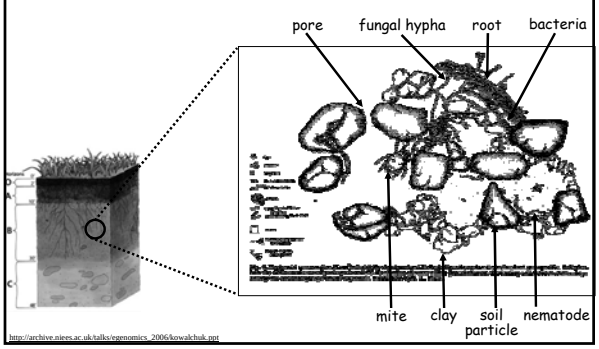
Life in the Soil



http://archive.nbes.ac.uk/talks/egenomics_2006/kowalchuk.ppt

Productivity depends on soil microbes

Table 1. Essential nutrient elements showing element, symbol and primary forms used by plants.

Element	Symbol	Primary Forms Used by Plants
NON-MINERAL ELEMENTS		
Carbon	C	CO_2 (g)
Hydrogen	H	H_2O (l), H^+
Oxygen	O	H_2O (l), O_2(g)
MINERAL ELEMENTS		
Major Nutrients		
Nitrogen	N	NH_4^+, NO_3^-
Phosphorous	P	HPO_4^{2-}, $H_2PO_4^-$
Potassium	K	K^+
Secondary Nutrients		
Calcium	Ca	Ca^{2+}
Magnesium	Mg	Mg^{2+}
Sulfur	S	SO_4^{2-}
Micronutrients		
Iron	Fe	Fe^{3+}, Fe^{2+}
Manganese	Mn	Mn^{2+}
Zinc	Zn	Zn^{2+}
Copper	Cu	Cu^{2+}
Boron	B	$B(OH)_3^0$ (Boric acid)
Molybdenum	Mo	MoO_4^{2-}
Chlorine	Cl	Cl^-

Decomposition depends on soil microbes

Plants require at least 16 elements for normal growth and for completion of their life cycle.

Those used in the largest amounts, carbon, hydrogen and oxygen, are non-mineral elements supplied by air and water.

The other 13 elements are taken up by plants only in mineral form *from the soil* or must be added as fertilizers.

Minerals must be available , continuously, and in balanced proportions to support photosynthesis and other metabolic processes of plants.

If **any one** of these essential elements is missing, plant productivity will be limited or will cease entirely.

Principle of limiting factors:
The level of production can be no greater than that allowed by the most limiting of the essential plant growth factors.

Applies in both cropping systems and in natural ecosystems.

Common limiting factors:

N,P,K: Primary nutrients - plants need relatively large amounts. Frequently supplied in fertilizers.

Ca, Mg, S: Secondary nutrients - required in smaller amounts

Plants absorb the essential elements through their root systems or their leaves in various forms. In general, the soil contains large amounts of all the elements, but only a very small percentage of these total amounts are actually **plant-available**.

For example, the actual total iron content of a soil may exceed 50,000 parts per million (ppm), however the portion available to plants may be less than 5 ppm.

The availability of nutrients to plants is determined by:

--the form and chemical properties of the element
--the soil pH
--interactions with soil colloids
--soil physical conditions such as aeration, compaction, temperature, and moisture --
microbial activity
Carbon cycle
Nitrogen cycle
Sulfur cycle
Phosphorus availability
Iron availability
Etc.

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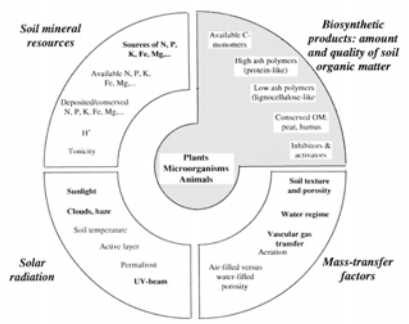
Two perspectives on soil microbial communities:

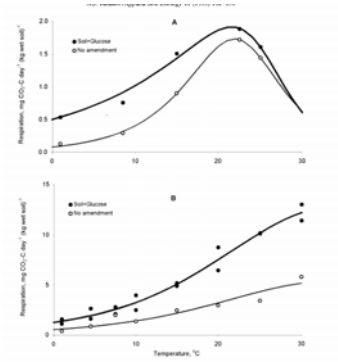
1. Systems view (nutrient cycling as a whole)
2. Single-process view (suppressive soil due to single antibiotic)

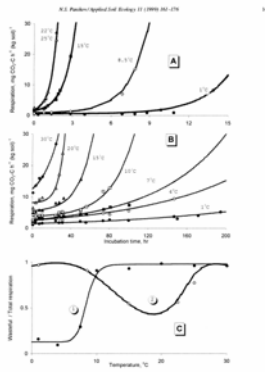
Both are important!

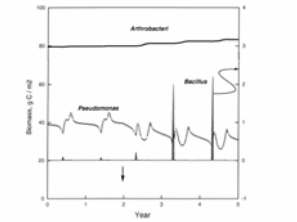
Environmental factors affecting soil communities

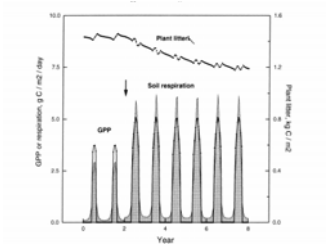


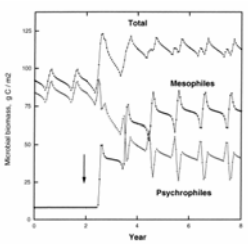
N.S. Panikov/Applied Soil Ecology 11 (1999) 161–176

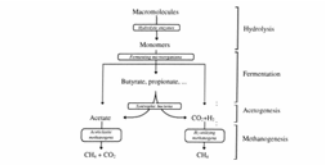










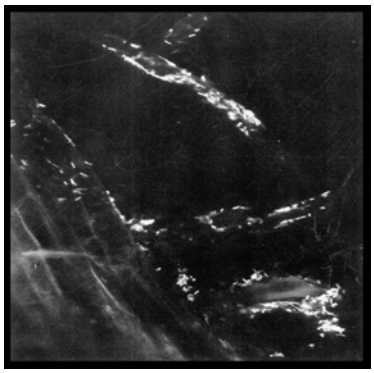


Suppressive soils

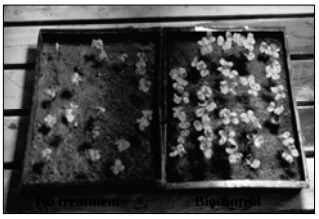
Fluorescent pseudomonads suppress *Fusarium oxysporum* (Fusarium wilt of many plants); iron competition, ISR, and direct inhibition of fungal growth

Fluorescent pseudomonads suppress *Gaeumannomyces graminis* var. *tritici* (take all of wheat) – 2,4-DAPG

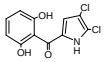
Trichoderma inhibits *Rhizoctonia solani* root rots - parasitism



Biological control of *Pythium* damping-off of cotton by *Pseudomonas fluorescens*



Known *interacting* antibiotics produced by *Pseudomonas*

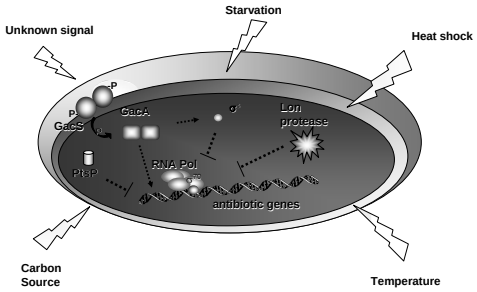


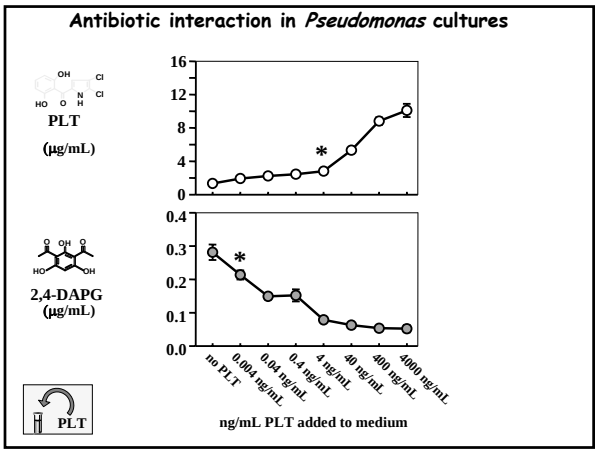
Pyoluteorin (PLT)
Oomycete pathogens – *P. ultimum*

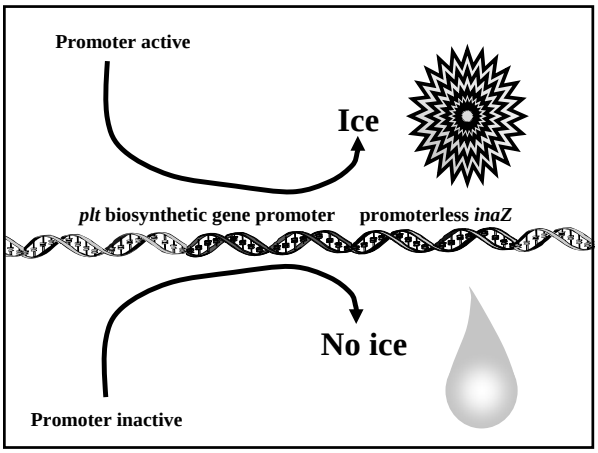
2,4-diacetylphloroglucinol (2,4-DAPG)
Broad spectrum: *Fusarium, Gaeumannomyces*, etc.

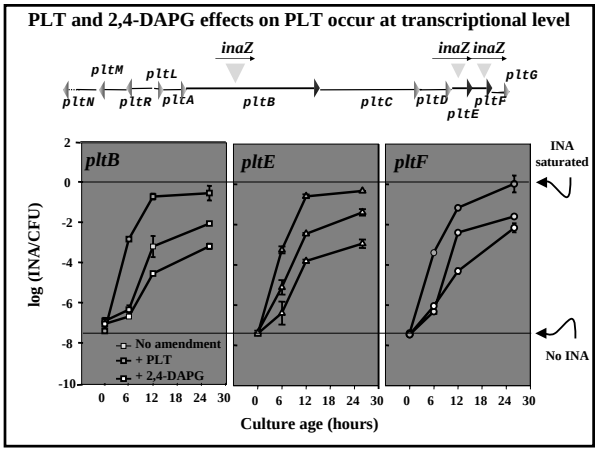
Pyrrolnitrin (PRN)
Rhizoctonia, Pyrenophora, Sclerotinia

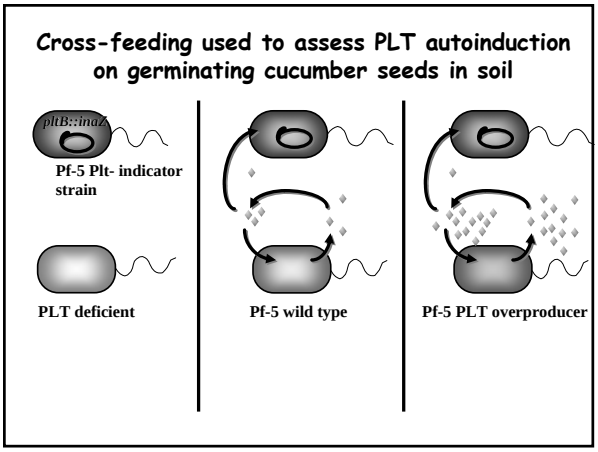
Factors known to influence antibiotic biosynthetic gene transcription in *Pseudomonas*

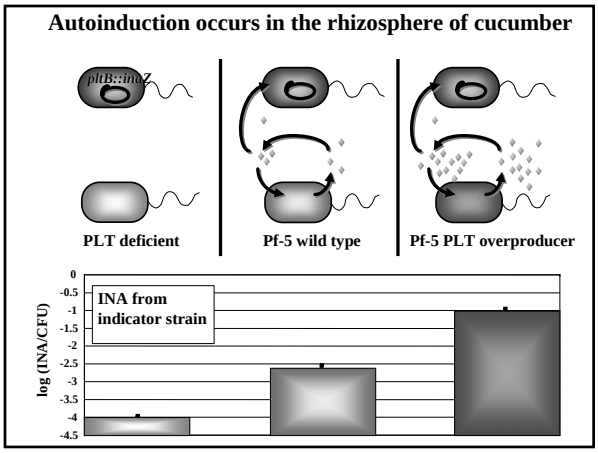


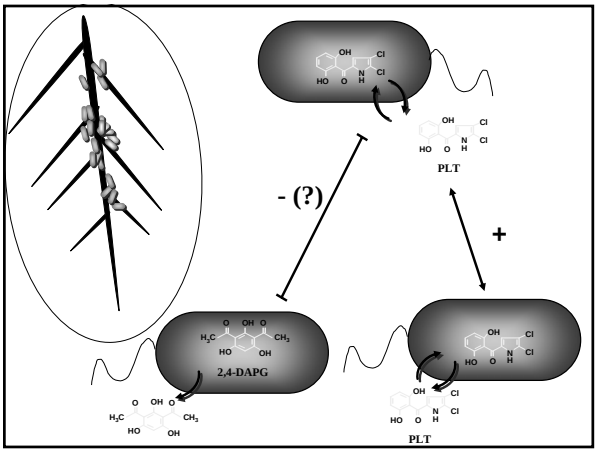

Antibiotic interaction in *Pseudomonas* cultures
PLT
(µg/mL)
2,4-DAPG
(µg/mL)
PLT
ng/mL PLT added to medium

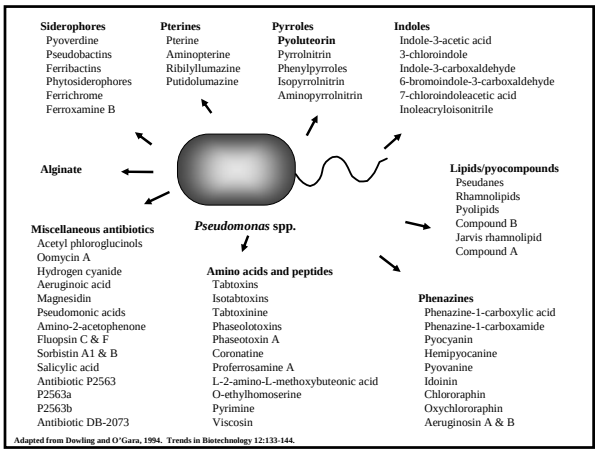

Promoter active
Ice
plt biosynthetic gene promoter
promoterless *inaZ*
No ice
Promoter inactive


PLT and 2,4-DAPG effects on PLT occur at transcriptional level
pltB
pltE
pltF
INA saturated
No INA
No amendment
+ PLT
+ 2,4-DAPG
log (INA/CFU)
Culture age (hours)

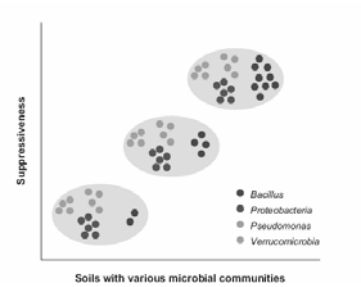

Cross-feeding used to assess PLT autoinduction on germinating cucumber seeds in soil
Pf-5 Plt- indicator strain
PLT deficient
Pf-5 wild type
Pf-5 PLT overproducer


Autoinduction occurs in the rhizosphere of cucumber
PLT deficient
Pf-5 wild type
Pf-5 PLT overproducer
INA from indicator strain
log (INA/CFU)


PLT
- (?)
+
2,4-DAPG
PLT



Adapted from Dowling and O'Gara, 1994. Trends in Biotechnology 12:133-144.



Identifying Microorganisms Involved in Specific Pathogen Suppression in Soil