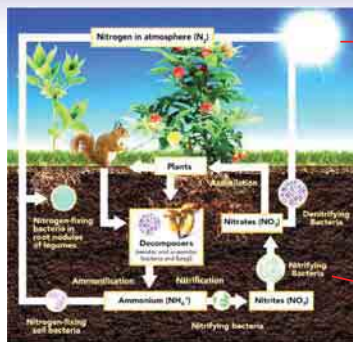
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# Probiotics As A Tool:

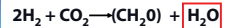
## Water Retention & Savings

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## Probiotics As A Tool: Water Retention & Savings



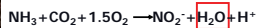
### Photosynthesis (bacteria)



Beneficial microbes help with water retention and drought resistance by:

- Producing water as a by-product of their normal cellular metabolism.
- Forming biofilms that can bind and retain water at the root zone.
- Incorporating water as part of their cells (60%-80%) and releasing this water to the plants during turnover.

### Nitrification



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## Probiotics As A Tool: Water Retention & Savings

Experiment #1



Experiment #2



Untreated

Soil Probiotics  
Low rate

Soil Probiotics  
Normal rate

- "Accidental" experiment - lights left on plants for 3 days straight without any watering.
- The lettuce treated with soil biology does not show the effects of drought.
- Increased water retention due to increased soil biology.

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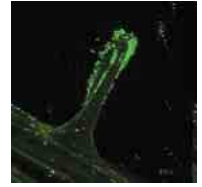
# Probiotics As A Tool: Transplant and Up-Plant Survival Increases

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## Probiotics As A Tool: Transplant Survival Increases

Beneficial microbes increase transplant survival in multiple ways:

- Beneficial bacteria form biofilms around the roots and protect plants from pathogens.
- Beneficial bacteria and their biofilms help retain vital nutrients in the rhizosphere and make them more available to a plant's root system.
- Polysaccharides produced by soil microbes absorb many times their weight in water, protecting plants from water stress during transplantation or periods of drought.
- Beneficial microbes produce growth-promoting hormones and other compounds that initiate healthy growth.



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## Probiotics As A Tool: Transplant Survival Increases



### Best Practice

- Many pines did not survive the out-planting.
- Seedlings are much smaller.

\*These pictures were taken 2 years after being treated with only a single root dip in probiotics.



### Soil Probiotics

- Note the vastly increased survival rate.
- Seedlings are way ahead of the controls in growth and are generally healthier.

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## Probiotics As A Tool: Transplant Survival Increases

### University of Florida Probiotic Transplant Study



"Initial observation of treated areas indicated a reduction in the need for re-setting cabbage transplants. Approximately 30% of untreated field area required re-planting; less than 10% of the (Probiotic) treated field area required re-planting"

-Dr. Amanda J. Gevens, University of Florida Plant Pathology

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# Probiotics As A Tool: Phytohormone Production: Better Root & Top Growth, Germination Increases, Increased Yield & Quality

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## Probiotics As A Tool: Higher Quality and Yields

<p><b>Growth promotion of red pepper plug seedlings and the production of gibberellins by <i>Bacillus cereus</i>, <i>Bacillus macroloides</i> and <i>Bacillus pumilus</i>.</b></p> <p><small>doi:10.1007/s10263-007-9071-0 Journal of Agricultural Science (2007), 140, 1-6 Institute of Agricultural Sciences &amp; Technology, Kasugakari National University, Shimizu 424, Japan</small></p>	<p><b>Gibberellic Acid (GA)</b> moves downward from its production site in new growth areas to the roots.</p> <p><b>Auxin</b> moves upward and downward, but only toward GA concentrations, to initiate rooting and stimulate cytokinin activity (<i>Bacillus thuringiensis</i>).</p> <p><b>Cytokinin</b> is produced in the root tips (if auxin has initiated their growth) and moves upward to perform key roles in cell division, chlorophyll formation, and GA synthesis. Some cytokinins will only perform in the presence of auxin (<i>Mack Boland</i>).</p>
<p><b>(Auxin production by bacteria associated with orchid roots)</b></p> <p><small>(Article in Russian) Tikhonova EA, Cherdonova TA, Natusov AI</small></p>	<p><b>Plant growth promotion by <i>Bacillus megaterium</i> involves cytokinin signaling.</b></p> <p><small>Cifuentes R, Valencia-Castell E, López-García J Instituto de Investigaciones Químico-Biológicas, Universidad Michoacana de San Nicolás de Hidalgo, Morelia, Michoacán, México</small></p>

Microbes produce plant growth hormones. This stimulates better root and top growth, yields and quality.

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### Probiotics As A Tool: Higher Quality and Yields

*New Phytol.* (1990), 112, 429-435

**Interaction of soil bacteria, mycorrhizal fungi and orchid seed in relation to germination of Australian orchids**


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 (Received 21 December 1988; accepted 12 April 1989)

**ABSTRACT**  
 Endotrophic bacteria were isolated from the mycorrhizal tissues of 12 out of 15 tested species of Western Australian terrestrial orchids. The bacteria were placed into eight groups based on a.c. light fluorescence, Gram staining and colony characteristics. The most commonly isolated bacteria from 9 out of the 12 orchid species sampled were strains within the *Pseudomonas fluorescens* group. The abundance of bacteria followed a seasonal pattern that differed between orchid genera especially on the basis of the morphology of fungus infected tissue. There was little evidence of specificity of bacterial groups to orchid taxa or parts of the plant infected by the fungus. Symbiotic germination of *Platanthera citrifolia* seed in association with seven bacterial isolates showed a significant promotion of germination and seedling development with three bacterial strains. The influence of a fourth strain was no different to the control while the remaining three strains significantly suppressed seedling development.

**Significant promotion of germination and seedling development with inoculation of beneficial bacteria.**

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### Probiotics As A Tool: Higher Quality and Yields Plants (Squash)




**Best Practice**      **Soil Probiotics**  
 Avg. pounds per acre: **8,800**      Avg. pounds per acre: **11,424**  
**\*30% Increase in Yield!**

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### Probiotics As A Tool: Higher Quality and Yields Vegetables

**Carrots**



**Best Practice**      **Soil Probiotics**

**Potatoes**



**Best Practice**      **Soil Probiotics**

(Experiments done by Green Living Technologies - GLTi)

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### Improved Plant Health/Yield Lettuce



**Best Practice**      **Soil Probiotics**  
 (Lettuce grown for the Subway food chain)

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### Improved Plant Health/Yield Orchids

**Odom's Orchids Trail Results**



**Best Practice**      **Soil Probiotics**




**Best Practice**      **Soil Probiotics**

"Our loss percentage seems to be down since we started using the Soil Probiotics. We were losing 5-10%, especially on the smaller plants, but it has gone down to less than 5% since we started the treatments. Most of even the smallest plants are now surviving."


Rob Schneider, Greenhouse Manager, Odom's Orchids

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### Improved Plant Health/Yield Horticulture (Lantana)



**Best Practice**      **Soil Probiotics**  
**3 Weeks**



**Best Practice**      **Soil Probiotics**  
**6 Weeks**

(Experiments done by the Ace Hardware chain)

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### Soil Probiotics Results CNLA Turf Study (Steve Bousquet)



Study performed for the Connecticut Nursery and Landscape Association (CNLA).

Per Steve Bousquet, Past President:

- A very noticeable difference in growth by Day 10.
- 50% better turf development in areas treated w/ Soil Probiotics.
- The turf treated with Soil Probiotics was 2 to 3 weeks ahead of the untreated lawns.
- Better recovery from herbicides with the use of Soil Probiotics.



Soil Probiotics Best Practice

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### Probiotics As A Tool: Higher Quality and Yields Turf Grass



This sports field had highly compacted soil that was inhibiting adequate root growth and the subsequent top growth of the turf. This picture was taken after only 1 application of a standard rate of soil probiotics.

*There is 3x the root growth with Soil Probiotics (plug on the right) compared to the untreated turf (plug on the left) in only 6 weeks!*

Soil Probiotics

Best Practice

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### Probiotics As A Tool: Higher Quality and Yields Turf Grass



Best Practice

Soil Probiotics

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### Probiotics As A Tool: Higher Quality and Yields Turf Grass



Before Treatment



4 Weeks After Soil Probiotics



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### Probiotics As A Tool: Higher Quality and Yields Trees (Pine)



Best Practice

Soil Probiotics



Best Practice

Soil Probiotics

Slash Pine candles from one of the world's largest commercial pine tree plantations.

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### Probiotics As A Tool: Higher Quality and Yields Woody Ornamentals (Blueberries)



Best Practice

Soil Probiotics

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# Probiotics As A Tool:

## Strategies for Integrating Biologicals into Your Turf Care or Growing Practice

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### Probiotics As A Tool: Strategies for Integration

#### How to stimulate or supplement microbes in your landscape or lawn care practice:

- 1) Bio-stimulation (inducing microbes):
  - a) Induce the growth of endogenous microbes (Pre-biotics).
  - b) Don't destroy the natural flora that is already there!
- 2) Bio-supplementation (adding microbes).
  - a) Compost & compost teas.
  - b) Controlled biological inoculants.



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### Probiotics As A Tool: Strategies for Integration

#### Practices and products that stimulate microbes in your lawn care or growing practice:

- Organic fertilizers (Pre-biotics): Includes humates, fish fertilizers, manures and kelp.
- Can be used alone or in combination with biological stimulants.
- Although excellent fertilizers, the odor from manures may turn off customers (better suited for agriculture or horticulture).
- Molasses and sugars induce the growth of soil microbes. However, this growth is not necessarily specific for beneficials.



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### Probiotics As A Tool: Strategies for Integration

#### Practices and commonly used inputs that adversely affect soil microbiology:

- **Tilling:** Destroys the complex organization of the rhizosphere and the crucial top layer of soil.
- **Roundup® (Glyphosate):** Roundup can reduce beneficial organism populations (*Pseudomonas fluorescens*) and cause increases in pathogen growth (*Fusarium*).
- **Fungicides & Antibacterials:** Kill fungi and bacterial populations in a non-specific manner.
- **Insecticides:** Can cause secondary effects on beneficial insect populations (colony collapse disorder).
- **Excess Fertilization:** Phosphate is toxic to beneficial organisms at high concentrations. Excess nutrients will stimulate pathogen growth.



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### Probiotics As A Tool: Strategies for Integration

#### Compost and Compost Teas



##### Pros

- Very effective and proven.
- More sustainable than other methods.
- Wide array of nutrients and natural fertilizer value (depends on inputs).
- Has some value in terms of increasing soil biology.
- Cheap to produce.

##### Cons

- Input dependent – inconsistent results.
- Difficult and labor-intensive to apply.
- “Backyard microbiology” – potential to grow pathogens or unwanted organisms without proper testing.
- Investment in equipment is needed.
- Time consuming to brew teas.
- Lack of stability – needs to be used within days to a week.

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### Probiotics As A Tool: Strategies for Integration

#### Compost Teas

##### horticultural myths



#### Compost tea: Examining the science behind the claims

**WSU:** Home gardeners are often asked about compost tea and other products but may not have ready access to objective information. This column is dedicated to those hard-working volunteers who want the current best science on products and practices so that they can continue to learn and improve.

**It is suggested by many authorities to use compost and not make the time or use the fossil fuels to process compost into teas.**

Can WSU Master Gardeners recommend compost tea use? The short answer is no because WSU Master Gardeners are volunteer educators who rely on science-based information, they cannot recommend a practice or product that lacks a legitimate scientific basis. Furthermore, it is illegal to sell unregistered substances for use as pesticides. There are no compost tea products registered as pesticides with the U.S. Environmental Protection Agency. Neither WSU Master Gardeners volunteers nor Web sites may encourage the use of compost tea as a pesticide.

If compost tea doesn't do anything, then how can it hurt to apply it?

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## Probiotics As A Tool: Strategies for Integration

### Controlled Biological Inoculants



#### Pros

- No preparation - buy and apply.
- Consistent since they are not input dependent and counts can be verified.
- More concentrated – highest counts of microorganisms available.
- Tested for safety and pathogens, not "Backyard microbiology".
- Stability for years (product dependent).

#### Cons

- Less sustainable than compost.
- Watch out for "colored water" – ask for the microscope test.
- Diversity is dependent on the strains used and stabilized.
- Higher product costs (although lower labor and application costs).

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## Probiotics As A Tool: Strategies for Integration

### Examples of Commonly Used Beneficial Microorganisms

#### Bacteria:

- *Bacillus* species (*subtilis*, *pumilus*, *megaterium* etc...): Organic breakdown, pathogen suppression, hormone production, detoxification.
- Nitrogen fixing bacteria (*Rhizobia*, *Rhodopseudomonas palustris* etc...).
- Nitrifying bacteria (*Nitrobacter winogradskyi*): Cycling nitrogen.
- *Pseudomonas fluorescens*: Good all-purpose species for pathogen suppression, phosphate solubilization, detoxification.

#### Fungi:

- *Trichoderma* species (*viride*, *hamatum*, *harzianum* etc...): Pathogen suppression, nutrient exchange, organic breakdown.
- Mycorrhizal fungi (many species): Form mutualistic relationships with roots for nutrient exchange and many plant health-promoting functions.

#### Nematodes:

- *Steinernema carpocapsae*: Fleas, cutworm, sod webworm, termites.
- *Steinernema feltiae*: Fungus gnats, ticks, thrips, leafminers.
- *Heterorhabditis bacteriophora*: Japanese beetles, grubs, root weevils, queen ants.

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## Probiotics As A Tool: Strategies for Integration

### Measuring Soil Biology

#### How is soil microbiology measured?

- **Visually:** Fungal growth is visible on roots as web-like structures. Worms can easily be seen. Plants and turf will visibly increase in growth, health and quality. Soil smells "organic".
- **Direct Measurements:** Extract microbes from soil in a liquid, stain and count under a microscope. Does not give much information on diversity of species.
- **Plate Counts:** Plate microbes on growth media, and count colonies that form.
- **By-product Analysis:** Measure by-products of microbes such as gas production, sugars secreted, enzymes produced etc... Solvita.
- **Genetic Analysis:** Extract DNA from microbes and sequence.

#### Where can you have soil microbiology tested?

**Soil Food Web** ([www.soilfoodwebnewyork.com/indexoriginal.html](http://www.soilfoodwebnewyork.com/indexoriginal.html))  
-Active and total bacteria, active and total fungi, nematodes. Not specific.  
**High Throughput DNA Sequencing** – i.e. Pyrosequencing - provides full genetic analysis of soil organisms, previously identified or not. This type of technology is very powerful but not yet economically viable.

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## Summary – Market Assessment

### Growing Consumer Demand

#### Natural and organic products are the fastest growing sector of agriculture and turf care.

- A 2008 survey indicated that about 12 million households were using only natural products on lawns and gardens, up from 5 million in 2004. *That's a 240% Increase!*
- 20% of consumers have bought an environmentally friendly lawn-and-garden product (2005).
- An estimated yearly 10% annual growth for the organic fertilizer market. That is twice the projected growth for all lawn and garden goods.
- Scott's organic line of products has doubled sales each year since their inception.



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## Summary

- Probiotics act as a natural tool to help you reduce fertilizer use and costs and to comply with fertilizer bans.
- Biologicals provide an effective alternative when pesticides are banned or undesirable.
- Probiotics are a cost effective part of a program that will help you in the growing and lucrative market for greener services and products.
- Simply, you will be able to provide higher quality services or products with higher yields and at a lower cost.

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## QUESTIONS?

### Soil Biology Primer:

[http://soils.usda.gov/sqi/concepts/soil\\_biology/soil\\_food\\_web.html](http://soils.usda.gov/sqi/concepts/soil_biology/soil_food_web.html)

### Soil Food Web NY (Sample Submission)

[http://soils.usda.gov/sqi/concepts/soil\\_biology/soil\\_food\\_web.html](http://soils.usda.gov/sqi/concepts/soil_biology/soil_food_web.html)



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