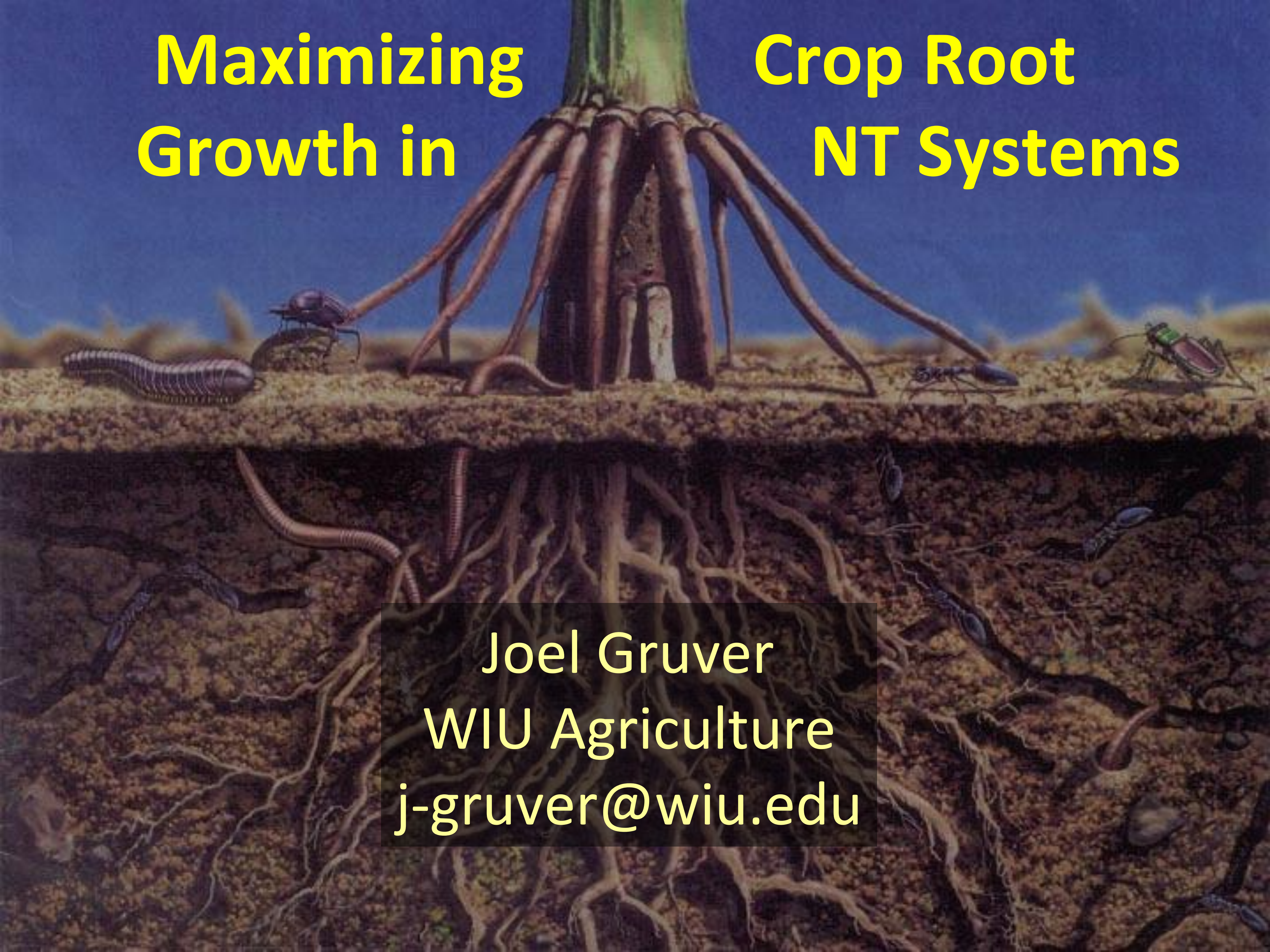
Maximizing Crop Root Growth in NT Systems



Joel Gruver
WIU Agriculture
j-gruver@wiu.edu


2100
JOHN DEERE


Which soil is a better environment for
root growth and function?

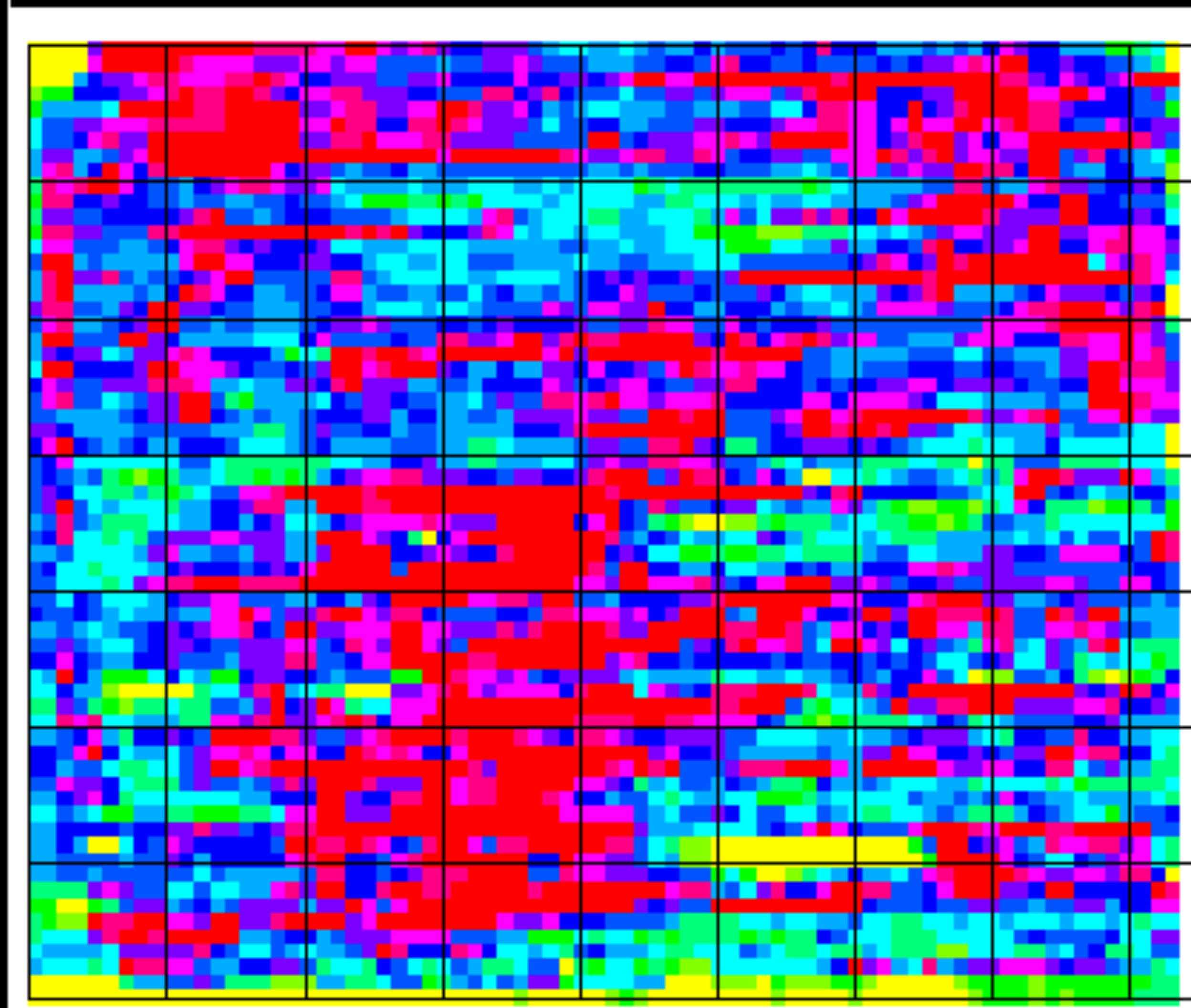
Davis Farm

Yield map for Field P

REGION
S:4455918.83650794 W:657169.03289474
N:4456253.12698413 E:657586.26973684

CELL-SIZE
n-s:5.06349206 e-w:4.86710526

- 1) <120 bu/ac
- 2) 120–130
- 3) 130–140
- 4) 140–150
- 5) 150–160
- 6) 160–170
- 7) 170–180
- 8) 180–190
- 9) 190–200
- 10) 200–210
- 11) 210–220
- 12) >220 bu/ac



WHY??

More questions than answers for many fields

Variation in inherent soil properties?

Variation in dynamic soil properties?

doi:10.2489/jswc.66.6.175A

FEATURE

Understanding and managing the causes of variability in root growth and function

Over the past few decades, a tremendous amount of time and money has gone into developing and applying technologies to manage crop variability within fields. Table 1 lists in order the factors that most commonly cause crop variability. The information in this table was developed by Aspinall (1997) b

s

a

Root performance = Genetics x Environment

Clearly, there are many causes of crop variability, and several are either directly or indirectly linked to soil erosion.

The purpose of this paper is to bring attention to soil erosion as a cause of soil landscape variability and to the potential to affect crop variability by managing soil erosion. The underlying message is that sound management of variable soil landscapes requires a balanced approach—the causes of the variability must be managed as well as the effects.

Table 1

Common causes of crop variability within landscapes (adapted from Aspinall 1997).

Cause	Description
Soil moisture	Excesses in lower slope landscape positions (depressions) and deficits in upper slope positions (knolls)
Variety	Crop sensitivity to adverse and advantageous conditions
Pests	Insect, weed, and disease problems
	...ility)
	posed by soil erosion (particularly on knolls)
Soil pH	Acidity problems associated with poor drainage (particularly in depressions) and alkalinity problems associated with exposed calcareous subsoil (particularly on eroded knolls)
Herbicide management	Drift, selection, timing, and rates (includes misses and overlaps)
Subsoil conditions	Depth to subsoil, compactness, and permeability
Fertilizer management	Placement and rates (includes misses and overlaps)
Soil fertility	Levels and balance of nutrients
Plant population	Inconsistencies in seeding and emergence

THE IMPACT OF CULTIVATION AND SOIL EROSION ON SOIL LANDSCAPE VARIABILITY

Figure 1a shows the soils within a natural, uncultivated, hilly landscape, typical of the

sumed to be negligible due to the presence of a permanent vegetative cover.

Cultivation can dramatically affect the variability of soils within landscapes, as shown in figure 1b. Figure 1b shows the impact of tillage between about 1900 and 1935. The hilltop has been stripped of topsoil, and soil has accumulated at the base

the eroded hilltops is dragged down the hillslope and buries productive topsoil at the base of the hillslope. Many examples of such "inverted" soil profiles already exist in the prairies. Over time, the whole soil landscape becomes less productive but more uniform.

NATURE|Vol 466|29 July 2010

AN UNDERGROUND REVOLUTION

Plant breeders are turning their attention to roots to increase yields without causing environmental damage. Virginia Gewin unearths some promising subterranean strategies.

Tangled, dirty and buried underfoot, roots are a mess to study. Digging them up is a time-consuming and sometimes back-breaking process. The shovel must be wielded with care to preserve the roots' delicate branching patterns, the root hairs and the microbes that cling to them. All of this explains why roots have been largely out of mind, as well as out of sight, for agricultural researchers — until now.

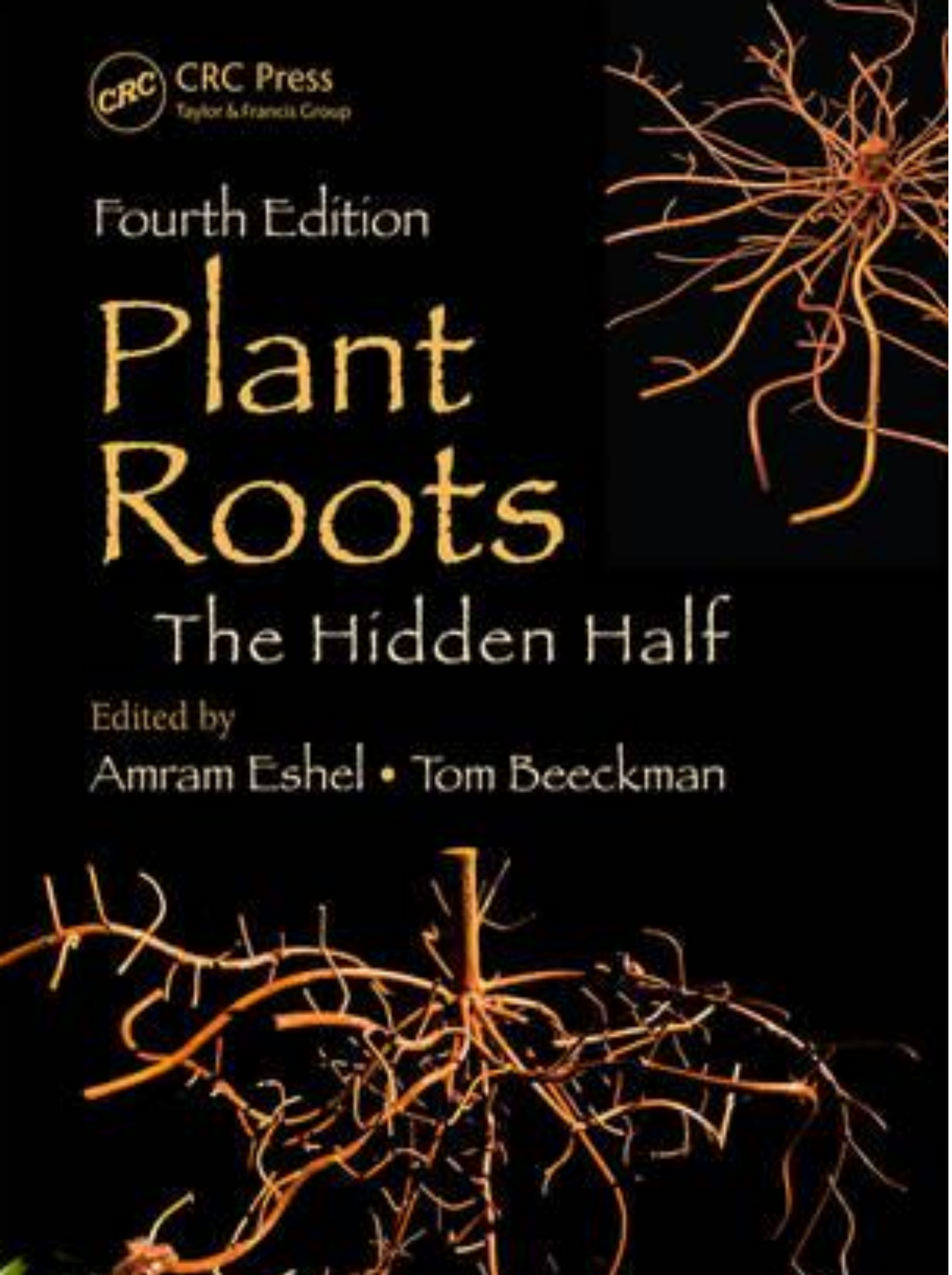
Many scientists are starting to see roots as central to their efforts to produce crops with a better yield — efforts that go beyond the Green Revolution. That intensive period of research and development, starting in the 1940s, dramatically boosted food production through the breeding of high-yield crop varieties and the use of pesticides, fertilizers and more water. But the increases were accompanied by a depletion of groundwater and, by 1998, an eightfold

to increase yields is because the tremendous genetic variation trapped in roots has been neglected," says Lynch. Here, *Nature* reports on four of the most promising leads for boosting food production through roots.

Designer roots

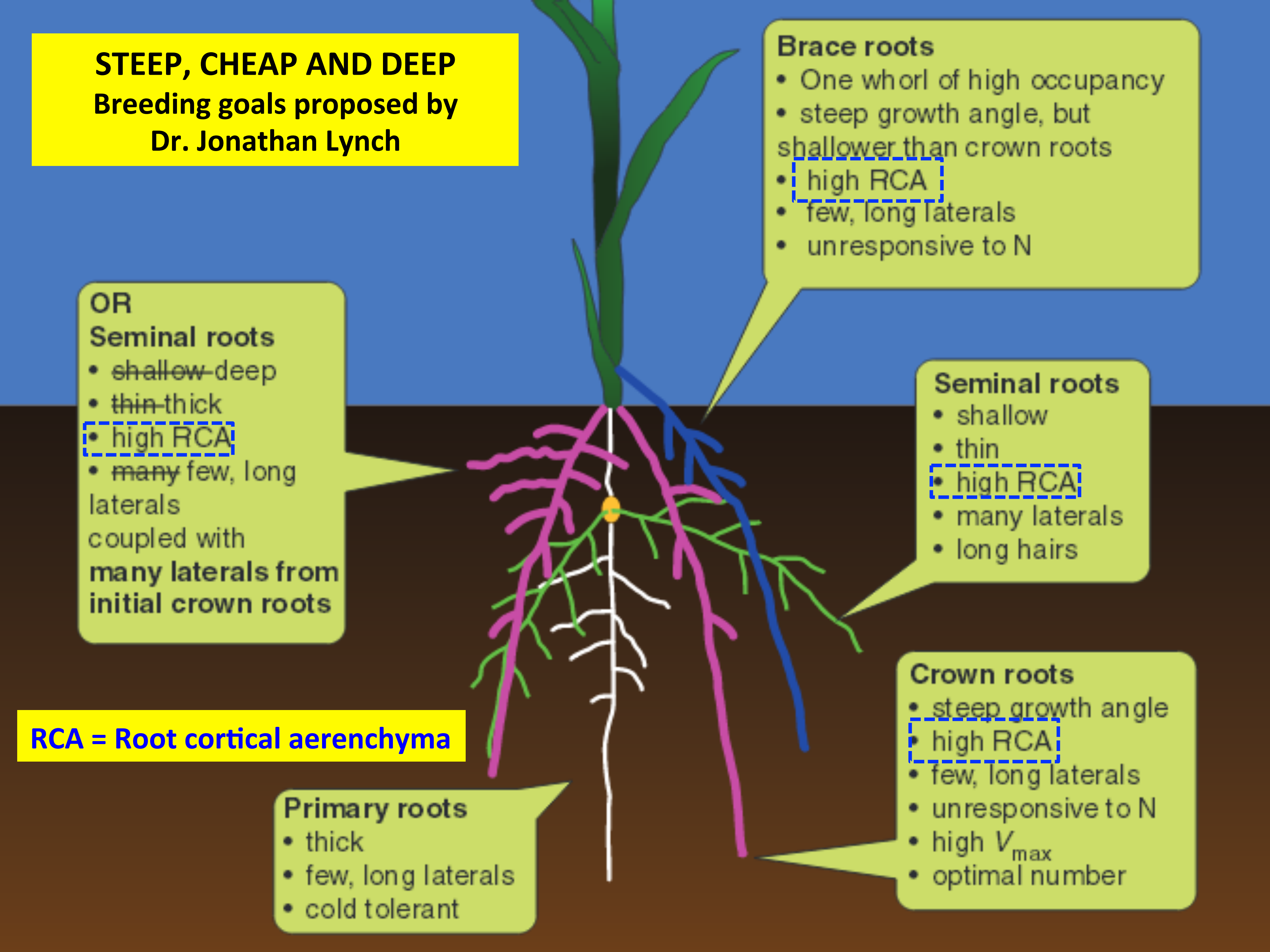
Roots are most efficient when their architecture is tailored to their environment. Deep roots can tap water beneath parched soils, whereas fine, shallow roots can exploit soils in which limiting nutrients are trapped at the surface.

Michelle Watt, a plant biologist at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Canberra, is working to produce varieties of wheat that are better suited to drought-prone areas. In a recent study of wheat lines, Watt's team found that the roots

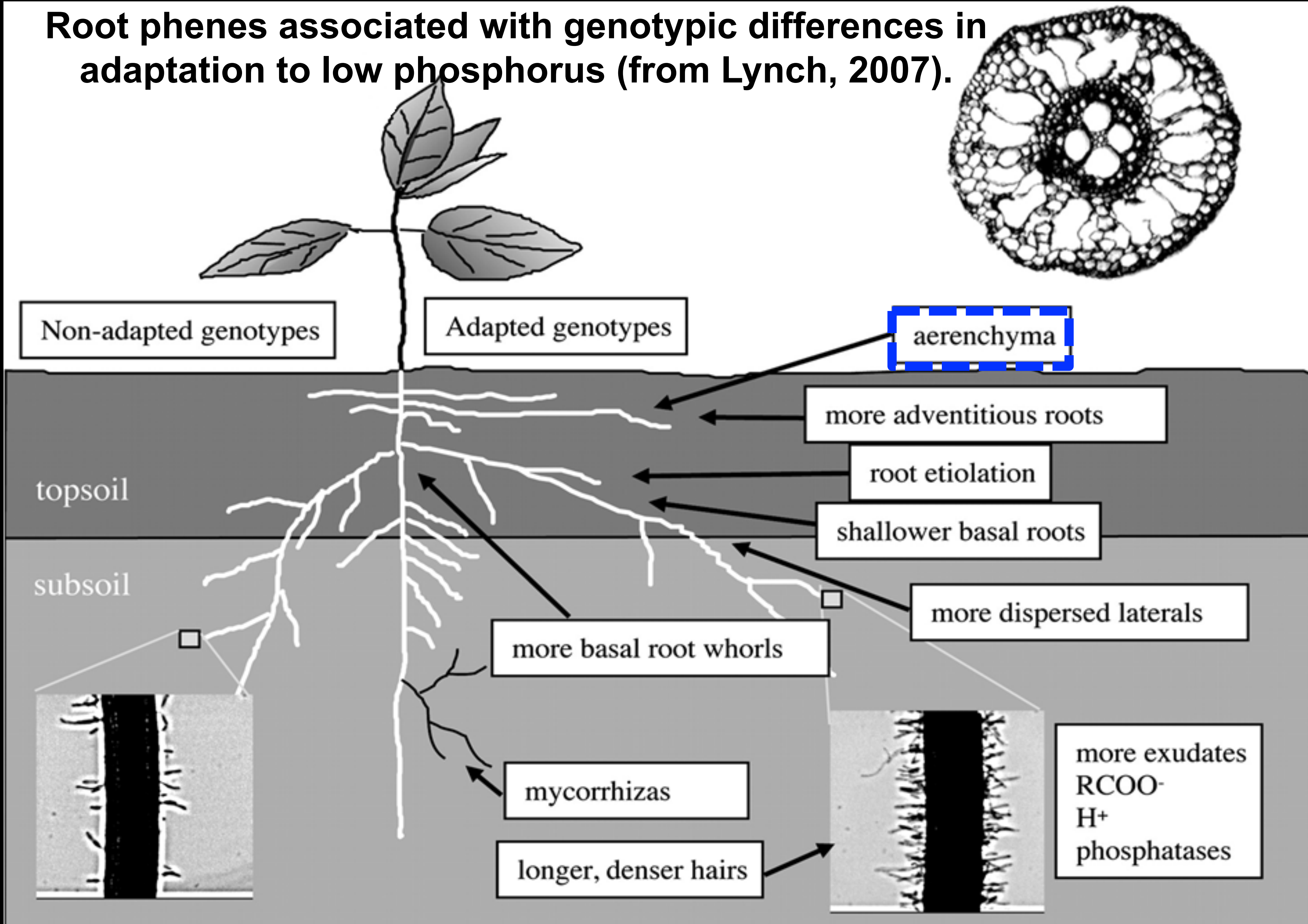


The decade since the publication of the third edition of this volume has been an era of great progress in biology in general and the plant sciences in particular. This is especially true with the advancements brought on by the sequencing of whole genomes of model organisms and the development of “genomic" techniques.

This fourth edition of **Plant Roots: The Hidden Half** reflects these developments that have transformed not only the field of biology, but also the many facets of root science.


STEEP, CHEAP AND DEEP
Breeding goals proposed by
Dr. Jonathan Lynch
Brace roots
• One whorl of high occupancy
• steep growth angle, but shallower than crown roots
• high RCA
• few, long laterals
• unresponsive to N
OR
Seminal roots
• ~~shallow~~ deep
• ~~thin~~ thick
• high RCA
• ~~many~~ few, long laterals
coupled with
many laterals from initial crown roots
Seminal roots
• shallow
• thin
• high RCA
• many laterals
• long hairs
RCA = Root cortical aerenchyma
Crown roots
• steep growth angle
• high RCA
• few, long laterals
• unresponsive to N
• high V_{max}
• optimal number
Primary roots
• thick
• few, long laterals
• cold tolerant

Root phenes associated with genotypic differences in adaptation to low phosphorus (from Lynch, 2007).



Lynch J P Plant Physiol. 2011;156:1041-1049

Breeding for flooding tolerant maize using "teosinte" as a germplasm resource

Yoshiro Mano and Fumie Omori

Forage Crop Breeding Research Team, National Institute of Livestock and Grassland Science, 768 Senbonmatsu, Nasushiobara, Tochigi 329-2793 Japan
Corresponding author: Y. Mano, E-mail: mano@affrc.go.jp, Fax: +81-287-36-6629

Received on September 22, 2006; Accepted on January 17, 2007

Abstract: Flooding or waterlogging is a major factor in reducing crop yields. In order to increase crop productivity in temporarily flooded soils

In quantitative trait locus (QTL) analyses for flooding tolerance, using teosinte as a germplasm resource, we have identified several QTLs associated to flooding traits. Based on the DNA

tion was only 0.16 million ton, while 16.5 million ton grain maize and 4.4 million ton soybean were imported in 2004 (Abstract of Statistics on Agricul-

flooding conditions (Fig. 1). In such temporarily flooded soils, the development of improved flooding-tolerant maize lines is required.

In a study of flooding tolerance, selection tests

Three primary factors affecting flooding tolerance in plants have been reported: (1) the ability to grow adventitious roots at the soil surface during flooding; (2) the capacity to form **root aerenchyma**; and (3) tolerance to toxins (e.g., Fe 2+, H2S) under reducing soil conditions. By analyzing these components separately, it could be possible to perform selections for genotypes exhibiting varying degrees of flooding tolerance.

Transgenic Corn Rootworm Protection Increases Grain Yield and Nitrogen Use of Maize

Jason W. Haegele and Frederick E. Below *

Author Affiliations

Abstract

Maize (*Zea mays* L.) hybrids expressing *Bacillus thuringiensis* (Bt) derived resistance to corn rootworm (*Diabrotica* spp.) are widely grown. Our hypothesis was that Bt hybrids exhibit increased N uptake, resulting in greater grain yield and N use efficiency (NUE) relative to their nonprotected counterparts. In 2008 and 2009, two transgenic corn rootworm

grain yield of Bt hybrids were detected in 2008, but NUE and NUpE were not significantly different between isolines in 2009. We conclude that transgenic corn rootworm protection has supplemental agronomic benefits, with greater N uptake and NUE in some environments.

Despite minimal corn rootworm feeding pressure on roots, the Bt hybrids produced an average of nearly 1.1 Mg ha^{-1} more grain than their RR2 counterparts. In the comparison of DKC61-72 RR2 and DKC61-69 VT3, Bt protection promoted **increased grain yield at low N** (+1.0 Mg ha^{-1}; $P \leq 0.01$) and a **31% greater response to fertilizer N**.

Breeding for better symbiosis

Z. Rengel
*Soil Science and Plant Nutrition, Faculty of Agriculture, The University of Western Australia, 35 Stirling Highway, Crawley WA 6009, Australia**

Key words: associative N_2 fixation, dinitrogen fixation, genotype, mycorrhiza, nodulation, rhizobia, root exudation, screening, selection, symbiosis

Abstract

Increased efficacy of symbiotic N fixation can be achieved by selecting not only the best host genotypes but by selecting the best combination of host genotype and nodule bacteria.

…targeted efforts to breed genotypes for improved N fixation and mycorrhizal symbiosis will bring benefits in increased yields of crops under a wide range of environmental conditions and will contribute toward sustainability of agricultural ecosystems in which soil-plant-microbe interactions will be better exploited

contribute toward sustainability of agricultural ecosystems in which soil-plant-microbe interactions will be better exploited.


Do your bean roots
look like this?

BASF ACQUISITION

BASF has completed the acquisition of Becker Underwood.

To learn more:

- BASF Acquisition: READ MORE
- BASF Crop Protection and Specialty Products USA: WWW.AGRO.BASF.US
- BASF Corporate: WWW.BASF.COM

NEWS

OSCAR FOR VAULT HP PLUS INTEGRAL?

VAULT® HP PLUS INTEGRAL®

Maybe it should win an award. After all, it is the star of three new videos on our VAULT HP plus INTEGRAL page. The productions walk you through our yield-boosting biological seed treatment system for soybeans. As these videos will show, VAULT HP is definitely ready for its closeup. Click here to learn MORE

PRESS RELEASE

novozymes
Rethink Tomorrow

Novozymes and Syngenta enter global commercial agreement

The partners are entering into an exclusive global marketing and distribution agreement on a unique biofungicide used to combat damaging fungal diseases across a range of crops.

COPENHAGEN, DENMARK – OCT. 26, 2012 – Novozymes, the world leader in bioinnovation, and Syngenta, one of the world's leading agricultural companies, today announced an exclusive global marketing and distribution agreement on the microbial-based biofungicide Taegro®, a natural solution with multiple modes of action used to combat fungal diseases across various crops. The two companies will join forces to

QUICKROOTS
TJ MICROMIX
GREENBEAN
CHALLENGE 2050
TECHNICAL BULLETINS
ORDERS

Welcome to TJ Technologies

2012 Growing Season Pictures
Click here

NEWS & EVENTS

03/11/2013:
TJ Technologies releases
Challenge 2050 liquid fertilizer

Press Release: January 30, 2012

Monsanto Acquires Select Assets of Agradis, Inc. to Support Work in Agricultural Biologicals

Monsanto also signs research collaboration agreement with and makes equity investment in Synthetic Genomics Inc., co-founding company of Agradis, Inc.

ST. LOUIS (Jan. 30, 2013) – Monsanto Company today announced it has purchased select assets of Agradis, Inc. (Agradis), a privately held company focused on developing sustainable agricultural solutions. Monsanto's purchase includes the Agradis name and its collection of microbes that can improve crop productivity. Monsanto has also acquired the company's R&D site in La Jolla, California. Additional details were not disclosed.

THE BIOAG ALLIANCE

MONSANTO

novozymes
Rethink Tomorrow

WHAT IS THE BIOAG ALLIANCE?

As the world population grows at tremendous pace over the next decades, we will need to significantly increase the output from our land while at the same time making sure we use our resources most efficiently to protect our environment. Novozymes and Monsanto have created The BioAg Alliance to boost research and commercialization of sustainable microbial technology that can help farmers do exactly that.

The alliance brings together leaders in agricultural innovation and microbiology. Novozymes' capabilities for discovering, developing and producing microbes and Monsanto's discovery capabilities, field testing, and market reach will create a strong team of innovation. The long term alliance is dedicated to fundamentally enhancing research and development of naturally derived microbial technology to increase productivity of the world's crops.

In the alliance structure, Monsanto and Novozymes will maintain independent research programs. Novozymes will be responsible for production of the microbial products, and Monsanto will serve as the lead for field testing, registration and commercialization of the alliance products, including Novozymes' current product portfolio in agricultural biologicals. The companies will share profits and alliance management.

Opening the black box

Nutrient cycling

Bio-control of
pests and
pathogens

Decomposition

soil structure formation
and stabilization

When are biological products most likely to result in Return On Investment?

ADVERSE CONDITIONS

Recommendations for Adverse Conditions or New "Virgin" Soybean Fields – If soil has not hosted the specific legume for more than three (3) years; Soil pH is less than 5.8 (The pH should be adjusted by liming prior to inoculation); Soil pH is more than 8.5; Soil organic matter is less than 1%; Drought or flooding has occurred; Topsoil conditions exceed 80° F; Soil erosion, or with the use of soil treatments and chemicals injurious to soil bacteria and inoculants, to **Maximize Soybean Yield Potential**: When planting soybeans under the conditions listed above,

ABM recommends a double (2X) rate of inoculants. **Follow these recommendations.**

If using Marauder, achieve a 2X inoculants rate as follows:

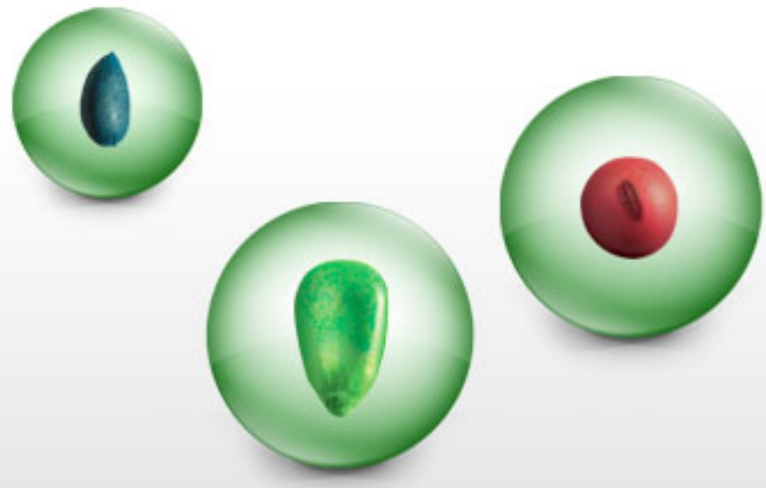
a. Apply a 1X rate of Marauder no more than 30 days prior to planting.
b. Additionally, apply at planting, a 1X rate of an America's Best Inoculant formulation:
   ABI Sterile Peat

PONCHO VOTiVO

THE SCIENCE | THE PROOF | THE PROMISE

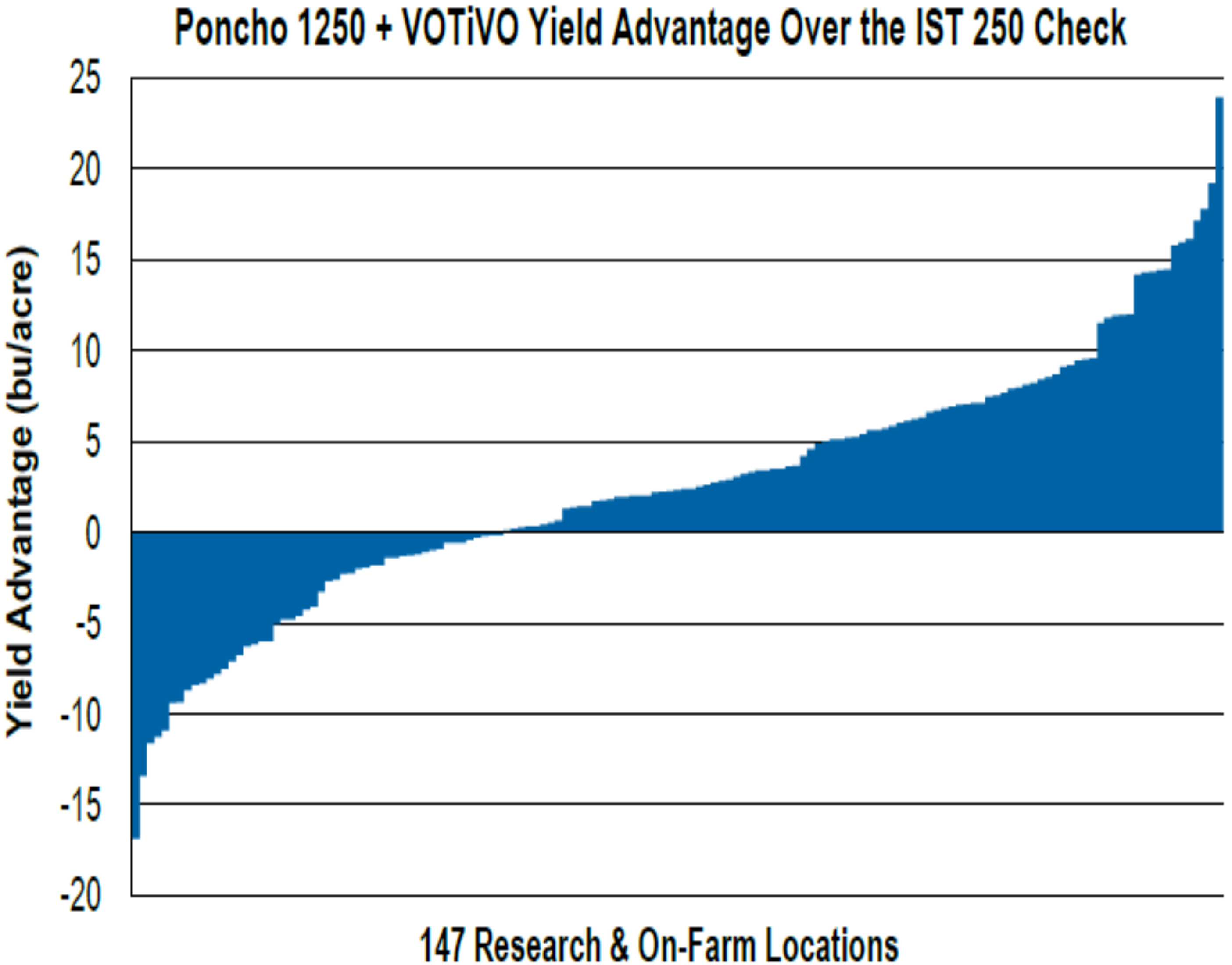
The Science Behind VOTiVO.

VOTiVO lives and grows with the plant's root system



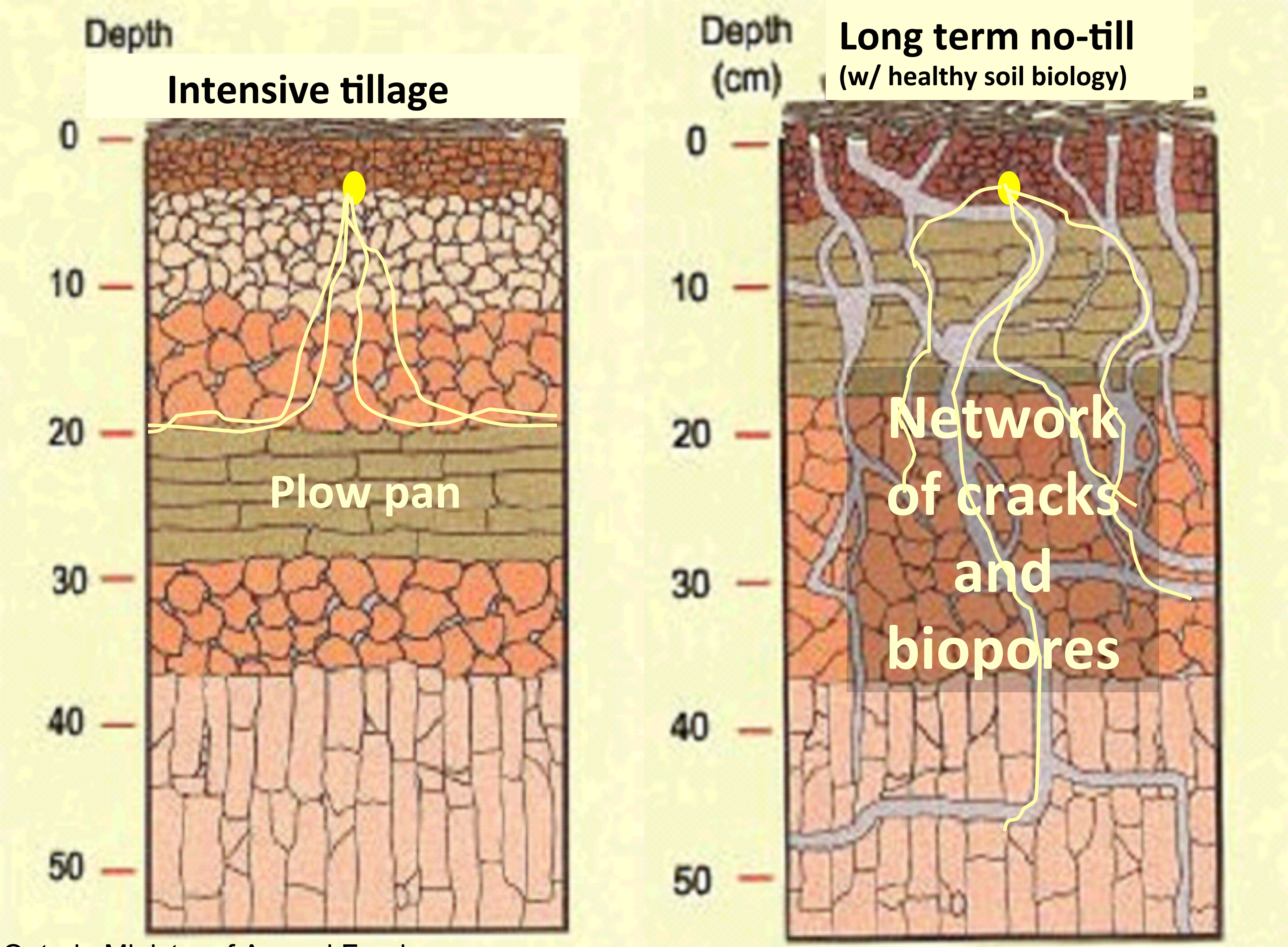
VOTiVO contains a naturally occurring soil rhizobacteria (*Bacillus firmus*)**, that live and grow on crop root systems**. The bacteria creating a biofilm that becomes a living barrier limiting the number of receptor sites which could otherwise be occupied by plant pathogens such as nematodes. Nematodes use gaseous and solid exudates from the root as means to detect a root's proximity, so reduced levels of exudates can decrease the ability of the nematodes to locate the receptor sites on the roots. The bacteria further reduce viable nematode populations by consuming exudates, depriving nematodes of an additional source of energy and nutrients.

The effects of Poncho and VOTiVO can not be isolated when the products are applied together



- A 3-year average corn grain yield with Poncho 1250 + VOTiVO was 2.6 bu/acre greater than the IST 250 check across 147 research & on-farm locations in 2010.
- In 97 of 147 research and on-farm locations (66%), Poncho 1250 + VOTiVO had a positive yield advantage over the IST 250 check with an average 6.3 bu/acre yield advantage.

www.lacek.com/inthefieldofdiscovery/download.cfm?



Ontario Ministry of Ag and Food

Contrasting stands of corn in the NC 9 tillage systems experiment

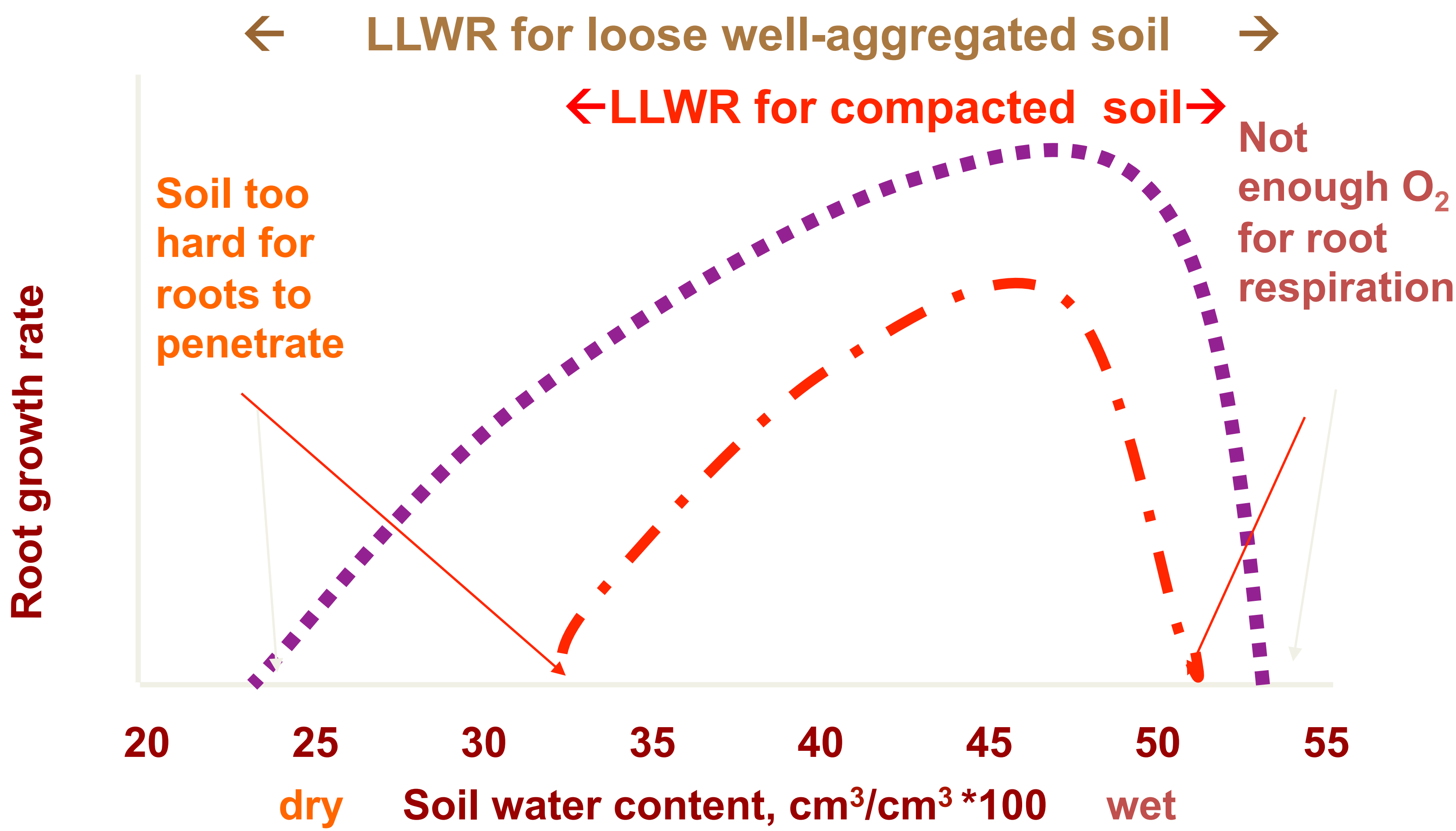
Many soils in IL can take a lot of abuse !

Physical changes are happening in flat black soils…

Same soil type – very different water holding capacity


Changes in air and water dynamics impact root growth and function

Least Limiting Water Range



Ray Weil


You really won't know what is happening underground unless you take a look…

All you need is a shop-vac and a hose :-> !

Its just like going to the dentist!


How often do you look
at crop roots?

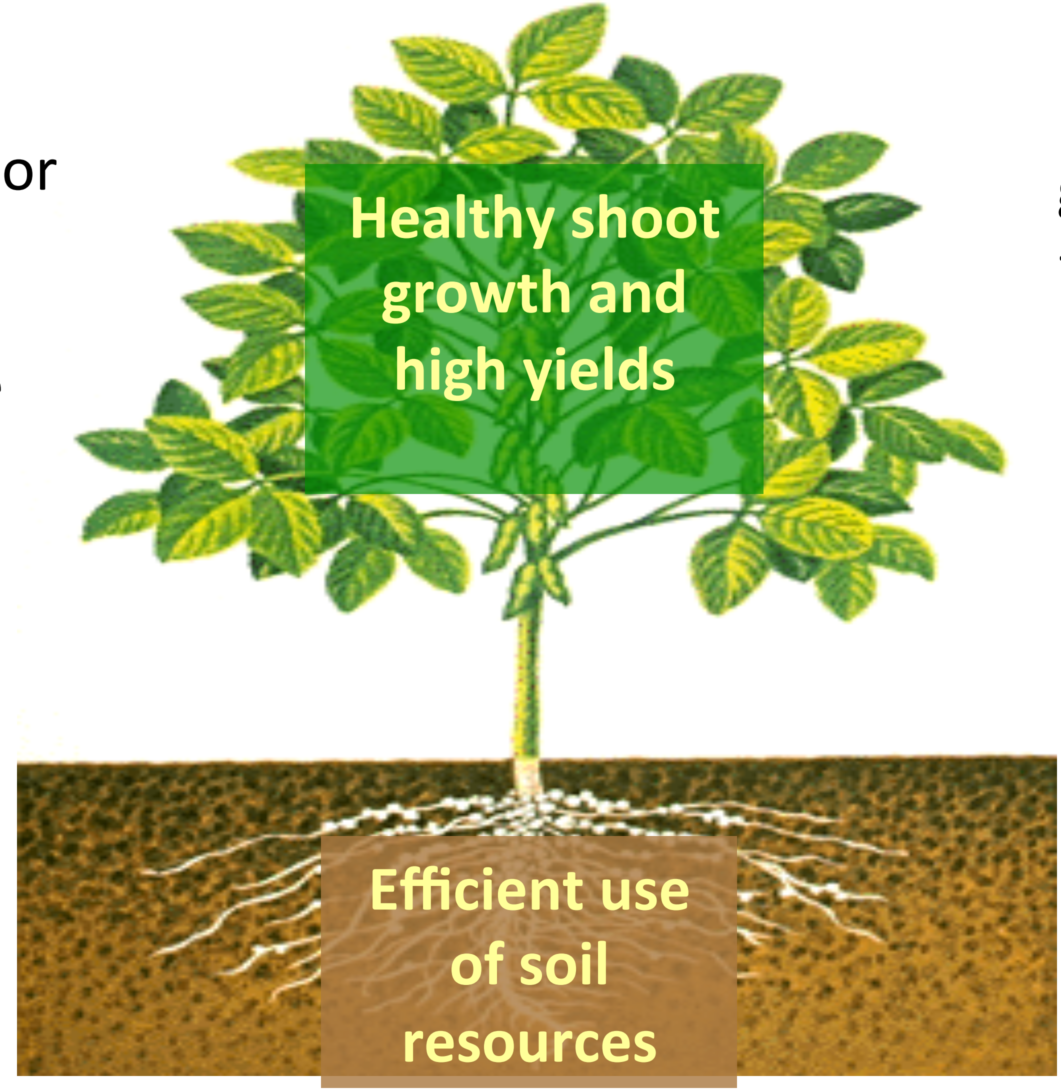
"**One of our primary goals is to get the first three sets of crown roots deep into the soil…** In vertical-tillage, no-till or strip-till conditions, the first set of crown roots will go down. But, when we do horizontal tillage before planting, except in a few conditions like sand, no matter what we did in the fall, the first two sets of crown roots almost always turn on the dense layer. Hopefully, with fall vertical tillage, the third set will penetrate.“

Ken Ferrie – Farm Journal, September 2006

What else should you look for?

white color

proliferate in all directions



extensive growth into the sub-soil

minimal evidence of deformities

Not all healthy roots are white in color!!

If you would like to receive Corny News Network articles and other corny information by email, contact R.L. (Bob) Nielsen. Other Corny News Network articles can be viewed at the CNN Archives.

SHARE

http://www.agry.purdue.edu/ext/corn/news/timeless/Roots.html

Root Development in Young Corn

R.L. (Bob) Nielsen
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West Lafayette, IN 47907-2054
Email address: rnielsen at purdue.edu

Successful emergence (fast & uniform) does not guarantee successful stand establishment in corn. The next crucial phase is the establishment of a vigorous nodal root system. Success is largely dependent on the initial development of nodal roots from roughly V2 (2 leaves with visible collars) to V6.

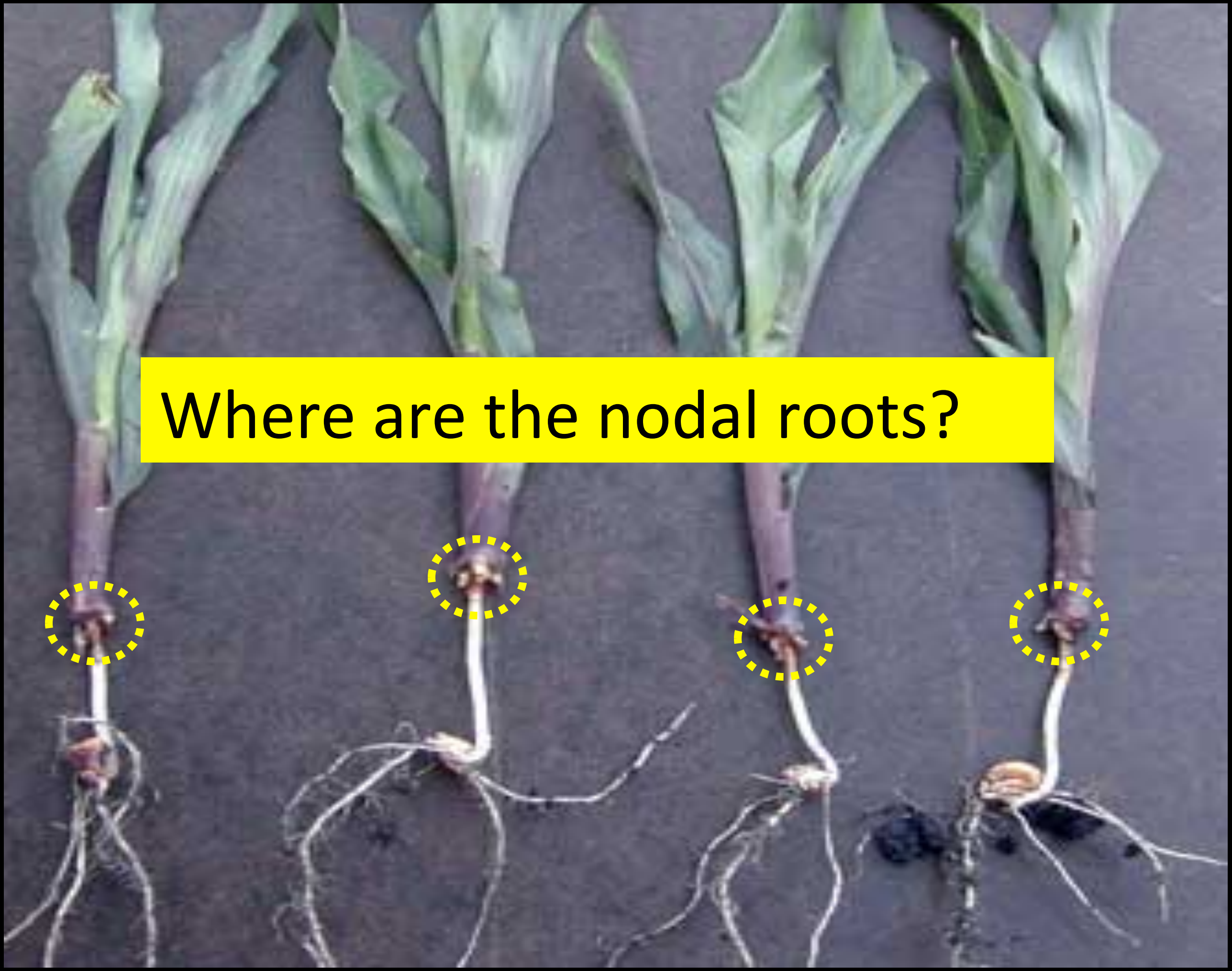
Corn is a grass and has a fibrous type root system, as compared to soybeans or alfalfa that have tap root systems. Stunting or restriction of the nodal root system during their initial development (e.g., from dry soil, wet soil, cold soil, insect damage, herbicide damage, sidewall compaction, tillage compaction) can easily stunt the entire plant's development. In fact, when you are attempting to diagnose the cause of stunted corn early in the season, the first place to begin searching for the culprit is below ground.

Understanding corn root development

The seed roots stop growing shortly after the coleoptile emerges from the soil surface.

The nodal root system becomes visible at ~ V1. The nodal root system becomes the dominant system by V6.

Have you ever heard of “floppy corn” or “rootless corn” syndrome?

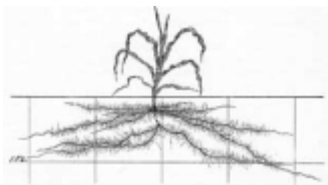


"*Floppy corn*" or "*rootless corn*" occurs when surface soil is too dry for healthy elongation of roots from the first node (V2 to V4). Young roots emerging from the first node will die if the meristematic tissue desiccates prior to extension into moist soil.

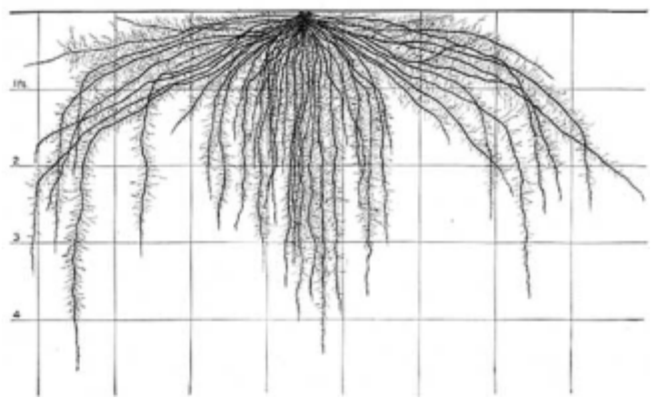
Corn root development

documented in the 1920s

4 weeks

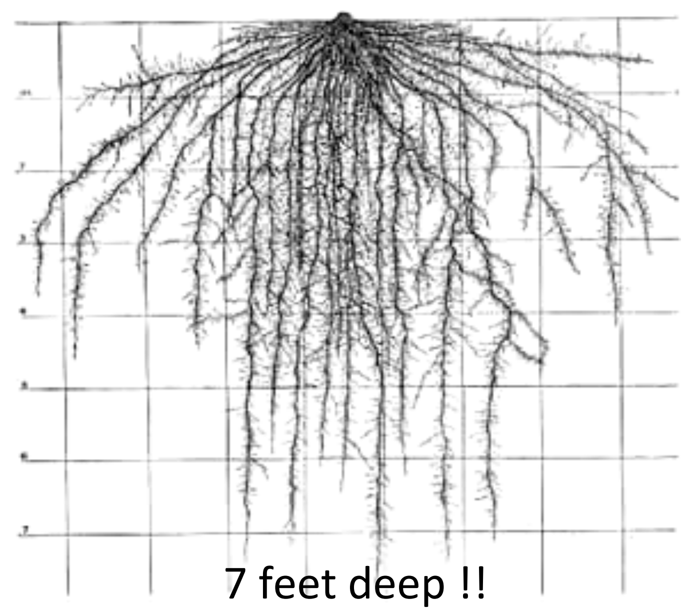


8 weeks



If this was possible 90 years ago, just think what is possible today?

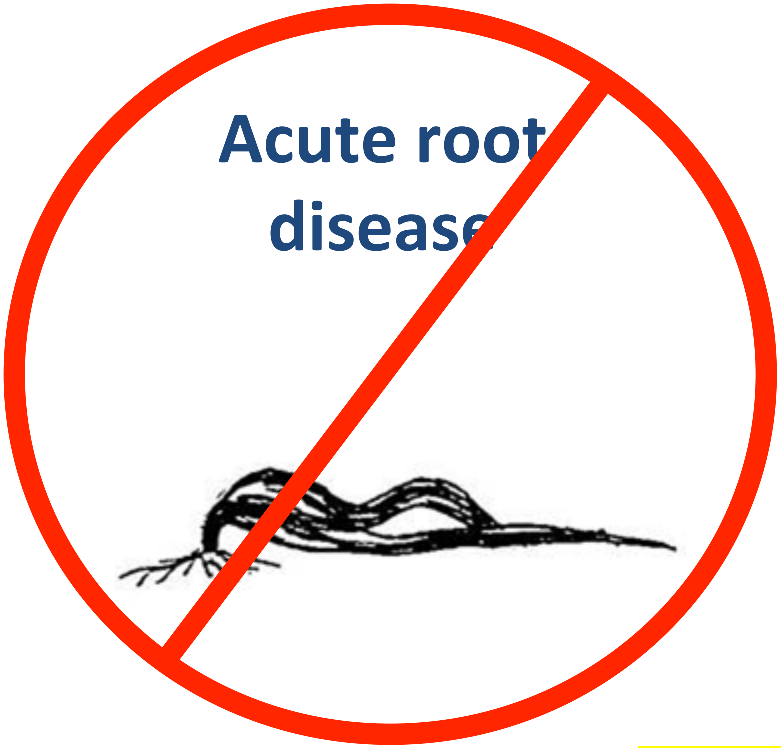
16 weeks



Crops grown on modern row spacings generally do not grow such wide root systems


Wading pool gardens in my back yard
How is it possible for healthy crops to grow with such a limited rooting volume?

This unfortunately is the norm in agriculture

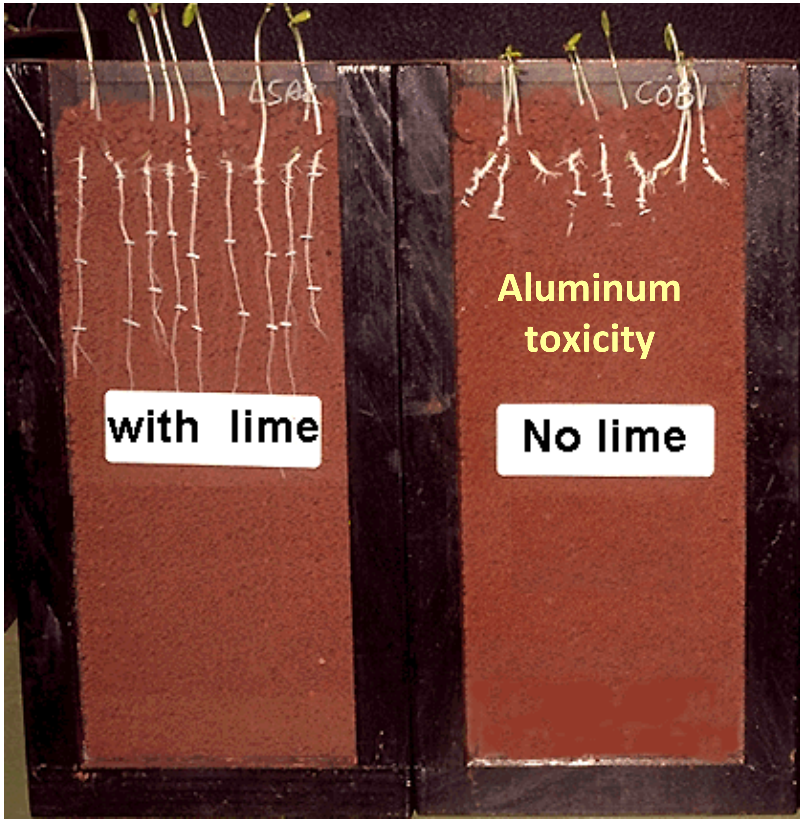


vs.

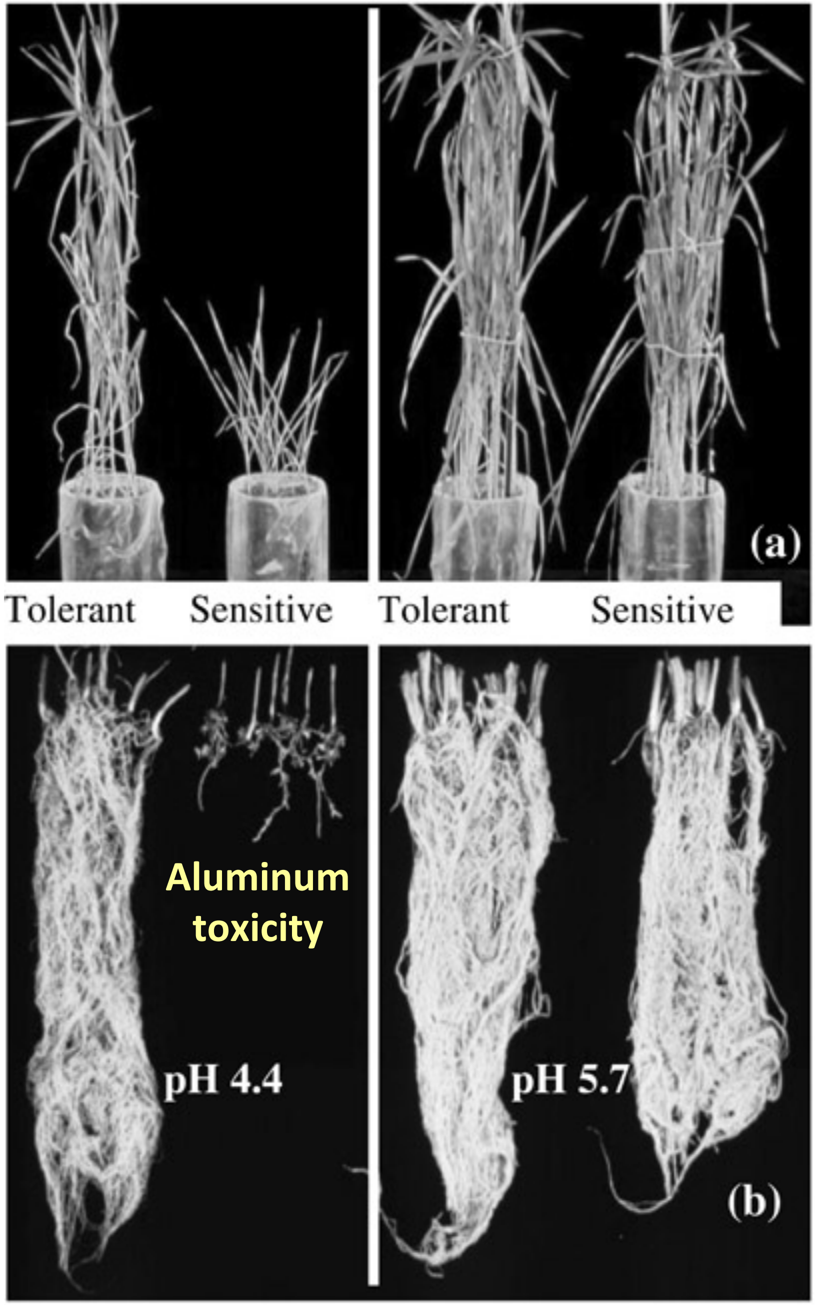
Chronic root malfunction

Chemical, physical and biological factors can cause CRM!

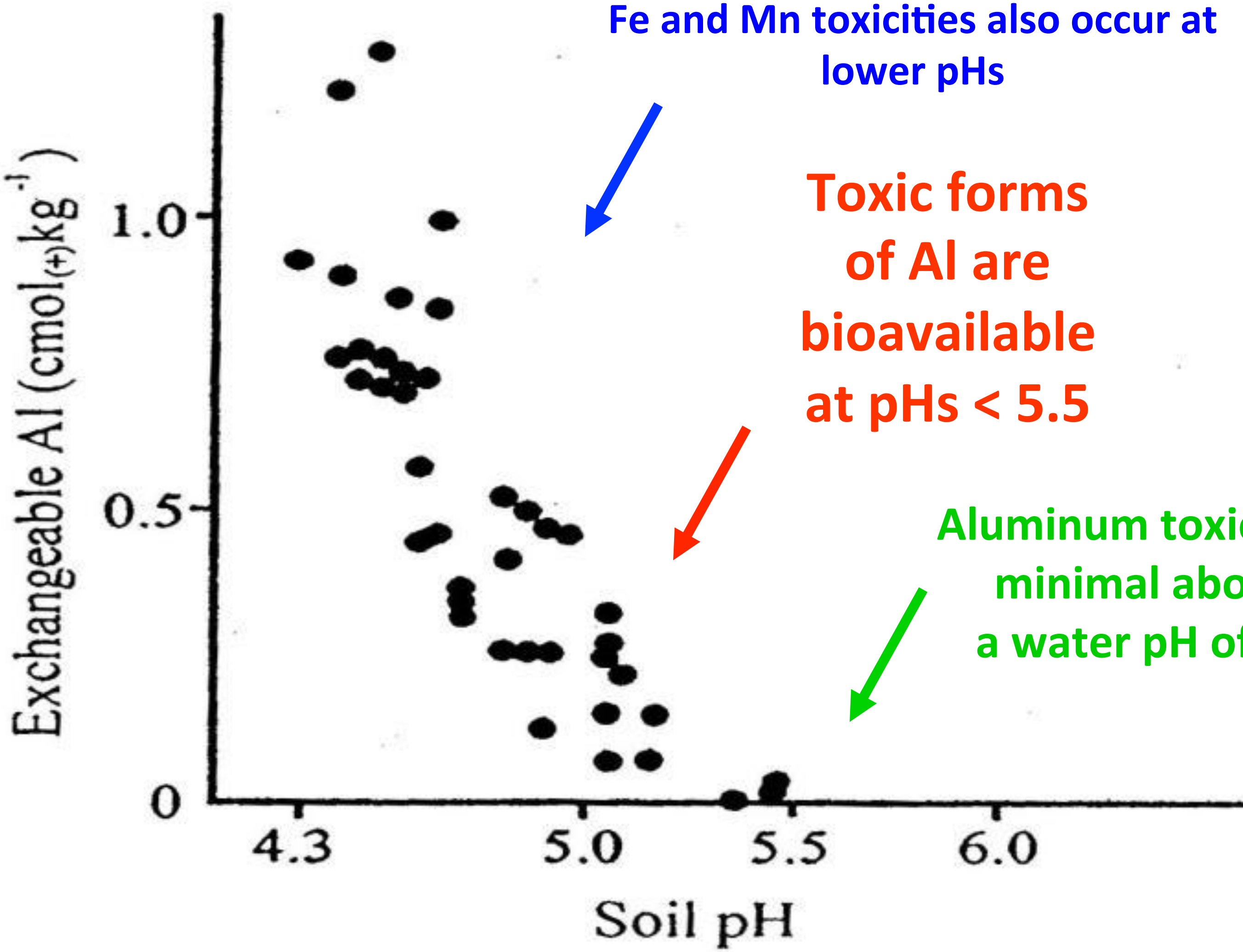
Chemical toxicities inhibit root growth & function



Al toxicity is very common in the SE US and in tropical countries like Brazil



Understanding aluminum toxicity



Fe and Mn toxicities also occur at lower pHs

Toxic forms of Al are bioavailable at pHs < 5.5

Aluminum toxicity is minimal above a water pH of 5.5

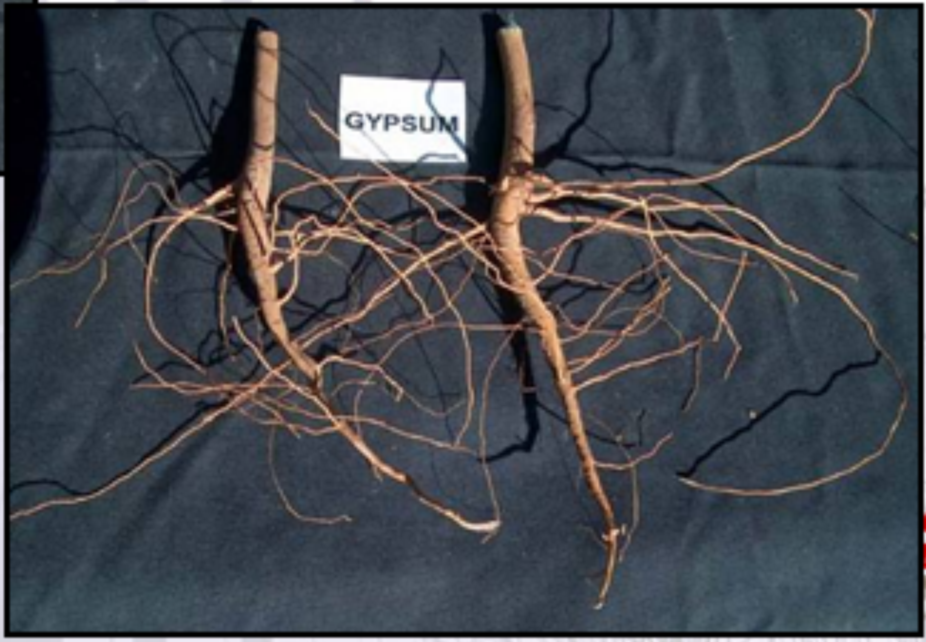
http://www2.ctahr.hawaii.edu/tpss/research_extension/rxsoil/alroot.gif

Functions of Gypsum in Agriculture

- Ca and S for crop nutrition
- Ameliorate subsoil acidity
  - Increases crop rooting depth
  - Increases water and nutrient uptake at depth
- Improve water infiltration and drainage
- Reduce soil crusting for better seedling emergence
- Ameliorate sodium-affected soils

Effect of Gypsum on Cotton Root Development - Mississippi

Contorted tap roots due to Al toxicity

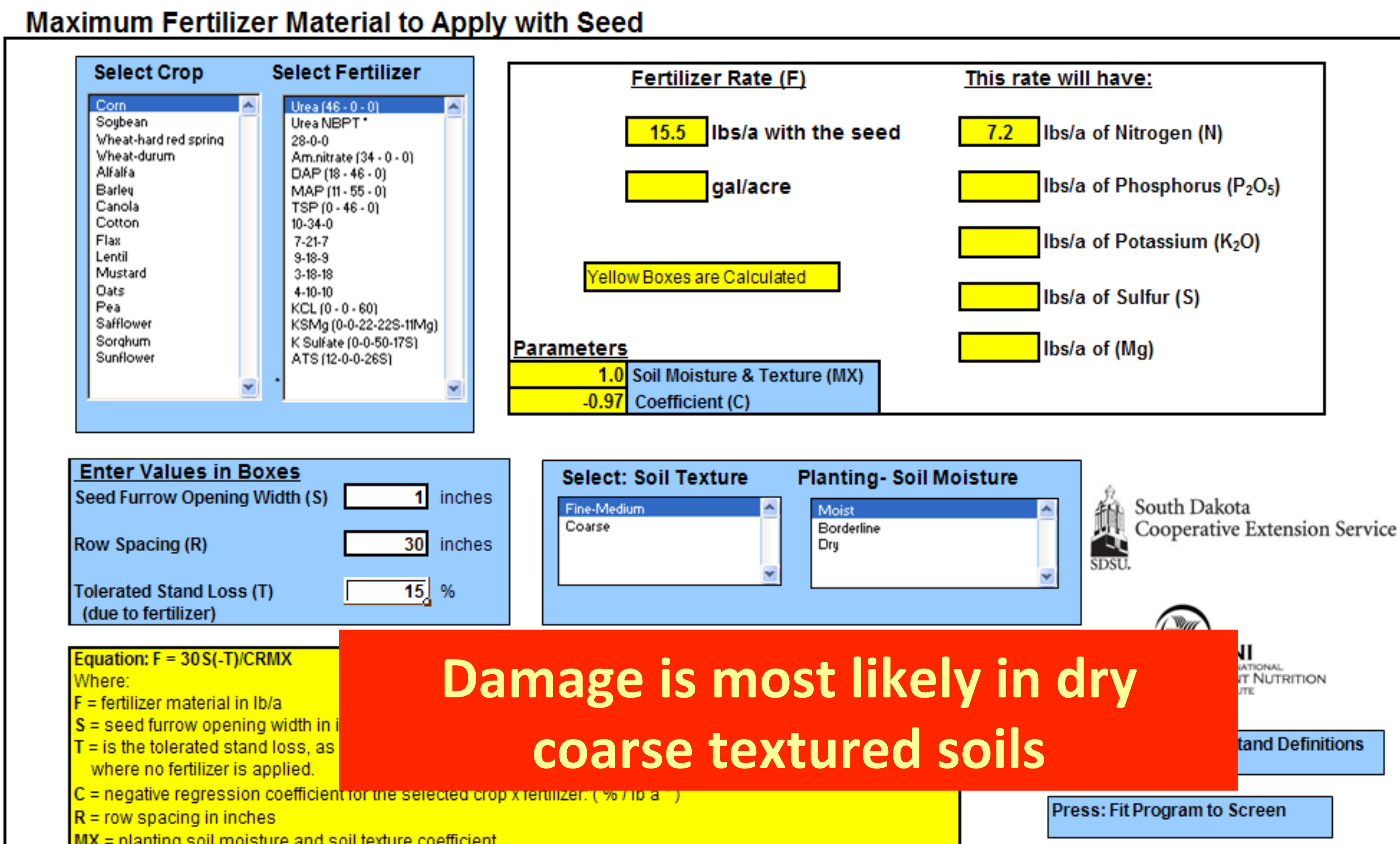


Straight tap roots in absence of Al

What damaged these corn roots?

Boron was included in starter fertilizer

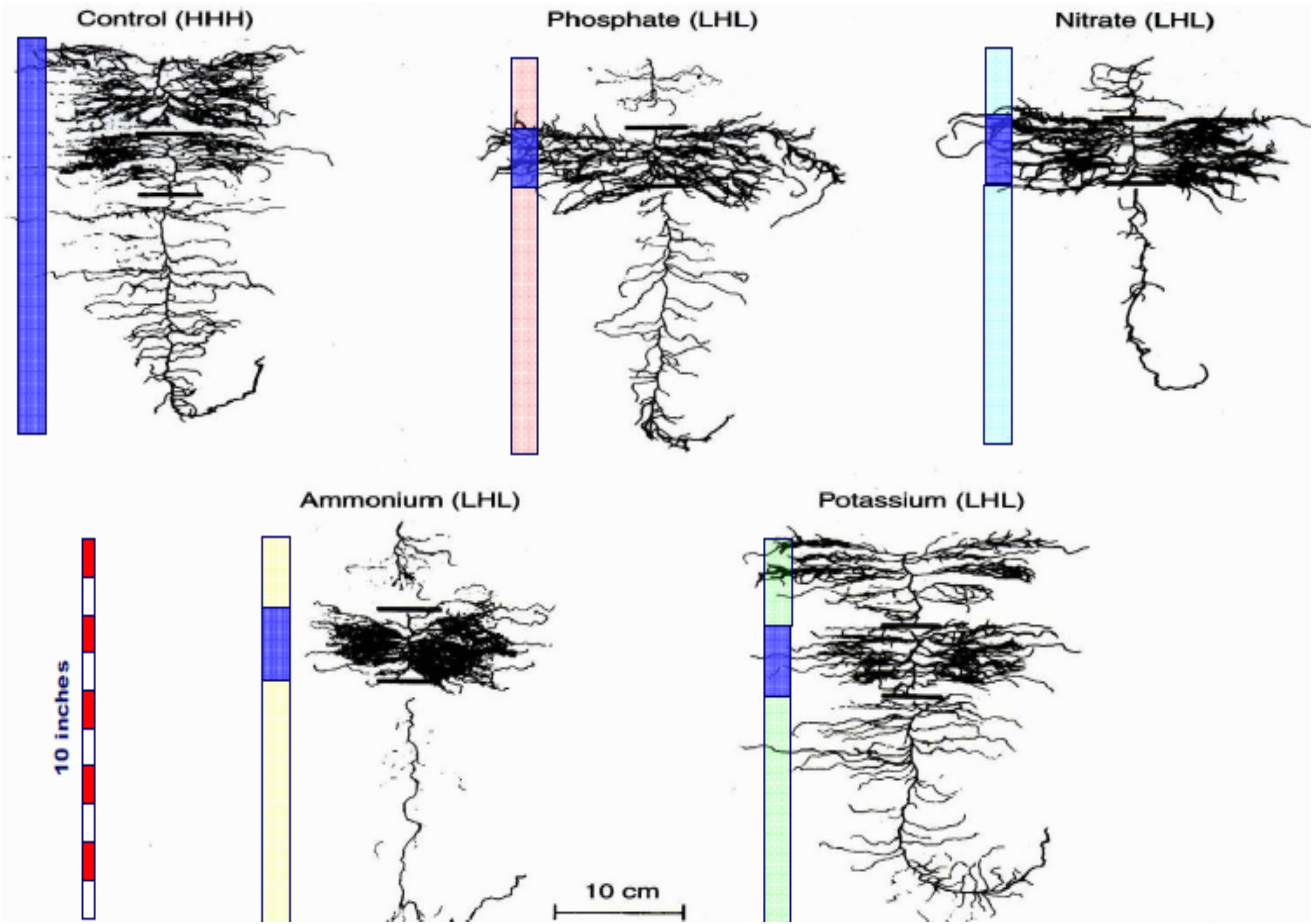
On-line tool for estimating maximum rates of in-row fertilizer



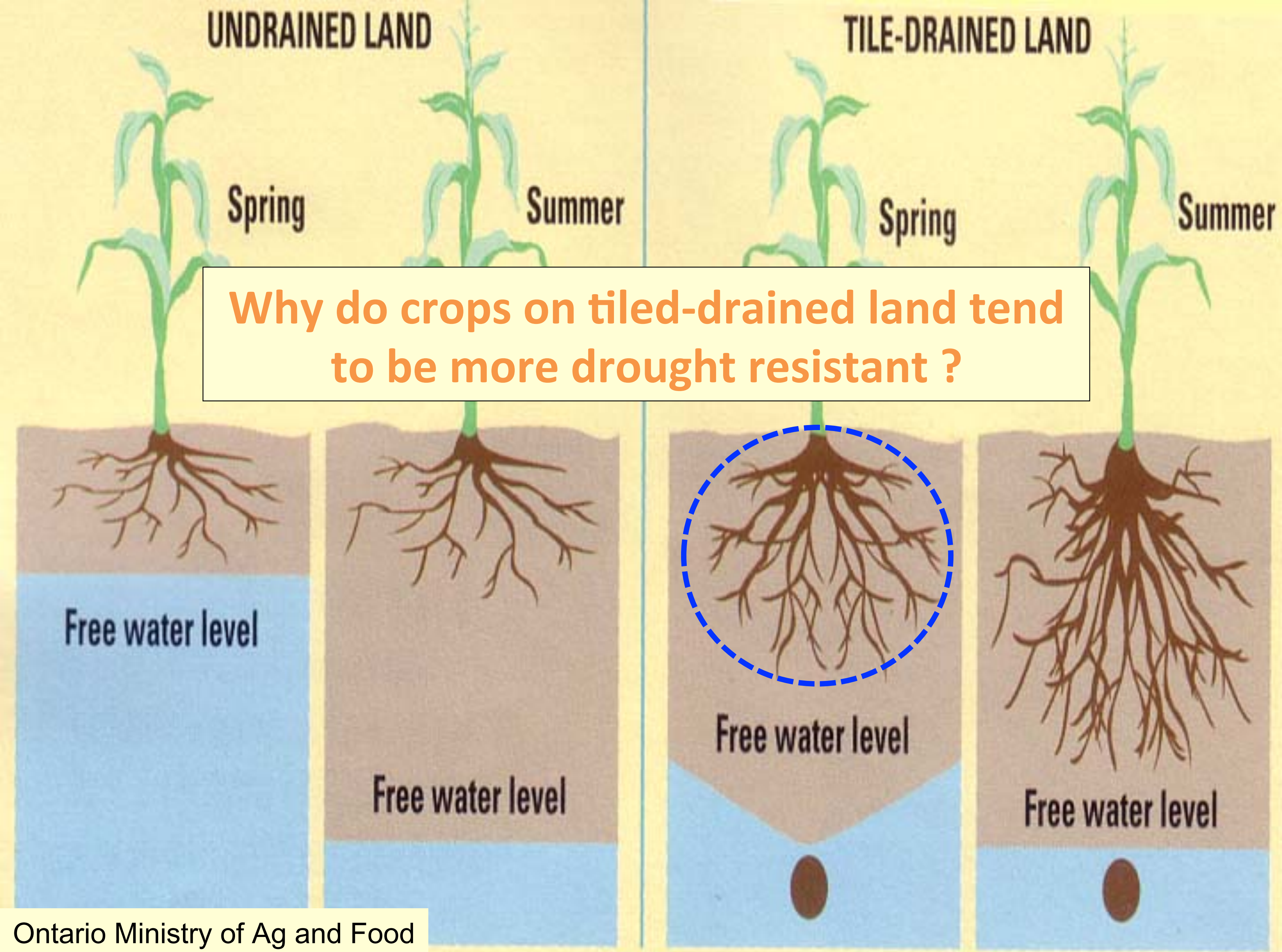
Damage is most likely in dry coarse textured soils

http://www.sdstate.edu/ps/soil-lab/loader.cfm?csModule=security/getfile&PageID=788496

N and P promote root branching and proliferation

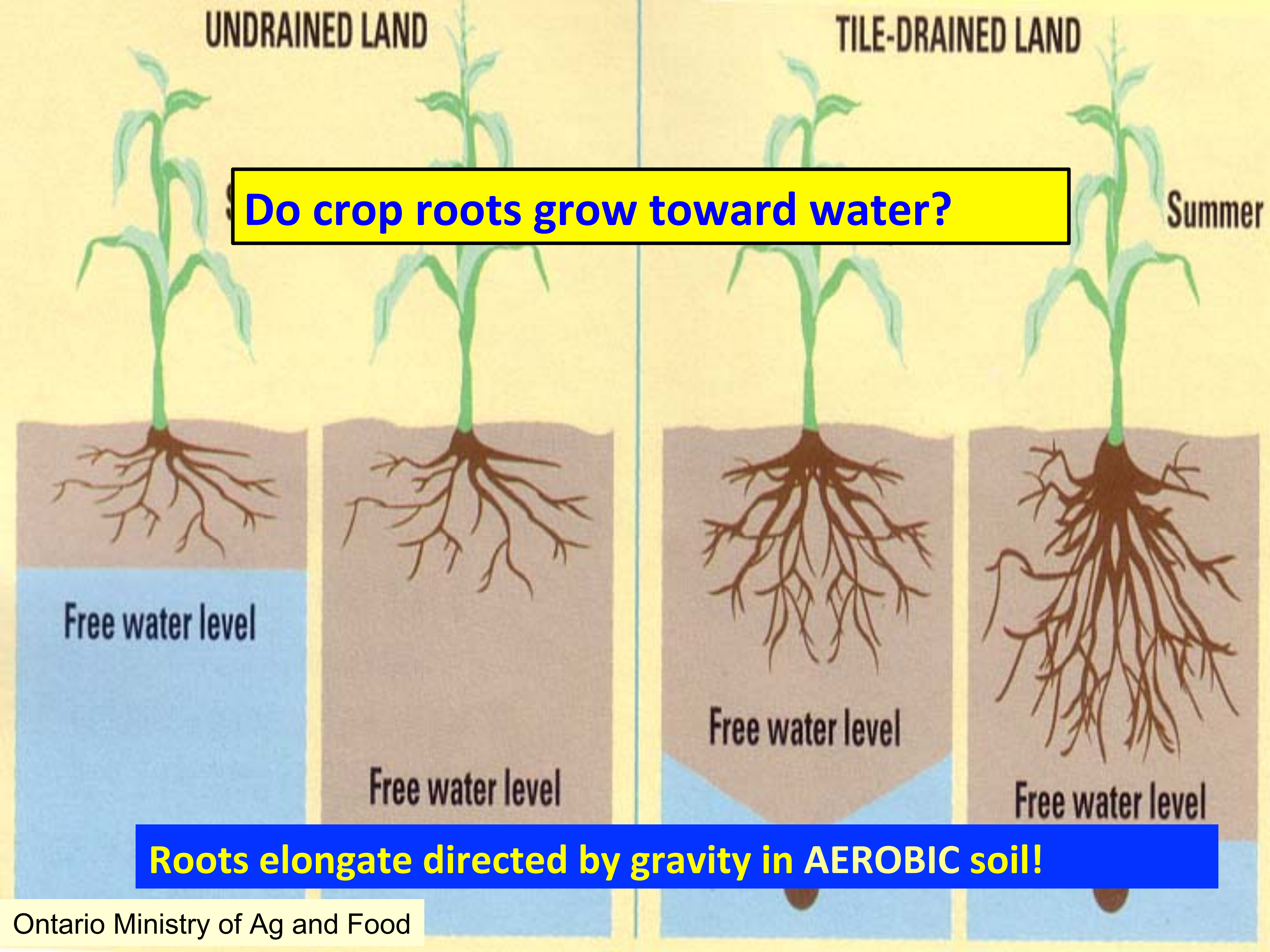


Why do crops on tiled-drained land tend to be more drought resistant ?



Ontario Ministry of Ag and Food

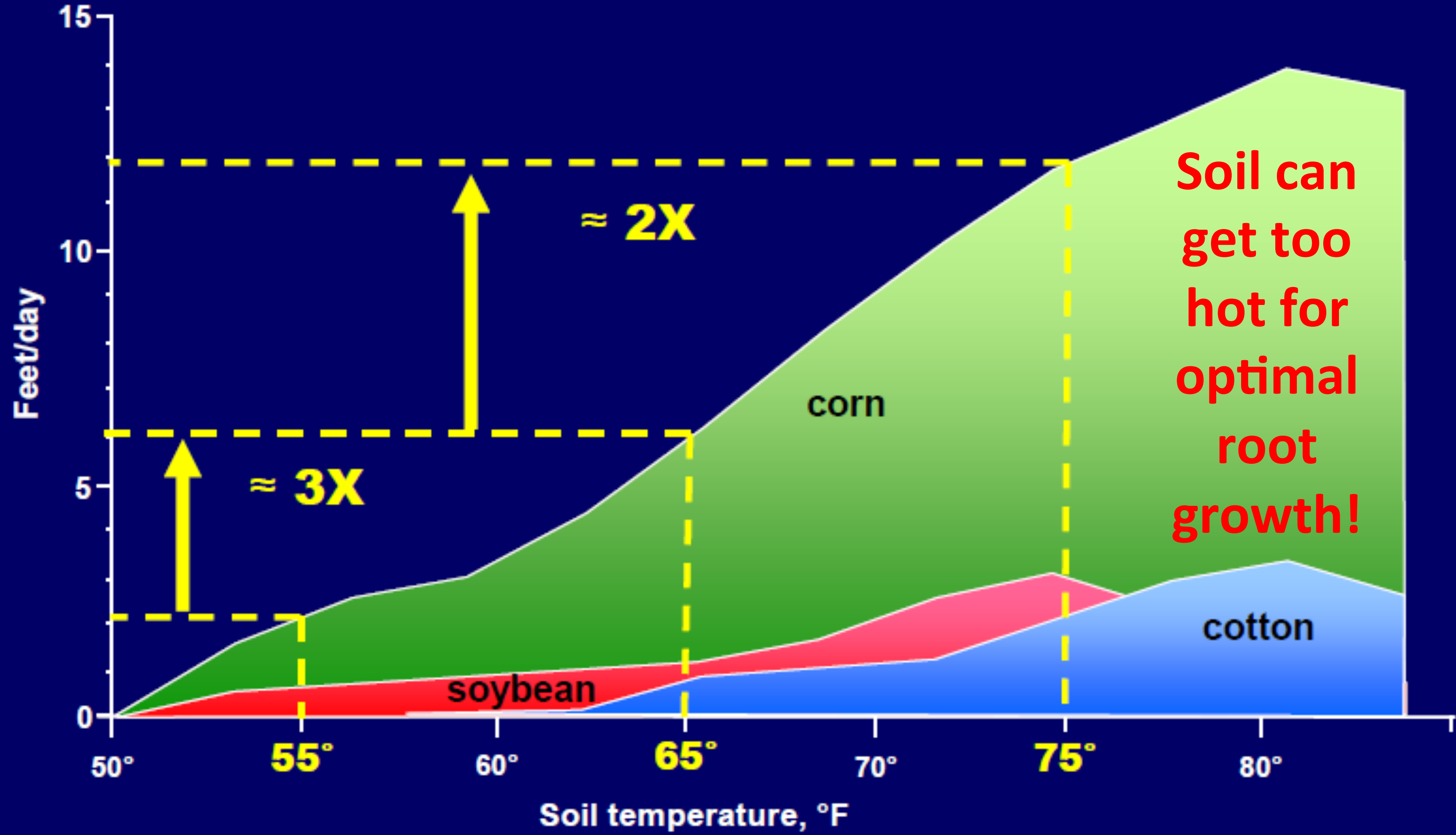
Do crop roots grow toward water?



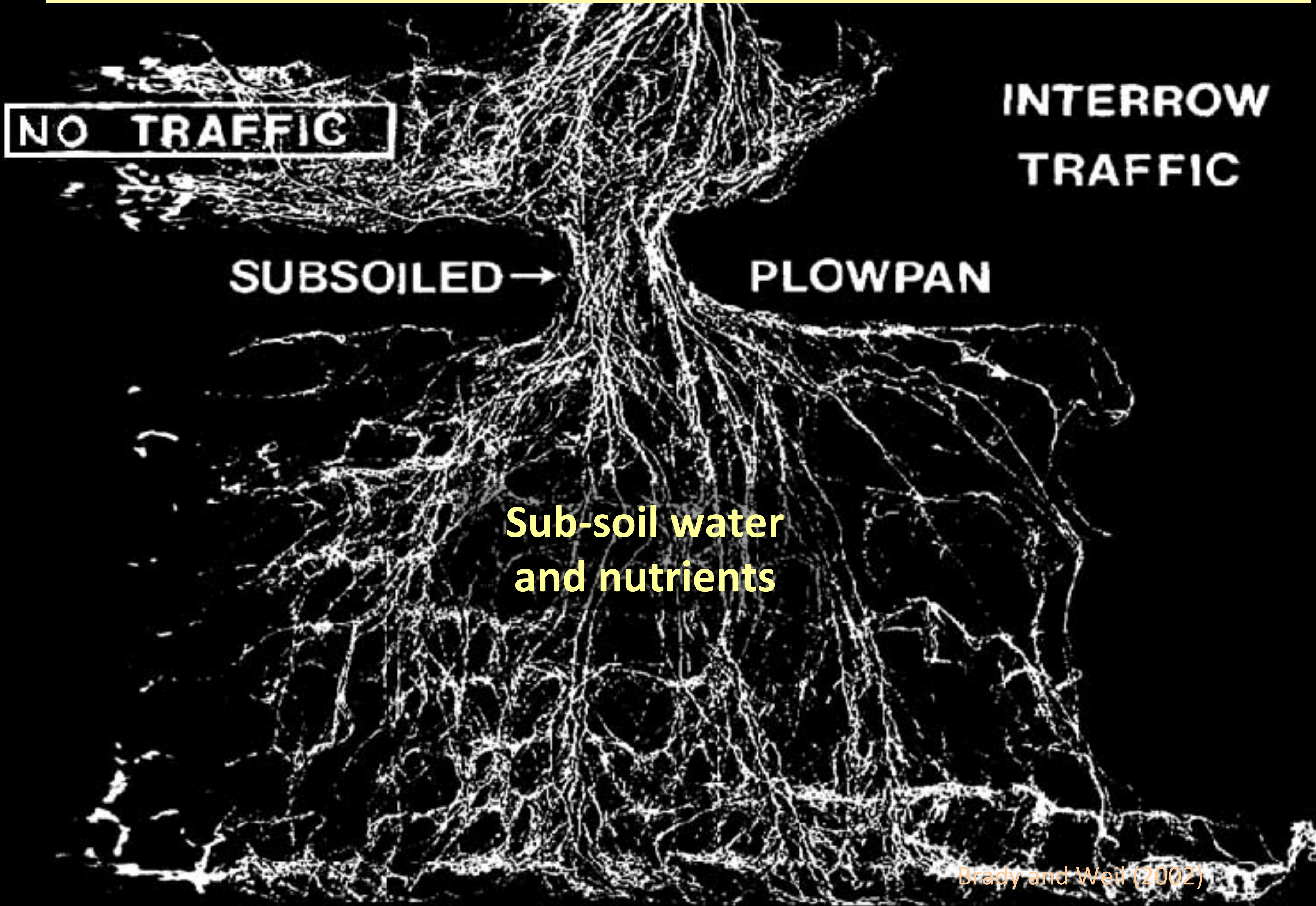
Roots elongate directed by gravity in AEROBIC soil!

Ontario Ministry of Ag and Food

Soil aeration affects soil temperature which strongly affects root growth rate



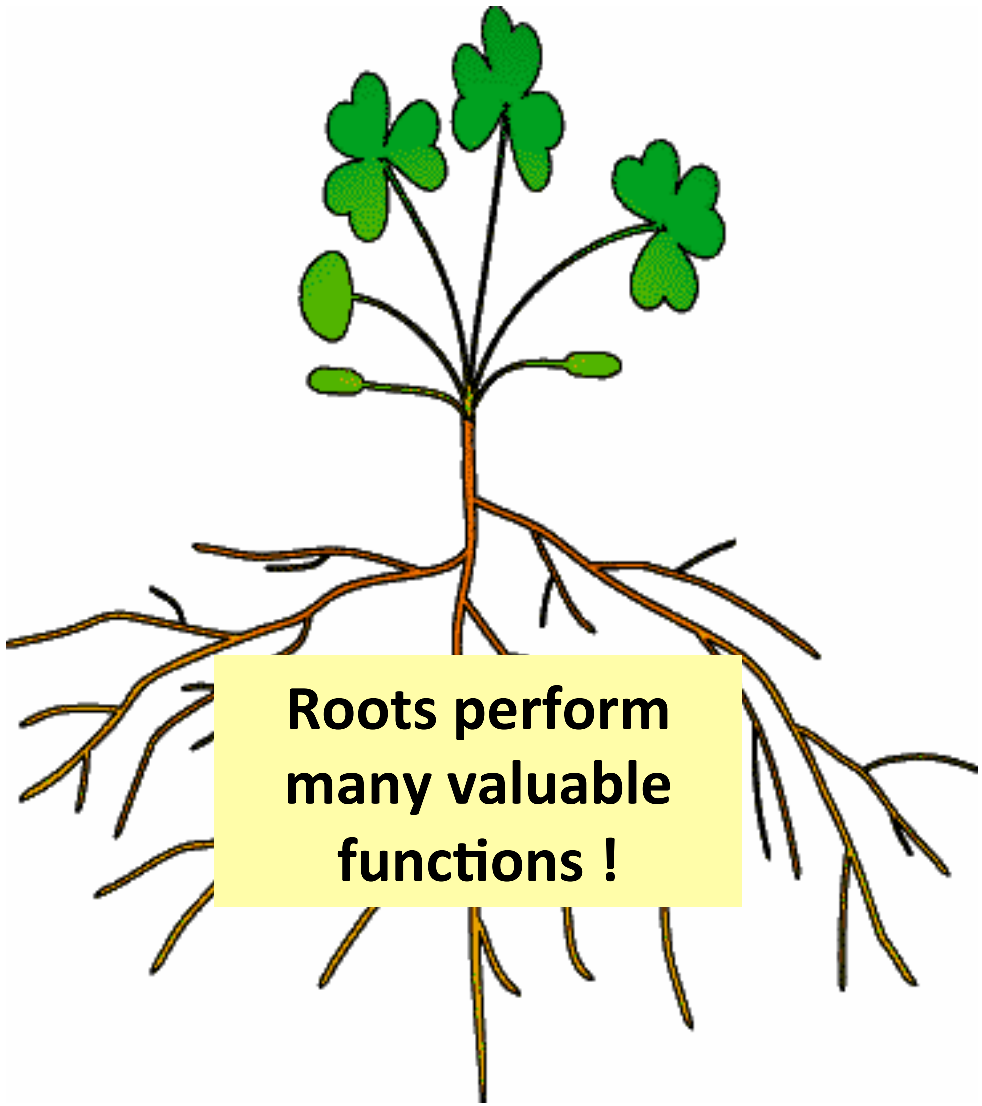
Compaction strongly impacts root growth and function



What causes sidewall compaction?

Waiting for drier soil
is the most important solution

Why are healthy roots so important?



In addition to the most obvious functions

<u>physical support</u> and <u>uptake of water and nutrients</u>

ROOTS are:

- Carbon pumps that feed soil organisms and contribute to soil organic matter
- Energy and nutrient storage organs
- Chemical factories that change soil pH, poison competitors, filter out toxins, concentrate rare elements, etc.
- A sensor network that helps regulate plant growth

Roots Respond to Many Stimuli

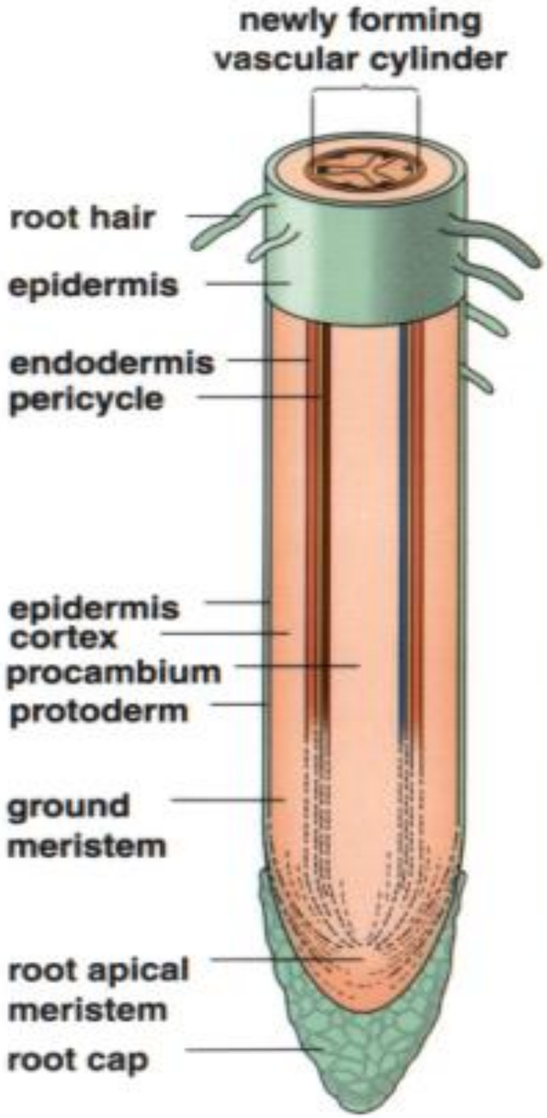
Stimuli that lead to Root Tropisms:

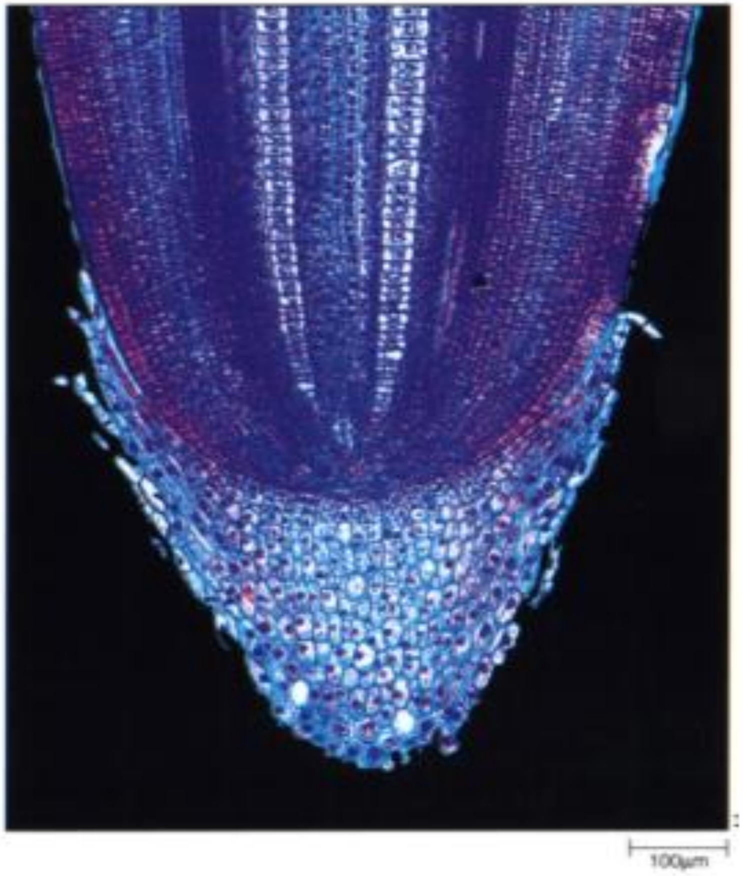
- Gravity,
- Light,
- Moisture,
- Chemical,
- Temperature,
- Touch (Thigmotropism),
- Water flow (Rheotropism),
- Trauma (Traumatotropism),
- Geomagnetic field (Magnetotropism),
- Electrical flux (Galvanotropism),
- *Etc.*

Roots review their environment and make 'choices' about what parts of it is profitable to explore, and what parts should be avoided.

(P. Barlow, 2009)

Physical protection
source of lubrication,
& sensor of gravity

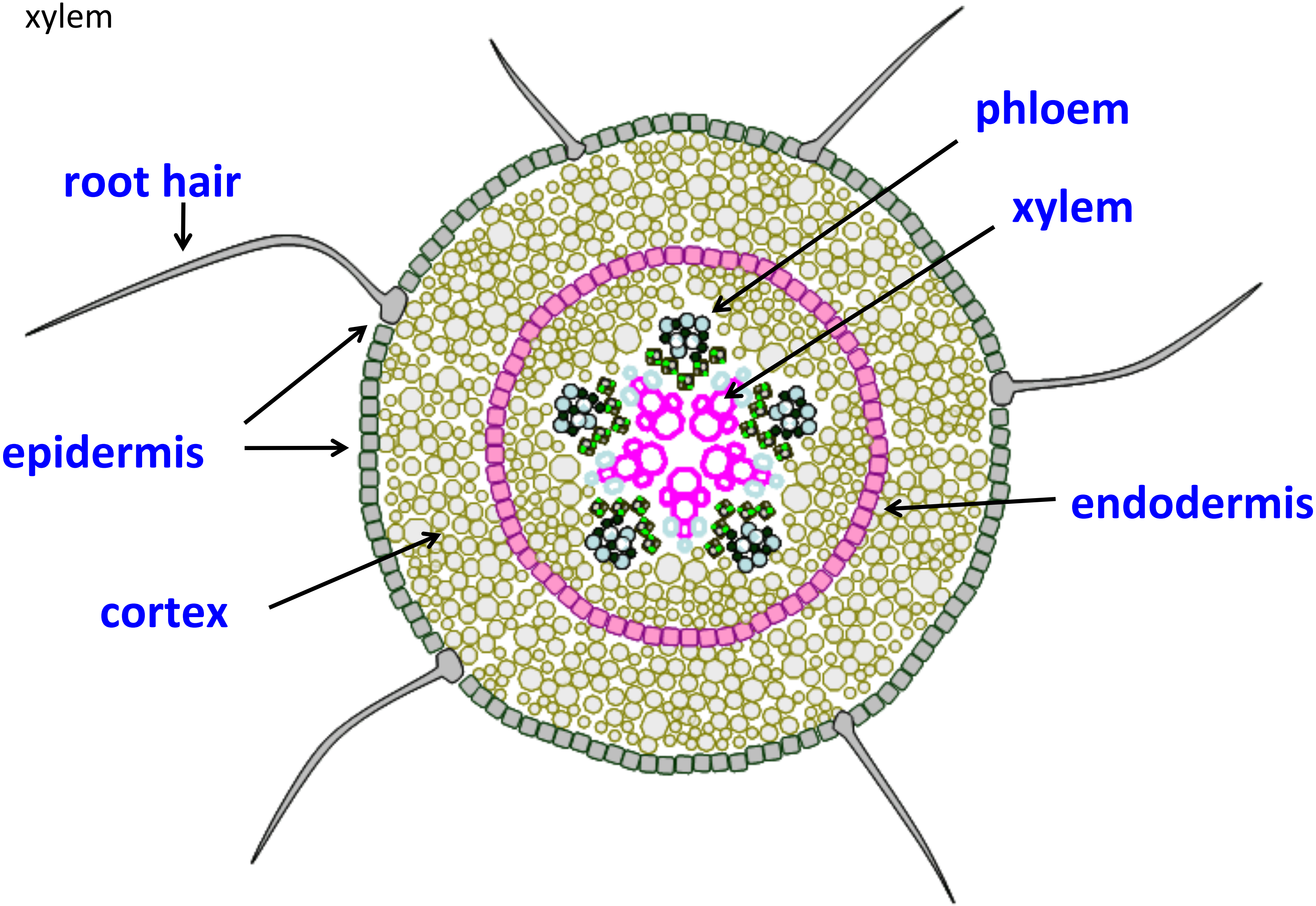




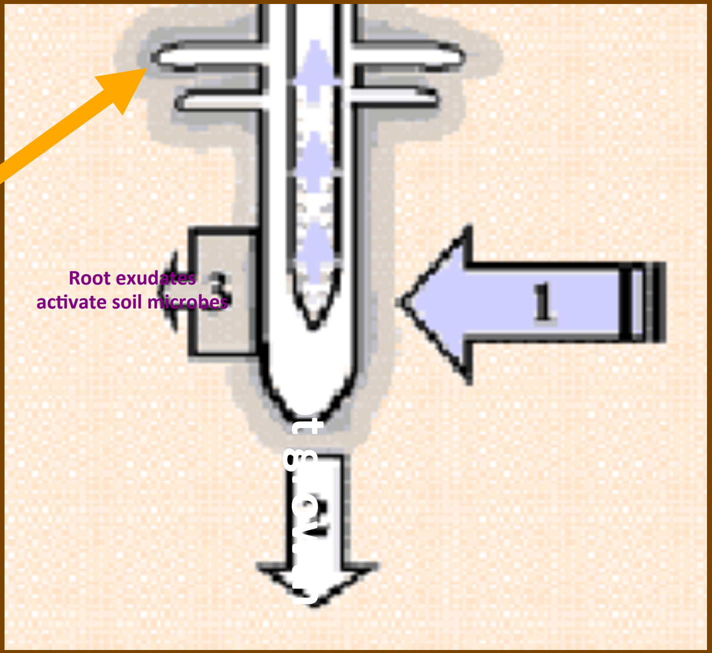
What is the function of the root cap?

What is the function of root hairs?

The cell wall of the endodermis (pink inner strip of cells) is waterproofed by the Casparian strip, which forces water to enter the symplast before it can enter the root xylem



The ins and outs of plant nutrition



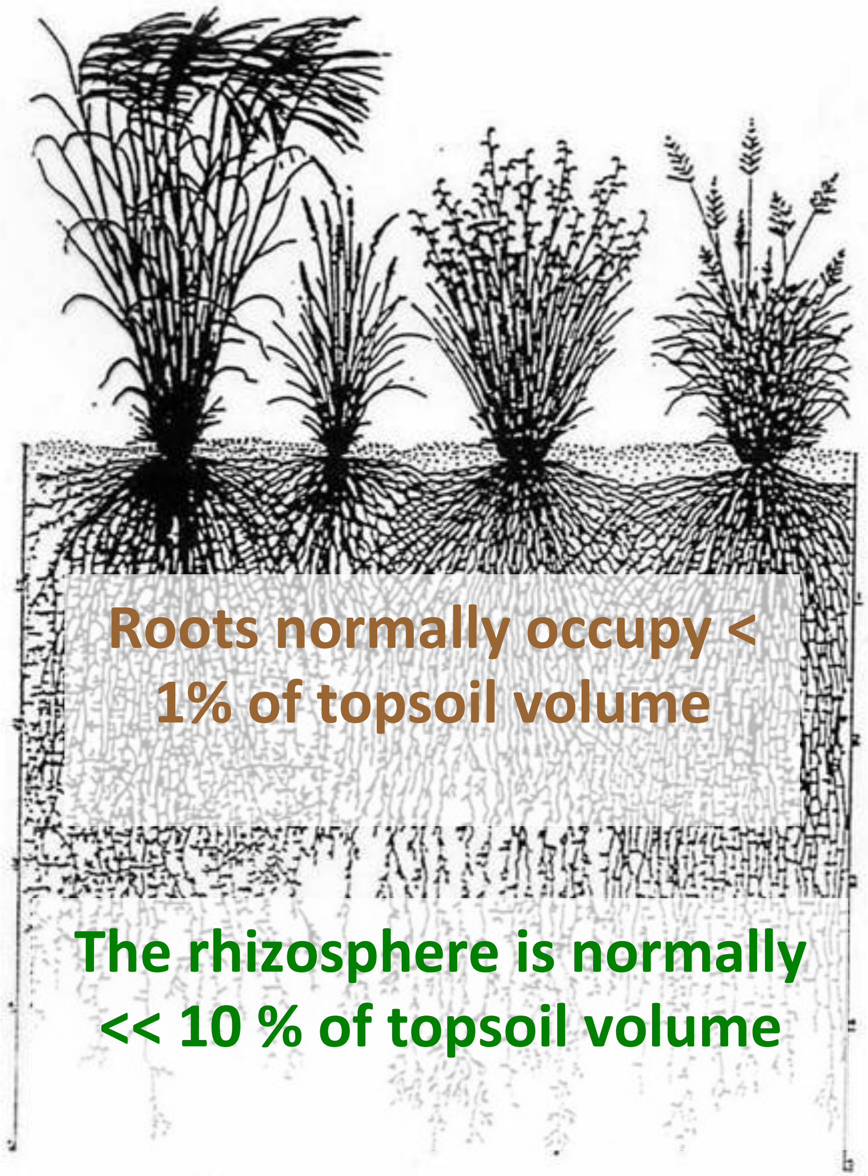
H_2O

Transpirational stream

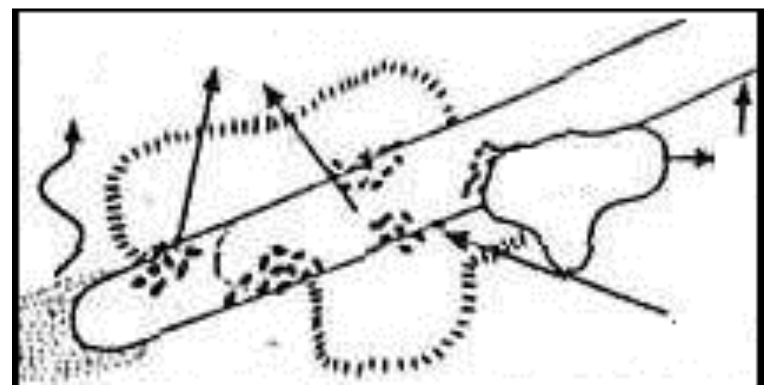
H_2O

Diffusion

Microorganisms produce most but not all of the enzymes need to digest OM

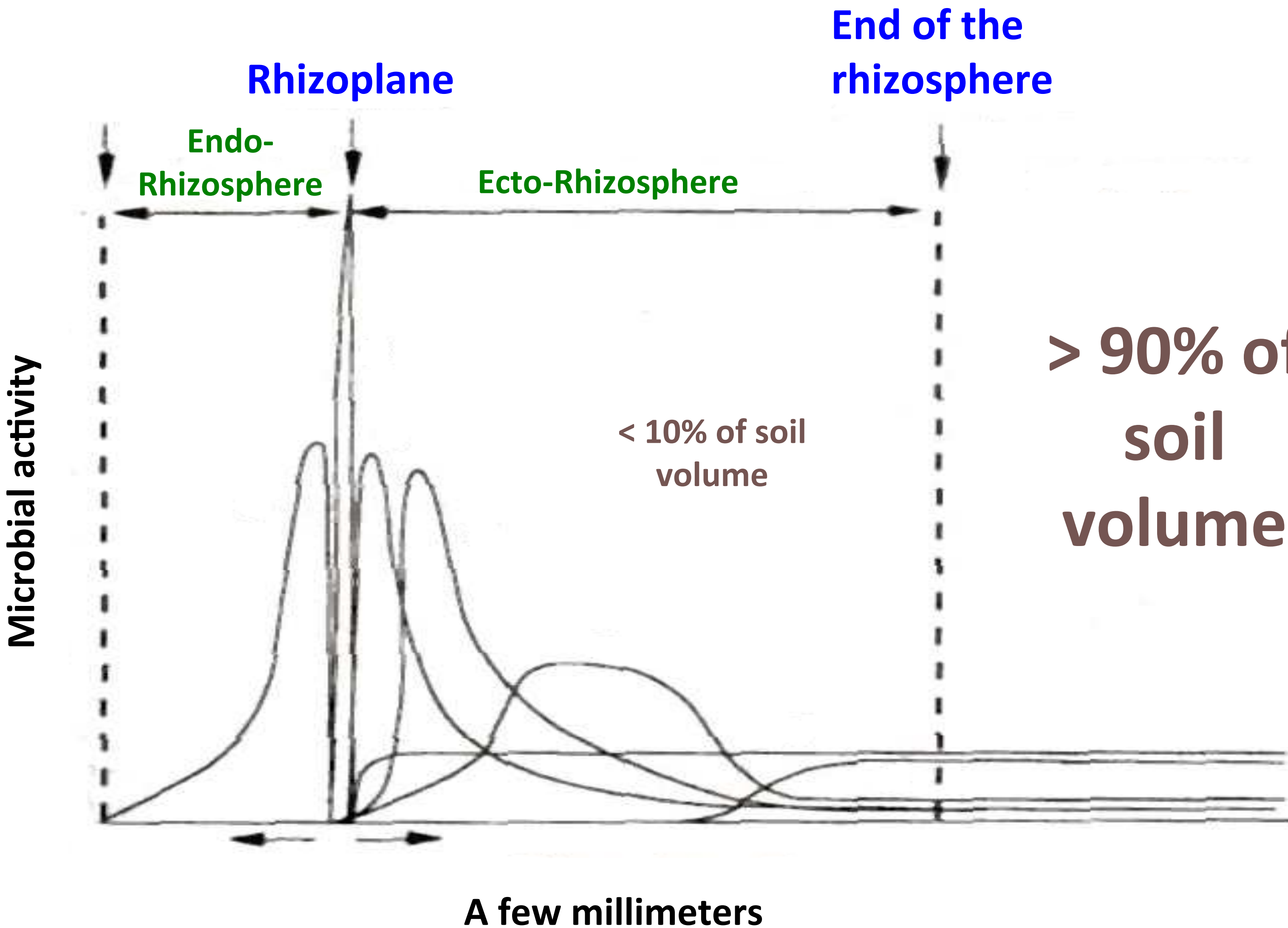


Rhizosphere



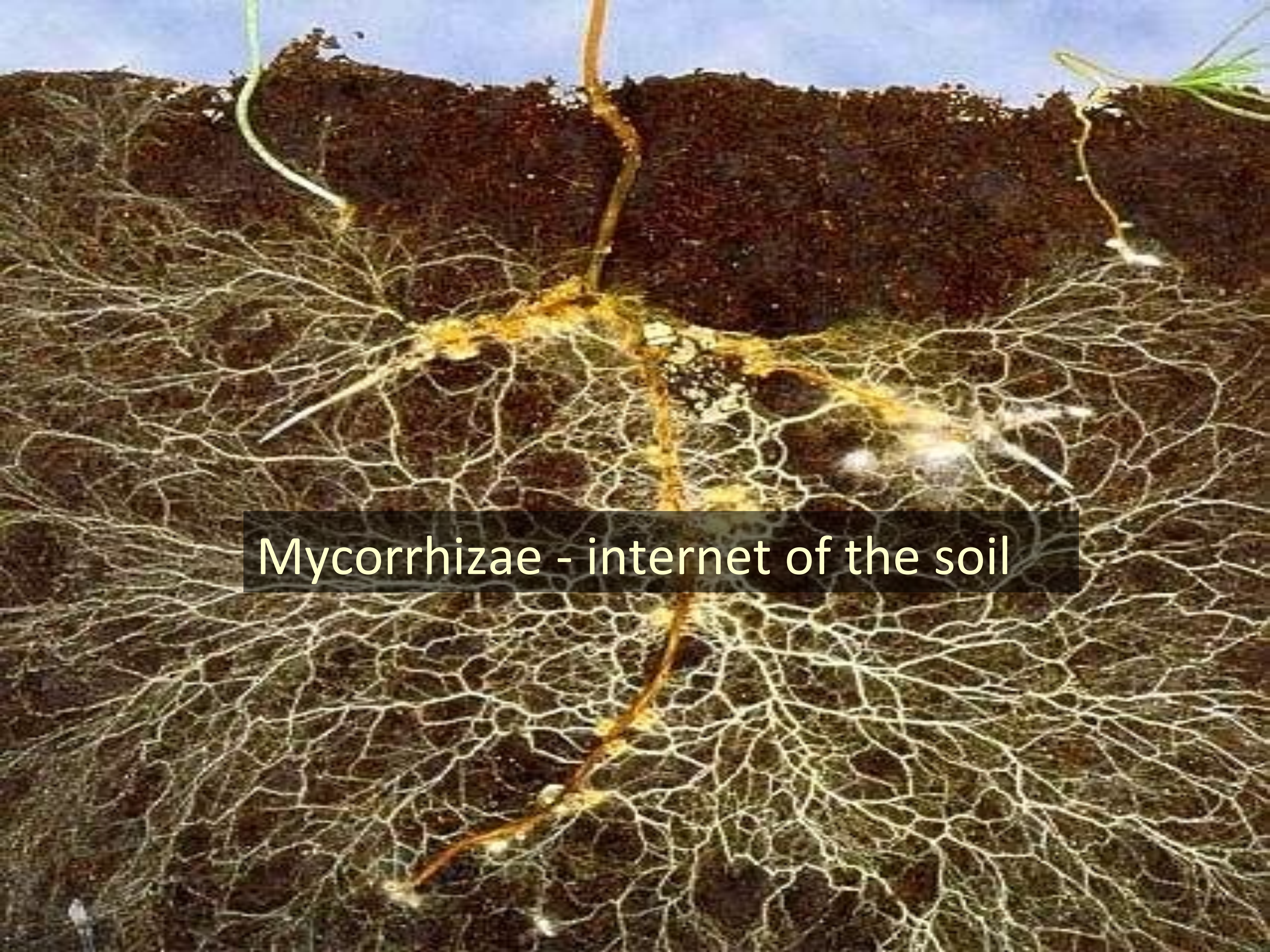
Zone of root influence

Navigating the rhizosphere



> 90% of soil volume

(Lavelle and Spain, 2001)


Mycorrhizae - internet of the soil

3 main strategies for managing soil biology

The NEXT generation
in seed treatment
HC
CORN
SabrEX
ROOT INOCULANT
with iGET Technology
SPECIMEN LABEL
Net Contents: 10 Oz. (284 grams)
Patent Pending

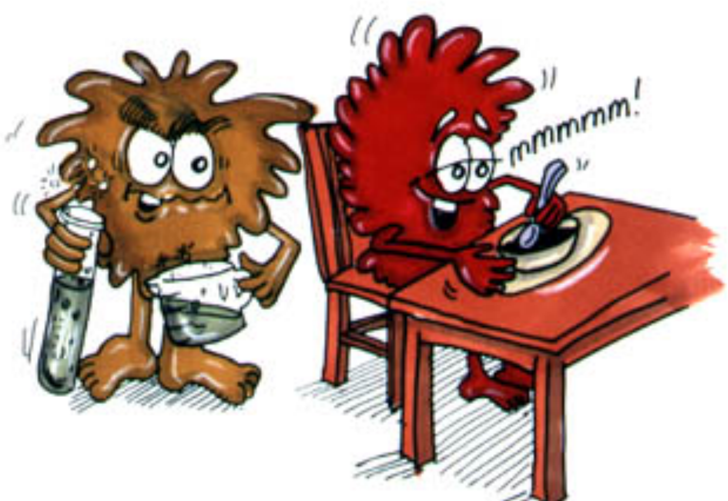
Table1 | **Evidence for, and effectiveness of, induced resistance in plants by *Trichoderma* species**

Species and strain	Plant	Pathogens	Evidence or effects	Time after application	Efficacy
T. virens G-6, G-6-5 and G-11	Cotton	*Rhizoctonia solani*	Protection of plants; induction of fungitoxic terpenoid phytoalexins	4 days	78% reduction in disease; ability to induce phytoalexins required for maximum biocontrol activity
T. harzianum T-39	Bean	*Colletotrichum lindemuthianum*; *Botrytis cinerea*	Protection of leaves when T-39 was present only on roots	10 days	42% reduction in lesion area; number of spreading lesions reduced
T. harzianum T-39	Tomato, pepper, tobacco, lettuce, bean	*B. cinerea*	Protection of leaves when T-39 was present only on roots	7 days	25–100% reduction in grey-mould symptoms
T. asperellum T-203	Cucumber	*Pseudomonas syringae* pv. lachrymans	Protection of leaves when T-203 was present only on roots; production of antifungal compounds in leaves	5 days	Up to 80% reduction in disease on leaves; 100-fold reduction in level of pathogenic bacterial cells in leaves
T. harzianum T-22; *T. atroviride* P1	Bean	*B. cinerea* and *Xanthomonas campestris* pv. phaseoli	Protection of leaves when T-22 or P1 was present only on roots; production of antifungal compounds in leaves	7–10 days	69% reduction in grey-mould (*B. cinerea*) symptoms with T22; lower level of control with P1. 54% reduction in bacterial disease symptoms.
T. harzianum T-1 & T22; *T. virens* T3	Cucumber	Green-mottle mosaic virus	Protection of leaves when *Trichoderma* strains were present only on roots	7 days	Disease-induced reduction in growth eliminated
T. harzianum T-22	Tomato	*Alternaria solani*	Protection of leaves when T-22 was present only on roots	3 months	Up to 80% reduction in early blight symptoms from natural field infection
T. harzianum T-22	Maize	*Colletotrichum graminicola*	Protection of leaves when *Trichoderma* strains were present only on roots	14 days	44% reduction of lesion size on wounded leaves; no disease on non-wounded leaves

competition

parasitism

4 main types of microbial interactions that promote root health

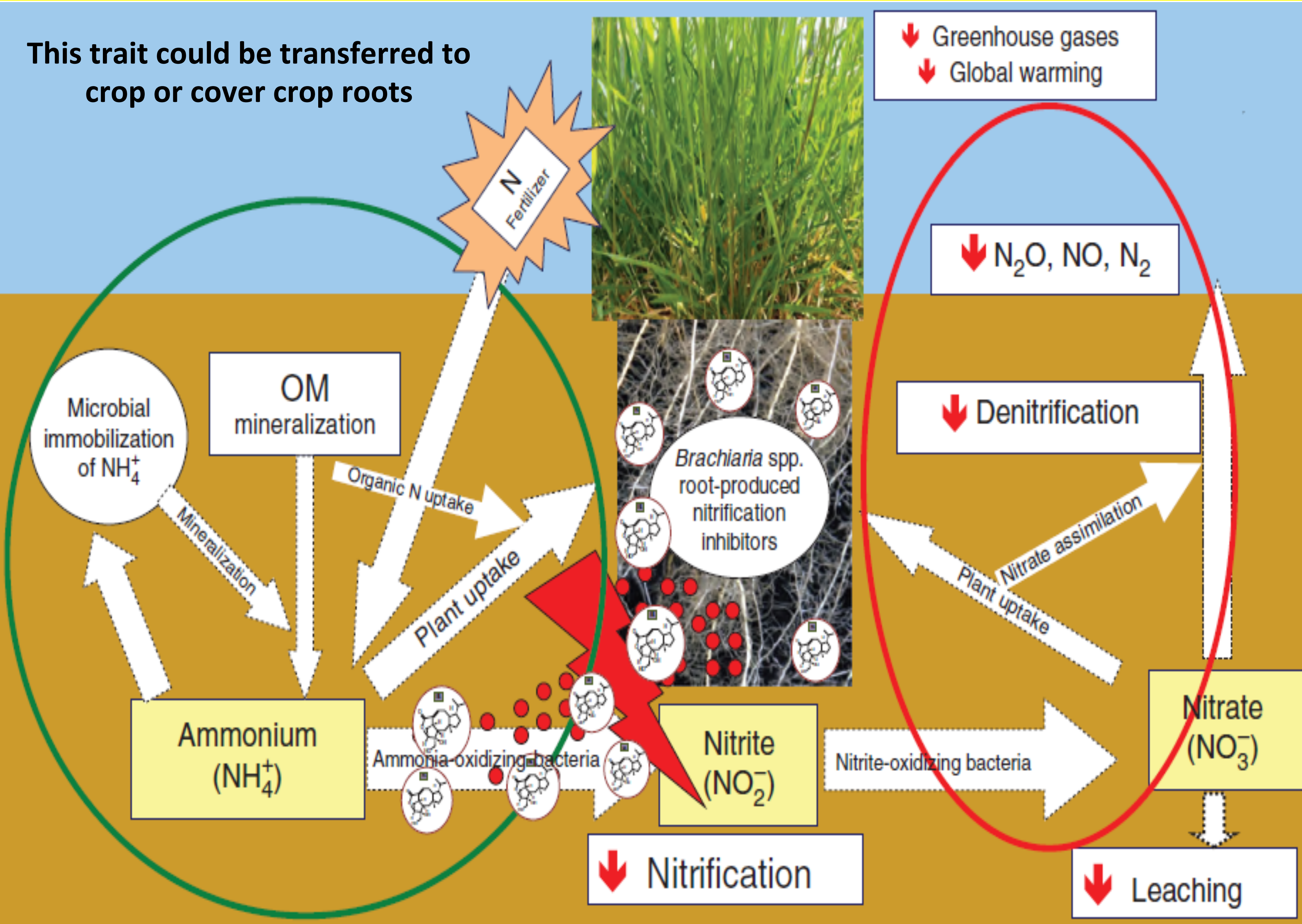


antibiosis

induced resistance

The root systems of natural vegetation often inhibit nitrification

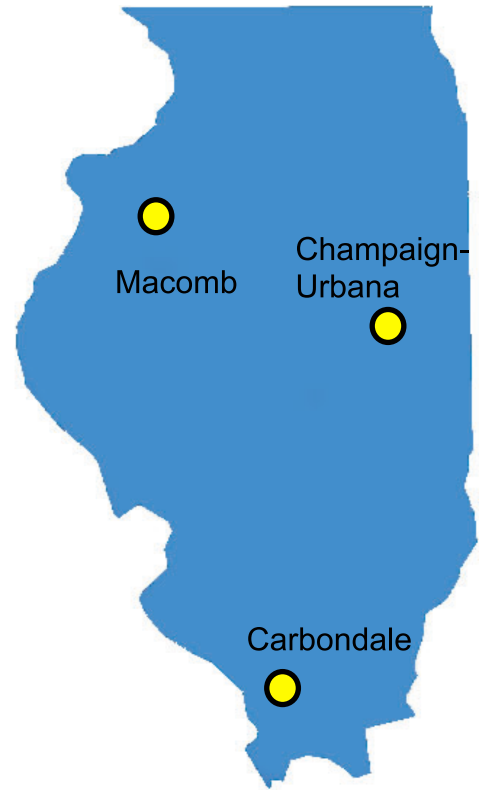
This trait could be transferred to crop or cover crop roots



Suppression of soybean diseases through the use of cover crops

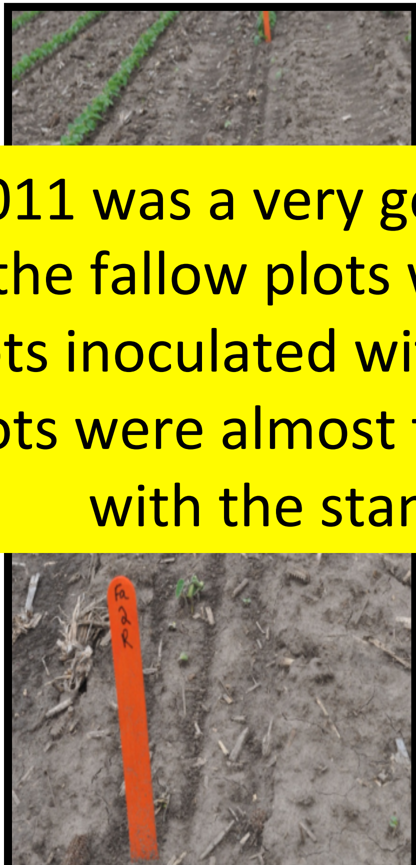
- University of Illinois
- Western Illinois University
- Southern Illinois University

NORTH CENTRAL SARE
Sustainable Agriculture Research & Education

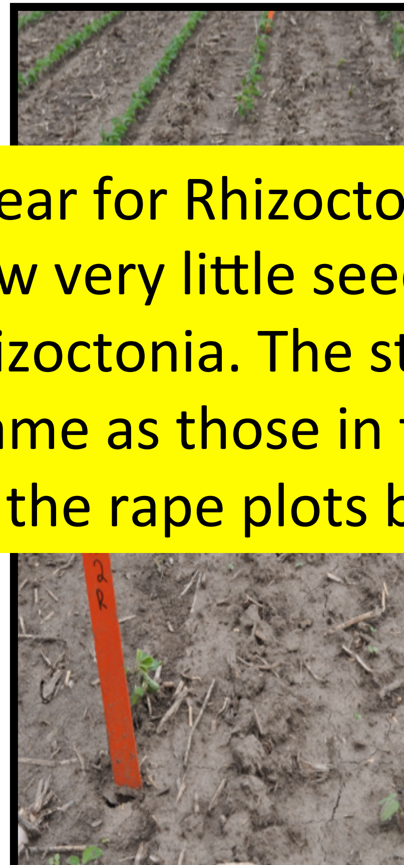


Soybean Stands in Rhizoctonia inoculated plots UIUC 2011

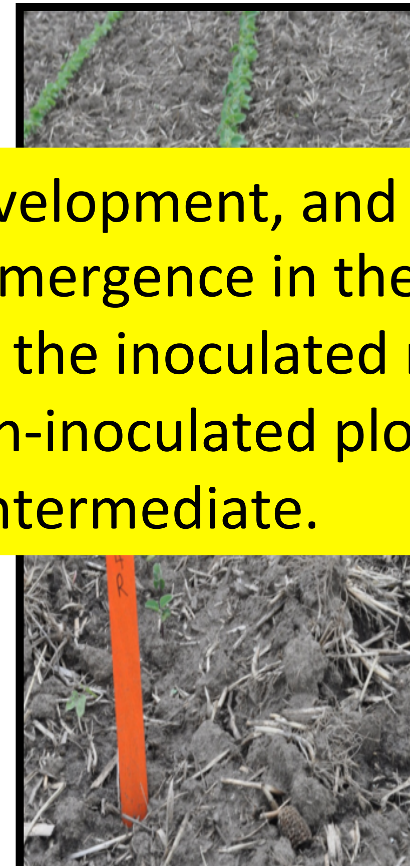
2011 was a very good year for Rhizoctonia development, and in the fallow plots we saw very little seedling emergence in the plots inoculated with Rhizoctonia. The stand in the inoculated rye plots were almost the same as those in the non-inoculated plots, with the stands in the rape plots being intermediate.



Fallow

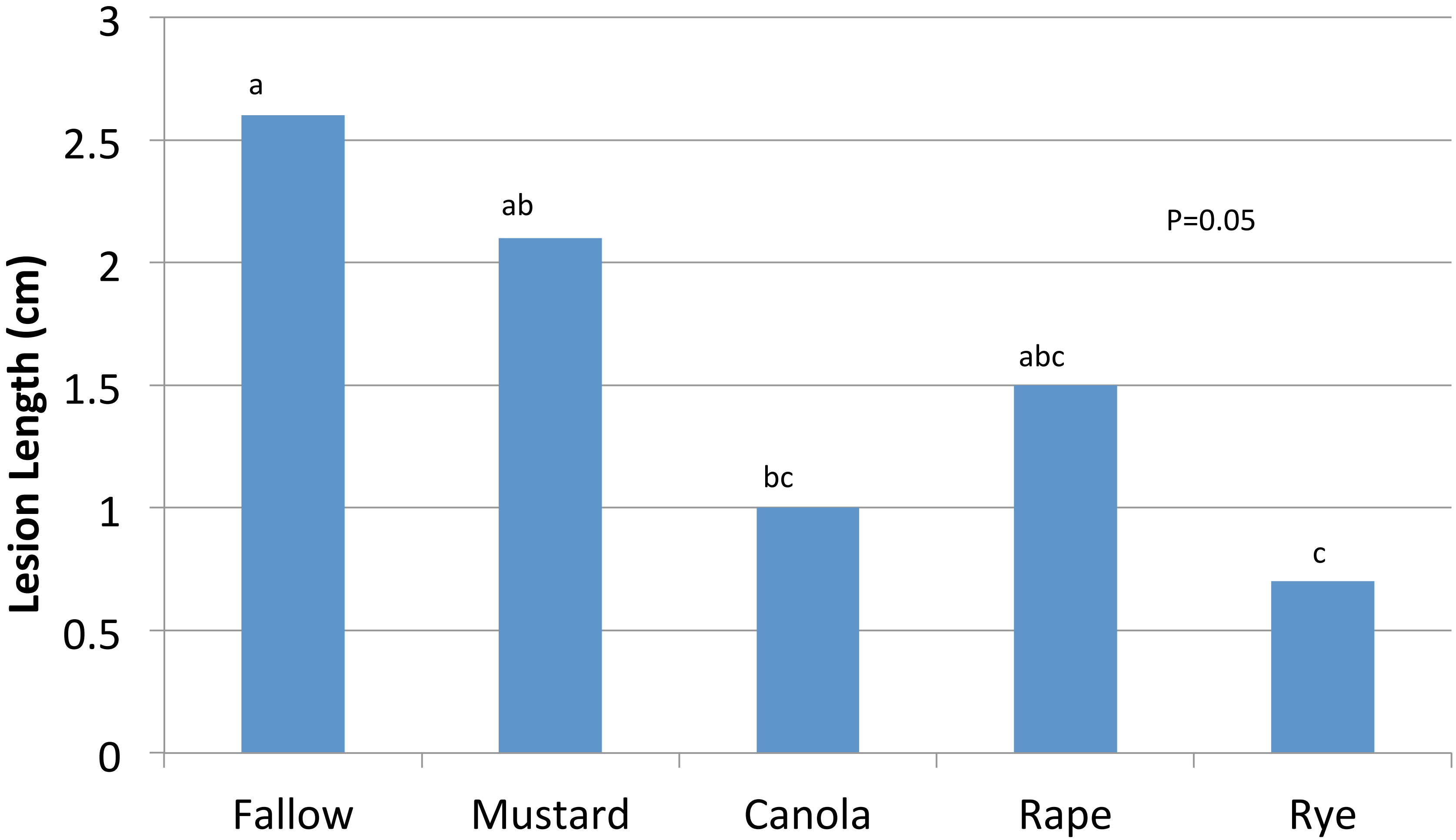


Rape

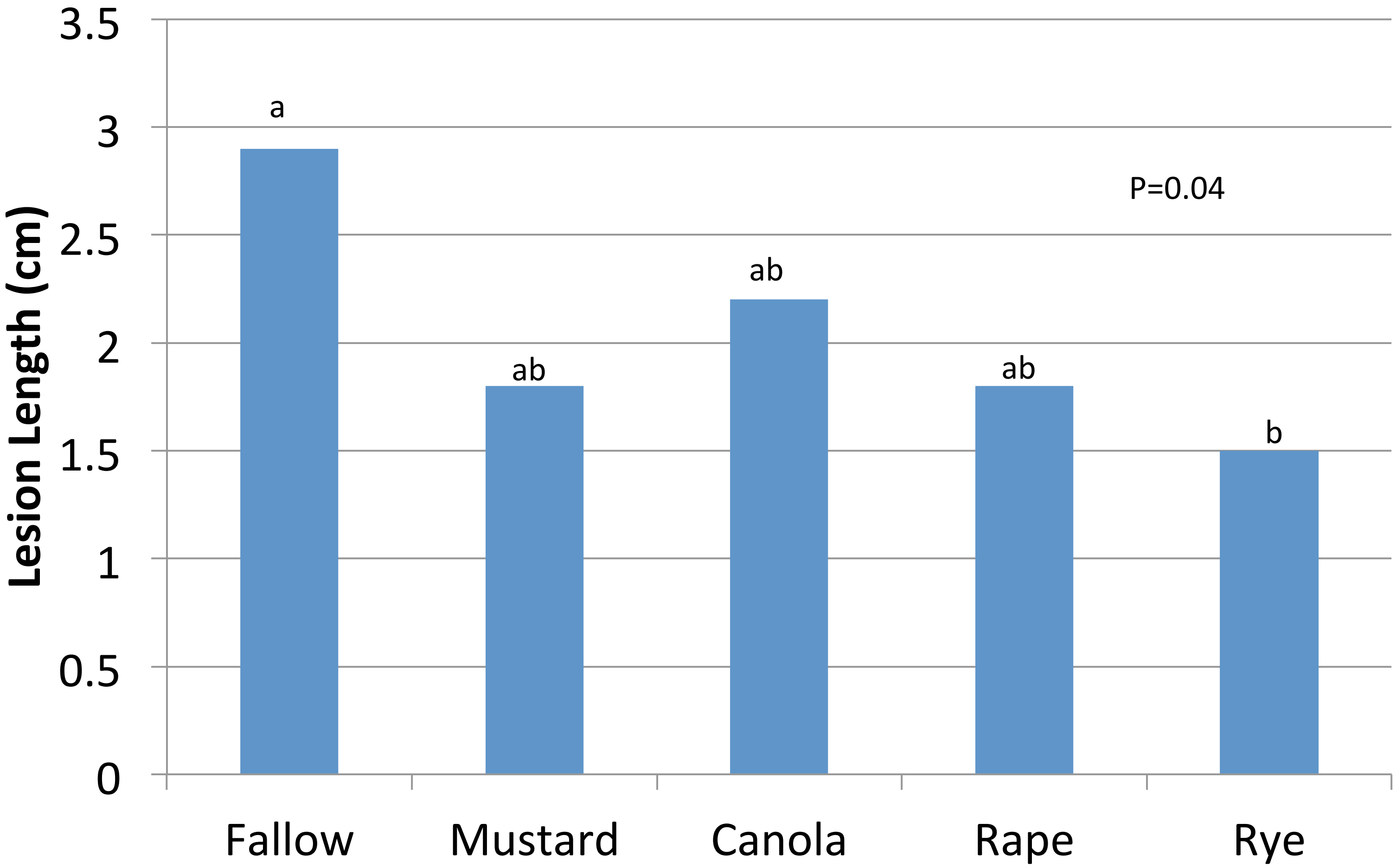


Cereal rye

Rhizoctonia root rot, UIUC 2012



Rhizoctonia root rot, UIUC 2013



Conclusions

Cereal rye and rape resulted in the highest soybean stands, but results were not consistent among locations.

Cereal rye has the potential to induce soil suppressiveness to Rhizoctonia root rot and SDS.

Cereal rye, rape, and canola can significantly decrease SCN egg counts.

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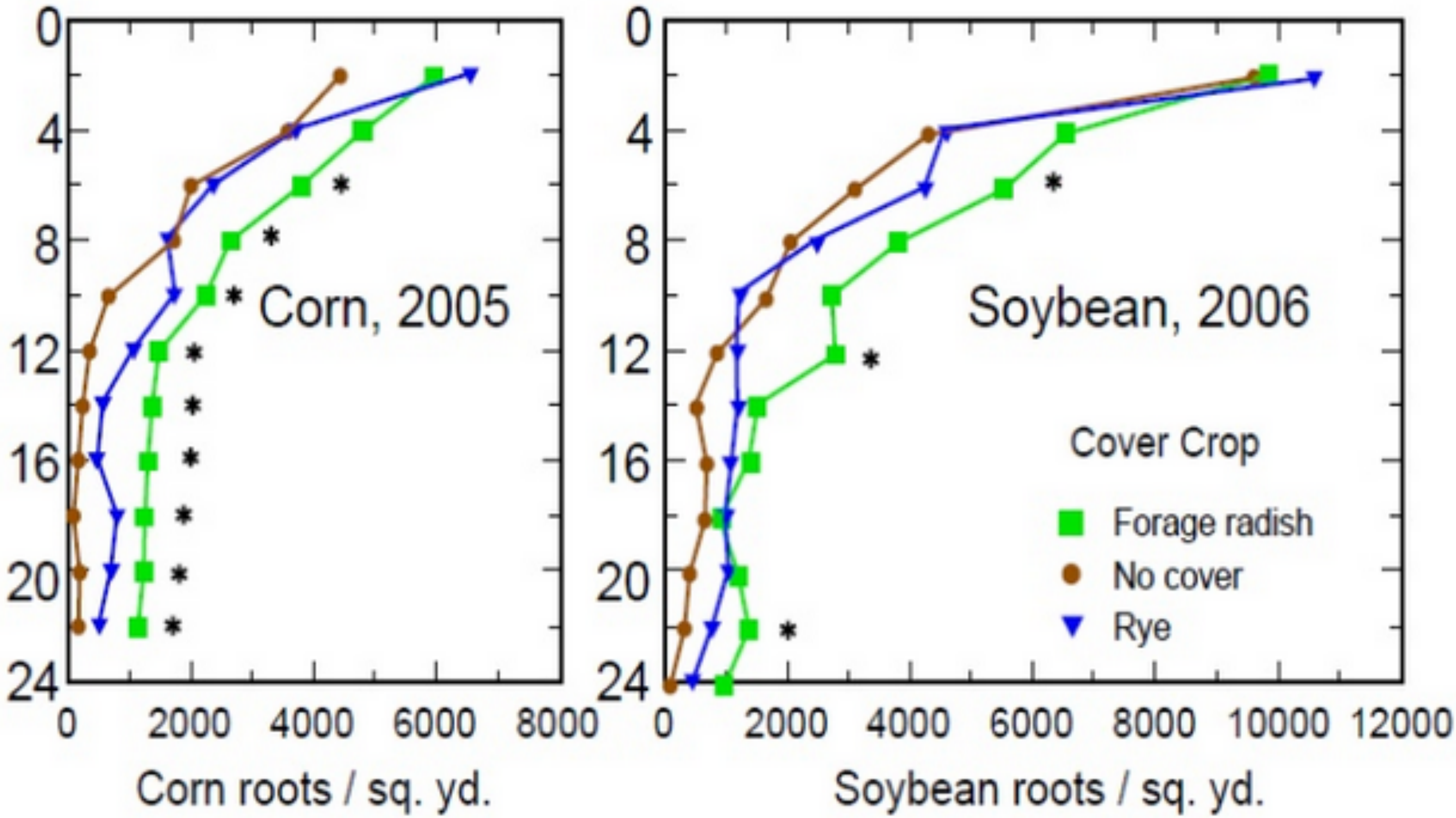
Hydra-Hume products from Helena are used in many industries--agriculture, golf courses, nurseries and more. Hydra-Hume binds in the soil with fertilizer elements and helps hold it in the soil. This decreases the downward mobility of fertilizer elements in the soil, which effectively increases fertilizer availability to plant roots, also described as "improving fertilizer efficiency."

Use precision planting

Precision planted cover crops in Indiana

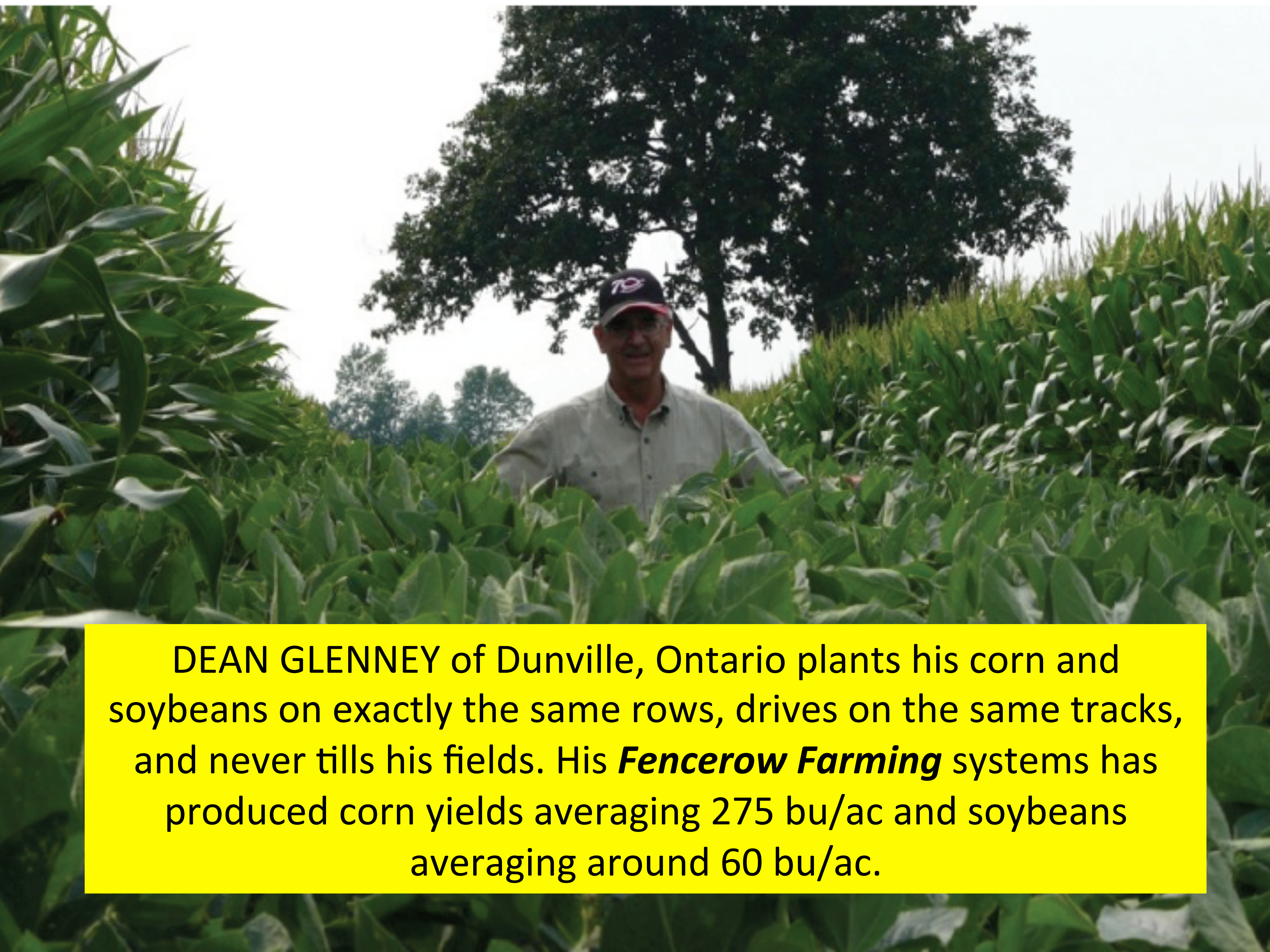

Precision planted radishes
at the WIU Organic research farm

Crop root density as affected by previous cover crop



Chen and Weil (2006)

BUILD IT AND THEY WILL COME
should be your foundational strategy for managing soil biology!



DEAN GLENNEY of Dunville, Ontario plants his corn and soybeans on exactly the same rows, drives on the same tracks, and never tills his fields. His ***Fencerow Farming*** systems has produced corn yields averaging 275 bu/ac and soybeans averaging around 60 bu/ac.

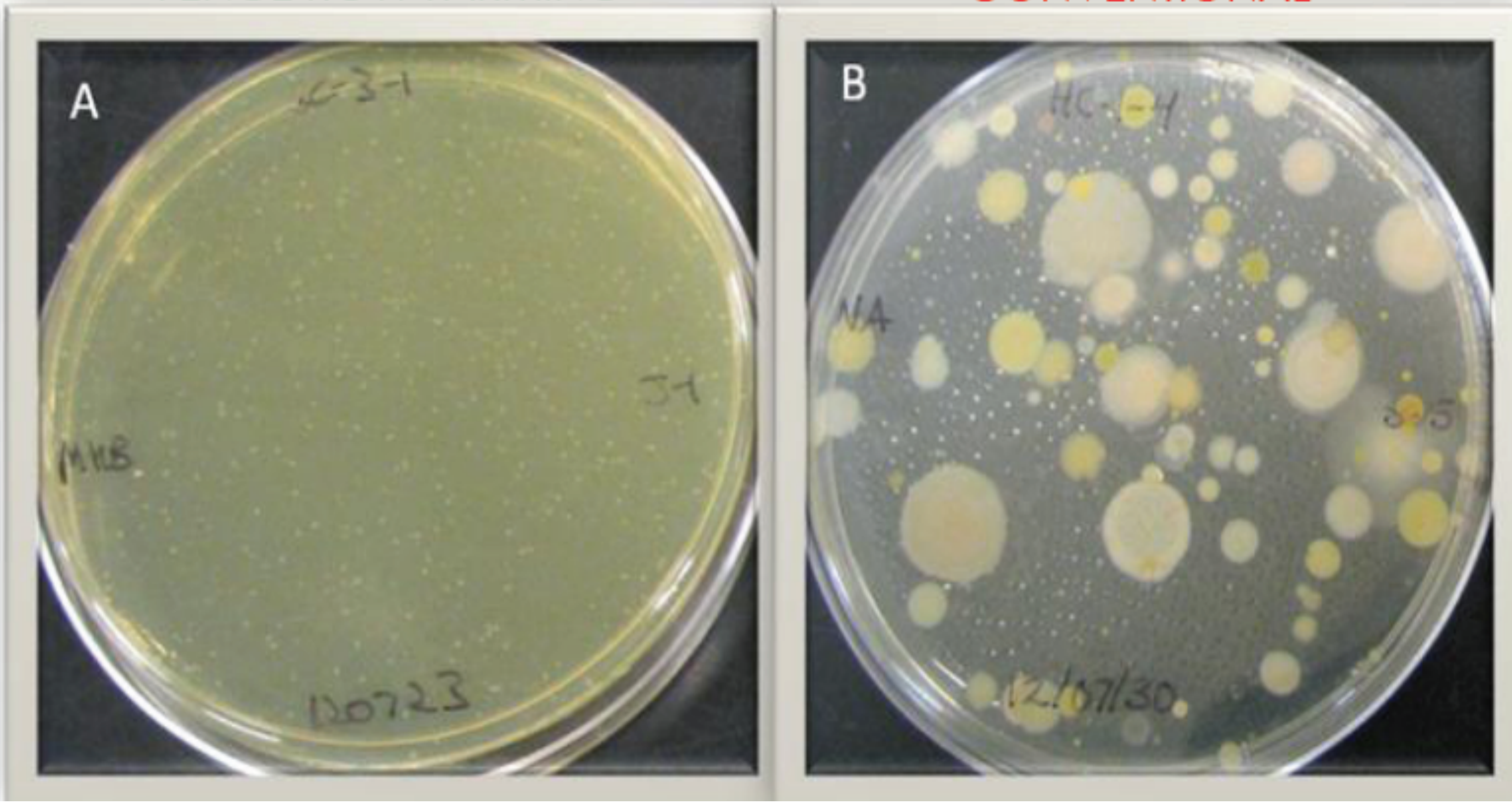
2012

"One of the things that pops up immediately in our analysis is that Mr. Glenney's plants use up all of the fertilizer almost within 70 days after planting. So some way this plant is sucking up all of the nutrients, but we're not sure why yet" "The other field still has quite a lot of fertilizer remaining even at the end of the season. It just doesn't get used. One of the fundamental things that's happening is in one field the root system must be more efficient in taking up the nutrients."

Dr. George Lazarovits

BACTERIA COLONIES FROM STEM JUICE

FENCE ROW FARMING | CONVENTIONAL



“We’re finding huge numbers of bacteria inside corn plants; and the bacteria that are inside Mr. Glenney’s corn plants are completely different than the bacteria typically found in corn.

Dr. George Lazarovits