Healthy Soil Foodwebs

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The Lab Measuring the Life in Your Soil

Soil Foodweb New York – Paul Wagner
Soil Foodweb Australia – Merline Olson
Soil Foodweb New Zealand – Cherryle Prew
Soil Foodweb Mexico – Jose Avalos
Soil Foodweb South Africa – Hardus Hern
Soil Foodweb Canada – Ted Leischner
Soil Foodweb England – Jody Scheckter/Jay Rataynake

Through the Microscope – direct biomass measurement

Direct Microscopy Required

- Comparing numbers of bacteria vs numbers of fungi is silly
- Species diversity is extremely important so all functions are happening at all times
  - How many important functions are there?
  - How many different conditions occur in a year? How many different species needed so each function always occurs?
- Direct counts do not rely on ability to grow on lab media

Habitat Diversity Relates Directly to Species Diversity

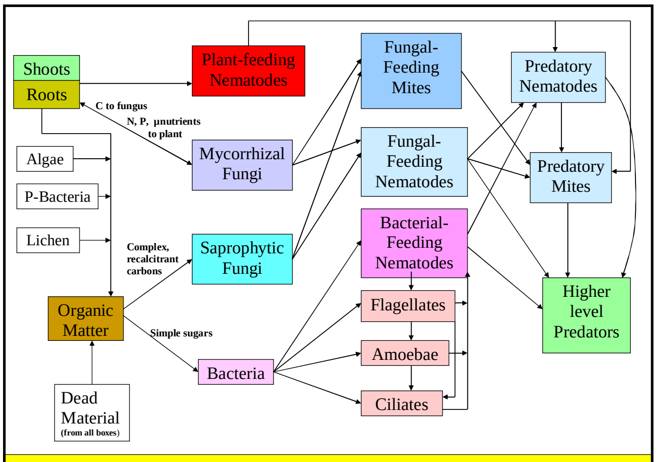
- The greater the types of
  - foods,
  - temperature,
  - oxygen,
  - moisture,
  - carbon dioxide and
  - other physical gradients, the greater the selection for a wide species diversity.
- Limit conditions to those that select for beneficial organisms

Biological plant production requires…..

- Managing chemistry, physics, biology and microbiology at the same time,
- In a way which addresses and solves weed, disease and insect pest problems at their root causes rather than merely masking symptoms with poisonous chemicals.
- Maximizes yield, crop quality, food nutrition and profit potentials while minimizing erosion, run-off and nutrient leaching

The Basic Premise

- **ALL the necessary biology must be present**
- The Full Food Web
- Full Diversity
- In the ratios that the PLANT YOU WANT TO GROW requires
- Nutrient retention, nutrients moved into plant available forms, soil airways and passageways built and maintained, toxinc decomposed, disease organisms kept in check by predator – prey interactions, and competition controlled by the plant



The Soil Foodweb in Lawns, Vegetable and Row Crops systems

Soil Foodweb Principles

•How do we know what biology is needed?

•Productivity increases with successional stage

– Textbook knowledge and observation from data collected

•How do you figure out where your land is on the successional sequence? **DATA**

SFI Data Are Based on Ecosystem Studies

Arid/ Semiarid Grassland, Crop & Pasture

- **Texas A&M, Colorado State, Wyoming, Nebraska, Kansas, Washington State, Mexico, Utah, New Mexico,**

Alpine, Tundra, Conifer Forests

- **Rocky Mts, Maine, New Hampshire, Canada, Alaska**

Deciduous Forest, Wetlands,

- **Oregon State, University of Georgia, North Carolina, Canada, Florida,**

Tropical Fruits and Vegetables

- **Hawaii, Mexico**

ALL have data published about foodweb

Study is in David Poste's book on Forest Systems

- Reference was given in SFI monthly electronic magazine
- Sign up at www.soilfoodweb.com

DATA HAVE BEEN PUBLISHED
Horseshoe Bend Agroecosystem

D.C. Coleman, P. Hendrix, Univ. GA

Soil structure building using plant inputs, compost

1984 – pesticides no longer needed

1986 – O, A, B, C horizons rebuilt, only 4 lbs/ac fertilizer/yr and yields equal or better than conventional

2 acres corn, soybean, sorghum

Conv – pesticides, herbicides, fertilizers	**Sustainable-** no pesticides, no fertilizers, occasional organic fertilizer

Publications: Applied Soil Ecology, Biology and Fertility of Soils, Ecology, Ecological Applications, Soil Biology and Biochemistry

Examples

- **Tomato -** Territorial Seed, Sunbow Farms, Tanimura and Antle, Earthbound Farms, Dennison Farms, Hono Ho'Aka
- **Strawberry** - NCSU, Pac Ag, Soil Rx, East Coast Compost, T&A
- **Orchards, Vineyards** - Columbia Gorge Organics, Ono Farms, HI, Marders, Dennison Farms, Watts Brothers, AlphaWolf, Clos du Bois, Gallo, Macari, BethShin, R&R, Wren, NY, Highlands, Salinas, CA
- **Potato** - Rustic Ag, Soil Logic, Nu-Vision Ag in Idaho, OSU, Kimm in Montana, Circle B, Utah, Monte Vista, CO
- **Wheat, Soybean –** Grant, NB, Hroncek, CO, Bio-Ag, Australia
- **Dairy –** Tulare County, CA, Natural Aeration, Spokane, WA
- **Landscaping** - HSLD, WA, Treewise, NY, Bainbridge, HI, Harrington, Koch, Creative Gardens, Boston Tree Preservation, Highlands, CA.
- **Turf** - SFI, Bandon Dunes, Creative Gardens, 6 NY, Woodbury, NJ, Philadelphia, CA: Olympic, Presidio, El Niguel, Coyote Hills, Uplands, Mirage, Bellagio, Las Vegas
- **Palm trees, cycads** - Mirage Hotel, Bellagio Hotel

Plate Counts versus Direct Determinations

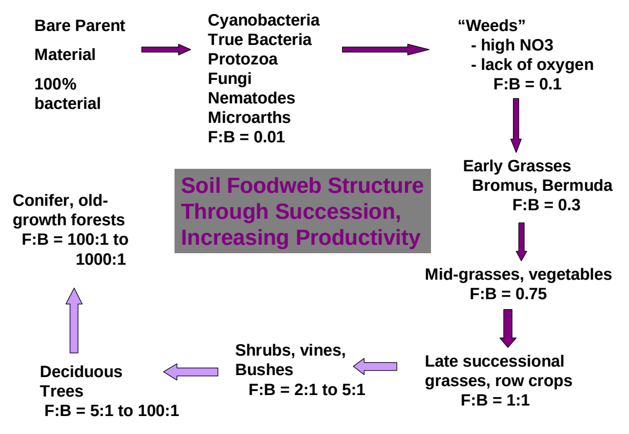
System	Plate Index	ug B/g	ug F/g
Old Growth Forest	0	500	1200
Pasture			
2 lb weight gain	5	675	830
1 lb weight gain	6	230	50
Ag field			
180 bushels	7	450	400
100 bushels	12	210	75

Production Gradient	AB (µg/g)	TB (µg/g)	AF (µg/g)	TF (µg/g)	Diameter (µm)	Protozoan Numbers /g F	Protozoan Numbers /g A	Protozoan Numbers /g C	Nematodes (#/g)	INDEX
Weeds	**56**	**147**	**11**	**64**	**2**	**6,400**	**6,400**	**51**	**7**	**1**
Garden	**78**	**144**	**3**	**19**	**2**	**51280**	**55400**	**1001**	**7.0**	**4**
Chem Pas	**44**	**127**	**13**	**55**	**2.5**	**5475**	**4242**	**33**	**2**	**5**
Pasture	**84**	**117**	**23**	**83**	**2.5**	**16178**	**6715**	**417**	**5**	**8**
Clearcut	**17**	**124**	**16**	**73**	**3**	**1819**	**5325**	**7**	**1**	**15**
OgGarden	**81**	**180**	**30**	**47**	**2.5**	**5787**	**5356**	**73**	**16**	**17**
O Potato	**94**	**229**	**10**	**237**	**2.5**	**7309**	**21998**	**5665**	**11**	**19**
Strawberry	**340**	**531**	**22**	**702**	**2.5**	**27070**	**27070**	**1123**	**1**	**22**
YoungFir	**165**	**245**	**29**	**1275**	**2.5**	**18**	**7489**	**0**	**18**	**23**
Oldgrowth	**194**	**458**	**79**	**2946**	**3**	**126**	**77716**	**0**	**24**	**25**
Variation	**17%**						**20%**		**8%**	

Publication

- International Conference on Eco-Biology of Soil and Compost
- Leon, Spain, September, 15 – 17, 2004
- Contact: Jose Maria Gomez Palacios
  - jmgomez@bpeninsular.com

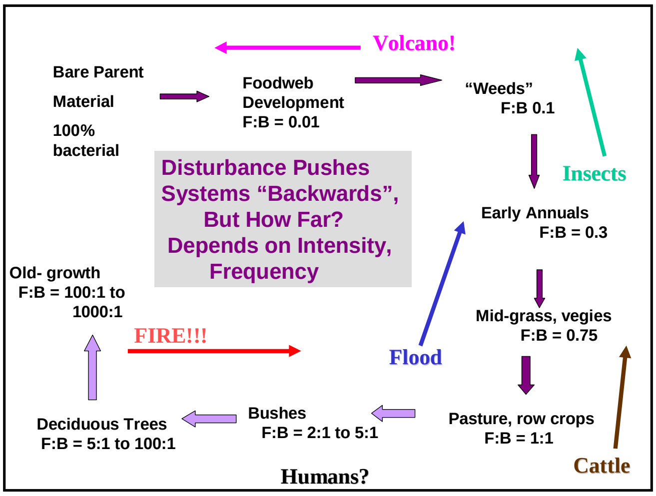
What does your plant need?



Why isn't everything an old growth forest?

DISTURBANCES

- GEMS
- AIR POLLUTANTS
- CLEARCUTTING, THINNING
- COMPACTION
- FERTILIZERS
- PESTICIDES, HERBICIDES
- TEMPERATURE (Freeze / Thaw)
- MOISTURE (Wet / Dry)
- TILLAGE (Intensity, Repetition, Timing)
- CROP (Monoculture, Intercropping)
- ORGANIC MATTER (Timing, Type, Placement)



Examples

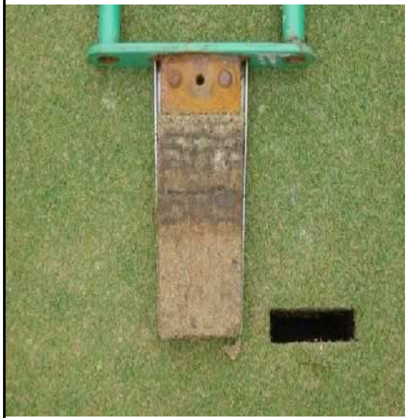
Esplanade, Surfer's Paradise
Steve Capeness, Peter Gamble

August 3, 2005

Black layer in turf strongly evident

No roots growing through the black layer

100% pure sand green



September 26, 2005

Following third application of compost tea to turf

Note significant decrease in black layer

FROM THIS | **TO THIS IN ONE YEAR**


Bob Long, Jeffries Compost, Adelaide, Australia


Bob Long, Jeffries Compost, Adelaide, Australia


Bob Long, Jeffries Compost, Adelaide, Australia

Kimm Seed Potatoes

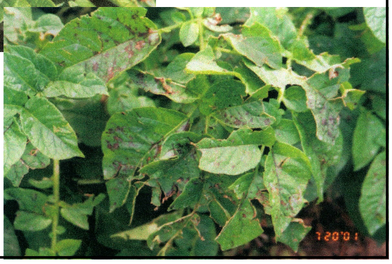
Montana

Compost Tea Experiment

Russet Norkotah

July 17, 2001 - Severe hail storm
July 18, 2001 - Compost tea appl
July 20, 2001 - Pictures taken

Yield increase 10.5 cwt/acre



2001 Compost Trial
New Brunswick Dept of Agriculture and Forestry

	Check	*1 Ton Compost*	*2 Ton Compost*	*4 Ton Compost*
Total Yield	404cwt/acre	455 cwt/acre	427 cwt/acre	437 cwt/acre
Mrkt. Yield	342 cwt/acre	384 cwt/acre	365cwts/acre	371 cwt/acre
Large	10.0% (>3")	11.5% (>3")	12.2% (>3")	10.1% (>3")
Smalls	12.6% (<2")	10.0% (<2")	9.9% (<2")	10.2% (<2")
Rough	3.0%	5.2%	4.8%	5.1%
	Total Yield	+ 51 cwt/acre	+23 cwt/acre	+33cwt/acre
	Mrkt. Yield	+ 42 cwt/acre	+23 cwt/acre	+29 cwt/acre

2003 Compost Tea Trial - Jolly Farmer

Russet Burbank - Ernest Culberson

	Check	*Compost Tea*	
Total Yield	304 cwt/acre	335 cwt/acre	+31 cwt/acre
Mkt. Yield	233 cwt/acre	272 cwt/acre	+39 cwt/acre
Large	10.3% (>10oz)	16.2% (>10oz)	+5.9%
Smalls	23.4% (<2")	19.0% (<2")	-4.4%

Biological V's Conventional Approach to Soil Management

Compost Tea Test Trial
Summer 2003

by Abron New Zealand
Russell Snodgrass, SFI Advisor

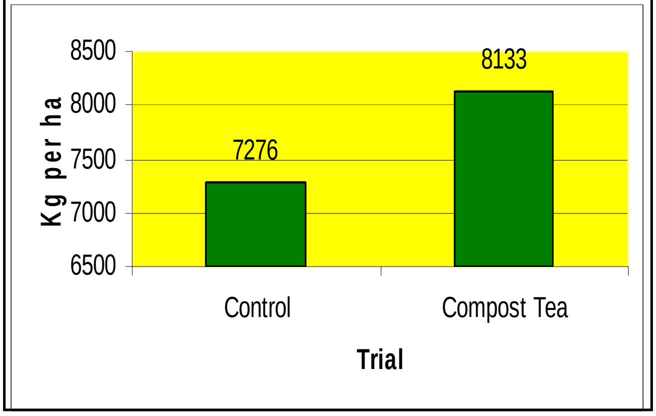
Background

- Trial area consists of two plots fenced off from stock and the pasture harvested every 20-30 days using a mower
- Trial was carried out on a conventional dairy farm in the Bay of Plenty, New Zealand
- All testing is done by Hill Laboratories and the Soil Foodweb Institute NZ
- Trial overseen by Mark Macintosh of Agfirst Consultants
- Trial started 1 October 2003
  Trial finished 24 February 2004

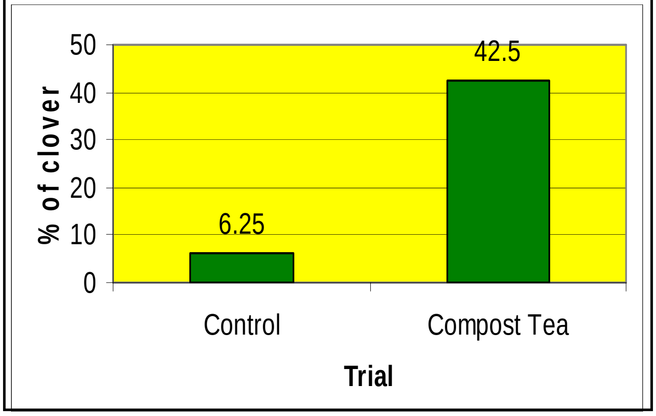
Treatment

- Compost Tea Plot
  - Three applications of compost tea and foods at 150L/ha applied every 4 weeks starting in October 2003
  - No fertiliser had been applied to the compost tea trial plot for the 12 months prior or throughout the trial
- Control Plot
  - Conventionally fertilised with urea at an application rate of 75kg/ha every 6-8 weeks (450kg/ha per year)
  - Phosphate Sulphur Magnesium applied at industry maintenance levels

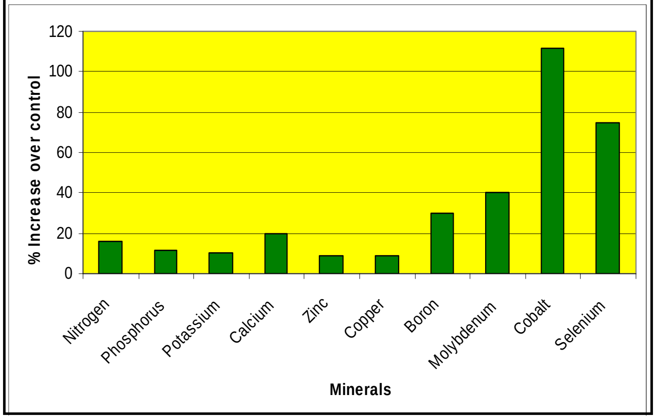
Total Dry Matter Grown



Average Clover % in Pasture Sward



Herbage Mineral Levels



Biological Soil Test Results

Soil Foodweb test done 4 weeks after 3rd application - Dec 2003

Biomass Data	**Control**	**Compost Tea**
Active Bacteria (ug/g)	64.2	30.4
Total Bacteria (ug/g)	348	257
Active Fungi (ug/g)	0.5	144
Total Fungi (ug/g)	113	227
Fungi to Bacteria Ratio	0.32	0.88
Fungi Hyphal Diameter (um)	2.5	3
Protozoa (per gram)		
Flagellates	8395	58730
Amoebae	8395	5873
Ciliates	4046	1767
Mycorrhizal fungi root colonisation (%)	0	4

Nematode

Numbers per gram fresh soil

Type	**Control**	**Compost Tea**	**Variance**
Bacteria feeders	1.98	4.52	128%
Fungal feeders	0.99	1.58	60%
Fungal / Root feeders	1.09	0.24	-78%
Root feeders	0.99	0.12	- 87%
Predatory Nematodes	0	0	0

Key Results

- 11.78% increase in total dry matter grown over the control
- $307/ha increased milk income from the extra dry matter grown
- Big increases in herbage mineral levels, resulting in reduced animal health costs
- 780% increase in clover content giving the soil access to more free nitrogen
- Huge reductions in root feeding nematodes, providing a better environment for increased clover growth

Summary

- The results from the trial show a significant increase in total yield
- More high quality pasture grown through the summer means more milk at a lower cost
- The huge increase in clover will mean substantial reductions in fertiliser nitrogen - this is possible because of the increased nitrogen fixing ability of the clover

Tane Datta, Hawaii, Worm compost and Compost Tea

Salts alone Plus organisms

Nutrient Film Technique

No tea

With compost tea in nutrient solution

Street Trees in Timaru, NZ: Dealing with foliar disease

- Trees around office building suffering anthracnose
- One tree chosen as control
- One tree chosen for three applications of compost tea; each 10 to 14 days
- Anthracnose begins to disappear immediately from tea treated tree; no improvement in control tree.
- Repeat of previous year experiment with same results (different trees)


03/11/2004


22/11/2004

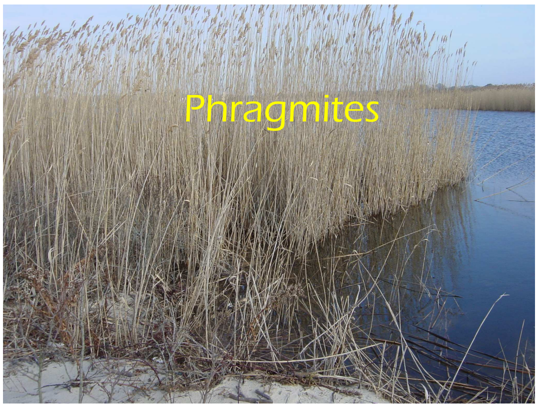

03/11/2004


22/11/2004

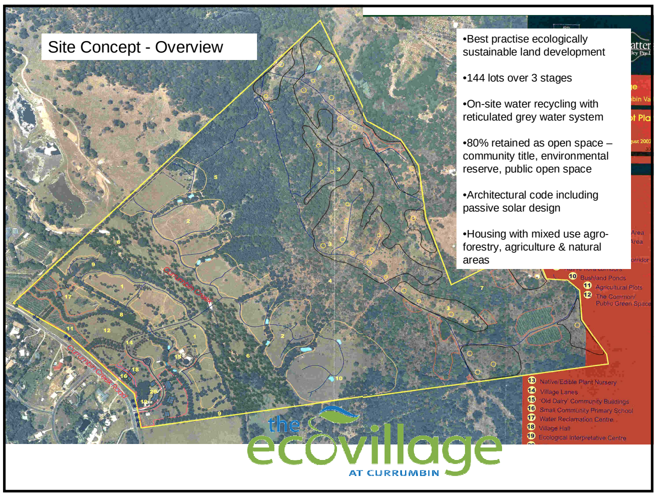

James Sotillo,
TreeWise.com

TreeWise
James
Sotillo


TreeWise

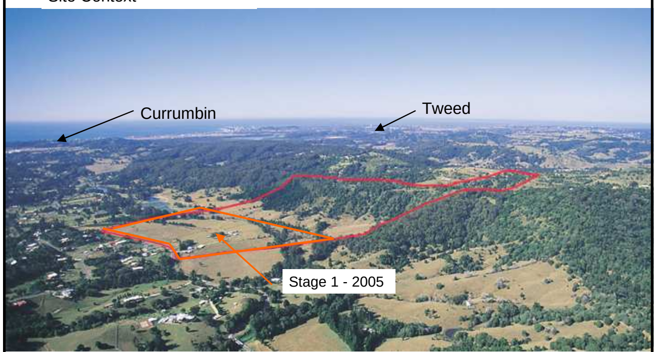

Phragmites

Site Concept - Overview



- Best practise ecologically sustainable land development
- 144 lots over 3 stages
- On-site water recycling with reticulated grey water system
- 80% retained as open space – community title, environmental reserve, public open space
- Architectural code including passive solar design
- Housing with mixed use agro-forestry, agriculture & natural areas

Site Context



Greg Hallet and Jane Oliver

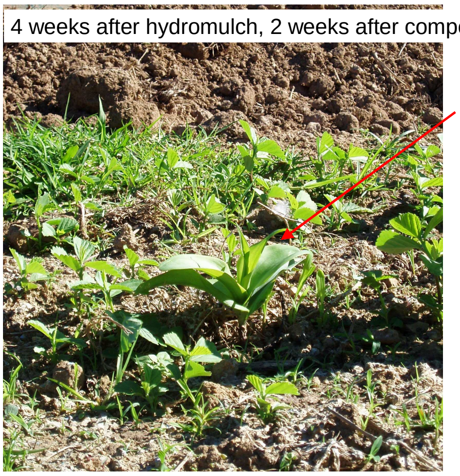
Cordyline (Palm lilly) seed after hydromulching

1st Compost Tea application within 1 week

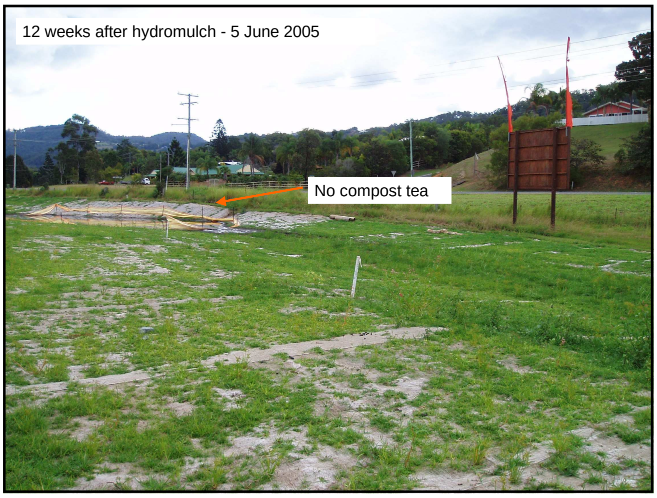
Compost Tea – 2nd application 31 March 2005

4 weeks later – 15 April 2005

4 weeks after hydromulch, 2 weeks after compost tea



Cordyline Sp. sprouting after 1 month



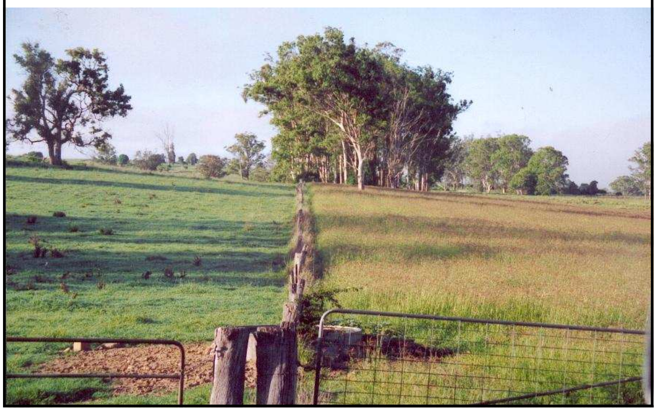
Stuart Larsson

Using Compost Products to Develop 'Soft Agriculture'

1993 Soil / 2003 Soil

Conventional V Compost 1997

Composted Paddocks 2004



Improving Soil Biology, which is what SFI does, results in:

1. Reduction in and in most cases, an end to pesticide applications,
2. Reduction and in most cases, an end to inorganic fertilizer applications,
3. Decrease in water required
4. Increase in yield, where applicable

Why does SFI Technology work?

Shifting the Scientific Paradigm requires changing false assumptions

- Roots of plants only go 10 cm into the soil.
- Soil is sterile below the root zone
- Nutrients are only in the top 10 cm of soil

<u>If you cut the top, do the roots fall off?</u>

Hendrikus Schraven holding ryegrass planted July 15, 2002

Harvested Nov 6, 2002
Mowed twice to ½ inch

70% Essential Soil,
30% Compost/organic fertilizer
Compost tea once

No weeds, no disease

www.soildynamics.com

<u>What's the Program</u>?

- Determine the missing biology, missing chemistry
- Add organisms (compost, ACT, inoculants, bio-control) and foods for the beneficial organisms,
- "Missing" biology kept active by having foods to consume
- Monitor to make sure improvements have occurred, that organisms are performing their functions

What's the Program?

- Autumn –
  - Apply organisms to soil, especially to residues, to prevent disease growth, improve soil structure all through the winter
  - Monitor to determine what survived, what might need to still be added
- Pre-Plant –
  - Apply organisms to soil and foods based on monitoring from fall
- Seed –
  - Apply organisms, foods, mycorrhizal fungi to the seed, or to soil below the seed
- Foliar
  - protect leaves from diseases, foliar feed nutrients

An example from Hendrikus Schraven

- The engineering approach has been used.
- Need to use biology to solve problems.
- Using biology requires education and knowledge.
- Organisms are NOT inert chemicals, can't treat them as such.
- Organisms need air, water, food and housing (soil structure).
- Even dormant, organisms have to be treated right, or they won't work for you

Steps to Fix Foodweb

- **Measure** soil biology and soil chemistry
- **Determine** soil nutrients and biology needed
- **Biology:** Use Compost and/or compost tea to add an INOCULUM of the desired organisms (diversity!)
- **Chemistry:** N, P, K, Ca:Mg, micronutrients, etc added as compost and/or organic fertilizer in "Essential Soil"
- Foliar compost tea applied through summer
- Pesticide residue prevented full recovery
- Compost added in fall to balance needed nutrients

1. Initial soil biology 2. add compost with fish, Ca, nutrients 3. assess soil again after six months

	AB	TB	AF	TF	F	A	C	Nema
Dec soil	2.3	135	0.8	25	0	0	0	21
Add	41	850	5.3	800	20	16	37	17
	floculate clays with Ca							
July soil	13.	317	8.4	139	11	9	26	14
Desired Range (Soil)	25	250	25	250	20,000+		50	30

Initial soil biology, added compost, soil after six months

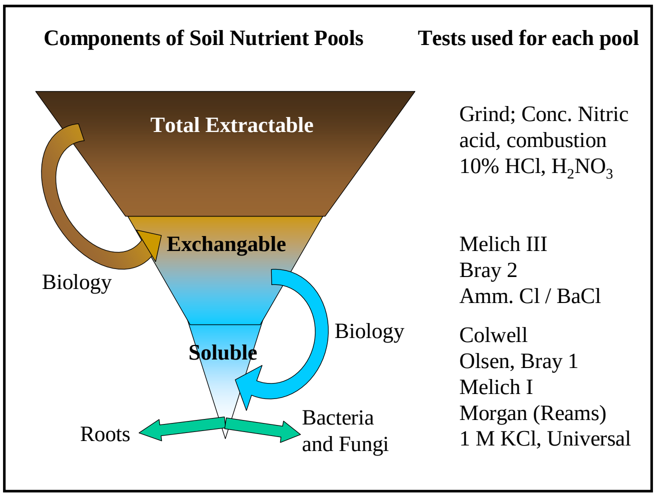
	AB	TB	AF	TF	F	A	C	Nema
Dec soil	0.3	75	0.0	3.0	0	0	1,300	113
Add	41	850	5.3	800	20	16	37	17
Lawn	3	215	13	197	14	11	13	7
Garden	22	117	21	293	23	52	43	14
DR	25	250	25	250	20,000+		50	30

Shifting the Scientific Paradigm requires changing false assumptions

- Examples of false assumptions
  - N is N: Just try drinking nitrate
  - Nutrients can only be supplied in inorganic forms
  - Loss of nutrients cannot be prevented
  - Excess nutrients must be supplied
  - Soluble and Exchangeable nutrients are all there is in soil

Soil Chemistry: Nutrient Pools

- **Total Extractable Nutrients** – not normally reported
  - Grind, complete digestion and combustion
- **Total Exchangeable Nutrients** (Melick 3, Ammonium Acetate 1N)
  - Strong extracting agents, but not ALL nutrients
- **Reams/Morgan Extract Soluble Nutrients**
  - Extracts soil solution or water soluble nutrients
  - Available nutrients – made available how?
- **Plant Tissue Tests**
  - Total Extractable chemical components



- Available nutrients may be lacking
- But a store of nutrients (total extractable) exists in MOST soils that are more than adequate to grow any plant. Sand?
- ACTIVE, functioning organisms must be present to move nutrients from one pool to the next.
- What organisms have been killed by pesticides? High levels of inorganic fertilizers?

Shifting the Scientific Paradigm requires changing false assumptions

More False Assumptions:

- The only way to manage weeds is to kill them
- The only way to manage disease is to kill it
- The only way to manage pests are to nuke them
- Insect pests, diseases and weeds are the result of unbalanced soils, not a lack of chemical weapons (Arden Anderson)

If you cut the top, do the roots fall off?

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The root of the matter is infiltration

Oxygen? Disease? Microbes?

Source: Conservation Research Institute

Size of Root System of a Rye Plant (*Secale cereale*)

Kind of Root	Number	Length	
		Meters	Feet
Main Roots	143	65	214
Secondary Roots	35,600	5,181	17,000
Tertiary Roots	2,300,000	174,947	574,000
Quarternary Roots	11,500,000	441.938	1,450,000
Total Root	14,000,000	609,570	2,041,214 (380 miles)

From Al Knauf

The Myth :

The reason roots in golf greens are only 1/8th inch deep is because the tops are cut 1/8th inch high

- Roots will go into soil as far as they can, to a limit set by the plant, not by shortness of the foliage

How far down do roots go?

- Visit some caves
- What is growing through the ceiling?
- How deep?

- Why would we have the attitude in agriculture that roots only go down a few inches?

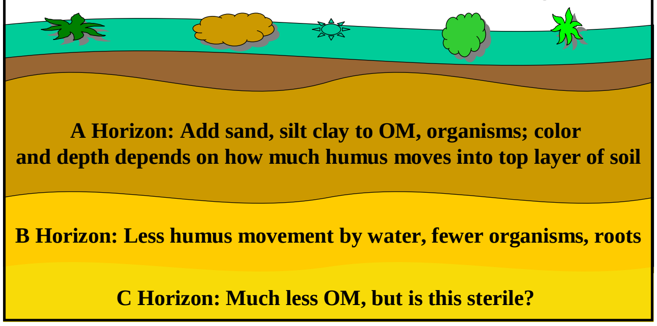
What agricultural practices result in compacted soil?

- Tillage
  - Slice and dice the organisms, especially fungi
  - Mix C and N together and set conditions that select for bacteria
- Inorganic Fertilizers
  - All inorganic fertilizers are salts and kill organisms even at low concentrations
- Pesticides
  - All have impacts on organisms

Soil Horizons

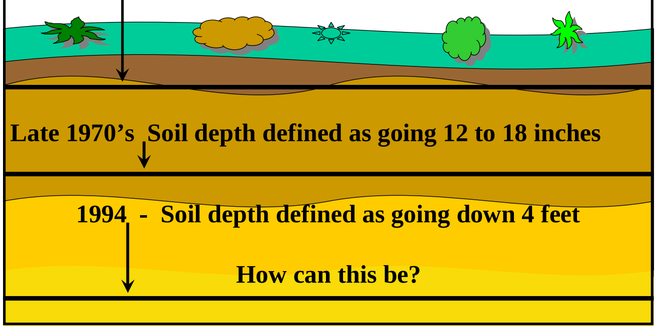
O horizon: O1 = recognizable plant debris

OH = dark brown humus (OM, organisms)



Soil Depth

1940 – 1950 Soil depth defined as going to 4 to 6 inch depth



Tillage

- Earliest plows were moldboard, which went to 4 to 6 inches, and where plowshare presses down, compaction starts. Water moving into soil can't move beyond that depth, and hardpan starts
- In 60's and 70's, hardpan and erosion was getting serious. Engineering solution was to till deeper. Chisel and disc plows till to 12 to 18 inches
- In the 80's, hardpans have formed at 12 to 18 inches. How do you fix that? Till deeper
- Deep rippers, sub-soilers. Compaction at 4 ft, so what do we do now? Can't till deeper!!!!!

How do you fix a compaction problem?

- Aeration must occur
- Aggregation must be restored
- How?
  - Mechanical aeration?
    - Physically aerates but does not build aggregate structure
  - Biological aeration?
    - Aerobic organisms have to establish, grow, and build structure

Biology and chemistry working together properly build soil physical structure

What comes first?

1. Clays must be floculated
2. Microaggregates must be built
3. Macroaggregates must be built
4. Air passageways and hallways must be present

If passageways and hallways and pores are present and stable, then…….

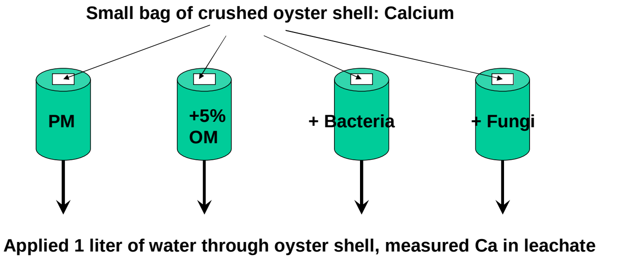
- Water infiltrates easily into the soil and moves into the medium evenly
- Air moves freely through the soil
- Nutrient cycling occurs normally
  - Aerobic bacteria and fungi can grow normally
  - Protozoa, nematodes and microarthropods consume bacteria and fungi and release plant-available nutrients

Calcium and Fungi are Key for Fixing Compaction

- Chemistry and Biology work together to form soil structure
  - Clays collapse when Ca:Mg too low
  - Calcium too low or Magnesium too high; Sodium too high
- When fungal biomass is lost (tillage, chemical toxics) then Ca:Mg ratio drops, because fungi are instrumental in holding Ca
- Calcium floculates clays; Mg stacks clays like plates
- Can't get air or water into soil when clays collapsed

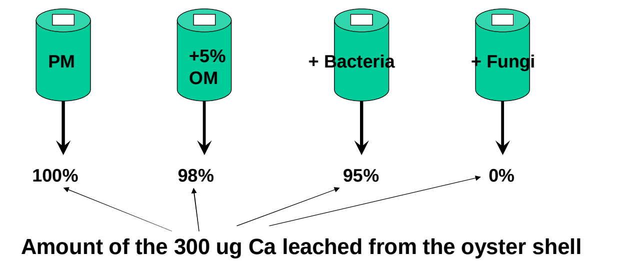
Sandy loam soil, no OM, sterile, re-packed to same bulk density

- Bag with oyster shell on surface of each replicate of the following treatments; 1 L water passed through, 300 micrograms of Ca leached into soil



Sandy loam soil, no OM, sterile, re-packed to same bulk density

- Parent material held no Ca. Sterile OM held only 2% of the leachable Ca, bacteria and OM held 5% of Ca, when fungi present, ALL CALCIUM held.

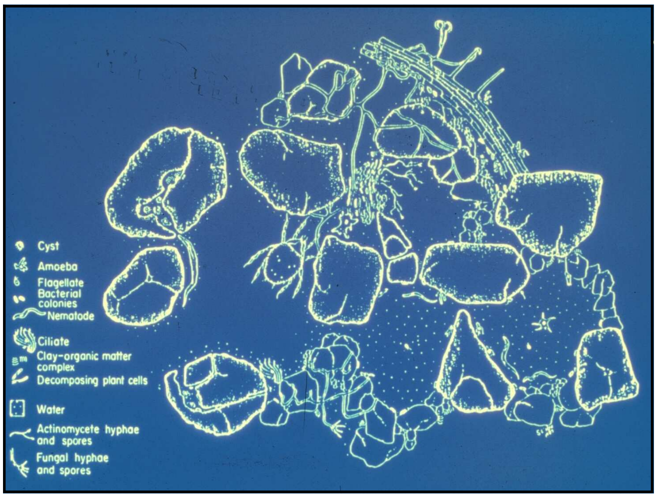


What holds Ca in soil?

- Fungal hyphae
- Repeated in clay, and same results, only clay held more Ca by itself (30% of leachable Ca), OM held more when clay present (10% instead of 2%)
- REMEMBER OM WAS REMOVED in these experiments, so when other experts start to disagree with these results, quiz them on OM levels

Biology and chemistry working together properly build soil physical structure

1. Clays must be floculated
   Ca and fungi required
2. Microaggregates must be built
   Bacteria bind clays together
3. Macroaggregates must be built
   Protozoa, nematodes, worms, arthropods
4. Air passageways and hallways must be present



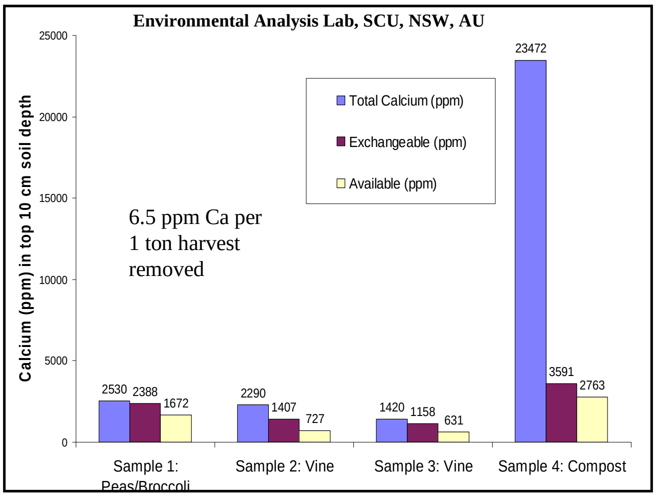
The right biology enhances these functions:

- Disease protection (no more pesticides!)
- Nutrient immobilization (stop leaching)
- Nutrient availability (right forms in the right place at the right time)
- Decomposition of toxins (get rid of residues)
- **Root health, root depth, water holding, aerobic conditions in soil, because soil structure is made by bacteria glue, fungal threads, wall placement by protozoa, nematodes, big critters**

How much Calcium do plants need?

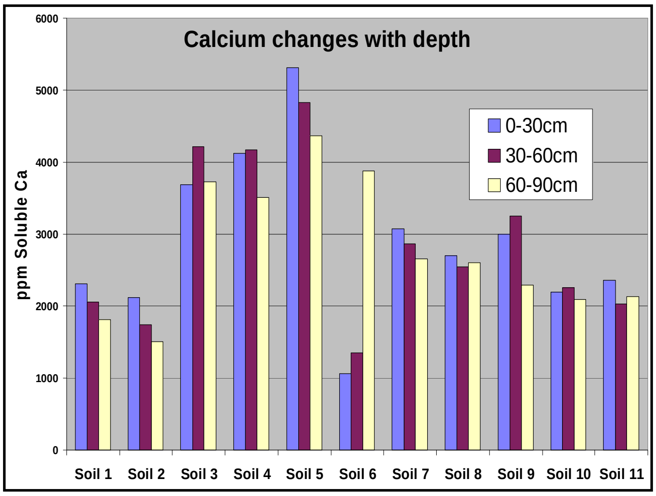
Plant Leaf Analysis – acid digest/combustion

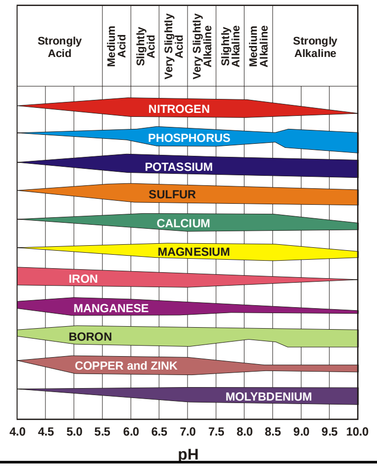
Nutrient	Units	Macademia	Adequate Range
N	**%**	**1.82**	**1.3 – 1.5**
P		**0.04**	**0.08 – 0.09**
K		**0.67**	**0.65 – 0.80**
S		**0.19**	**0.17 – 0.25**
C		**52**	**50 – 52**
Ca	**%**	**0.65**	**0.65 – 0.75**
Mg		**0.12**	**0.09 – 0.11**
Na		**0.02**	**Variable**
Cu	**ppm**	**148**	**5 – 10**
Fe		**101**	**20 – 200**
B		**28**	**40 - 80**
C:N	**Ratio**	**28.3**	**30**



But that's just the top 10 cm depth of soil, don't roots go deeper?

- **Compaction?**
- **How deep does soil go?**
- **What are nutrient concentrations deeper in soil?**





Without biology, you are stuck with pH as the sole arbiter of what is available to plant roots, as indicated to the left. But add organisms, and plant nutrition is no longer ruled by chemistry alone.

Roots CAN go deeper than you thought

- If structure is present
- Indicator of poor soil health if roots of crop plants, or trees, don't go deeper into soil than a few inches
- There is a difference between what is being observed right now, and what is possible
- Human-imposed compaction
- Use root depth to tell you about soil health

IT'S YOUR JOB TO MAKE SURE YOUR ROOTS DO GO DEEPER

How do we fix it?

Get the right biology back in the soil

- Tie up nutrients that otherwise leach, run-off, erode
- Make nutrients available at rates plants need, when plants need them
- Compete with, inhibit, consume diseases, pests
- Build soil structure so air and water can go deep into soil, so roots can follow
- Move not-plant-available nutrients into plant-available forms

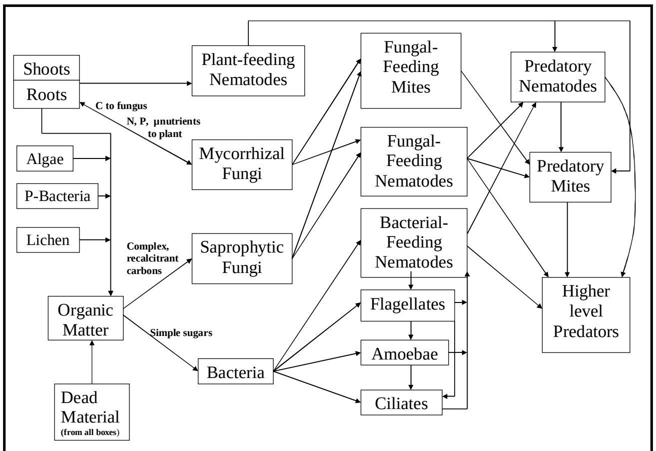

Stream Bank Repair August 1998
Hendrikus Schraven Landscaping,
www.soildynamics.com


May 1999
Work by Hendrikus Schraven Landscaping


Sept 1998
Work by Hendrikus Schraven
Landscaping

ALL the biology must be present

- Which is “most important?”
- Holistic system, can’t forget any part
- No retention without bacteria and fungi
- No return to plant available forms without protozoa, beneficial nematodes and microarthropods
- Need to understand the **WHOLE** foodweb



The Soil Foodweb in Lawns, Vegetable and Row Crops systems

The right biology enhances:

- Disease protection (no more pesticides!)
- Nutrient immobilization (stop leaching)
- Nutrient availability (right forms in the right place at the right time)
- Decomposition of toxins (get rid of residues)
- Build soil structure, improve root health, root depth, water holding, aerobic conditions in soil, via bacteria glue, fungal threads, wall placement by protozoa, nematodes, big critters

Did you remember the roots?

- How important are roots to plants?
- Weeds – only 20% of the energy fixed into roots
- Grasses 60% of their energy goes
- Vegetables into the roots
- Shrubs, Trees 80% of their energy into roots

The energy going into roots:

1. Builds structural roots
   a. prevent the plant from falling over
   b. firm anchor in the soil
      - How deep do roots go?

2. Lateral roots take up nutrients only by diffusion, no enzymes to break down organic matter.

3. Exudates - 50% of energy into roots is released as:

Simple Sugars, Proteins, Carbohydrates

Why would a plant release exudates?

Who do these cakes and cookies feed?

- Would these foods feed pathogens?
  - You would have dead plants……
- Would these foods feed organisms that are beneficial-to-the-plant?
- Consume the nutrients and foods that might feed any pathogen
- Convert N from nitrate to something that does not enhance disease-organism growth
- Occupy the space so pathogens can't grow

Organism numbers in different soils

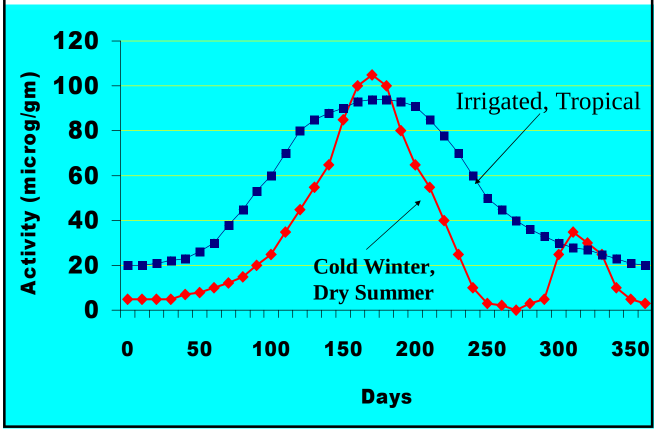
Organism Assays	Agricultural Soil	Ag-Rhizo-sphere	Healthy Soil	Healthy Rhizosphere
Total bacteria (#/gram dry soil)	1 X 10^{6}	1 X 10^{12}	6 X 10^{8}	1 X 10^{12}
# of bacterial species/g soil	5,000	5,000	25,000	25,000
Total fungi (ug per g dry soil)	5	20	150	300 – 500
# of fungal species /g soil	500	?	8,000	8,000
VAM colonization	0	0	55%	55%

←—— **Bacterial Foods** ——→

←—— **Fungal Foods** ——→

Simple	**More Complex**	**More Complex**	**Very Complex**
Amino Acids	**Proteins**	**Hormones** **Vitamins**	**Fulvic acids (Minerals)**
Carbohydrates	**Chlorophyll**	**Fats**	**Humic Acids**
Sugars	**Polysaccharides** **Amino sugars**	**Lipopolysaccharides**	**Coal**
		Cellulose	**Lignin**
Organic Acids	**Fatty Acids**	**Waxes**	

Seasonal Activity of Microorganisms



Why Have Organisms Around Roots?

- **Disease Suppression Mechanisms**
  - Use exudates so no food left for pathogens
  - Produce antibiotics, inhibitory compounds, toxins to prevent pathogen or pest growth
  - Occupy infection sites on root surface by beneficial organisms so pathogen cannot bridge cell wall, infect cells
- **Other benefits?**

- Be careful not to make **claims** of disease suppression, or disease prevention, until documented in the scientific literature
- Is there any need to prove that a good source of the organisms will do what we know they will do?
- Maybe all we have to do is document return to healthy levels of organisms

The right biology enhances these functions:

- Disease protection (no more pesticides!)
- **Nutrient immobilization (stop leaching)**
- Nutrient availability (right forms in the right place at the right time)
- Decomposition of toxins (get rid of residues)
- Build soil structure, improve root health, root depth, water holding, aerobic conditions in soil, via bacteria glue, fungal threads, wall placement by protozoa, nematodes, big critters

Nutrient retention

- **Most leachable forms of N**
  - **NO_3^-**
  - **NO_2^-** **The Inorganic Forms of N!!!**
  - **NH_4^+**
  - **NH_3 (anaerobic and stinks!)**
- Least leachable N

Nutrient retention

- **Least leachable N (aerobic or anaerobic)**
  - **Bacteria**
  - **Fungi** **Why?**
  - **Protozoa**
  - **Nematodes**
  - **Microarthropods**
  - **Roots**
  - **Organic matter**

Least leachable

↓

More leachable

What forms do plants need?

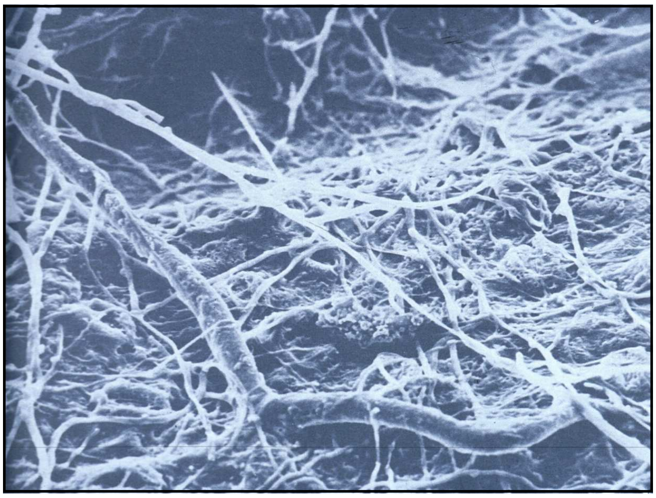
- Soluble or not-soluble?
- Around the root, or away from the root?
- Annual or perennial plants?
- Bacterial or fungal-dominated?

N	S	P
NO_3	SO_4	PO_4
NH_4		

- How do plants get these forms of nutrients?

First of all, AEROBIC bacteria and fungi stick to everything

- Bacterial glues
  - pH > 7
- Fungal threads
  - Organic acids whose pH is?
  - Glomulin
- R. Foster's book on Ultrastructure of the Rhizosphere



Bacteria and fungi don't wash away.

They need their food, and they are going to stick to it!

Bacteria and fungi don't wash away.

What is the concentration of nutrients

in Bacteria?

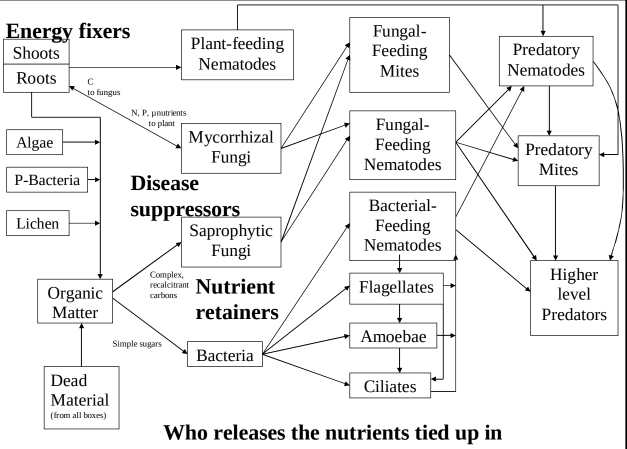
in Fungi?

Organism Group	C:N
• Bacteria	
• Fungi	
• People	
• Green Leaves	
• Protozoa	
• Nematodes	
• Deciduous trees	
• Conifer trees	

Organism Group	C:N
• Bacteria	5:1
• Fungi	20:1
• People	30:1
• Green Leaves	30:1
• Protozoa	30:1
• Nematodes	100:1
• Brown plant material	150 – 200:1
• Deciduous wood	300:1
• Conifer wood	500:1

Bacteria and fungi are more concentrated in N than any other organism. They hold or retain N

- Also true for P, S, K, etc.
- What is the C:N of bacterial or fungal food?
- Do bacteria or fungi release N?



Who releases the nutrients tied up in the bacterial or fungal biomass?

The right biology enhances these functions:

- Disease protection (no more pesticides!)
- Nutrient immobilization (stop leaching)
- **Nutrient availability (right forms in the right place at the right time)**
- Decomposition of toxins (get rid of residues)
- Build soil structure, improve root health, root depth, water holding, aerobic conditions in soil, via bacteria glue, fungal threads, wall placement by protozoa, nematodes, big critters

Nutrient Cycling (per unit biomass)

• Flagellates need	30 C	1 N
• 1 bacterium	5 C	1 N
	-25 C	ok

More bacteria needed - how many?

Flagellates need	30 C	1 N
• 6 bacteria	30 C	6 N
	C ok	but too much N!

- 5 N released for every 6 bacteria consumed.
- What form of N? NH_4
- Is this what plants need? Convert to Nitrate?

Is this enough N to grow plants?

- 5 N released for every 6 bacteria consumed.
- Each protozoan eats 10,000 bacteria per day, so that's 8,000 N molecules released per day per protozoan!
- Healthy soils contain 50,000 protozoa per gram
- So, protozoa eat 500,000,000 bacteria per gram of soil per day, which releases 40,000,000 molecules of N per gram soil per day.

Perennials vs Annuals

- What form of N needed?
- Aerobic bacterial-dominated soils, what form of N?
  - Alkaline glues
  - Nitrifiers
- Fungal-dominated soils, what form of N?
  - Organic acids
  - Nitrifiers?
- Anaerobic bacterial dominated soils?

Observations

- Aerobic bacterial-dominated soils maintain alkaline pH, and therefore nitrate is the dominant pool of inorganic N
- Aerobic fungal-dominated soils maintain pH between 5.5 and 7, and therefore ammonium is the dominant form of N
- Are the inorganic forms of N always dominant in soil?
- What other forms of N are there?
- What happens in anaerobic soil?

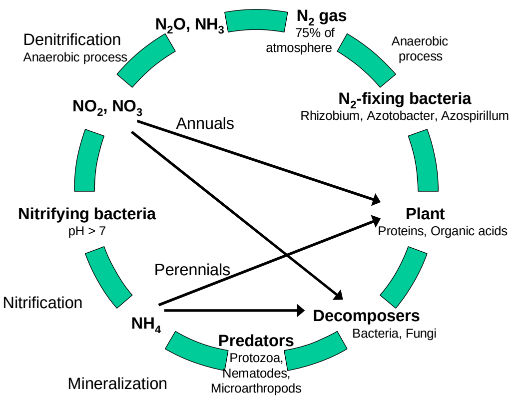
There is hope…..

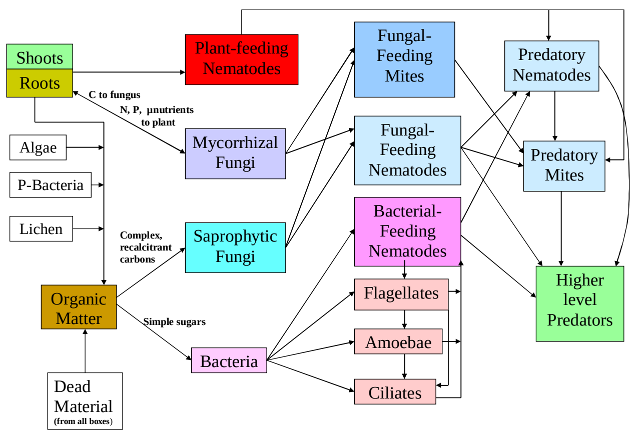
- We can return the soil to health
- It will not cost billions, or even millions of dollars
- It will not take years
- Within one growing season, you can get the increased yields, decrease your costs and improve nutrition in the food you produce
- IF you get the biology right for your plant
- IF you get the WHOLE FOODWEB back

Let’s put some of this info together…

- Let’s go through the Nitrogen cycle and understand it when the BIOLOGY is correctly fitted into what you have been taught as a strictly chemical process…….

N cycle





The Soil Foodweb in Lawns, Vegetable and Row Crops systems

Where does added biology come from?

- Requirements:
  - Maximum diversity of ALL organism groups
  - Food resources for all these organisms to remain viable
  - Indigenous organisms adapted to the climate
  - Balanced for the plant you want to grow
  - Easy to apply
  - Inexpensive
  - No pathogens or pests
- What gives you all these things

Types of Compost

- Compost is the **oxidative** decomposition of organic matter
- Therefore composting is an **AEROBIC** process

- Thermal compost
- Worm compost (vermi-compost)
- Static compost

Thermal Compost

- Heat to 131 F for a full 3 days to kill weed seed, pathogens, pests
  - But NOT HIGHER than 155 – 160 F so beneficials NOT killed
  - Turning required
- Regulations
  - Minimum 131 F for 10 – 15 days, turn 5 times; why the difference from above?

Worm Composting

- Worms consume bacteria, fungi, protozoa, nematodes growing on foods added to the bin surface
- Worms turn the compost, kill pathogens, pests by passage through digestive system, or contact on worm surface; BUT WHAT DENSITY FOR WHAT INPUT RATE?
- Low rates of composting if cold, increase as temperature increases, but once above 85 to 90 F, worms get too hot and slow down again
- 60 to 70% moisture is optimal

What is compost?

- **Aerobic** <u>decomposition</u> by BACTERIA and FUNGI of a mix of organic material; nutrient cycling requires predators
- Thermal compost
  - Commercial, back-yard, household
- Worm or Vermi-compost (cold composting)
  - Batch or flow-through
- Static compost – heat uneven, anaerobic, takes longer
  - Malcolm Beck's "Secret Life of Compost"

Thermal Compost

- Heat to 131 F for a full 3 days to kill weed seed, pathogens, pests
  - But NOT HIGHER than 155 – 160 F so beneficials NOT killed
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- 60 to 70% moisture is optimal

Three kinds of organisms

- **Aerobic**

  Enzymes use O2 as final electron acceptor in respiration in order to make energy

- **Facultative anaerobic**
  - Two enzyme systems, one aerobic, the other anaerobic
  - Neither very efficient, both cost the organism energy to maintain, so cannot compete well with true aerobes

- **Anaerobic**
  - Enzymes use minerals as final electron acceptor to make energy

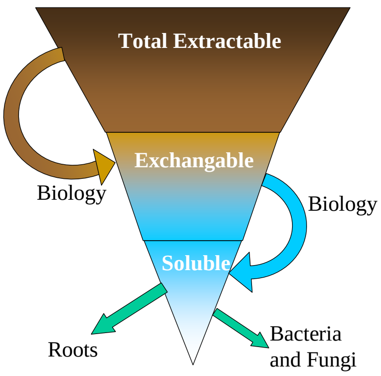
Is compost a fertilizer?

- What is fertilizer?
- N, P, K? What forms?
- Soluble, Exchangeable, Total pools
- What moves nutrients from one pool to another?
- What do plants take-up?
- How much is actually in compost?

How Much Compost to Use?

- Adequate to bring the organisms back to required levels
- Survival of organisms on transfer to soil
- Growth once added to soil?
- Nutrient addition
  - Soluble? Exchangeable? Total Extractable?
  - Movement from pool to pool requires soil biology
- 1 ton of compost contains how much N?

Components of Soil Nutrient Pools

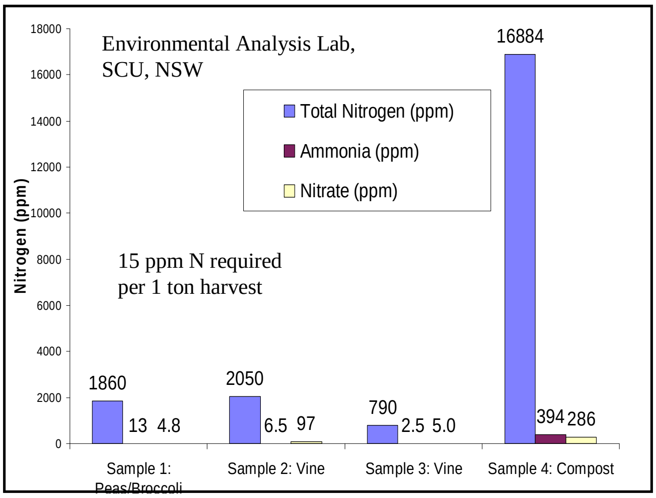


Tests used for each pool

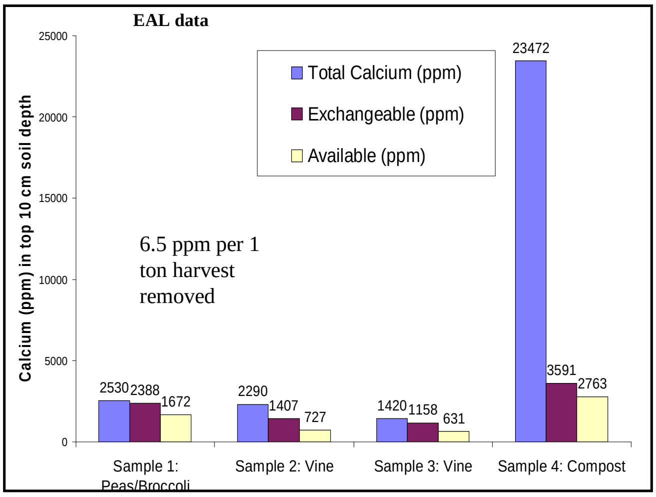
Grind; Conc. Nitric acid, combustion
10% HCl, H_2NO_3

Melich III
Bray 2
Amm. Cl / BaCl

Colwell
Olsen, Bray 1
Melich I
Morgan (Reams)
1 M KCl, Universal



Environmental Analysis Lab,
SCU, NSW
Total Nitrogen (ppm)
Ammonia (ppm)
Nitrate (ppm)
15 ppm N required
per 1 ton harvest
Nitrogen (ppm)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
16884
1860
13 4.8
2050
6.5 97
790
2.5 5.0
394 286
Sample 1: Peas/Broccoli
Sample 2: Vine
Sample 3: Vine
Sample 4: Compost

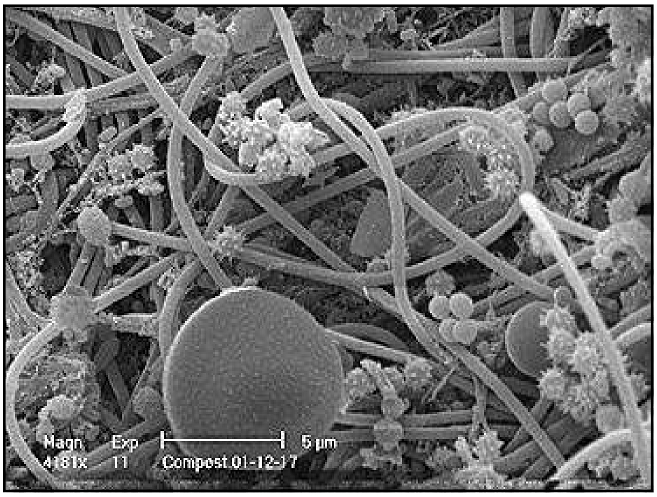


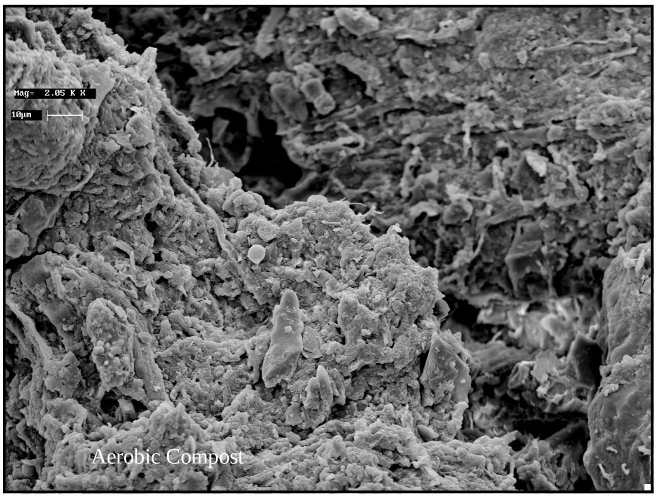
EAL data
Total Calcium (ppm)
Exchangeable (ppm)
Available (ppm)
6.5 ppm per 1
ton harvest
removed
Calcium (ppm) in top 10 cm soil depth
25000
20000
15000
10000
5000
0
23472
2530 2388 1672
2290 1407 727
1420 1158 631
3591 2763
Sample 1: Peas/Broccoli
Sample 2: Vine
Sample 3: Vine
Sample 4: Compost

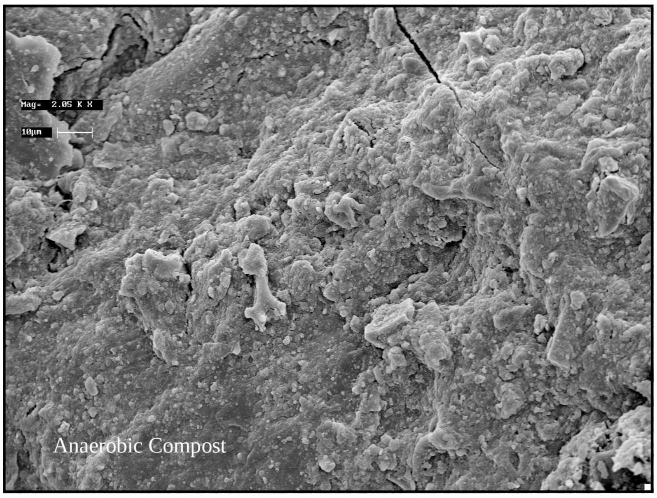
Magn 2000x
Exp 10
10 µm
Compost 01-12-17

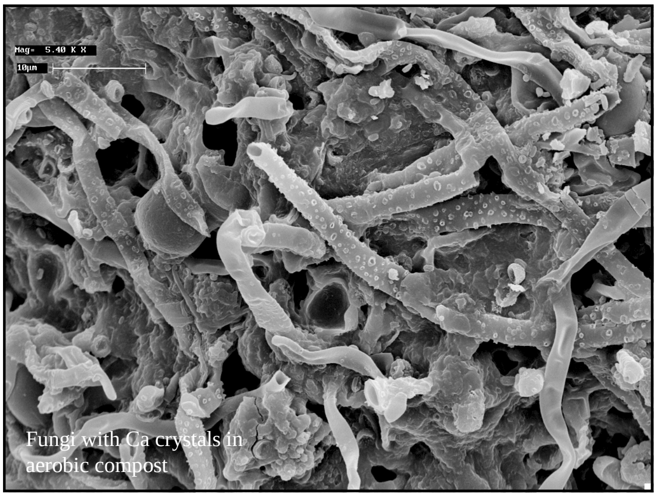
Organisms in Compost

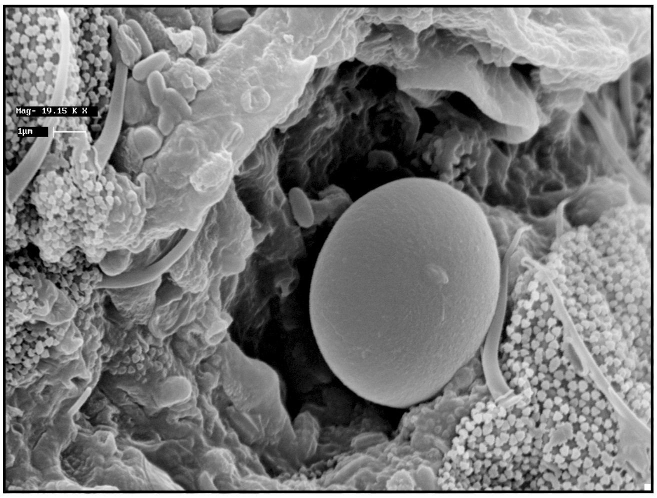
Method	Bacteria	Fungi
Direct Methods		
Numbers	1,000,000,000/g	Doesn’t make sense
Biomass	250 ug/g	150 to 300 ug/g
Species	22,000/g	5,000/g
Plate Methods		
Numbers	1,000,000 /g	100 to 150 /g
Species	12 max	4 to 8 max
DNA	25,000/g (or more)	8,000 to 12,000/g

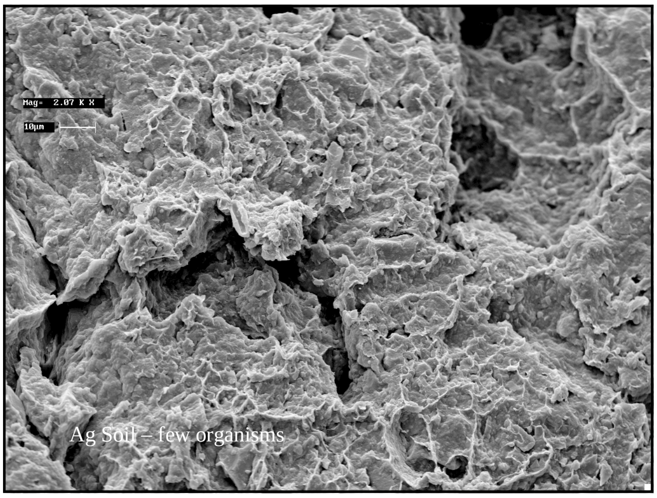





Mag= 2.05 K X
10µm
Anaerobic Compost


Mag= 5.40 K X
10µm
Fungi with Ca crystals in
aerobic compost


Mag= 19.15 K X
1µm



Lismore, NSW 2480
Phone: 02 66225150
FAX 02 66225170
E-Mail: info@soilfoodweb.com

Sample Received:
Plant: Banana
Invoice #
Grower:

Date Mailed:

Equal fungi to bacteria

TRT	DW of 1 gram Fresh Material	Active Bacterial Biomass (µg/g)	Total Bacterial Biomass (µg/g)	Active Fungal Biomass (µg/g)	Total Fungal Biomass (µg/g)	Hyphal Diameter (µm)	Protozoa Number F	Protozoa Number A	Protozoa Number C	Total Nematode Numbers (#/g)
Com-post	0.57	15.7	693	28.0	820	3	15,000	28,000	25	65
	OK	OK	High	Excel	Excel	Good		Good		Good
DR	0.45 - 0.75	15- 30	150 - 300+	2 - 10+	150 - 200 +	2.5 or higher	10,000+	10,000+	20 - 100	50 - 100

TRT	TF to TB	AF to TF	AB to TB	AF to AB	Plant Available N Supply from Predators (lbs/ac)	Root-Feeding Nematode Presence
Com-post	1.18	0.005	0.02	1.78	150 - 200	None detected
	OK	Mature	Mature	Fungal	OK	
DR	1 - 5	< 0.10	< 0.10	> 1.00	200 - 250	ID to genus

BACTERIAL-FEEDERS	**#/g**
ACROBELES	22
CEPHALOBUS	11
BURSILLA	1
RHABDITIDAE II (ST)	12
RHABDITIDAE II (LT)	2
PRISMATOLAIMUS	10
FUNGAL-FEEDERS	
MESODORYLAIMUS	2
EPIDORYLAIMUS	1
APORCELLAIMELLUS	2
FUNGAL/ROOT -FEEDERS	
QUINISULCIUS	1
TYLENCHORYNCHUS	1
ROOT-FEEDERS	0

Lismore, NSW 2480
Phone: 02 66225150
FAX 02 66225170
E-Mail: info@soilfoodweb.com

Sample Received:
Plant: Asparagus
Invoice #
Grower:

Date Mailed:

Equal fungi to bacteria

TRT	DW of 1 gram Fresh Material	Active Bacterial Biomass (µg/g)	Total Bacterial Biomass (µg/g)	Active Fungal Biomass (µg/g)	Total Fungal Biomass (µg/g)	Hyphal Diameter (µm)	Protozoa Number F	Protozoa Number A	Protozoa Number C	Total Nematode Numbers (#/g)
Com-post	0.22	1.70	1932	0.00	0.31	2.5	0	230	2,667	3
	Wet	Low	High	ND	Low	OK		Anaerob		Low
DR	0.45 - 0.75	15- 30	150 - 300+	2 - 10+	150 - 200 +	2.5 or higher	10,000+	10,000+	20 - 100	50 - 100

TRT	TF to TB	AF to TF	AB to TB	AF to AB	Plant Available N Supply from Predators (lbs/ac)	Root-Feeding Nematode Presence
Com-post	0.0002 Very Bact	None Too low	0.00 Too low	No fungi Bacterial	50 - 60 Too low	None detected
DR	1 - 5	< 0.10	< 0.10	> 1.00	200 - 250	ID to genus

BACTERIAL-FEEDERS	**#/g**
	None detected
FUNGAL-FEEDERS	
	None detected
FUNGAL/ROOT -FEEDERS	
Malenchus	1
ROOT-FEEDERS	
Lesion	2

Organism numbers after compost addition

Organism Assays	Agricultural Field	Compost (1ton/ac)	Ag soil with compost
Total bacteria (#/gram dry soil)	1 X 10^6	6 X 10^9	17 X 10^8
# of bacterial species/g soil	5,000	25,000	25,000
Total fungi (ug per g dry soil)	5	150	500
# of fungal species /g soil	500	8,000	8,000
F, A C	0, 0 1,450	12,000, 31,000 29	6,000, 17,000 67

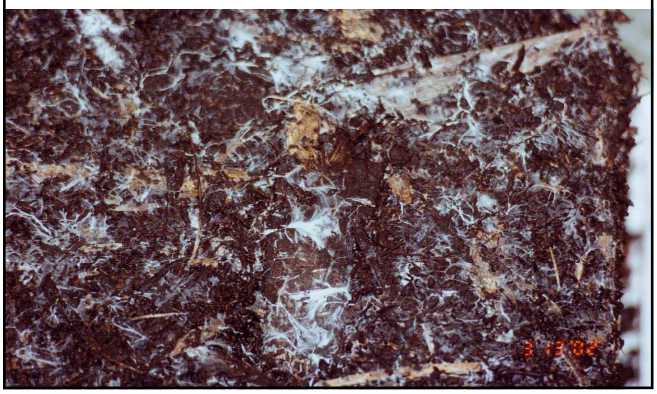
Visual indicators of good compost

- **Smell** If it smells bad, it is bad!
- **Color** NOT BLACK
  Deep, rich brown indicates humics
  Tan, honey color means fulvics
- **Texture** Crumbs, air passages, aggregates visible
- **Fungal Strands**
  Visible thick threads, in compost, not aerial, not fuzz

Beneficial Fungi

Thick strands, like latex

Color can be variable – pink, orange, brown, tan, white



How to select for the “good guys”?

- Foods
- Conditions in piles
  - Temp
  - Moisture
  - Disturbance
- Chemistry
- Structure (physics)

How to make Compost

- **Equipment**
  - **Chipper, grinder**
  - **Thermometer**
  - **Pitch fork, front-end loaders, turners**
  - **Oxygen probes, CO2 probes**
  - **Moisture**
- **Starting materials – FOODS**
  - **High N**
  - **Green**
  - **Woody**

Factors important in making thermal compost

- **Temperature** > 135 F or 55 C for 3 days,
  No higher than 155 F or 70 C
- **Oxygen versus carbon dioxide**
  AEROBIC - Not below 5 to 6 mg/L oxygen, not above 7 to 9% CO2
- **Physical structure – percent “chunkiness”**
  5% > 1 inch diameter
- **Turning – mechanically or with earthworms**
  - **Monitor Temperature, CO_2**

The Composting Process

- **Water – Chlorine? Nitrates?**
- **Covers - saturation, drying**

The Composting Process

- 50% Moisture
  - Too low, no decomposition
  - Too high, lack of oxygen
- Maturity – microbial activity finished
  - Temperature does not elevate when turned
- Stability – nutrients are available
  - Immobilization phase ended

Bacterial Starting Materials: Commercial Compost

25% Hi N – alfalfa, beans, peas, manures

- Salts, Antibiotics, Heavy Metals
- Cow < poultry < pig = human

45% Green

Diversity desired

30% Woody

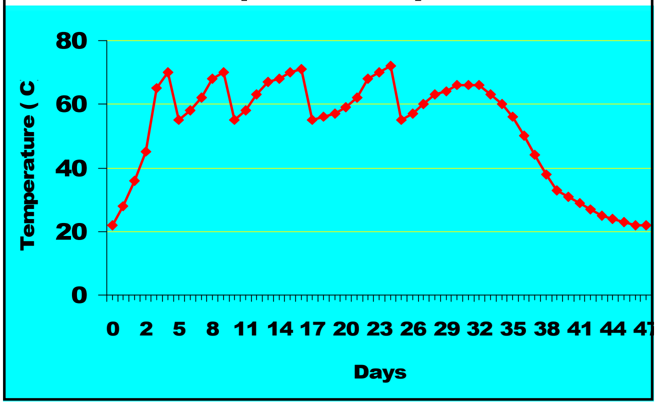
Fungal Starting Materials: Commercial Compost

25% Hi N

30% Green

45% Woody

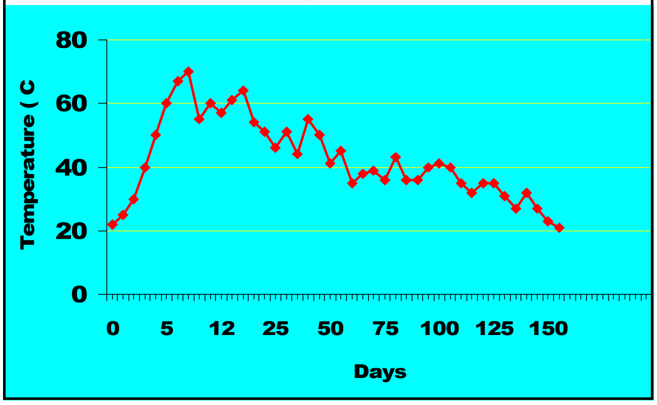
Commercial Compost Temperature Cycle



Back-Yard Composting

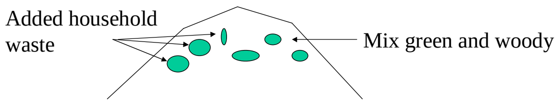
- As long as you maintain ratios, the seasonal variation in N, green, woody have little effect.
- Anaerobic starting materials – signal carried through composting cycle
- Minimize turning by reducing Hi N. Offset with increased time.
- **10% Hi N, 45% green, 45% woody, turn once, but compost for 3 - 4 months** to get rid of E. coli
- Work with Merry Bradley, Master Composter, Eugene, OR

Backyard Compost Temperature Cycle

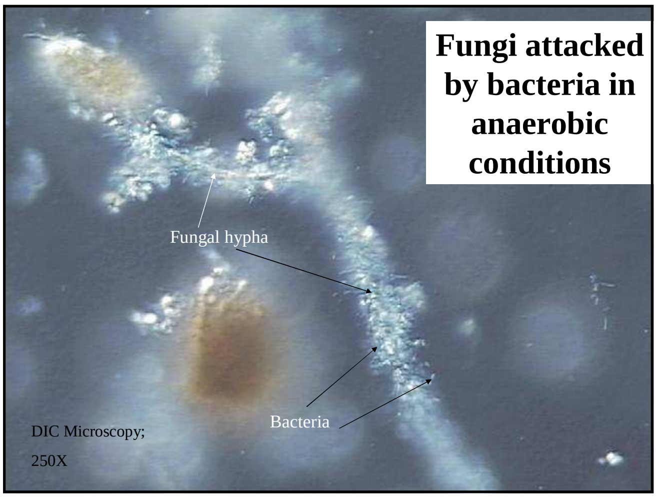


House-hold Composting

- Make pile with 50% Green and 50% Woody
- Add household wastes into pile, at least 2 feet into pile, spaced through pile, until no more “spaces” left



- Add 10% high nitrogen
- Start compost temperature cycle, measure temperature, moisture



Compost Standards

- Measured in fresh compost, expressed per gram dry compost
- 15 to 30 or more µg active bacteria /g dry weight compost
- 150 µg (fungal compost) to 300 or more µg (bacterial compost) total bacteria /g dry weight compost
- 2 to 10 µg or more active fungi /g dry weight compost
- 150 (bacterial compost) to 500 or more (fungal compost) µg total fungal biomass/g dry weight compost
- Hyphal diameters on average 2.5 micrometers or greater
- 50,000 or more protozoa per gram dry weight compost
  25,000 or more flagellates
  25,000 or more amoebae
  50 - 100 ciliates. Higher numbers indicate anaerobic conditions resulting from compaction, water-logging, discontinuities in soil
- 20 to 100 BENEFICIAL nematodes per gram dry weight of compost

Compost Tea Definitions

- **Actively-Aerated Compost Tea**
  - Water extract
  - Brewed
  - Active and total bacteria, active and total fungi, protozoa, nematodes (sp vs #s)
  - Soluble nutrients from the compost
  - Aerobic (O_2 above 6 ppm) vs anaerobic (pathogen growth, loss of nutrients, toxins)
  - with or without added foods to grow beneficials
- **Non-aerated Compost Tea – variable results**

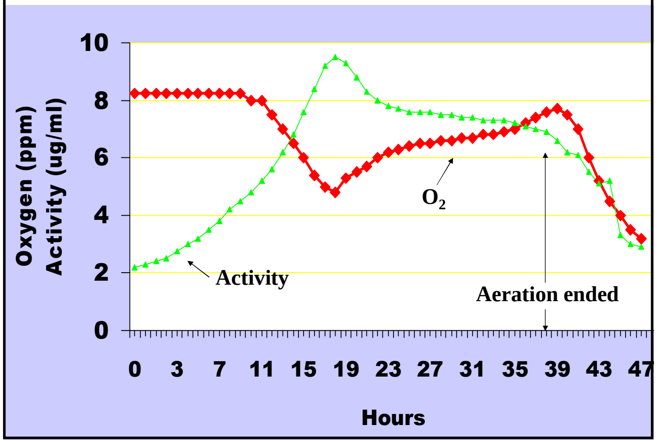
Compost Tea Definitions

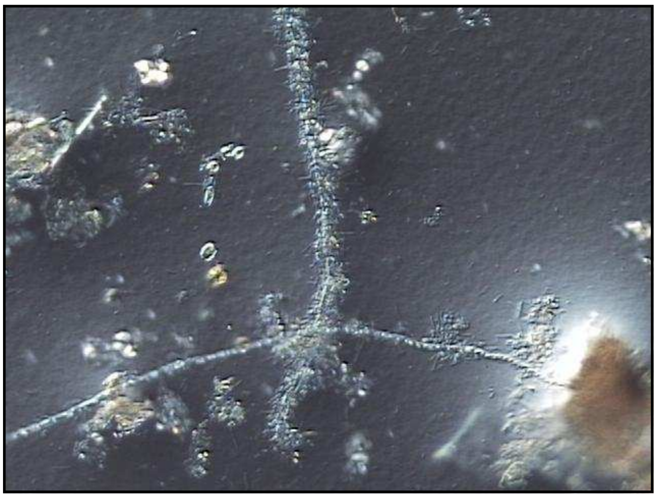
- **Compost Extract –** no brewing time
- **Compost Leachate –** no brewing, few organisms removed
- **Plant tea –** compost not involved
  - bacteria, fungi from plant surfaces, aerobic or anaerobic
- **Manure tea – compost not involved**
  - anaerobic (pathogens present, 90 to 120 day rule required)
- **Put-to-sleep teas –** loss of species, minimal activity

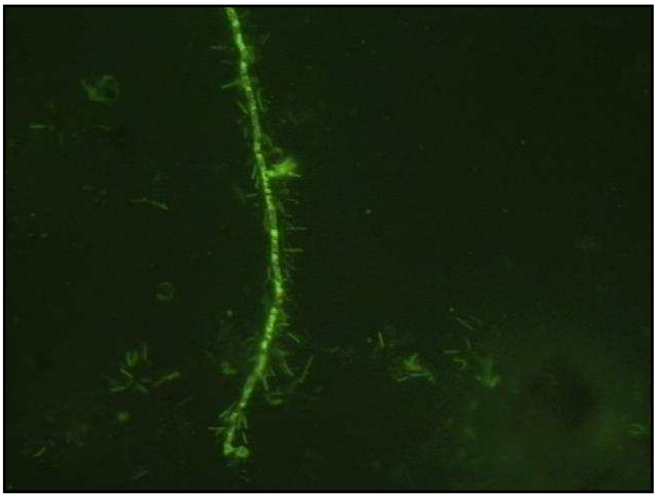
Factors involved in making GOOD CT

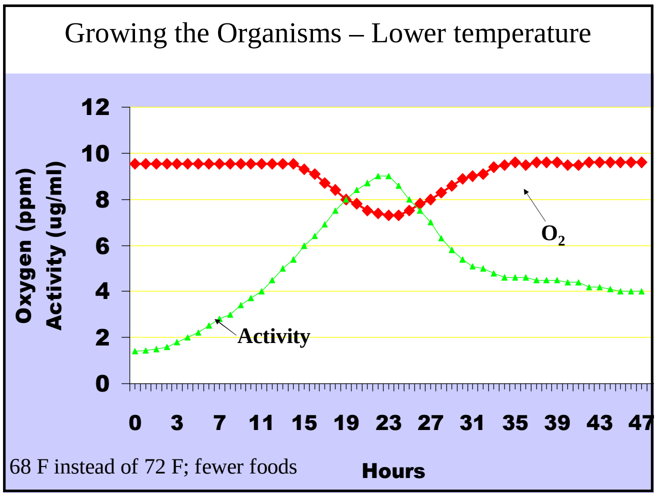
- Compost (Inoculum, Nutrients)
- Aeration, Extraction (Machine)
- Temperature
- Foods
- Water
- CLEANING!
- Timing
- Sprayer
- Application factors (Soil, Foliar)

Growing the Organisms – Aerobically!

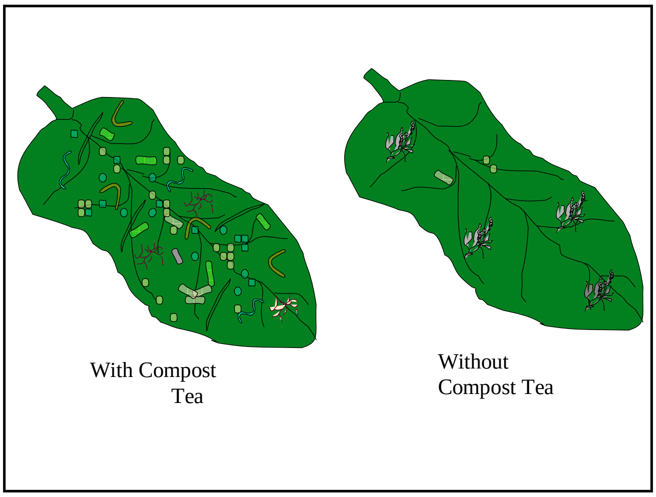


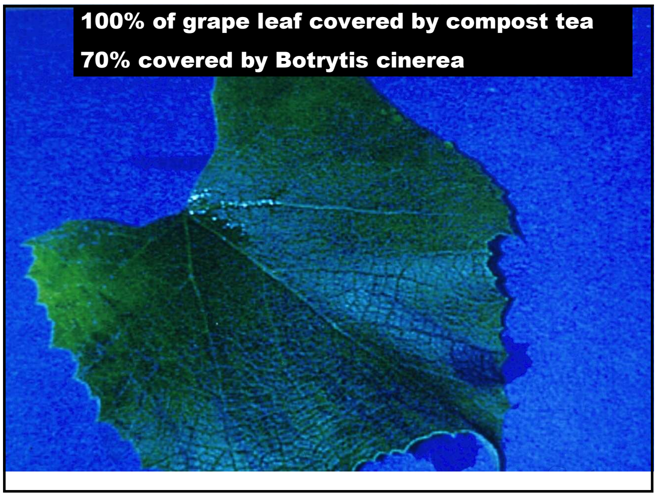


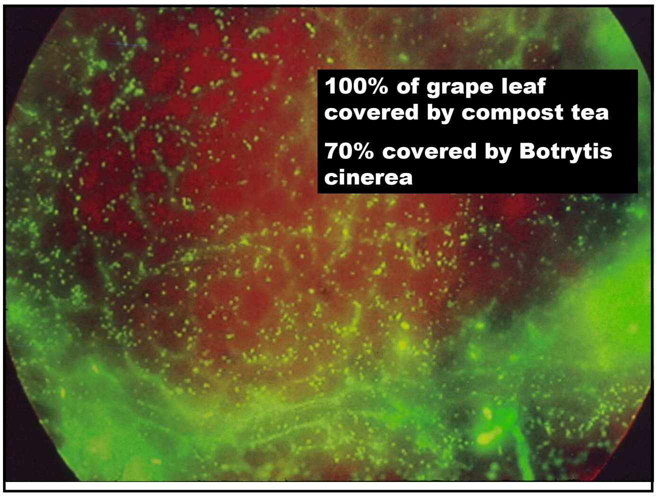




Growing the Organisms – Lower temperature
Oxygen (ppm)
Activity (ug/ml)
12
10
8
6
4
2
0
0 3 7 11 15 19 23 27 31 35 39 43 47
Hours
Activity
O2
68 F instead of 72 F; fewer foods


With Compost
Tea
Without
Compost Tea


100% of grape leaf covered by compost tea
70% covered by Botrytis cinerea


100% of grape leaf covered by compost tea
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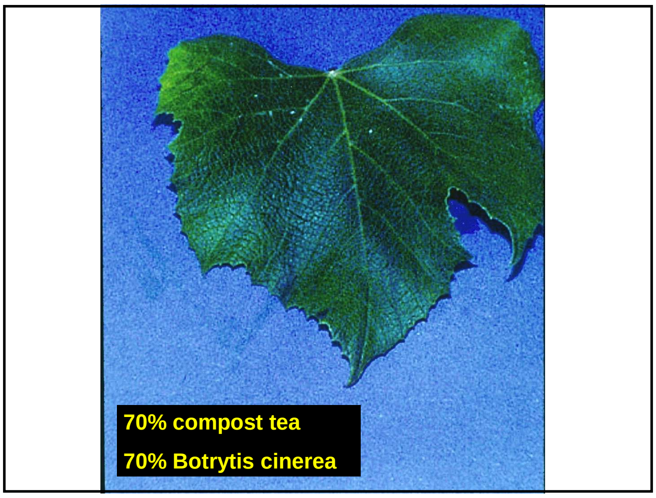
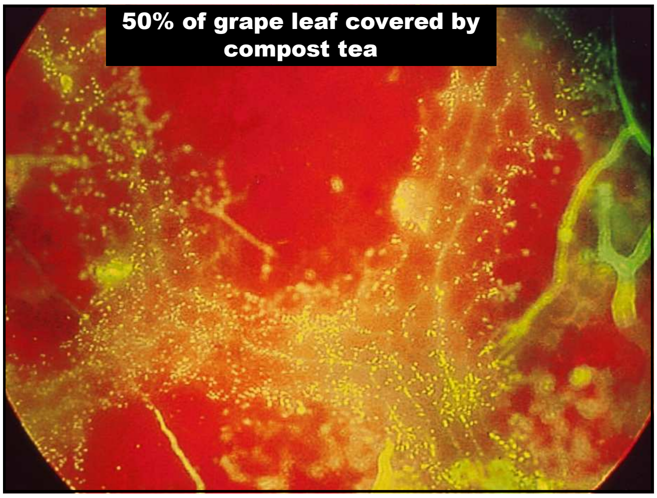
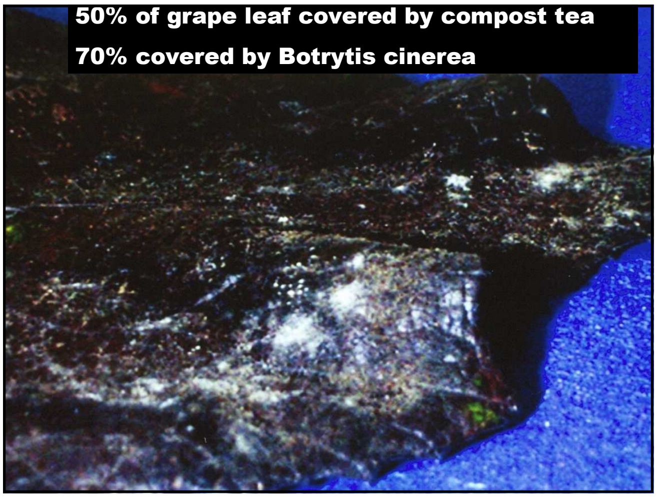
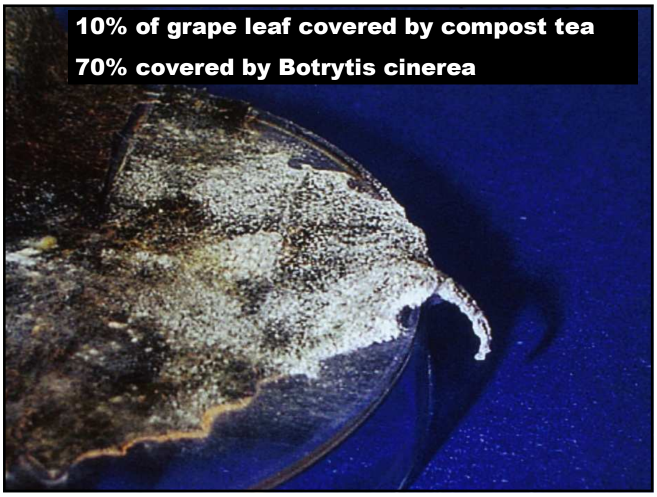

70% compost tea
70% Botrytis cinerea


50% of grape leaf covered by compost tea





Extraction Possible?

	Active	Total Bacteria	Active	Total Fungi
Desired Ranges	**10-150**	**150 - 300**	**2 – 10**	**5 - 20**
Compost Tea (using manufacturer's directions)				
ETB	35	6,700	23	30.1
KIS	53	4,050	11	23.5
AG	12	1,445	3.4	11.9
EW	435	15,096	4.7	14.3
JS	46	266	2.6	17.7
Bacterial tea				
SS	2	1,500	0.00	0.00
GSI	16	4,300	0.5	1.79

	Tea lacking Suppressiveness	Tea Capable of Suppressing Disease
Plate Methods (MPN or CFU) mean, (standard deviation)		
TSA	1.6 (0.5) X 10^8	1.6 (0.7) X 10^8
King's B	5.0 (1.4) X 10^3	1.2 (0.2) X 10^3
Cellulose	35 (12)	210 (43)
Spore-formers	7.9 (0.4) X 10^2	0.3 (0.1) X 10^2
Direct Microscopy (ug per ml)		
Active Bacteria	8.0 (2.6)	12.7 (5.0)
Total Bacteria	25.1 (1.0)	245 (34)
Active Fungi	0.00	3.76 (1.00)
Total Fungi	0.35 (0.12)	11.1 (2.33)
Leaf Coverage (%)		
Bacterial	27 (4.7)	86.9 (9.7)
Fungal	0	5.1 (0.6)
Disease (5 plants)	All died of blight	None died

The Process

When to apply

Soil Drench (20 gal/ac) spring and harvest OR 0.5 to 1 ton compost/ac

On seed

Crops – 1st true leaf, pre-, post-blossom

Perennials – Bud swell, monthly until no disease danger, weekly if disease pressure high

Control – treatment DATA good idea in first year

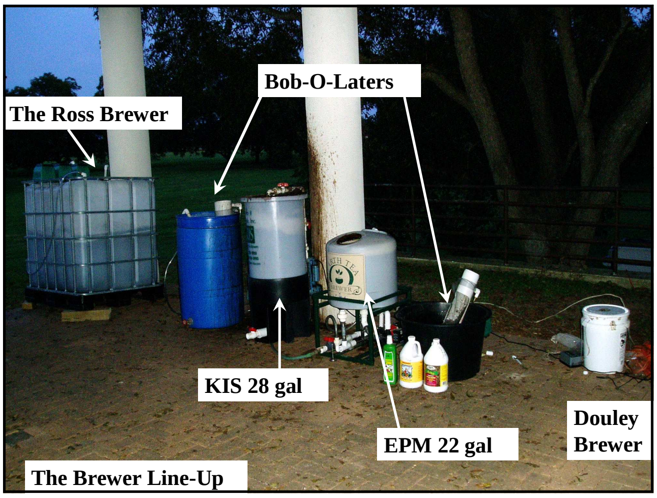
Treatment schedule and coverage

Date	Treatment	Coverage of foliage by B and F: Before	After
June 25	1st tea	B 47 F 1	B 68 F 3
June 30	2nd tea	B 21 F 0	B 93 F 1
July 4	3rd tea		
July 9	4th tea	B 80 F 6	B 92 F 7
July 18	5th tea		
Lots of rain – fields wet			
July 30	Foods	B 76 F 1	B 97 F 4

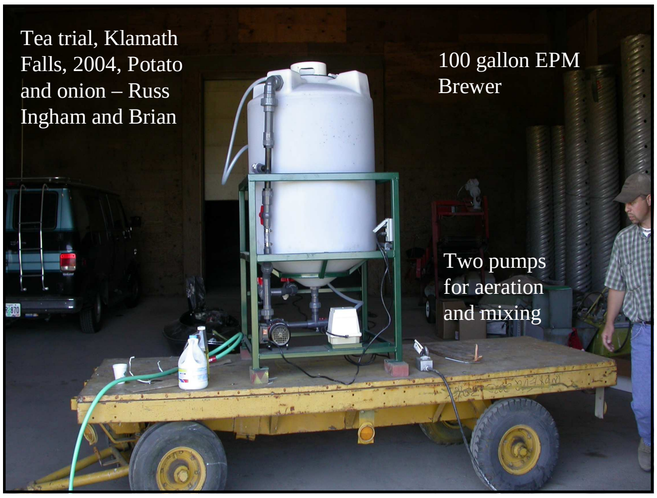
Aug 7	6th tea	B 60	F 1	B 89	F 4
Lots of rain – fields wet					
Aug 13	Foods	B 65	F 1	B 90	F 6
Aug 19	7th tea	B 90	F 4	B 96	F 8
Aug 27	Foods	B 85	F 3	B 89	F 7
Sept 3	8th tea	B 63	F 3	B 88	F 7
Sept 10	Foods	B	F	B 91	F 7
Sept 24	Foods	B 60	F 6	B	F

Measures of Success in the Real World

- Document that the organisms were in the tea
  - Qualitative test, Quantitative test
- Measure root depth this year, and then end of season next year
- Measure soil compaction with penetrometer, clod hardness, aggregates presence, visible pores
- Visible fungal strands, microarthropods
- Water drop test
- Speed of plant residue disappearance


The Ross Brewer
Bob-O-Laters
KIS 28 gal
EPM 22 gal
Douley Brewer
The Brewer Line-Up


Ray O'Grady, 1000 L brewer, Macademia Plantation, Australia, 2004


Tea trial, Klamath Falls, 2004, Potato and onion – Russ Ingham and Brian
100 gallon EPM Brewer
Two pumps for aeration and mixing

Tea machines in Mallanganee, NSW

Testing tea makers at the SFI Mexico lab

Compost Tea Standards

- 2 to 10 or more µg active bacteria /ml compost tea
- 150 µg to 3000 or more µg total bacteria /ml compost tea
- 2 to 10 µg or more active fungi /ml compost tea
- 5 to 20 or more µg total fungal biomass/ml compost tea
- 2,000 or more protozoa
  1,000 or more flagellates
  1,000 or more amoebae
  5 - 10 ciliates. Higher numbers indicate anaerobic conditions resulting when organism growing so fast that oxygen is consumed
- 2 to 10 BENEFICIAL nematodes/ ml (desired; typically lacking in tea)
  1 - 5 bacterial-feeders
  up to 5 fungal-feeders
  1 - 5 predatory nematodes (typically lacking in tea)
- Minimum of 10% active bacteria and fungi


Broadly Vineyard – Tea spraying, August 2001


Previous tree care company was applying a soil fungicide to control Wilt. Tree continued into failure.


Leaf litter compost high in fungal biomass and fungal- feeding nematodes applied from stem to minimize root disturbance. Fungal tea was then applied to root zone.

15 months later not a trace of wilt on the trees

Tent caterpillar – gone after one tea application

Managing Soil Quality

1. **Assess biology and chemistry**

   Weeds, unhealthy plants indicate stress – but WHAT is causing the problem?

2. **Add appropriate chemistry**
3. **Add organisms**

   Bacteria, Fungi, Protozoa, Nematodes Mycorrhizal fungi, Microarthropods – Compost and Compost Tea

4. **Feed the Biology**

   Cover Crops, Commercial products, Compost, Compost tea

5. **Monitor**

- Soil applications after leaf fall to improve residue decomposition, decrease pathogen survival, improve water holding, nutrient availability
  - 20 gal/ac (200 L/HA) compost tea applied to residues or 1 to 5 tons/ac compost WITH CALCIUM
  - Should see half the weight of residues disappear in one month, if good temperature, moisture and biology
  - Visible hyphal strands or threads should be seen
- Leave everything as surface layer as much as possible
- Foliar applications for foliar problems
  - 5 gal/ac (50 L/HA) compost tea for each 6 feet, or 2 m height of canopy
  - At bud swell, then monthly. If there is a disease alert, then weekly until the disease propagules finish dispersal

The data we need to see to help you when you get "stuck"

- Just like medical records, the doctor is hard put to help if you haven't been keeping records
- Where was the soil when you started?
- How did it get there? Past management
- What were your management decisions?
  - What went on when?
  - Why those choices?
- What observations? Penetrometer, root depth, disease, pests, plant health, soil biology