



Stimulate the Seed

# The New Technologies

Dr. Gary Harman





# ENHANCEMENT OF PLANT PRODUCTIVITY THROUGH ABM'S PRODUCTS

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*Professor Emeritus, Cornell University*



# THE TECHNOLOGICAL AND PROPRIETARY ADVANTAGES OF ABM

## The technological and proprietary advantages of ABM

- *Trichoderma*
- *Bradyrhizobium and Rhizobium*
- *Bacillus*
- Microbial metabolites
- Additives and Adjuvants
- Knowledge-based systems

# INTEGRATED PEST MANAGEMENT

- **If organisms are resistant to most chemical pesticides, can apply both**
- **Chemical pesticides give high level pest control, but for only days or at most months**
- **Endophytic plant symbionts can provide long-term, at least season long advantages**
- **Can include N-fixing bacteria**

# UNDERSTANDING MECHANISMS IS CRITICALLY IMPORTANT

Understanding mechanisms is critically important for:

- Strain selection
- Optimizing products and uses
- Developing products and applications

Strains need to be:

- Multifunctional
- Endophytic plant symbionts
- May need strain mixtures for optimal results

# OLD STRAIN AND NUE

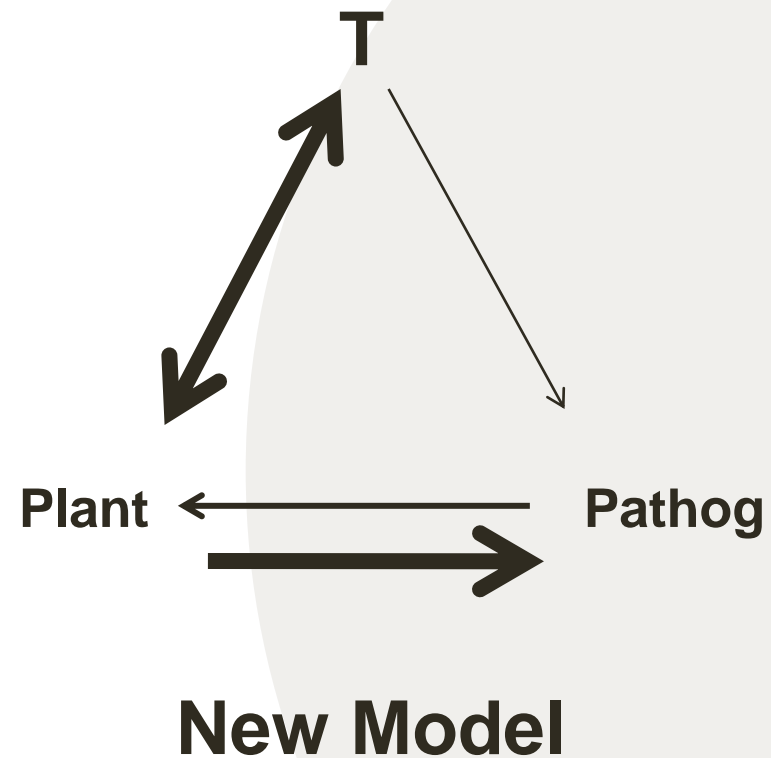
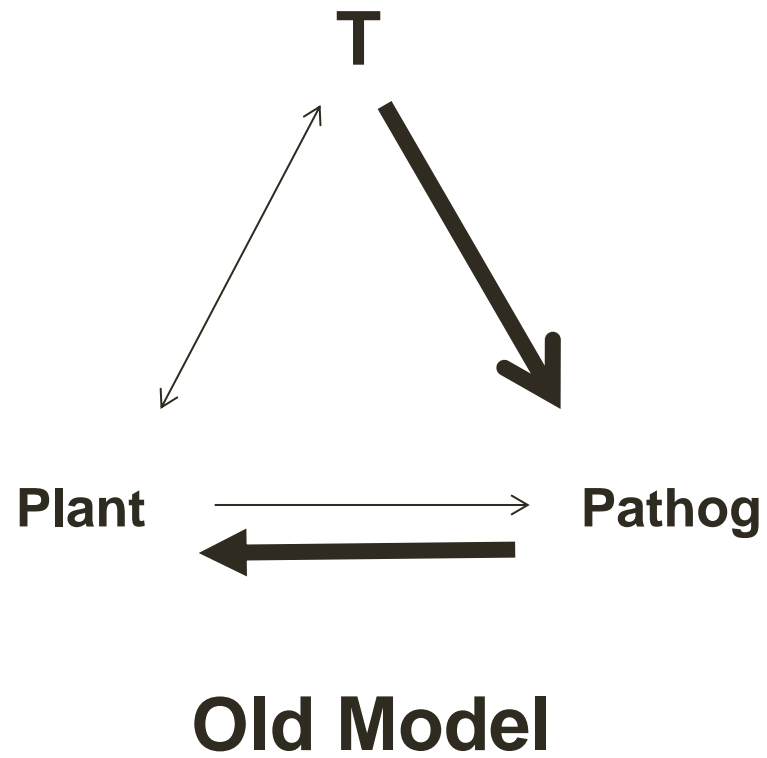
## Old Strain T22

- Seed treatments with T22 frequently gave yield improvement, enhancement of N use efficiency
- Some maize genotypes gave negative yield interactions
- **RESULTS VARIABLE:  
WE DID NOT UNDERSTAND MECHANISMS**

## First Observation of NUE in 1998

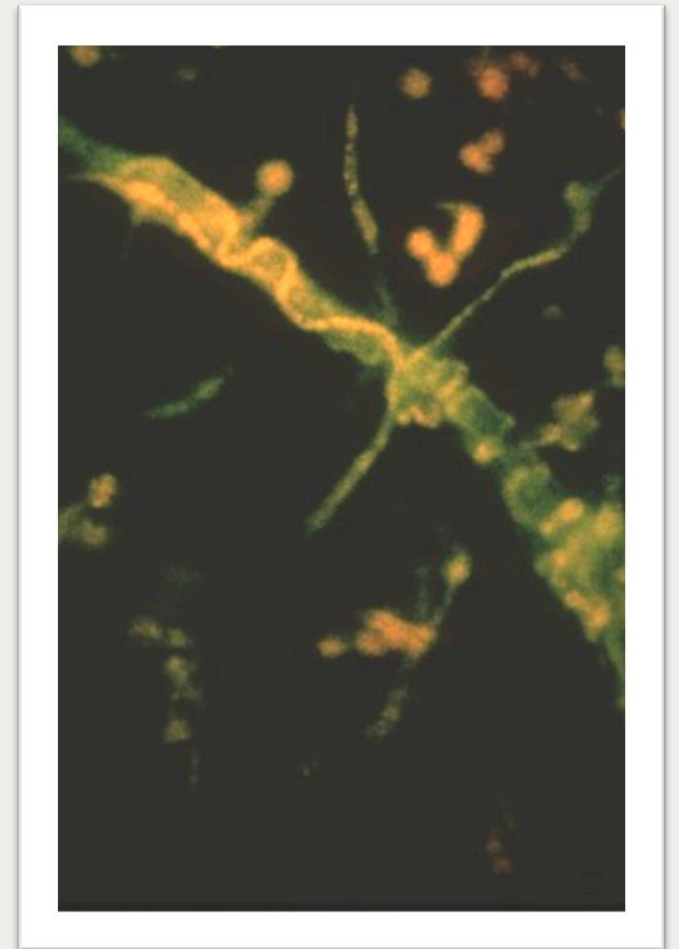
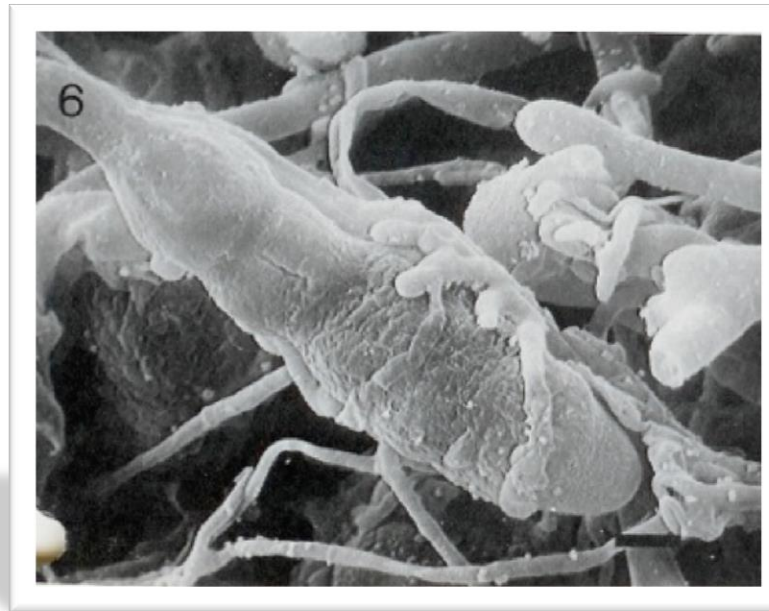
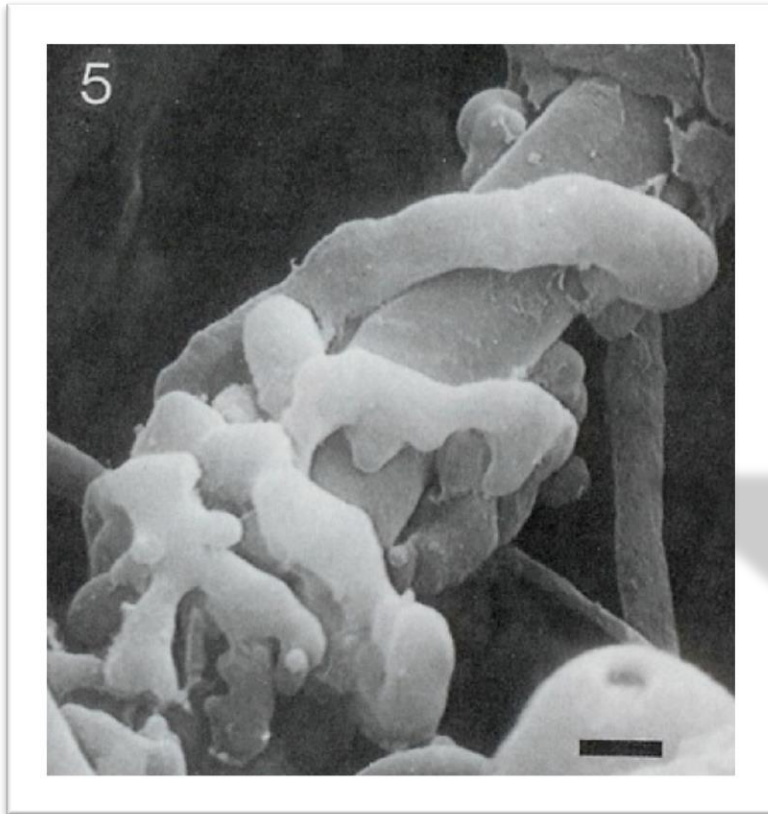


# FROM UNDERSTANDING COMES PROGRESS



# OLD MODEL – MYCOPARASITISM

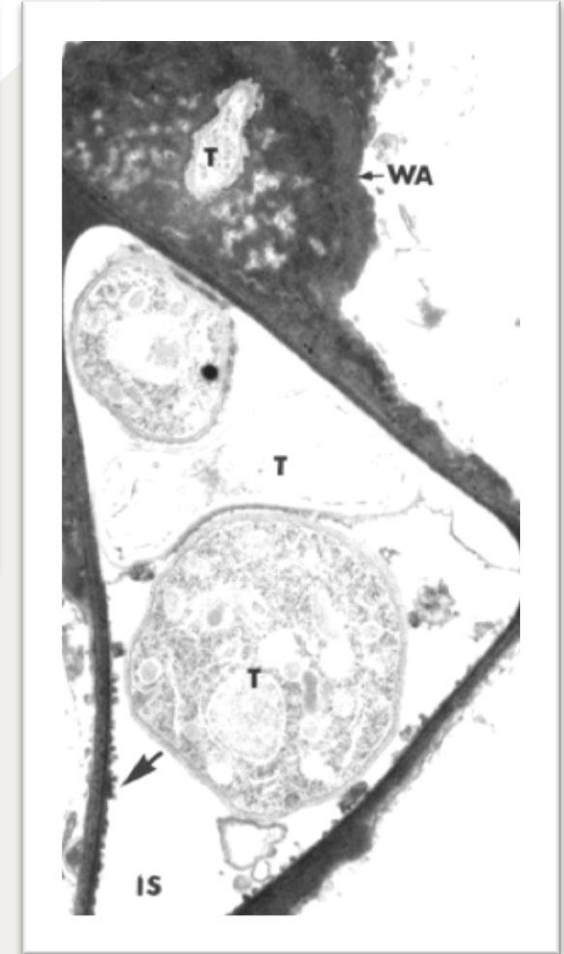
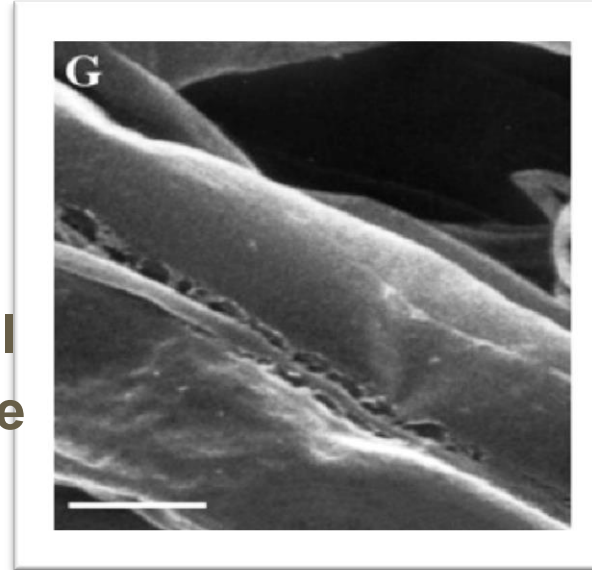
Probably is important in some systems but may be primarily of ecological importance.





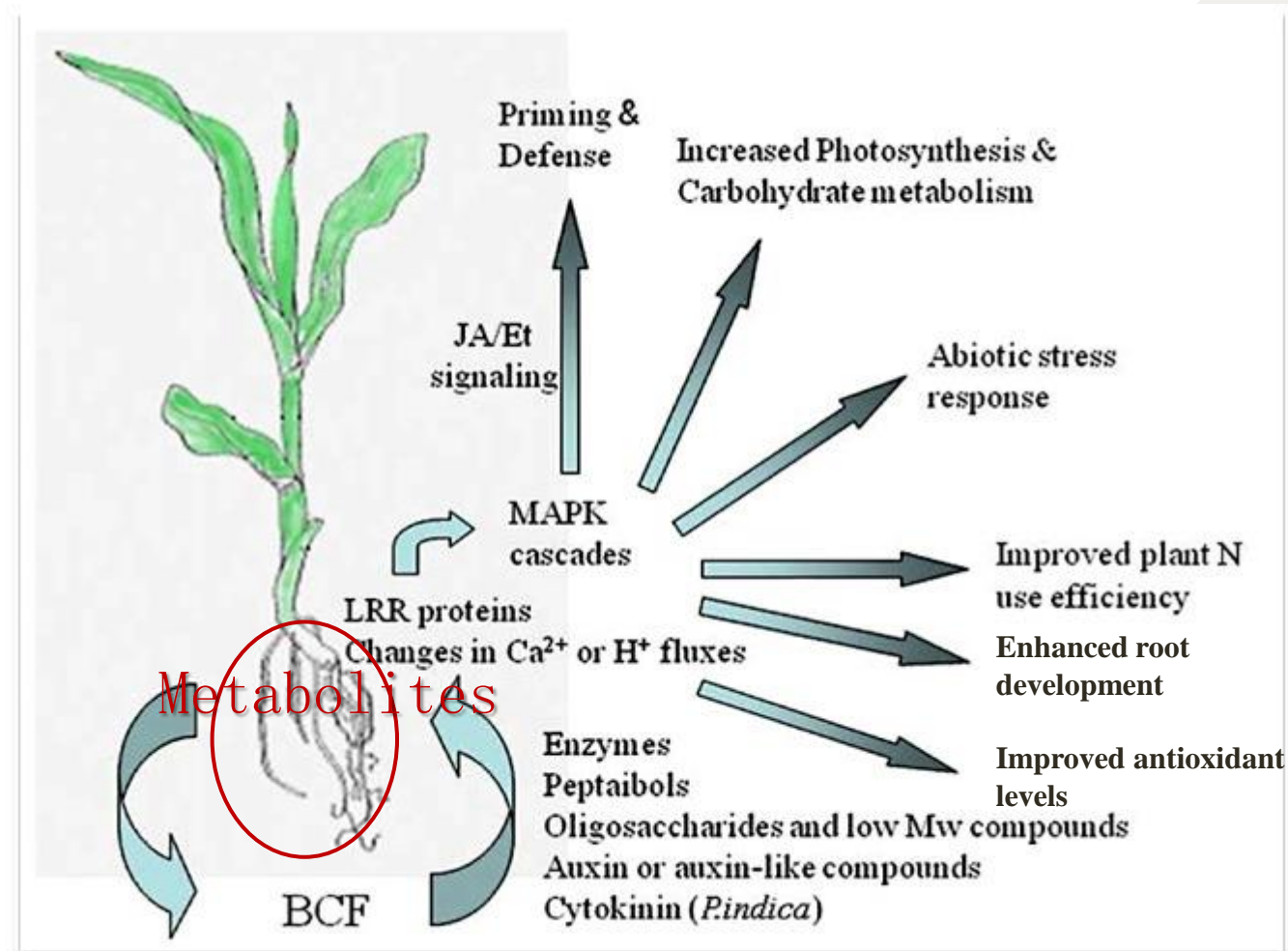
# INTERACTIONS OF *TRICHODERMA* WITH PLANT ROOTS

- *Trichoderma* colonize and penetrate roots
- Once in roots they establish chemical communication with plants that cause plants to wall off fungal hyphae
- The best strains establish long-term relationships with plants that are highly beneficial



# GLOBAL SUMMARY OF TRICHODERMA RESPONSES IN PLANTS

Greatest changes in plant gene expression in shoots, *Trichoderma* only in roots.



# METABOLITES VS ENDOPHYTIC MICROORGANISMS

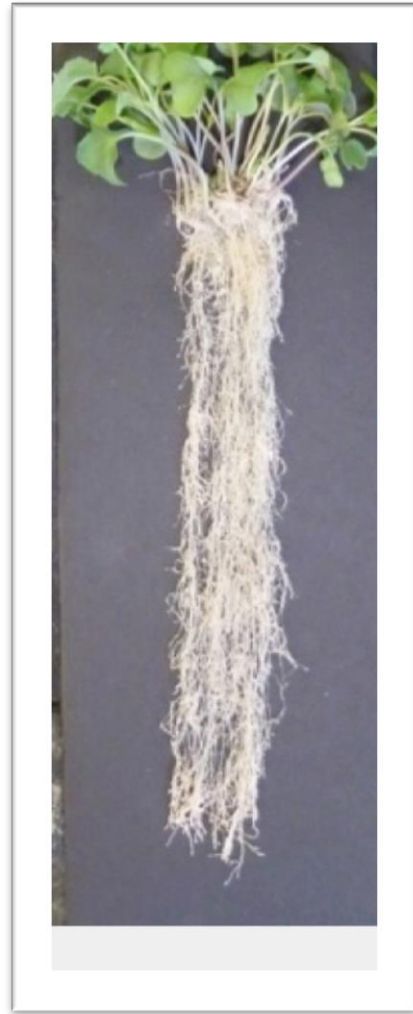
## Metabolites

- Active at very low concentrations
- Products of endophytic microbes by which systemic changes are induced
- Activity transitory, only a short time
- Induce systemic alteration of plant physiology
- Examples: Optimize, metabolites we are developing

## Endophytic Symbiotic microbes

- Added to seeds at low levels, must grow to be effective
- Colonize roots and produce metabolites
- Season-long activity
- Induce systemic alteration of plant physiology
- Examples: *Bradyrhizobium*, *Trichoderma*, *Bacillus*

# ABM DEVELOPING METABOLITES FOR SMALL SEEDS



# TRICHODERMA ALLEVIATE ABIOTIC STRESSES IN THE GREENHOUSE...

## Water Deficit



## Salt



## AND IN THE FIELD

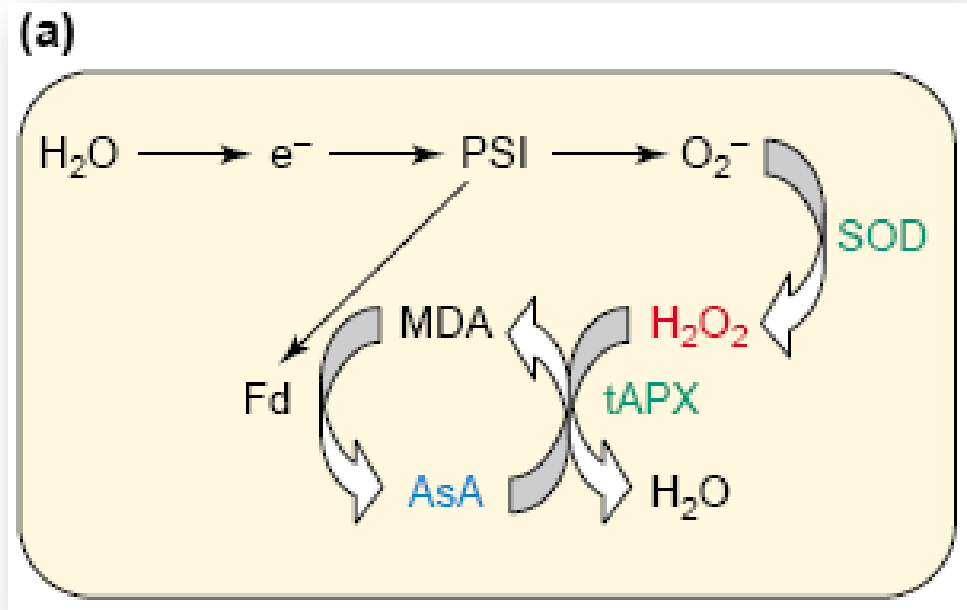


# WORKS YEAR AFTER YEAR—MN 2013



# GENOMICS TELLS US THE MECHANISMS— ROS MANAGEMENT IS PART OF THE STORY

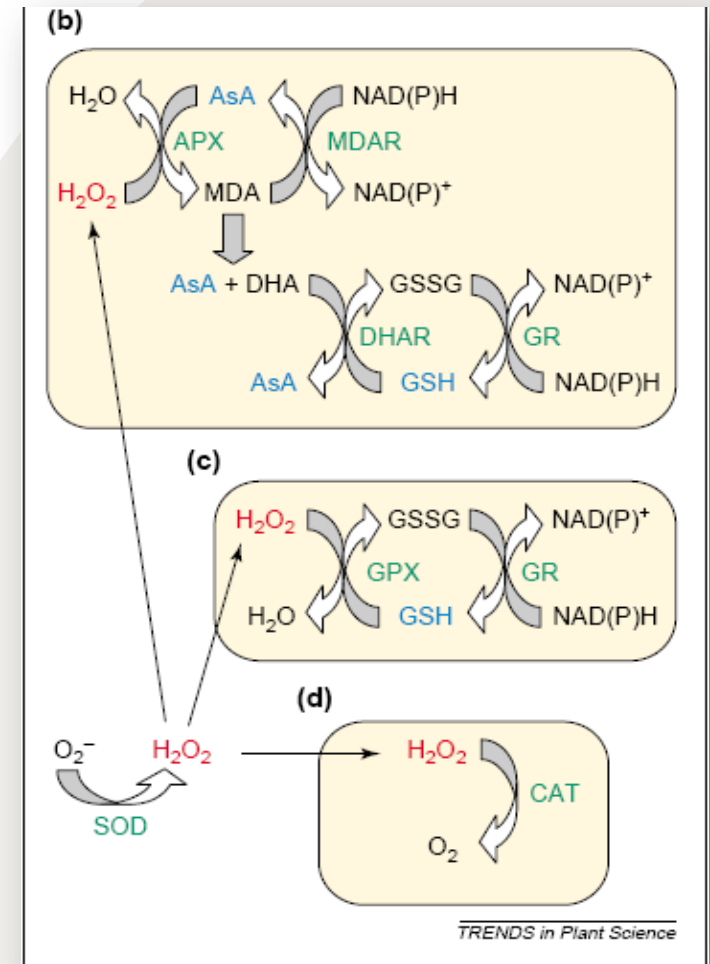
## Water-Water Cycle



## Glutathione- ascorbate cycle

## GPX cycle

## Catalase





# AS IS IMPROVED PHOTOSYNTHETIC CAPABILITY

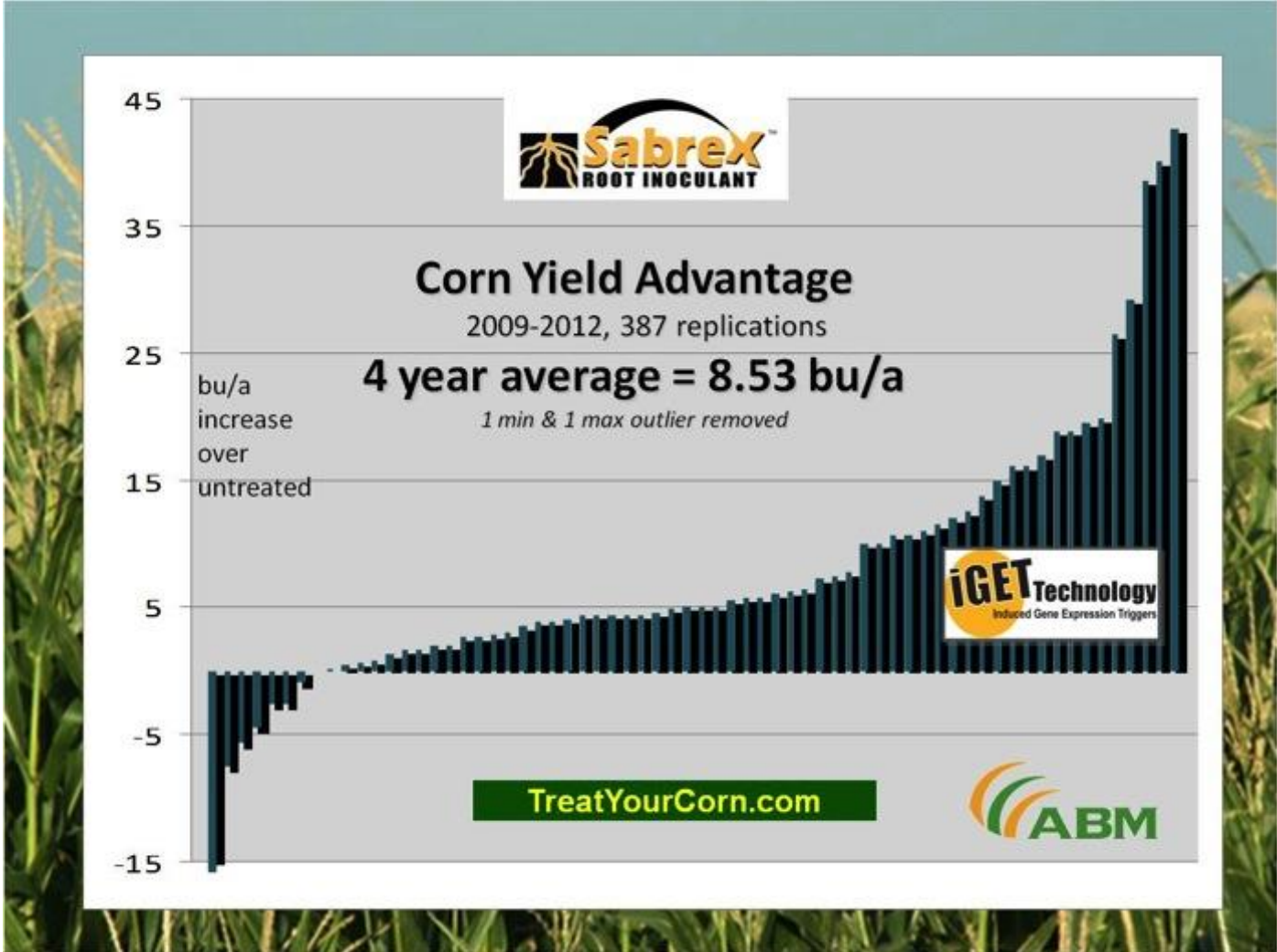


# MULTIPLE SYMBIONTS ARE A GOOD THING

- Multiple strains of the same genus
- Different organisms, so long as compatible—e.g., *Bacillus* & *Trichoderma*
- Multiple functions—e.g, N fixation plus the other attributes.



# CONSISTENT RESULTS, HIGH ROI TO GROWERS

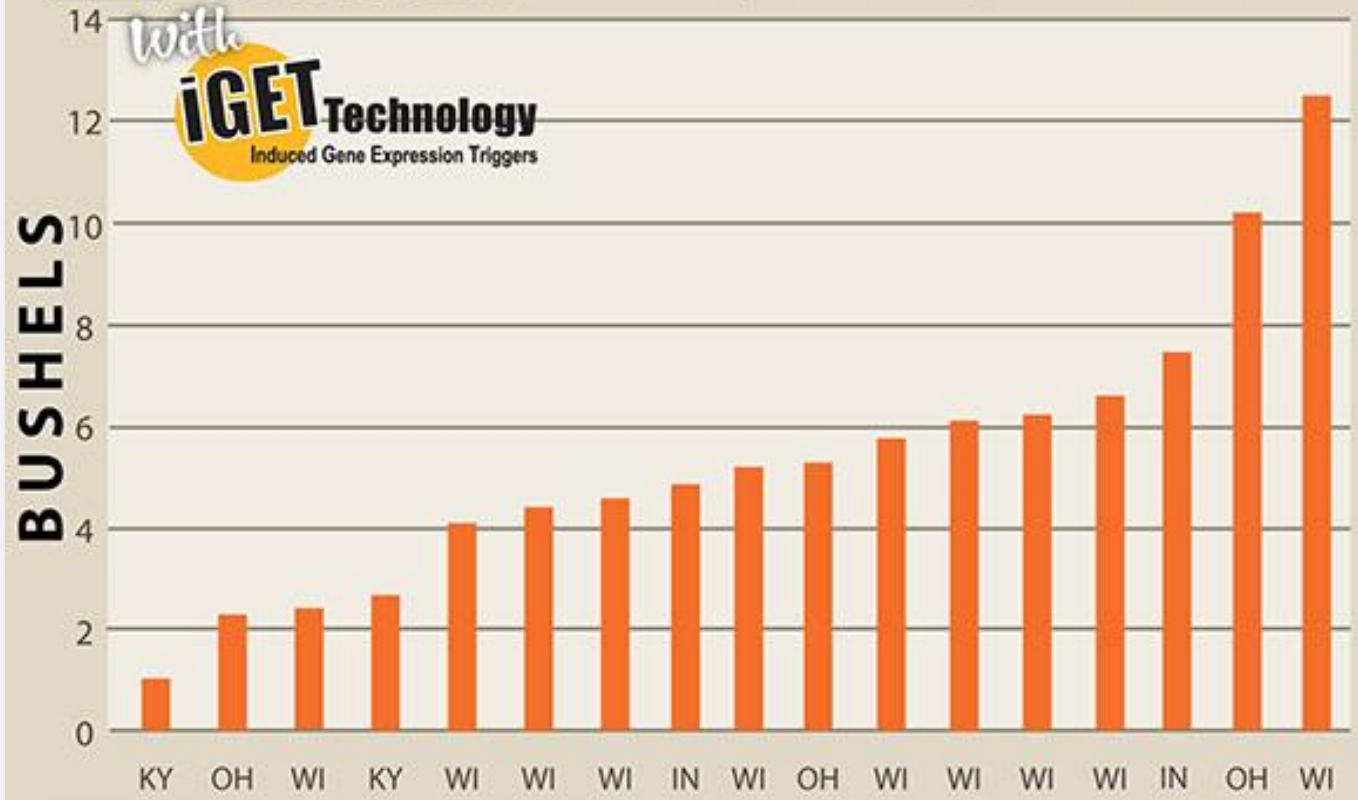




## Wheat Yield Advantage

Winter wheat harvested 2009-2012 (45 reps)

4 year average = 5.3 bu/a



*bu/a increase over untreated*

# UNIQUE TRIPLE STACK INOCULANT FOR SOYBEANS

- **Unique triple stack for soybeans**
- **Effective over wide range of soil and climate conditions**
- **Three rhizobia strains for wider crop response**
  - Hot dry soils
  - Cool wet soils
  - Nitrate carryover

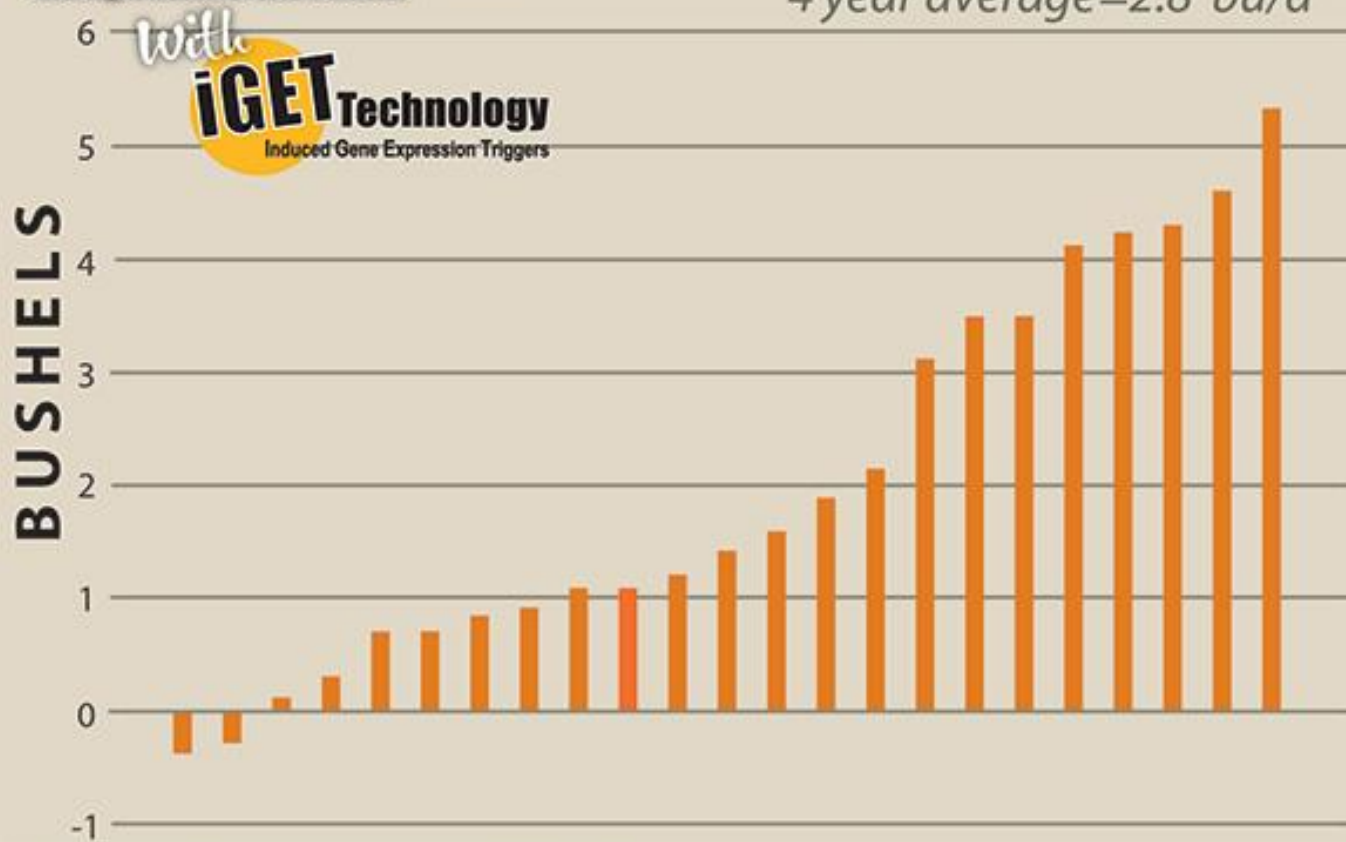


**Excalibre SA**<sup>TM</sup>  
Encapsulated Inoculant

## Soybean Yield Advantage

2009-2012, 127 replications

4 year average = 2.8 bu/a



bu/a increase over untreated

# MARAUDER™ SOYBEAN INOCULANT SYSTEM



- Aggressive nodulation by the Bradyrhizobia
- Ultra Low application rate, with improved treatability
- 60 day planting window after application to seed
- Bacillus-based product

## Soybean 2012 – 127 — Wisconsin

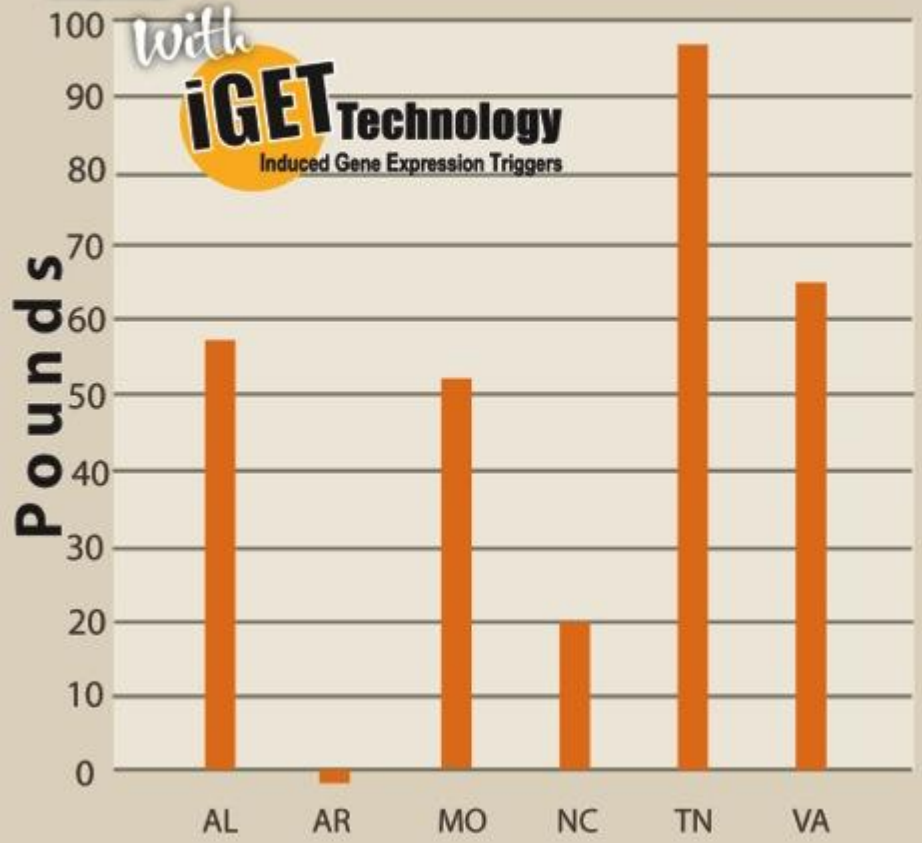
	V4 plant	V4 plant	Days to canopy	R3 plant	Harvest R8 grain	Adjusted to @13% grain	
<i>Treatment list</i>	<i>Density x1000</i>	<i>Vigor 1-9</i>	<i>Closure days</i>	<i>Vigor 1-9</i>	<i>Moisture %</i>	<i>Yield bu/acre</i>	<i>Increase bu/acre</i>
Untreated	150.0	6.0	62.8	7.0	14.2	43.84	
<b>Marauder™</b>	<b>152.1</b>	<b>7.3</b>	<b>60.8</b>	<b>8.0</b>	<b>14.2</b>	<b>46.22</b>	<b>2.39</b>
Excalibre SA™	155.1	7.8	60.5	8.3	14.2	46.46	2.63
GraphEx SA™	153.3	7.5	60.8	8.0	14.2	45.71	1.87
Optimize 400	150.2	7.0	61.8	7.8	14.2	44.66	0.83





Cotton  
Yield  
Advantage

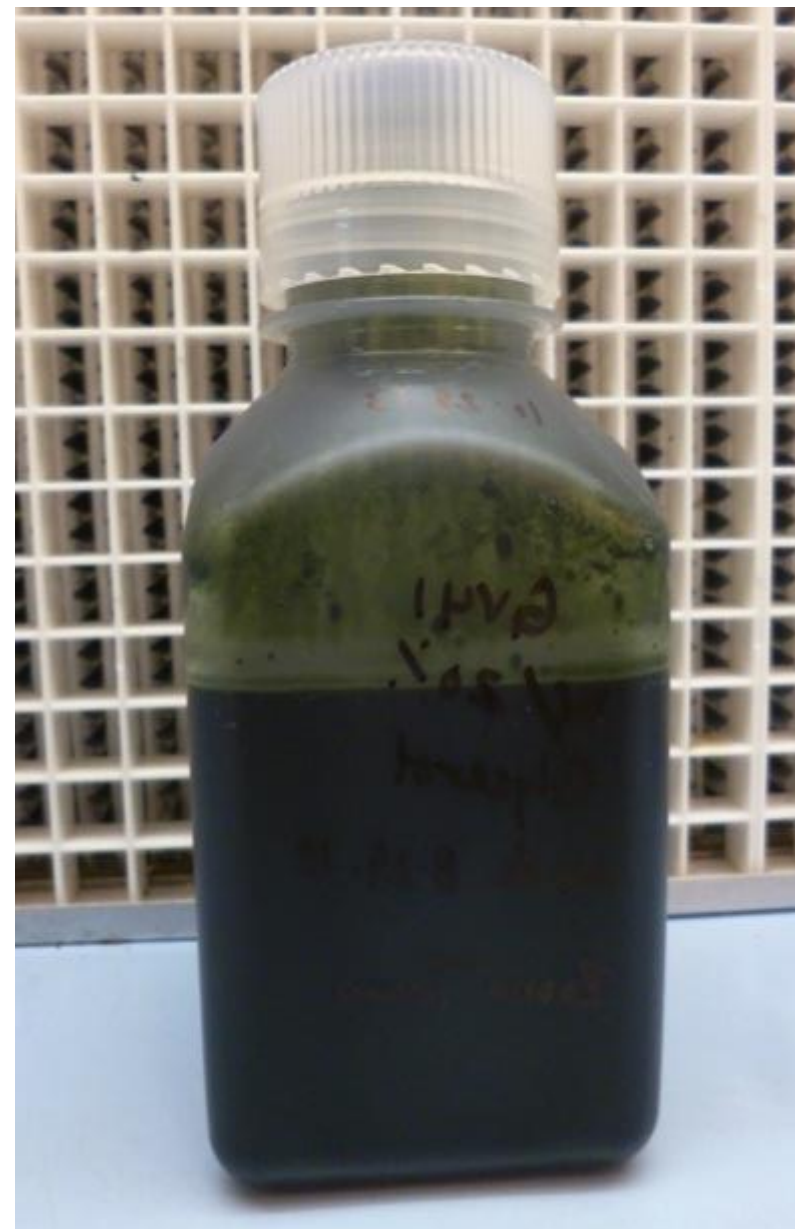
Average 48.65



*pound/a increase over untreated*

# FORMULATIONS

- Designed for conventional ag but Omri listing soon as well as some EPA registrations
- **Seed treatments**
  - Planter box
  - WP concentrates
  - Liquid concentrates
    - 1 gallon treats 2000 acres
- **Others**
  - Solid and liquid fertilizers
  - Organic pesticides
- **Proprietary technologies**



# **PRODUCTS IN THE PIPELINE**

**Highly effective organic broad spectrum pesticide**

**Products for greenhouse, turf and related uses**

**Seed treatments to enhance productivity of vegetable, flower, turf seeds**

**Knowledge based systems for plant variety improvement based on further develop of genomic technologies**

# ORGANIC PESTICIDE



Powdery mildew



White flies and greener

# THE KNOWLEDGE-BASED ADVANTAGE

- **-Omic technologies, followed by actual field results, demonstrate that**
  - Our biological up-regulate entire pathways.
    - Provide a wide range of advantages to plants WITHOUT genetic modifications—simply make plants work harder.

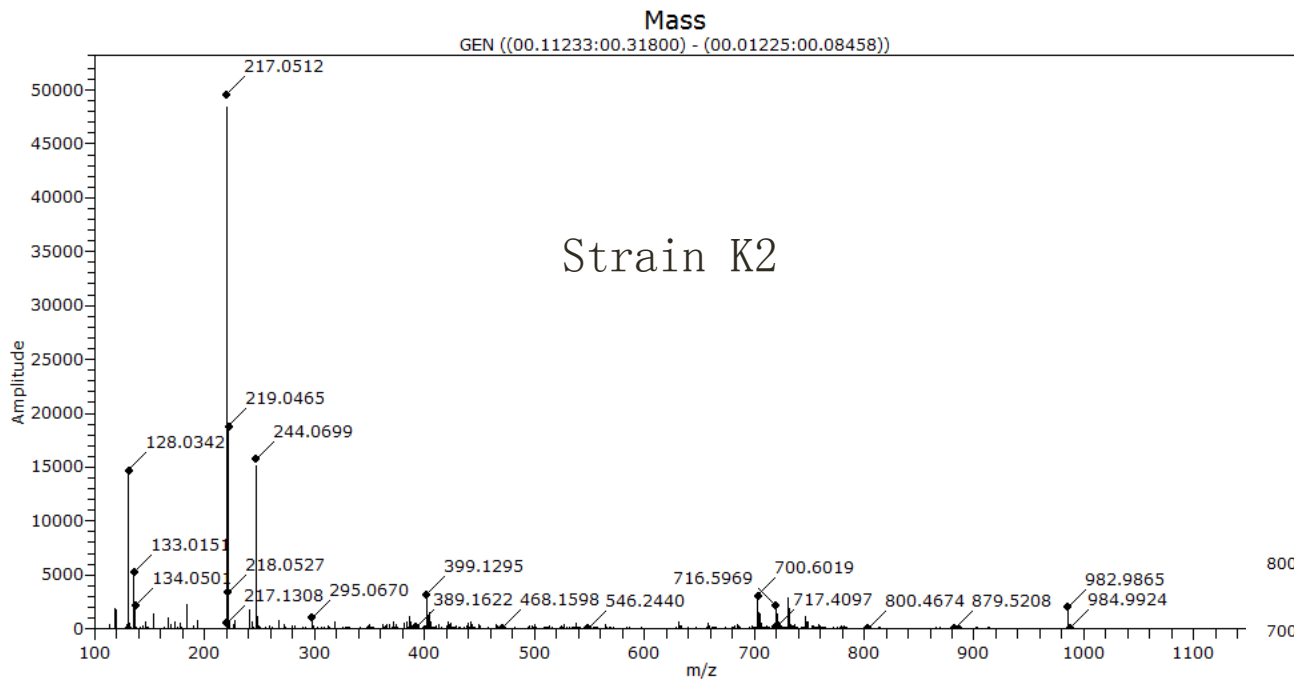
## Advantages of this technology base

- Better and better strain selection
- An excellent model for genetic crop improvement—if we know what genes and pathways are up-regulated by Trichoderma, then plant breeders and geneticists can use this info as a tool for crop improvement

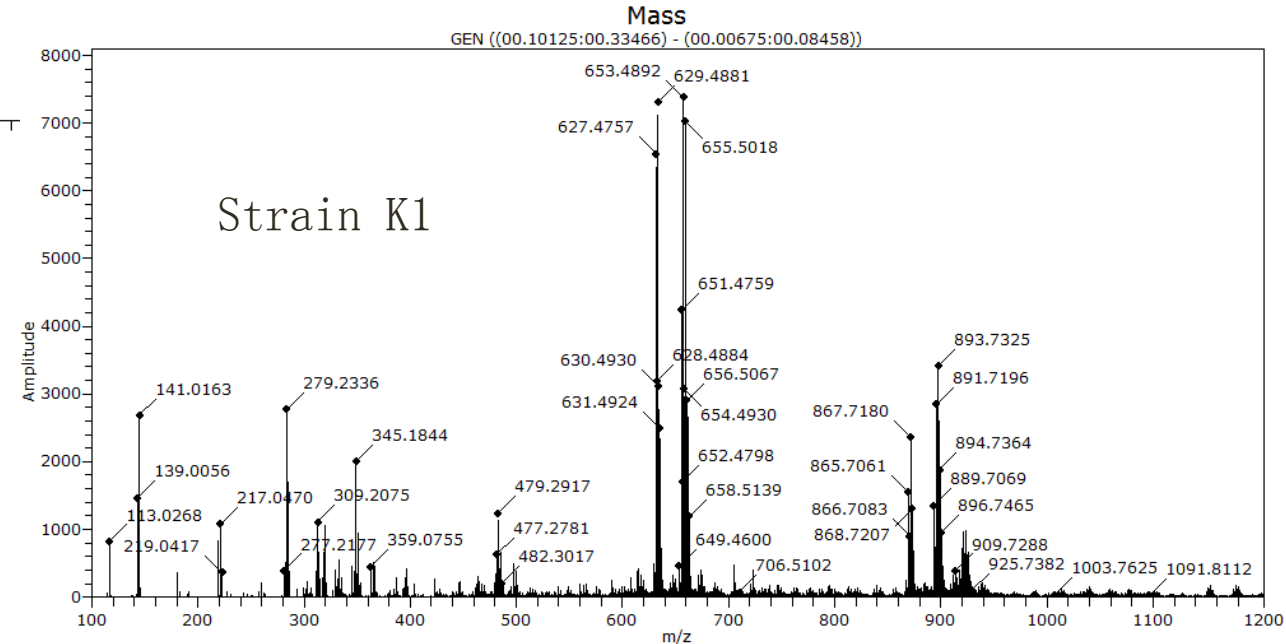
# RAPID PRODUCT IDENTIFICATION

- **We wanted to develop systems for rapid identification for**
  - Quick and rapid strain ID especially for patent protection purposes
  - Source coding for fruits and vegetables
  - Identity preserved seeds
- **Two approaches**
  - Genomic sequencing, ID of particular sequences that can be used.
    - For source coding and identity preserved seeds, we would use food grade organisms as source codes
  - Rapid time of flight mass spectroscopy.
    - 20 second determinations
- **Two patents filed**

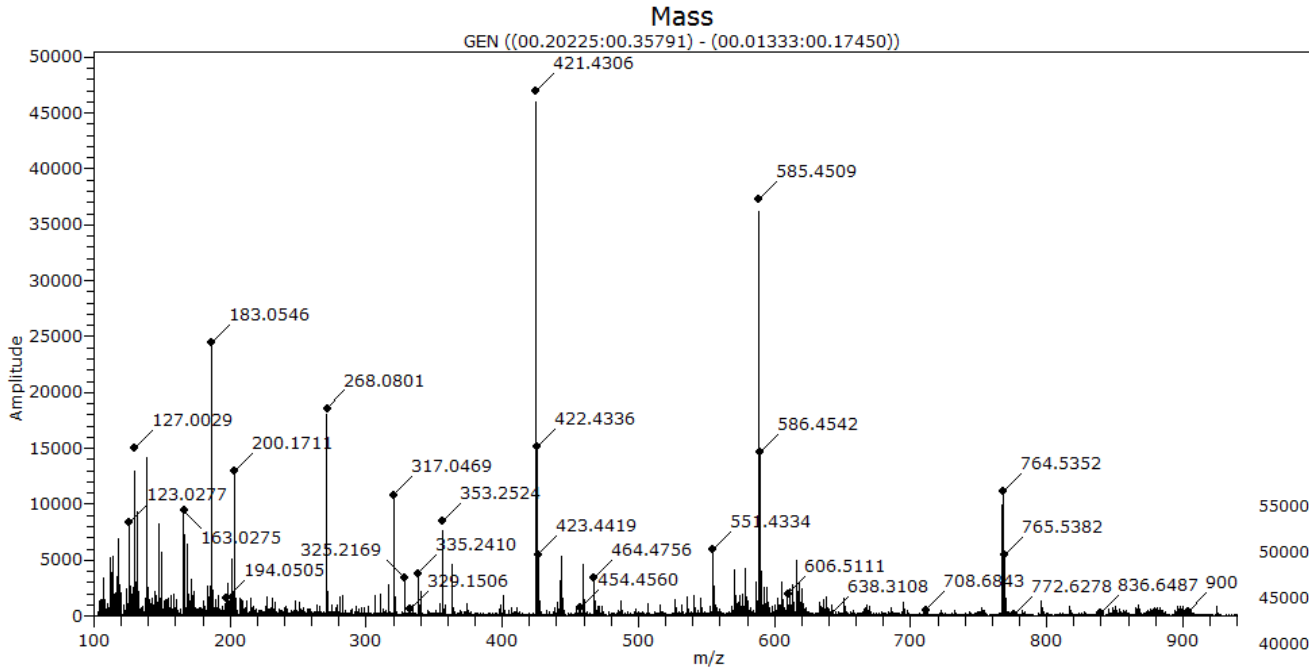
# TRICHODERMA STRAIN ID USING CELL WALLS



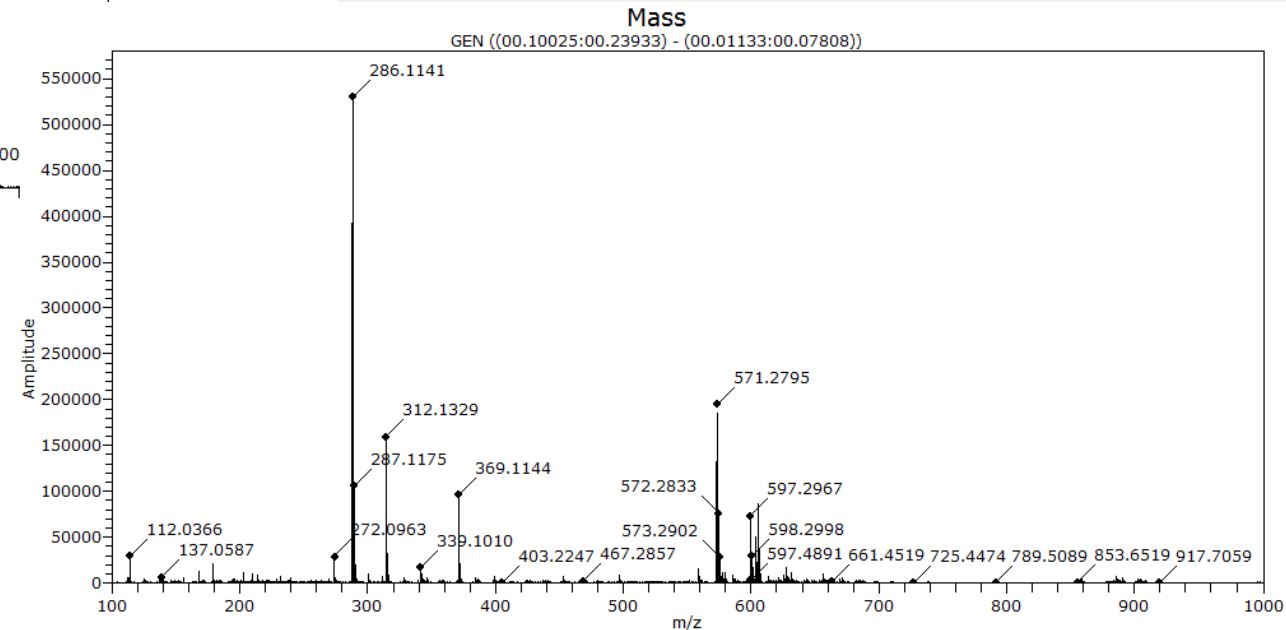
All solid materials, unusual for this type of analysis. Results in 20 seconds.



# SOURCE CODING USING FOOD GRADE MATERIALS AS MARKERS



Just spot with identifiers and place spot in machine. Results in 20 seconds. Thousands of tags to choose from.





# SPECTRAL DIFFERENCES WITH THREE TAGGING COMPOUNDS

Material 1	Material 2	Material 3
421.4306	286.1141 (arabinoside)	369.1147
585.4509	571.2795 (piperamide)	309.0851
183.0546	312.1329	339.0997
268.0801	369.1144	177.0106
422.4366	287.1175	370.1173
586.4542	598.2998	310.0886
764.5352	597.4891	119.0355
765.5382	572.2833	178.0143
217.0483	217.0485	307.0817
215.0329	215.0316	367.1041
219.0457	133.0412 (malic acid)	337.0928
244.0683	399.1238	675.2267
	315.0936 (quinic acid)	645.2127 (dimoracin)
	191.0561 (gallic acid monohydrate)	615.2000

Thousands of tags to choose from.



## **ABM IS COMMITTED TO:**

**A complete knowledge of the plant gene and protein expression changes that lead to improvements in crop performance that are induced by iGET (induced gene expression triggers) microbial technologies.**

**Pairing of the best in new crop improvements/genetics with iGET systems to maximally increase crop productivity.**

**This won't be just *Trichoderma* based, we will use the best of other microbes**

- Novel new classes and strains of microbes, including PGPR
- New and improved products for iGET type systems

# ASSOCIATE SCIENCE OFFICER

- **Dr. Molly Cadle-Davidson**
  - Highly skilled in molecular biology, genomics, metabolomics
  - Becoming trained to become the CSO when Harman retires
  - Will go to work officially Jan. 1 but she is already heavily involved in grant writing, etc.



## NEWEST EMPLOYEE

- Dr. Walid Nosir
- Comes with his own IP
- Biofilters that
- Remove pathogens from hydroponic, other fertigation systems.
- Adds *Trichoderma*, *Bacillus*, metabolites automatically
- More rapid plant growth, better roots, earlier fruiting or flowering, NO disease



## SOUTH AFRICA—DR. RONEL HENDRICKS

- ABM South Africa
- Skilled in microbiology, microbial production and technology.
- Production and distribution to the southern hemisphere
- Product testing and development in southern hemisphere—365 days of testing and development.
- Additional product development, production systems and development



# WORLD WIDE ROLLUP STRATEGY

- **We know the best people around the world in plant-microbe technologies**
- **We are bringing these people together in ABM to drive technology development.**
- **Knowledge derived can be used to:**
  - Create even better strains
  - Determine changes in plant gene expression/pathways that can be used for plant genetic improvement. Pathways upregulated = improved plant performance is a powerful guideline for plant genetic improvement.

# PROFESSOR OF BIOTECHNOLOGY APPLIED TO PLANT PATHOLOGY--ITALY

*M. Lorito on the national TV channel Canale 5*

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of Arboriculture, Botany and Plant Pathology  
Section of Plant Pathology, Biocontrol Laboratory



**Matteo  
Lorito**

## CONSULTING SCIENTIST DR. DAVID KUYKENDALL



- Expert on Bradyrhizobium, Rhizobium
- Inventor of the Triple Stack inoculum, peanut inoculant

## PROFESSOR JIE CHEN, SHANGHAI JIAO TONG UNIVERSITY



- Already has products introduced into China that he has developed.
- Potential for us to sell his products in China, acquire new ones.
- Good cooperater with expertise in *Trichoderma* and plant-*Trichoderma* genomics

**ABM IS COMMITTED TO HIGH LEVEL SCIENCE  
TO BRING TO ITS CUSTOMERS THE MOST  
ADVANCED PRODUCTS IN SHORTEST TIME**

*Performance tested, rapid translation from the lab to the  
field.*