UNRAVELLING SOIL AND CROP HEALTH FROM THE AIR

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Dr. Ali

Dr. Saldias

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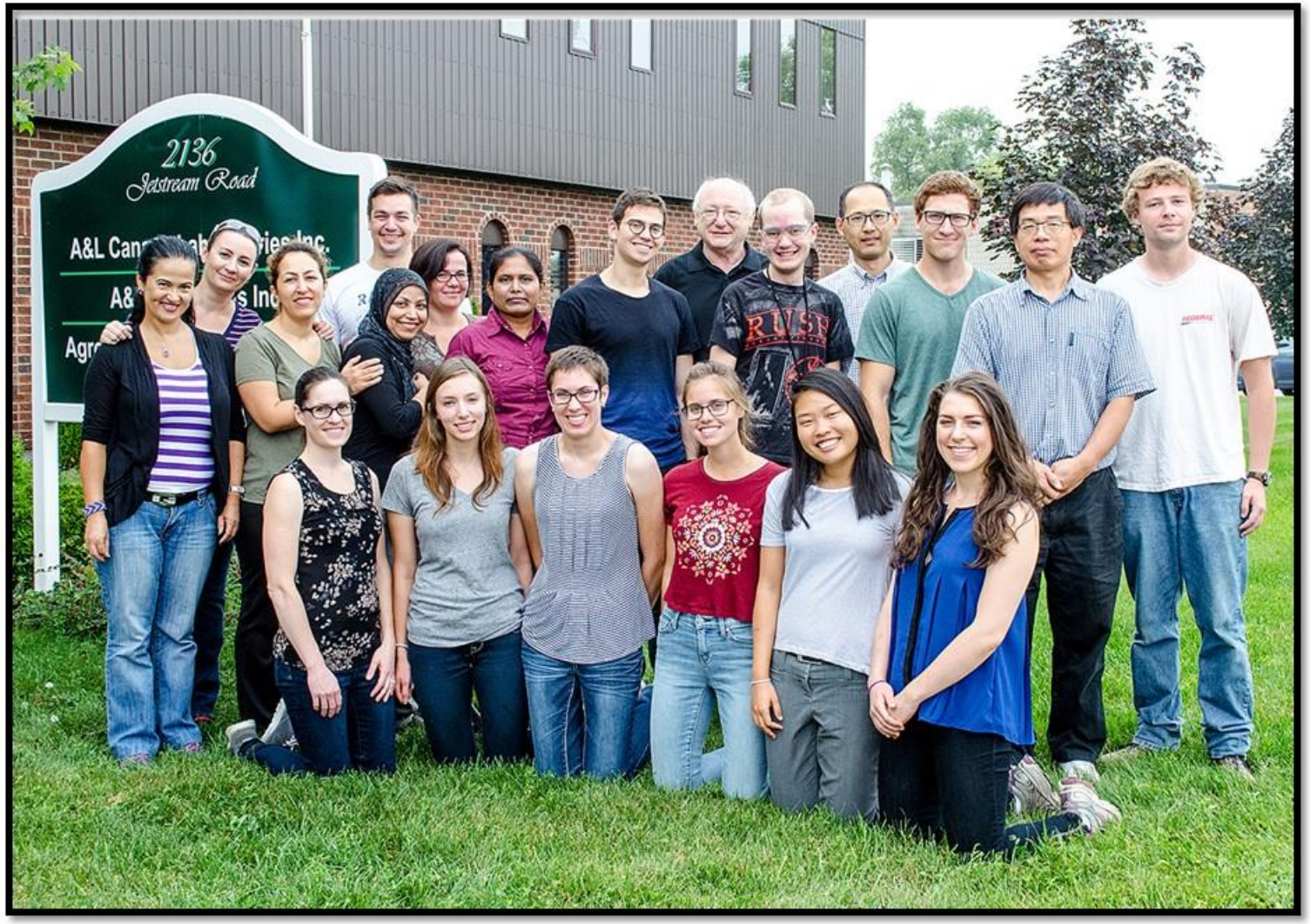
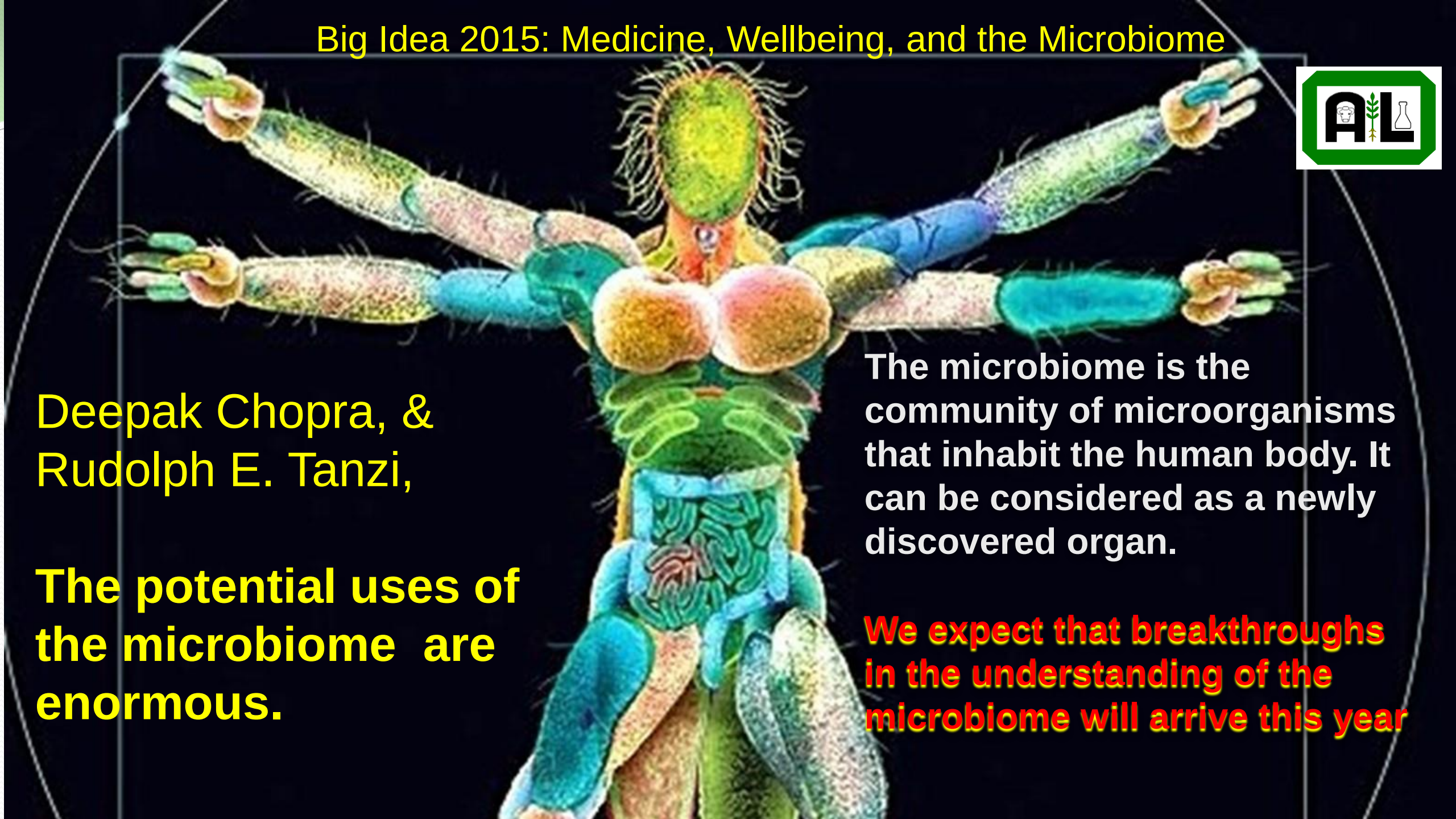


Big Idea 2015: Medicine, Wellbeing, and the Microbiome



Deepak Chopra, &
Rudolph E. Tanzi,

The potential uses of the microbiome are enormous.

The microbiome is the community of microorganisms that inhabit the human body. It can be considered as a newly discovered organ.

We expect that breakthroughs in the understanding of the microbiome will arrive this year

Mom Knows Best: The Universality of Maternal Microbial Transmission

Funkhouser and Bordenstein PLOS Biology |Aug 2013 | Vol 11 | Issue 8

- Infants are ‘‘inoculated’’ with mom’s microbes as they exit the birth canal
- C-section infants have microbiomes similar to human skin: in 2010, 33% of all births in the USA were C-section
- C-section babies have higher incidences of asthma, celiac disease, type 1 diabetes, inflammatory bowel disease, etc.
- Hospitals are now starting to collect the maternal microbiome on gauze prior to a C-section and swab the baby upon removal from the womb
- COST < $1
- **POTENTIAL LONG TERM HEALTH COST SAVINGS: BILLIONS**

GUT BACTERIA 'may be obesity weapon’

Bacteria were placed into mice grown in a sterile environment such that they had no gut bacteria of their own.

Transplanting gut bacteria from obese people into mice led to weight gain while bacteria from lean people kept them slim.

- SOIL IS A LIVING ORGANISM COMPOSED OF BILLIONS OF MICRO AND MACRO ORGANISMS

- IN NATURAL ECOSYSTEMS THE MICROBES ARE AN ESSENTIAL ELEMENT OF PLANT PRODUCTIVITY

- GROWERS ARE INTRESTED IN THE ROLE OF MICROBIOLOGY BUT THEY ARE NOT SURE ABOUT HOW THEY CAN BE USED

  TO SOME EXTENT THE USEAGE OF BIOLOGICALS HAS BEEN TAINTED BY HYPE AND VARIABLE RESULTS

RHIZOBIA FIX NITROGEN

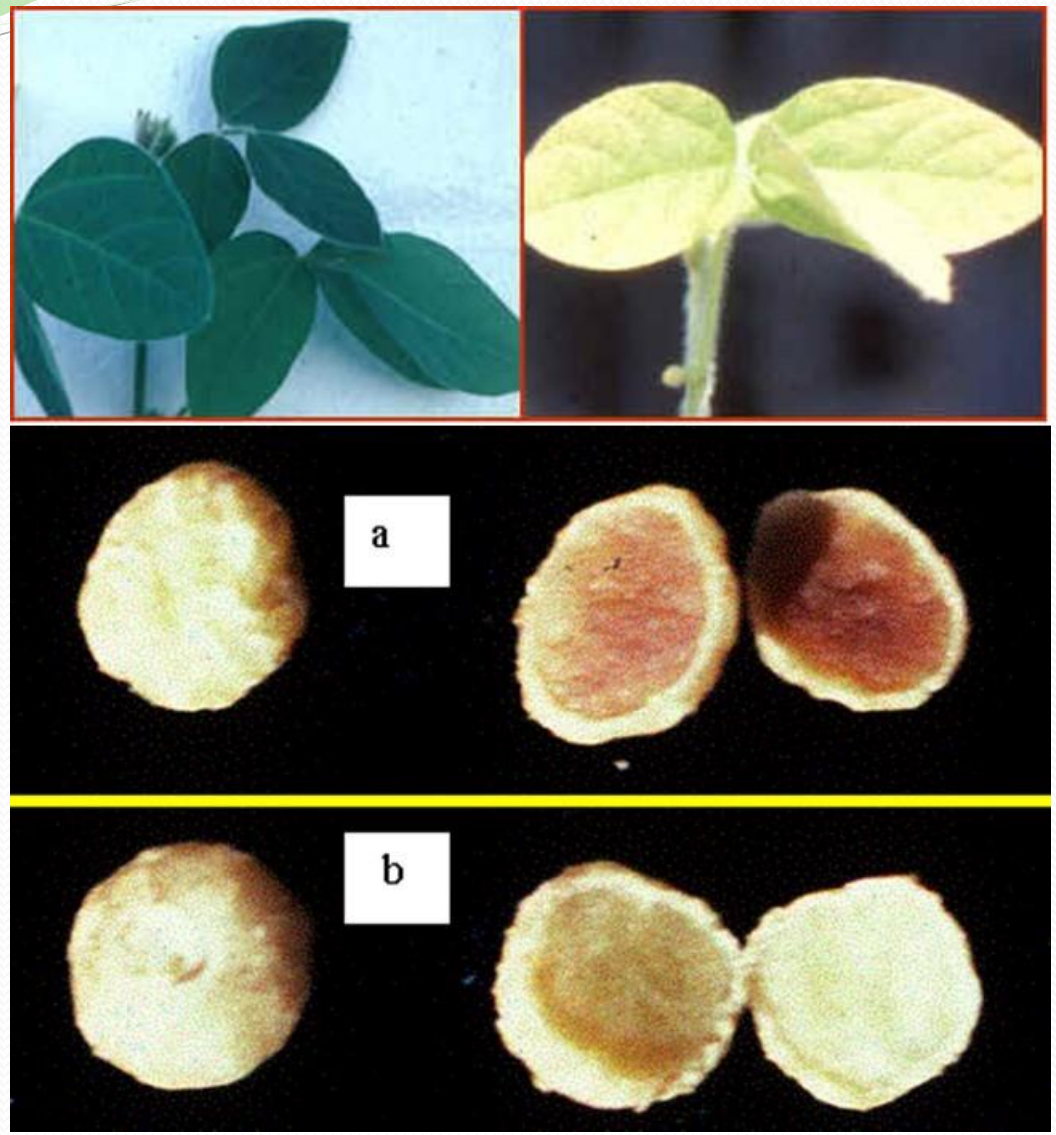
MUCH OF THE TECHNOLOGY FOR THEIR USE WAS DEVELOPED IN CANADA

- plant and soil specific
- Nodulation related to population density
- Interactions in the plant for recognition, nodule formation etc. are regulated by at least 26 genes and an unknown number in the bacteria

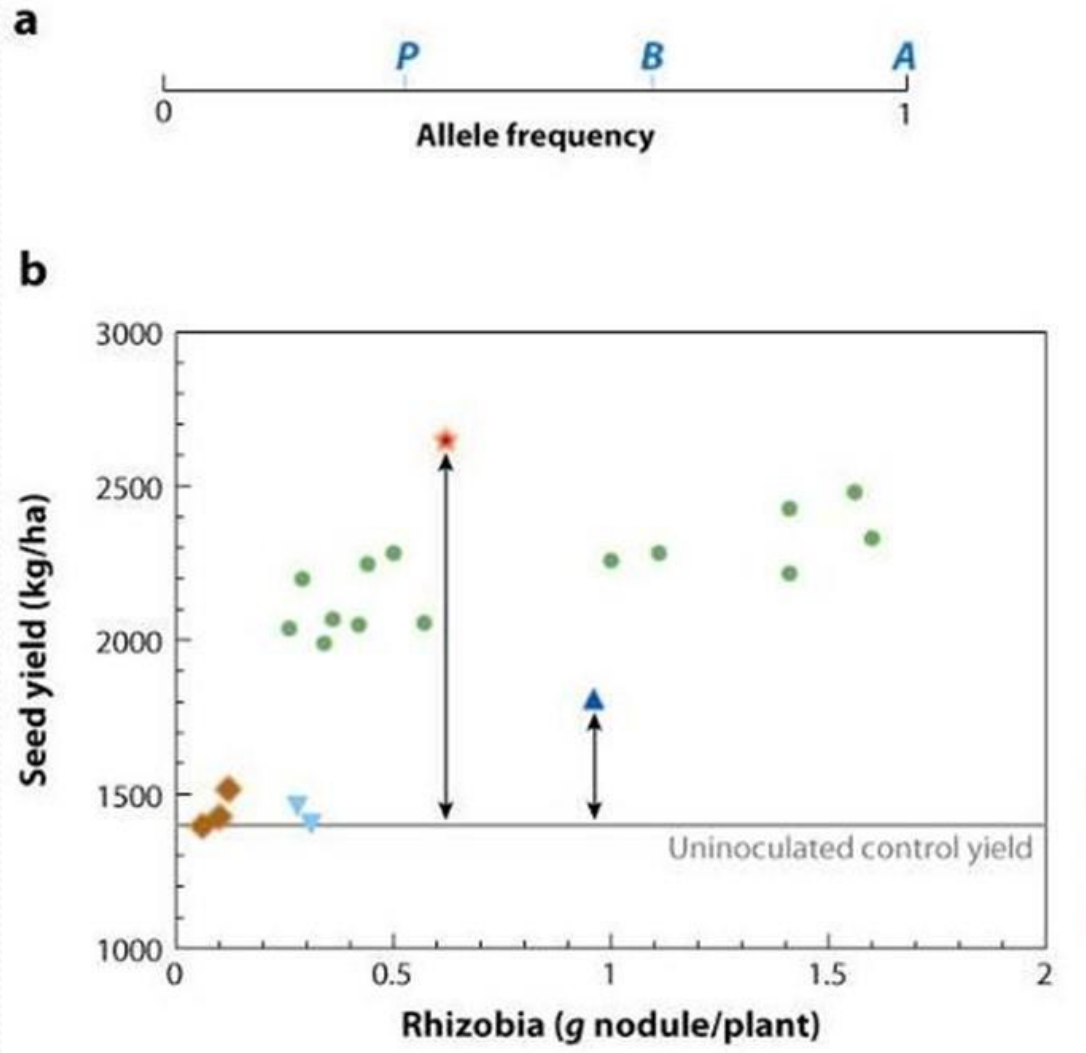
WHY WAS THIS INTERACTION MAINTAINED?

BECAUSE PLANT BREEDERS HAD A <u>PHENOTYPE</u>

NOT ALL RHIZOBIUM INTERACTIONS ARE BENEFICIAL



Gwata et al. African J. Biotech. 2: 417-420, 2003



Kiers ET, Denison RF. 2008.
Annu. Rev. Ecol. Evol. Syst. 39:215–36

Plant Soil (2010) 336:129–142
DOI 10.1007/s11104-010-0454-7

REGULAR ARTICLE

Enhancement of rice production using endophytic strains of *Rhizobium leguminosarum* bv. trifolii in extensive field inoculation trials within the Egypt Nile delta

Youssef G. Yanni · Frank B. Dazzo

Large-scale field experiments evaluated 5 varieties X 7 endophytic Rhizobia strains over 5 seasons, including **sites ranked as the world's highest in rice production**.

Inoculation increased yield in 19 of the 24 trials.

Increased yields were up to 47% in farmers' fields; average 19.5%.

Potential is billions in increased rice yields at reduced cost

The Brazilian Model Maximizing energy balance (output vs input) growing sugar cane

A brief story of nitrogen fixation in sugarcane — reasons for success in Brazil

***Funct. Plant Biol.*, 2002, 29, 417–423**

José I. Baldani[AB], Veronica M. Reis[A], Vera L. D. Baldani[A] and Johanna Döbereiner[†]

[A]Embrapa Agrobiologia – C.P. 74.505, CEP 23851–970 Seropédica, Rio de Janeiro, Brazil.
[B]Corresponding author; email: ibaldani@cnpab.embrapa.br
[†]In memoriam

Abstract. Sugarcane was first introduced into Brazil in 1532, in São Vicente (São Paulo State) by the Portuguese. Since the first cane selection and breeding programs started in Brazil, both local and introduced material were used. In none of the breeding programs were large amounts of nitrogen fertilizer utilized, and this may be the reason why today the best materials have little demand for nitrogen fertilizer, and an effective association has developed between endophytic nitrogen-fixing bacteria and the plant. In some cases high inputs of associated biological nitrogen fixation have been observed. The oil crisis also played a role in the sugarcane story, since the alcohol-from-cane-juice (PRO-ÁLCOOL) program installed to find a substitute for gasoline in cars, stimulated the selection of highly efficient varieties with low nitrogen fertilizer input. The recent promising results involving the inoculation of micropropagated sugarcane plants with endophytic diazotrophic bacteria, along with the ongoing Brazilian sugarcane plant and bacterial genome programs, suggest that the success of the Brazilian sugarcane business may continue for many years to come, considering the potential to be exploited.

1. **Plant selection and breeding was based on little nitrogen use.**
2. **The early research on utilization of microbes that supported plant growth and productivity**

Sugarcane endophytes are an integral component of production

- Most of the nitrogen required by the crop is provided by bacterial sugar cane **endophytes**
- These endophytes include: *Gluconacetobacter diazotrophicus*, *Herbaspirillum spp., Azospirillum* spp. and *Burkholderia* spp.
- *G. diazotrophicus* has been isolated from coffee, pineapple, sweet potato, etc., It has zinc and phosphate solubilizing activity, produces auxins, and antagonizes sugar cane pathogens
- Under commercialization by Azotic Technologies

Gluconacetobacter diazotrophicus

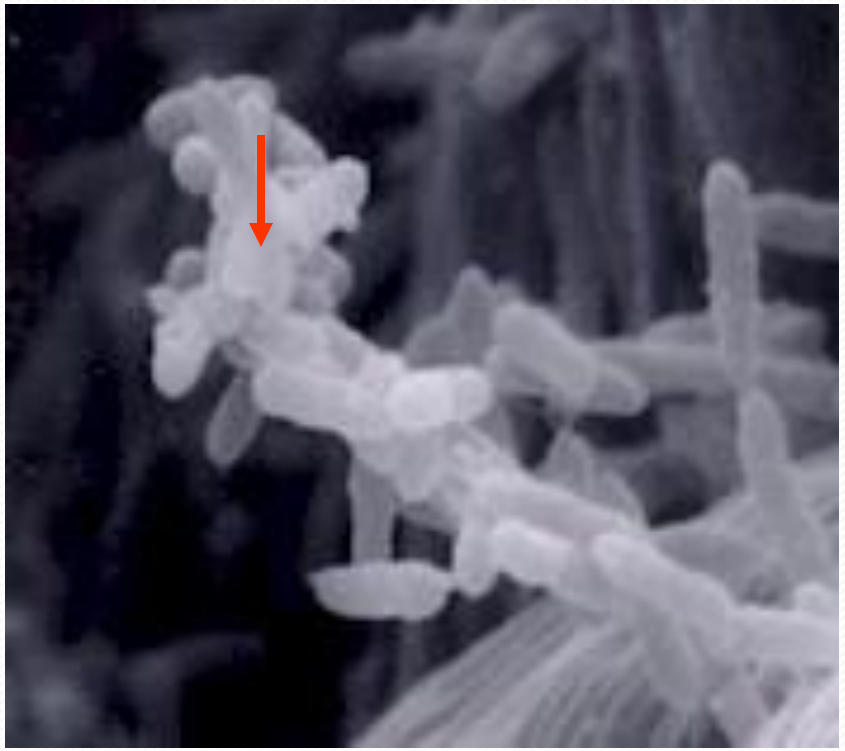


Table 3. Nitrogen fertilizer levels applied to sugarcane plants grown in different countries

Source: IFA (1999)

Country	Nitrogen fertilizer (kg ha^{-1})
Argentina	100
Australia	150–250
Brazil	50
India	100–300
Mexico	120–200
Philippines	120–200
South Africa	80–120
USA — Hawaii	300–400

Eur J Plant Pathol
DOI 10.1007/s10658-007-9201-1

FULL RESEARCH PAPER

Management of resident plant growth-promoting rhizobacteria with the cropping system: a review of experience in the US Pacific Northwest

R. James Cook

Fig. 1 Views of the same area within a 1-ha experimental plot cropped to continuous monoculture wheat starting in 1967/68 crop year. *Left*, 1974, the 7th year of monoculture facing north, showing the response to chloropicrin fumigation. *Right*, 1982, the 15th year of monoculture wheat, facing south but otherwise the same area within the 1-ha plot, with the man standing on the border separating a subplot fumigated from an adjacent subplot not fumigated. Yield of wheat in the non-fumigated plots was roughly 50% of the yield in fumigated plots in the 7th year of monoculture and 95% of the yield in fumigated plots in the 15th year of monoculture

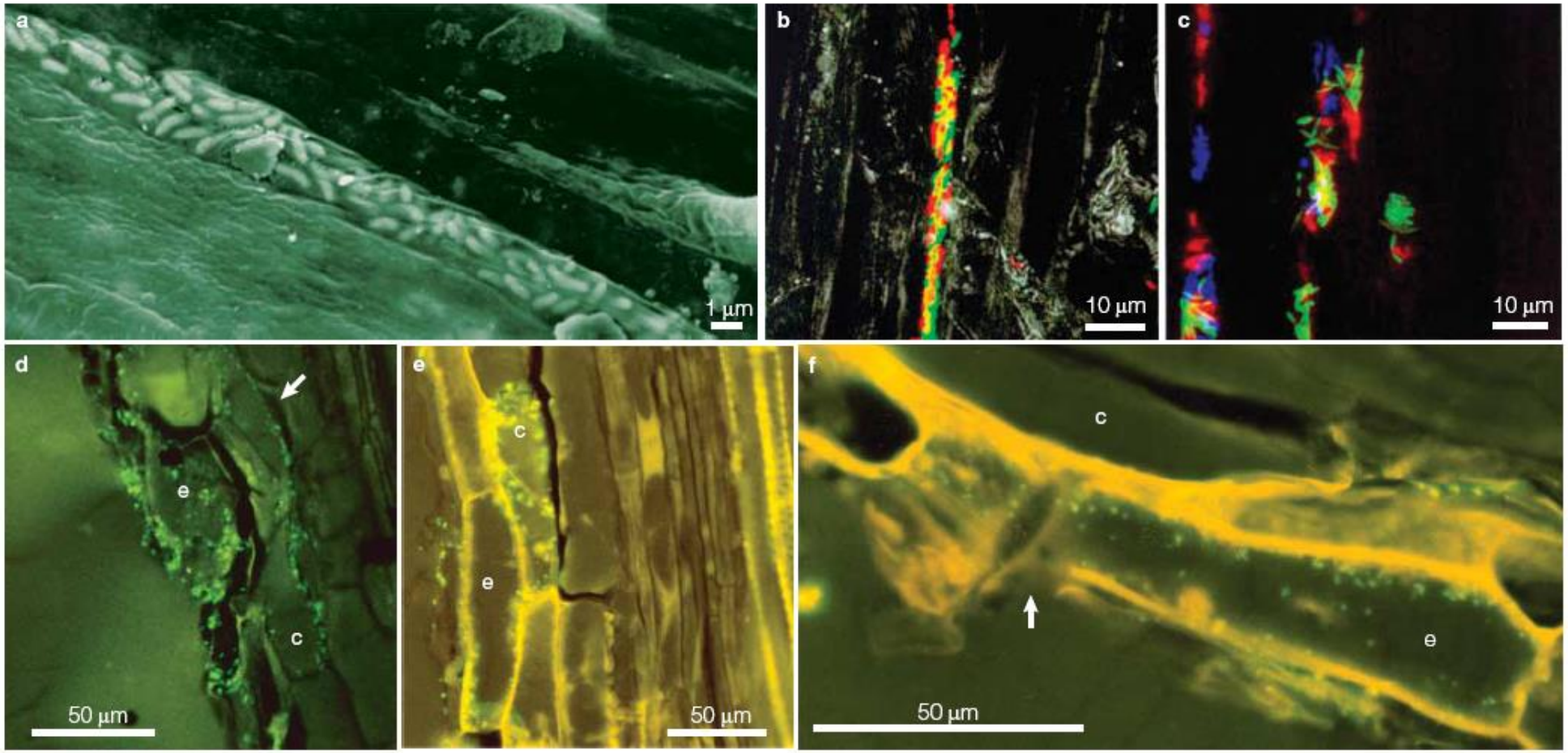


Figure 3 | **Root colonization by fluorescent pseudomonads. a** | Scanning electron micrograph of a microcolony of *Pseudomonas fluorescens* strain WCS365 on tomato root[90]. **b** | Confocal scanning microscopy analysis of tomato root colonization by *P. fluorescens* WCS365 expressing autofluorescent proteins. A mixture of two WCS365 derivatives expressing either cyan fluorescent protein (red cells) or yellow fluorescent protein (green cells) is shown; the overlap of the red and green colours results in yellow. **c** | A mixture of three WCS365 derivatives; the red and green cells are the same as those in panel **b**, and the blue cells express red fluorescent protein[105]. **d–f** | Immunofluorescence microscopy of *P. fluorescens* strain CHA0 cells associated with the epidermis (**e**) and the cortex (**c**) of tobacco roots. Bacterial cells are present between and inside the epidermal and cortical cells. The arrow in **d** points to bacteria present between cortical cells. The arrow in **f** indicates the damaged cell wall of an epidermal cell[107]. Panel **a** reproduced, with permission, from REF. 90 © (1997) American Phytopathological Society. Panels **b** and **c** reproduced, with permission, from REF. 105 © (2000) American Phytopathological Society. Panels **d–f** reproduced, with permission, from REF. 107 © (1997) Blackwell Publishing.

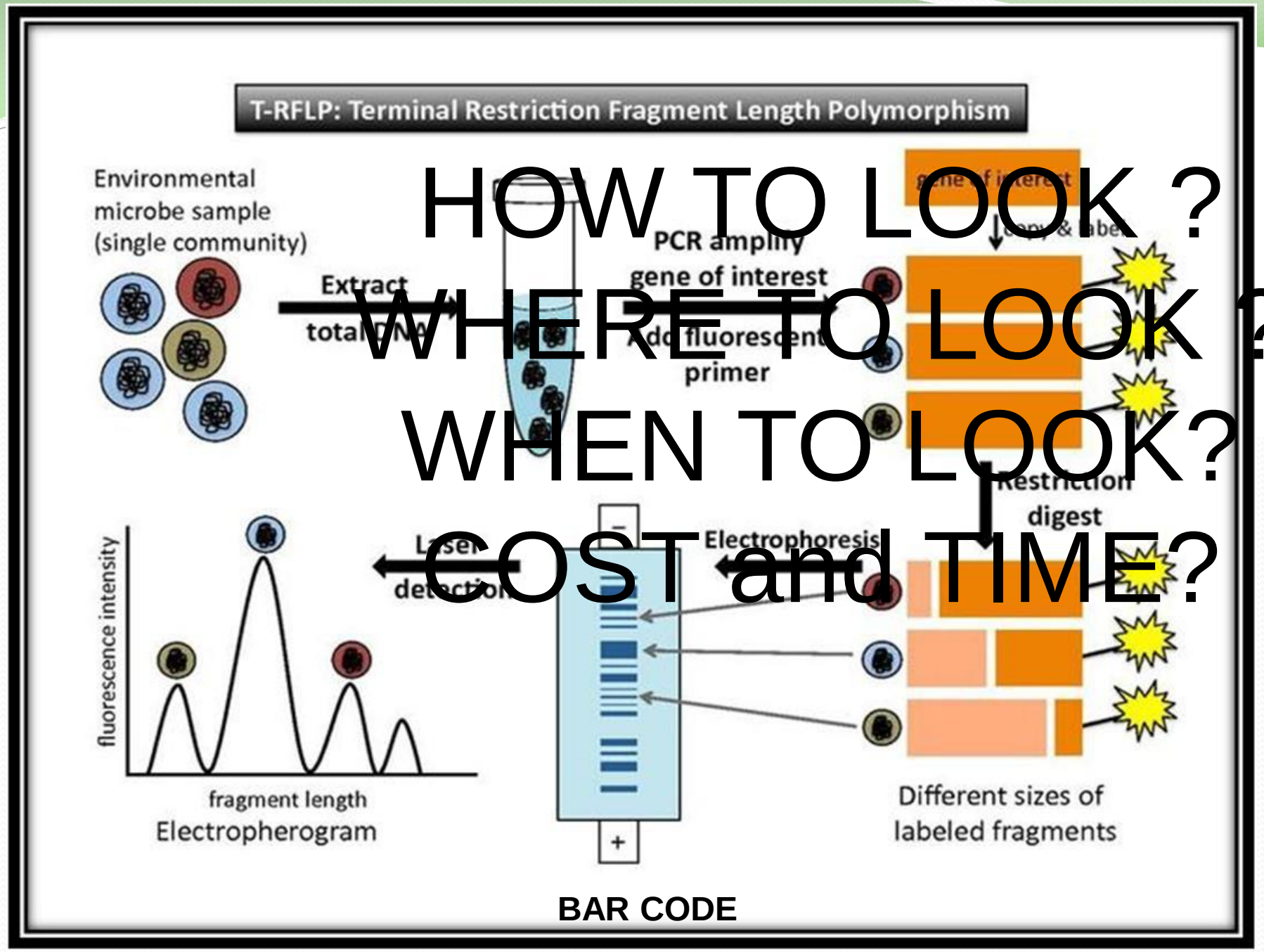
Farm Management Effects on Rhizosphere Colonization by Native Populations of 2,4-Diacetylphloroglucinol-Producing *Pseudomonas* spp. and Their Contributions to Crop Health

Dorith Rotenberg, Raghavendra Joshi, Maria-Soledad Benitez, Laura Gutierrez Chapin, Amara Camp, Clara Zumpetta, Adam Osborne, Warren A. Dick, and Brian B. McSpadden Gardener

Department of Plant Pathology, The Ohio State University, OARDC, Wooster 44691.
Accepted for publication 9 December 2006.

Fence Row Farming

Average Corn Yield at 301 bu/acre for corn and 62bu/acre soybeans; yields 2-3 times that of the county average



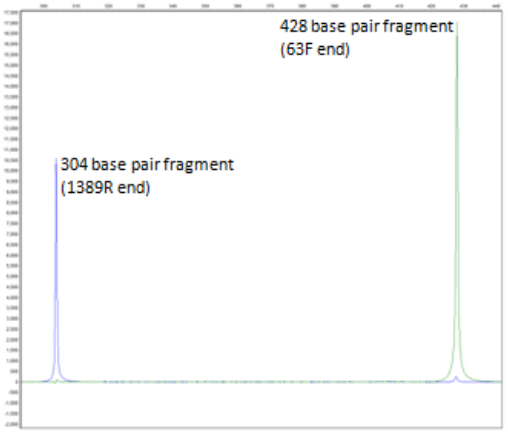
HOW TO LOOK ?

WHERE TO LOOK ?

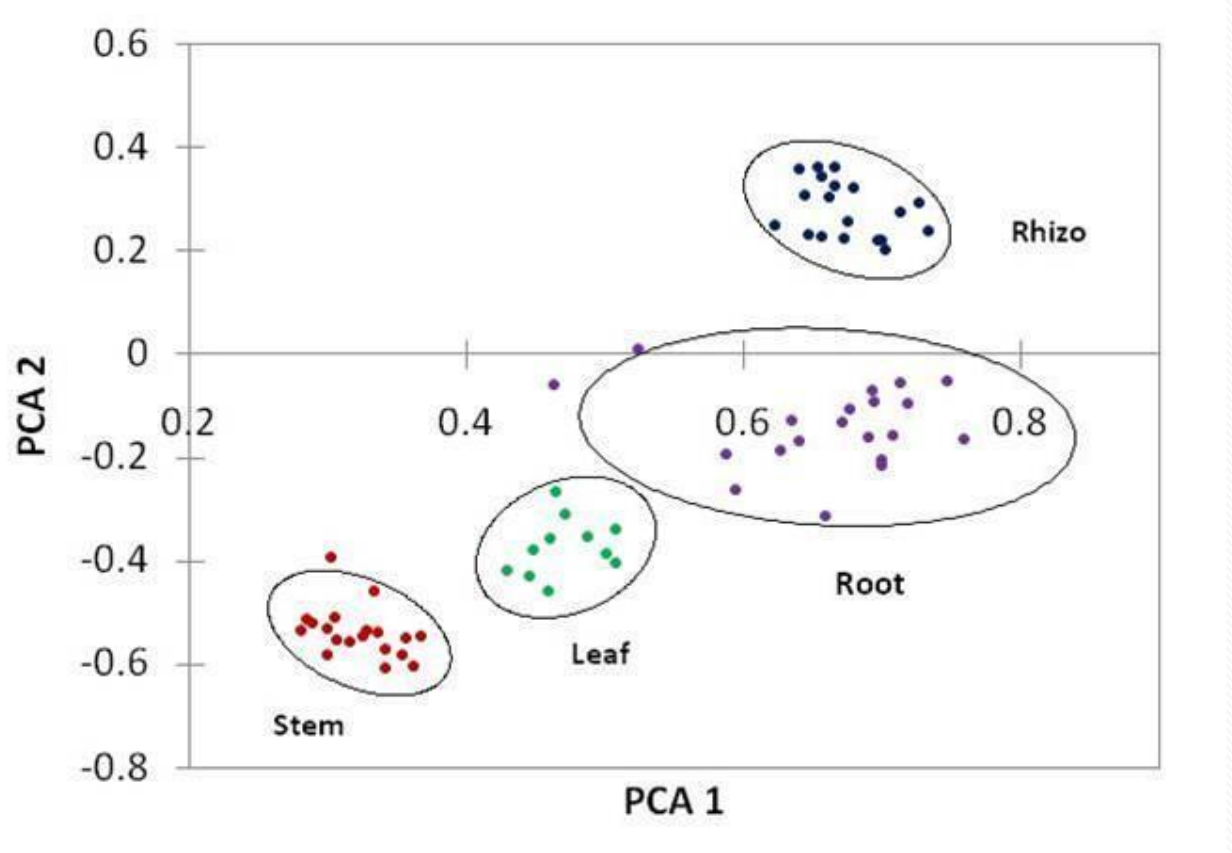
WHEN TO LOOK?

COST and TIME?

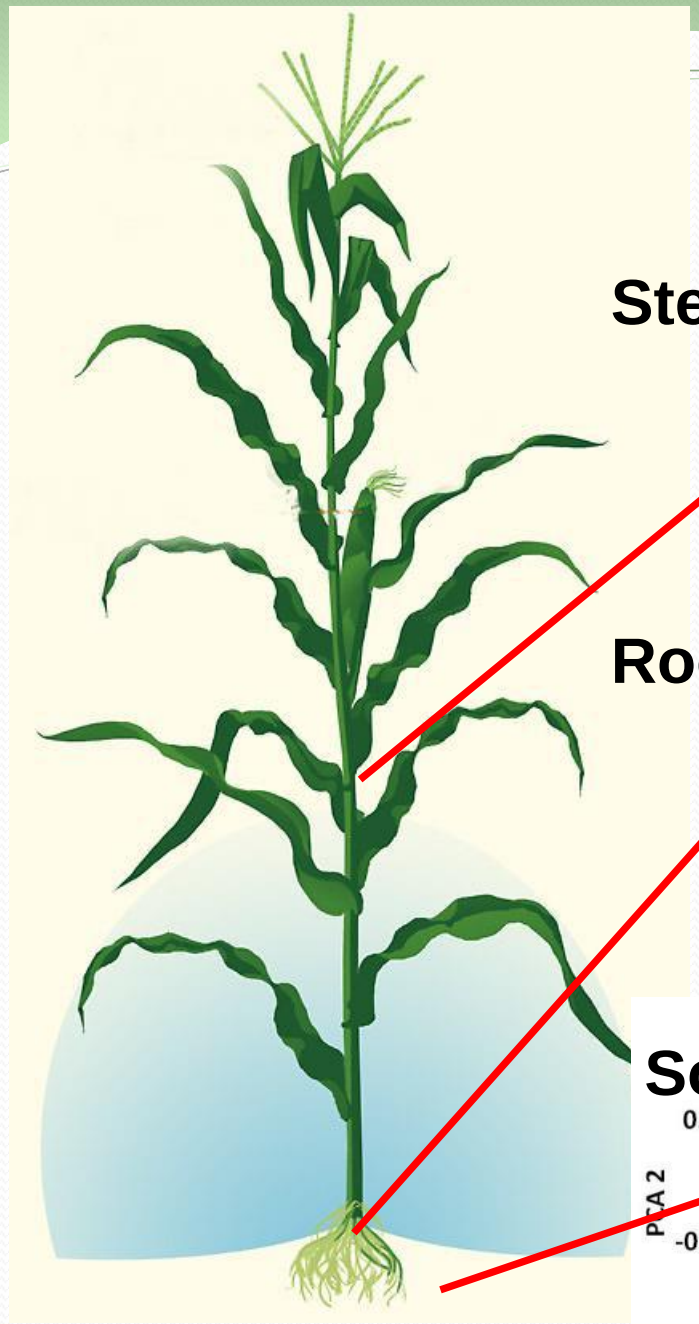
TRFLP Chromatogram of *Streptomyces scabies* amplified with 63F and 1389R then cut with HhaI



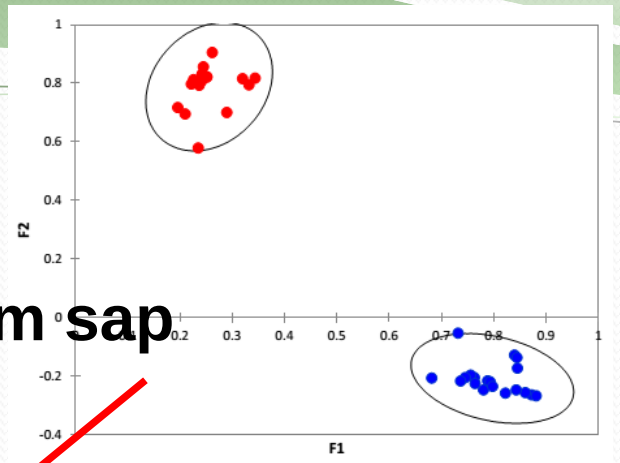
Bacterial diversity analysis using TRFLP technique



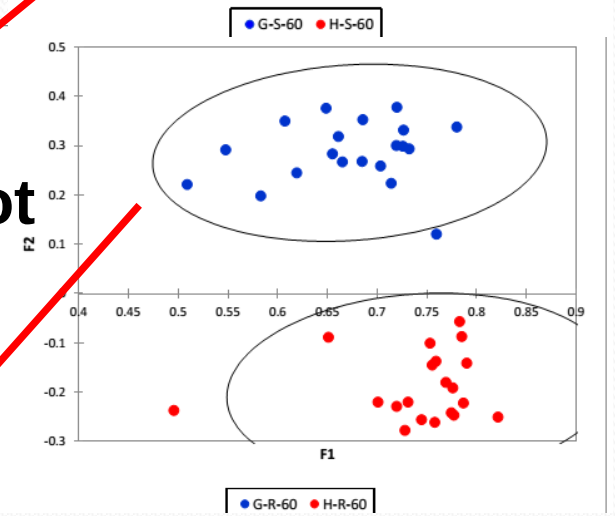
TRFLP of bacteria populations in various corn tissues of 20 plants at sampled from a high yielding soil at 60 days (V10) after planting.



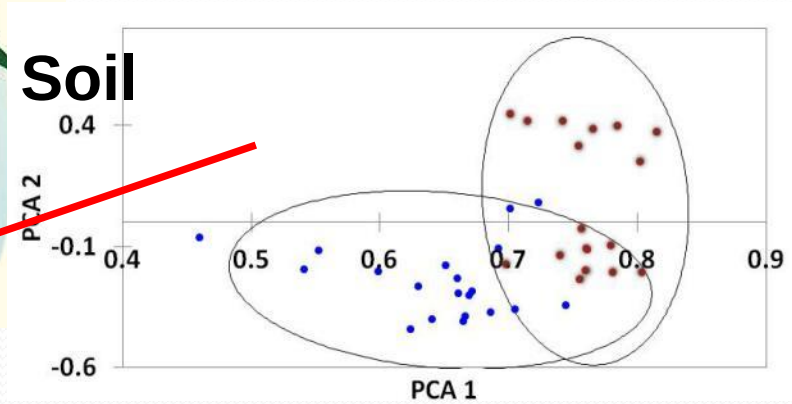
Stem sap



Root



Soil

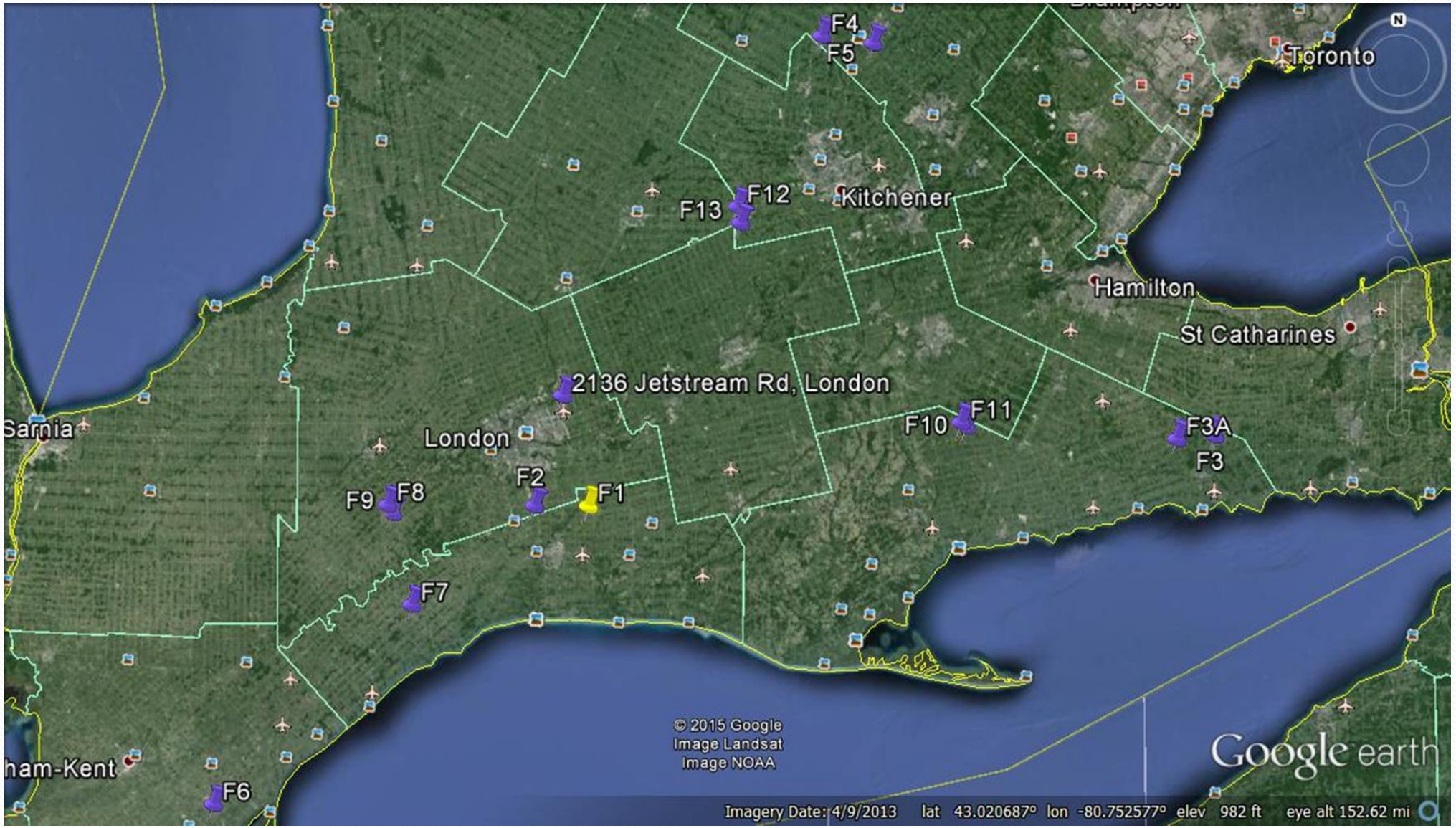


- = 150 Bu/A
- = 300 Bu/A

Comparison of Bacterial profiles using TRFLP of 20 corn plants harvested from a high and average production site at 60 days (V10) after planting

The populations change with crop development.

SAMPLING LOCATIONS IN ONTARIO



FIELD SAMPLING

MicaSense Camera: five spectral bands: B1 (blue) centered on 475 nm; B2 (green) centered on 560 nm; B3 (red) centered on 668 nm; B4 (REP) centered on 717 nm, and B5 (NIR) centered on 840 nm

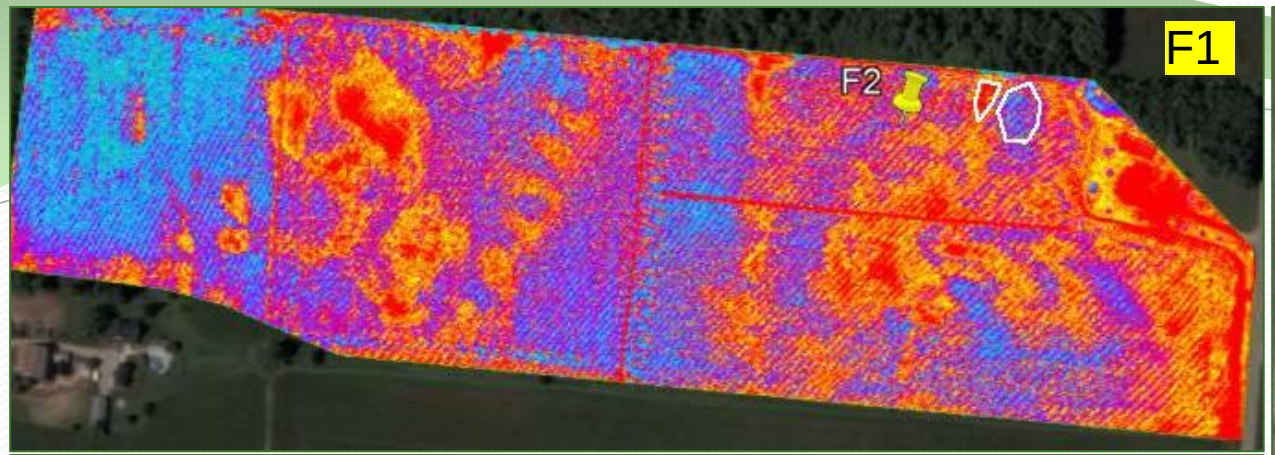
UAV developed by A&L Canada: weight is slightly less than 2.0 kg

NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

EVEN SMALL PLOTS HAVE ENORMOUS VARIABILITY AMONG THE PLANTS

(UofG long term rotations)

Dr Bill Deen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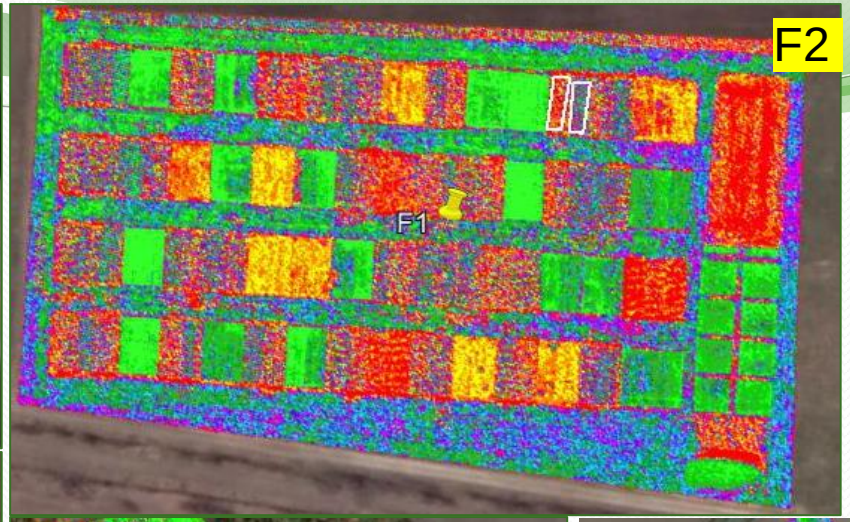
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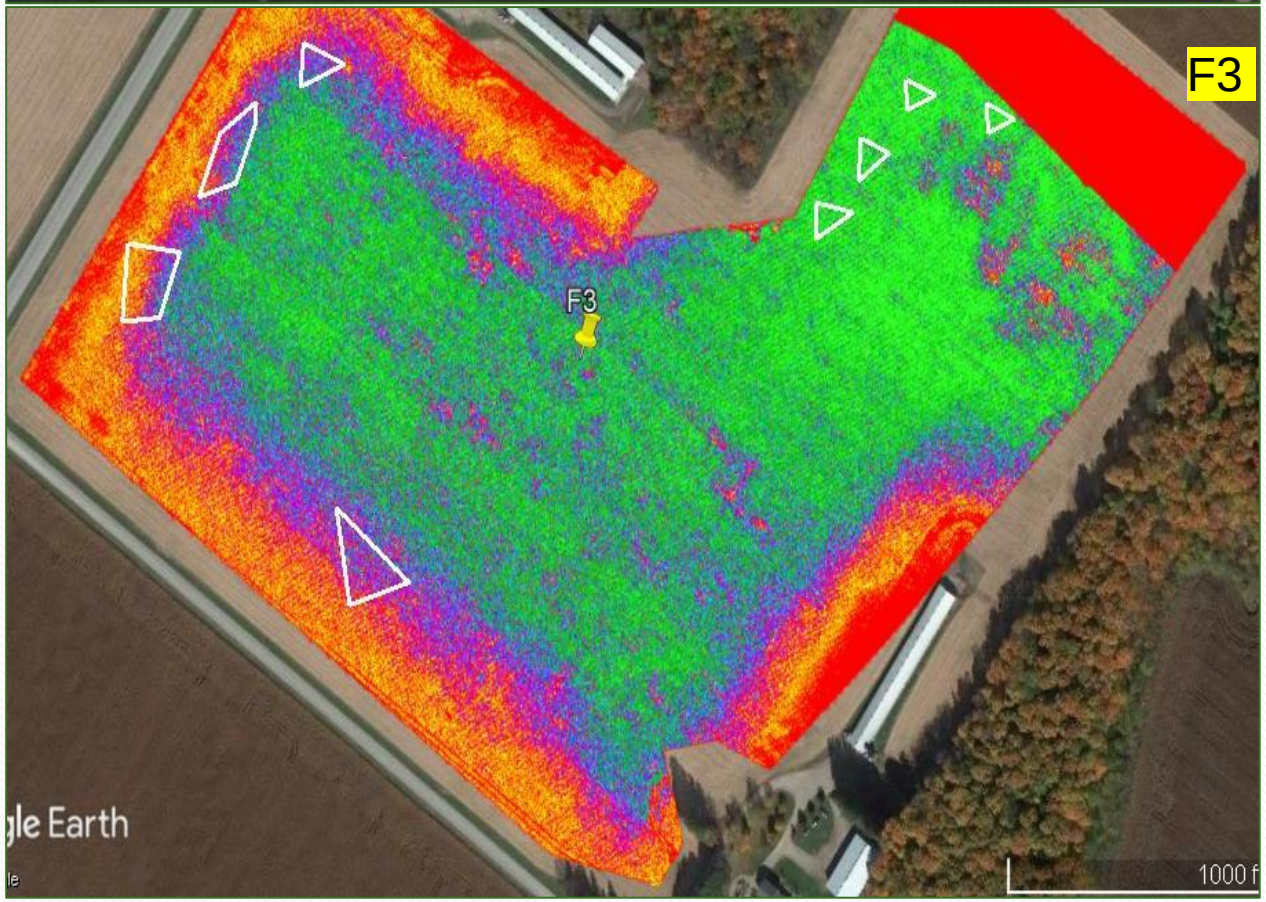
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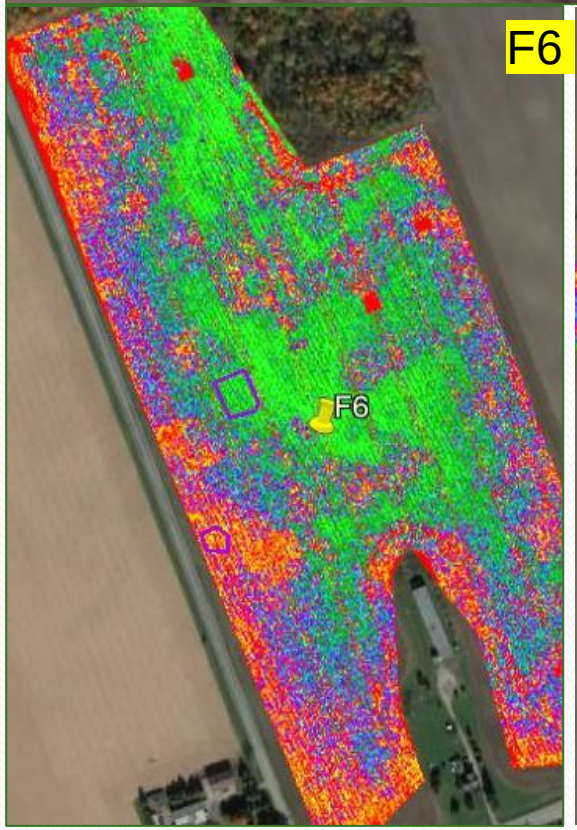
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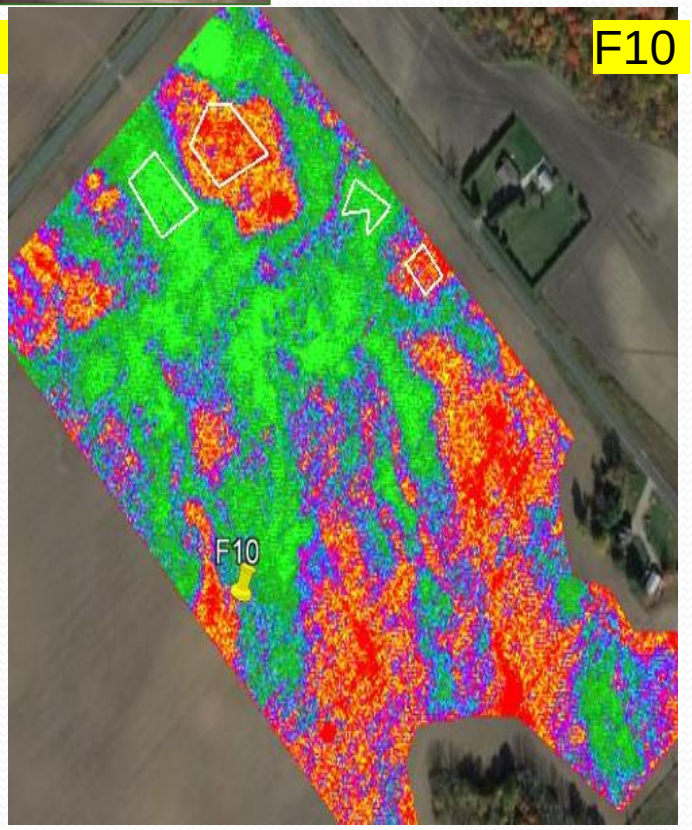
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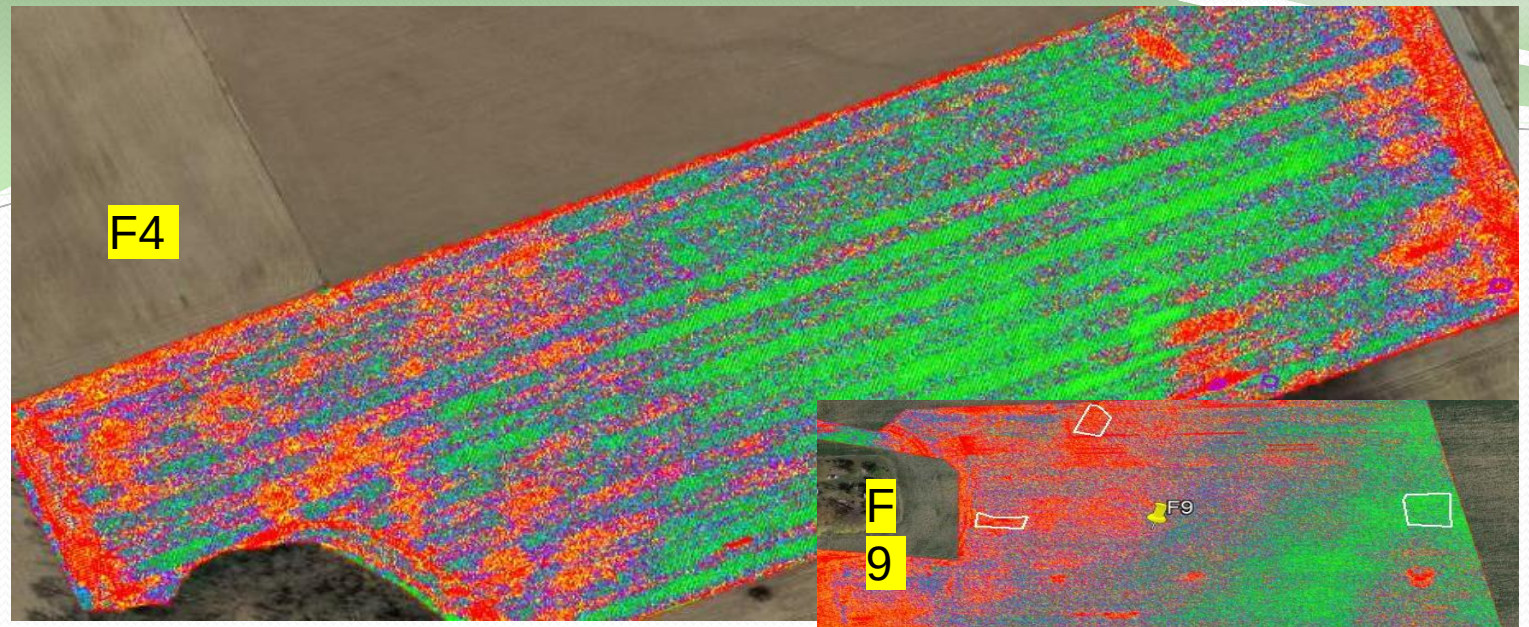
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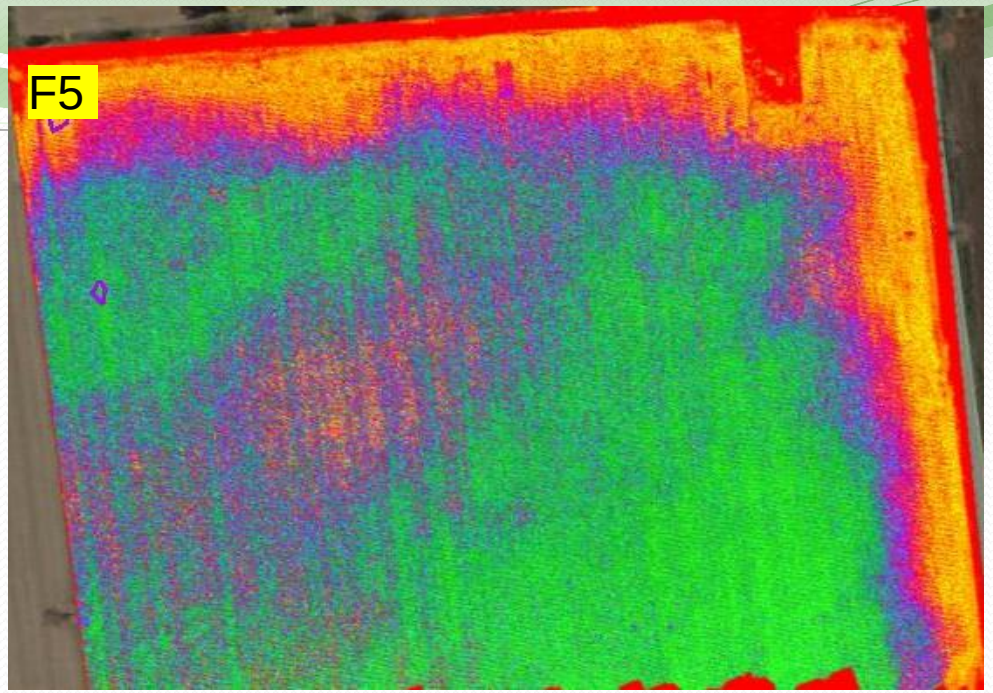
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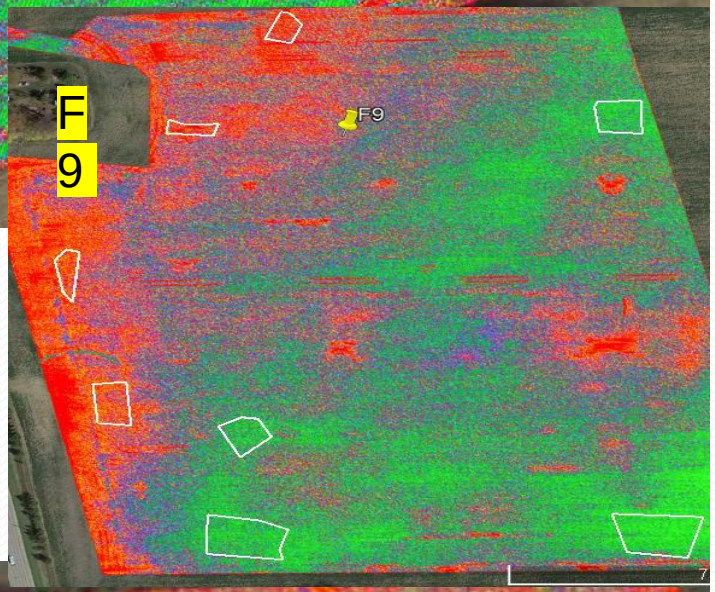
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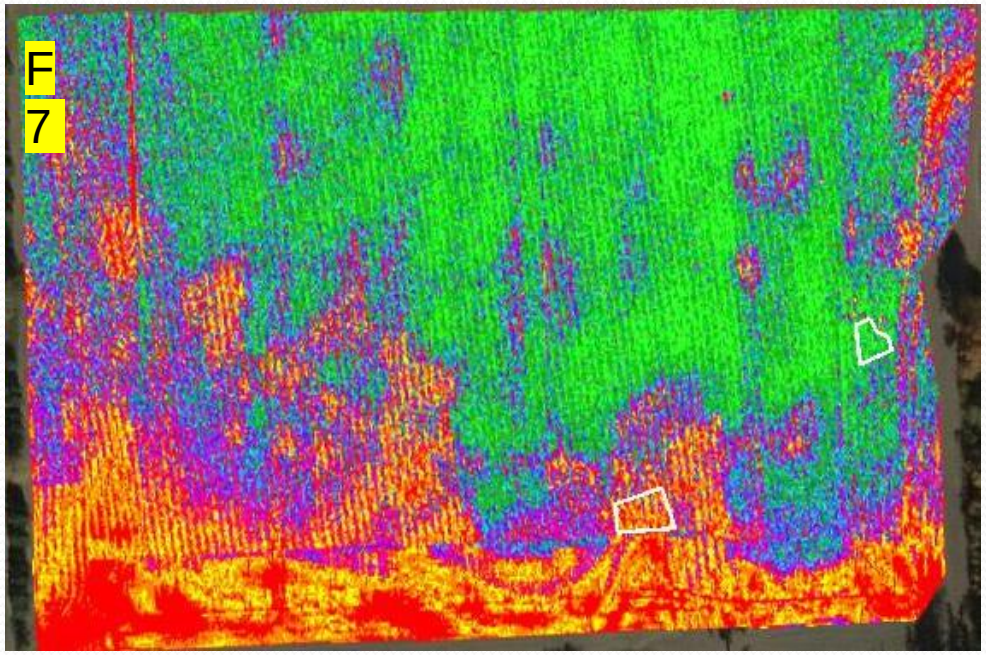
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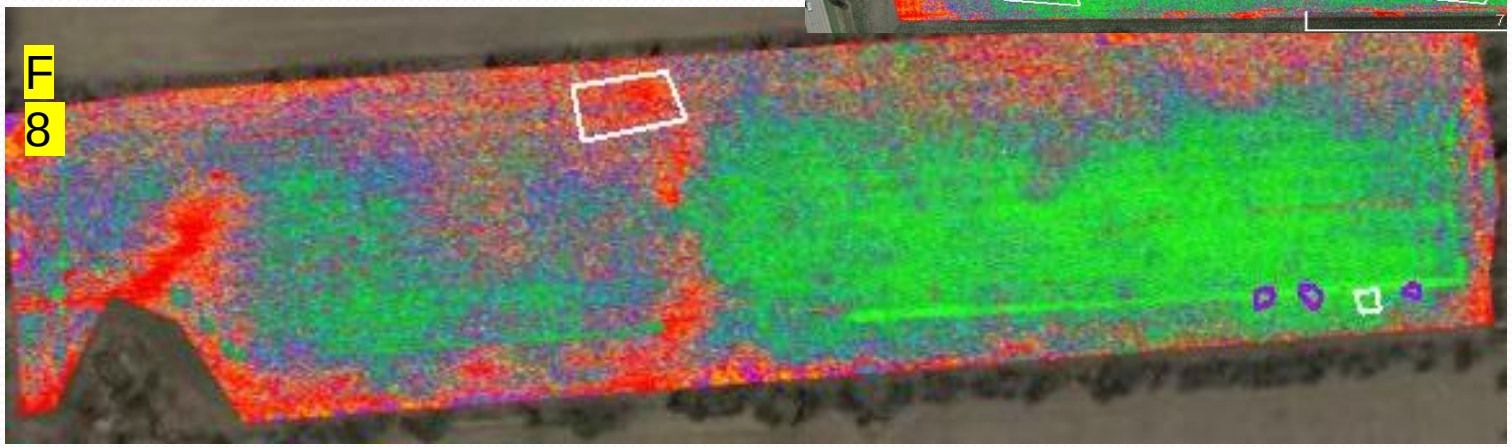
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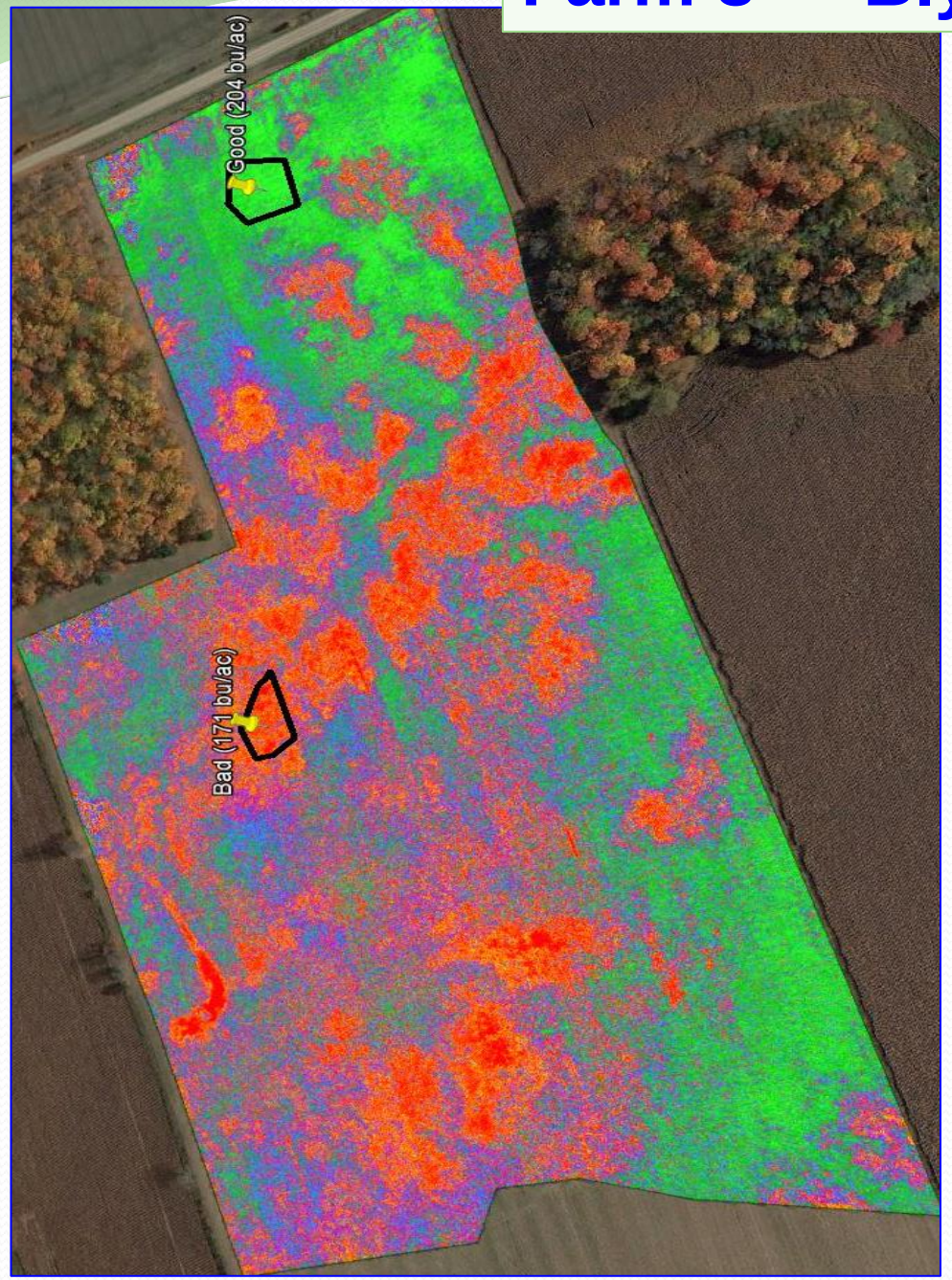
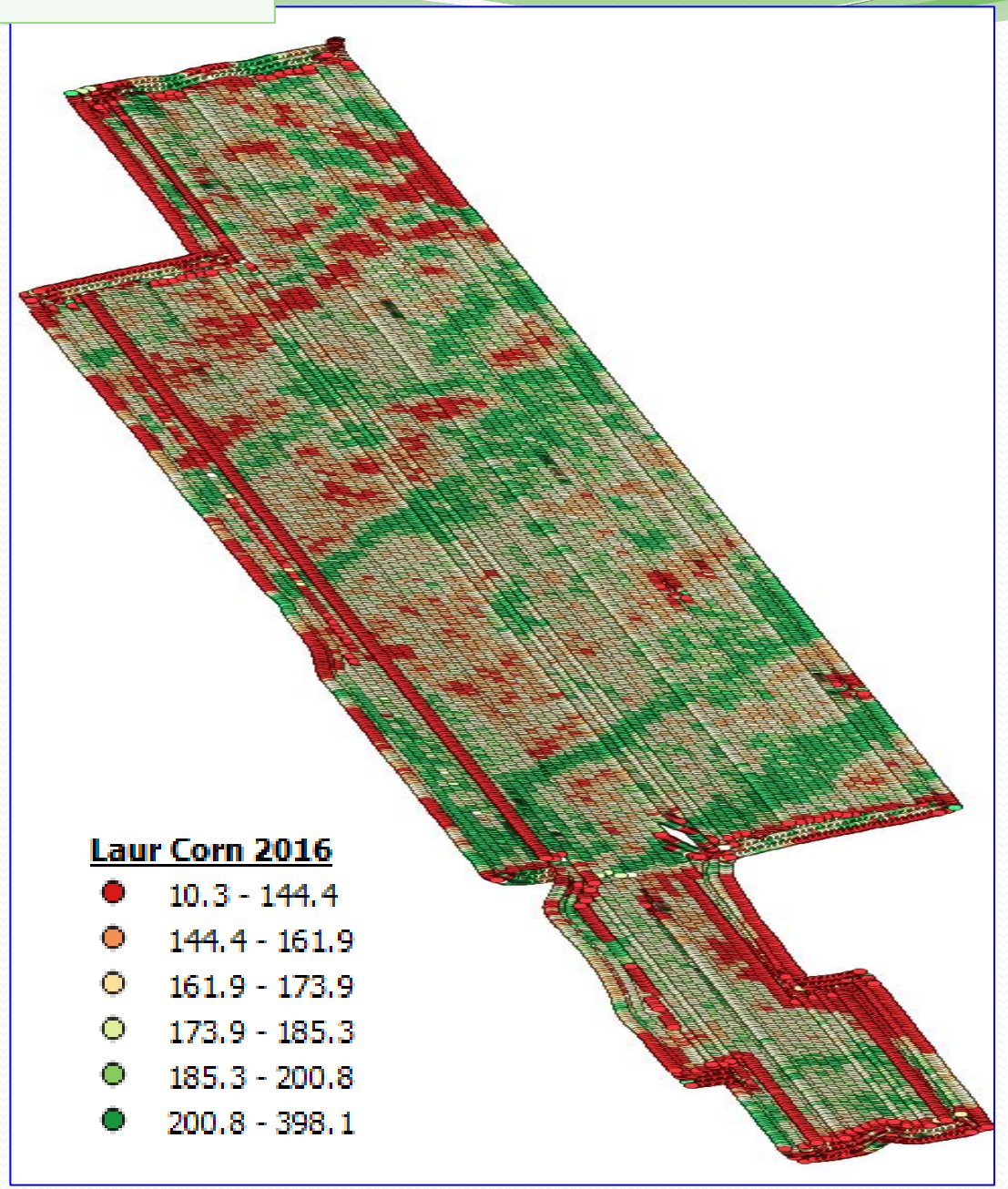
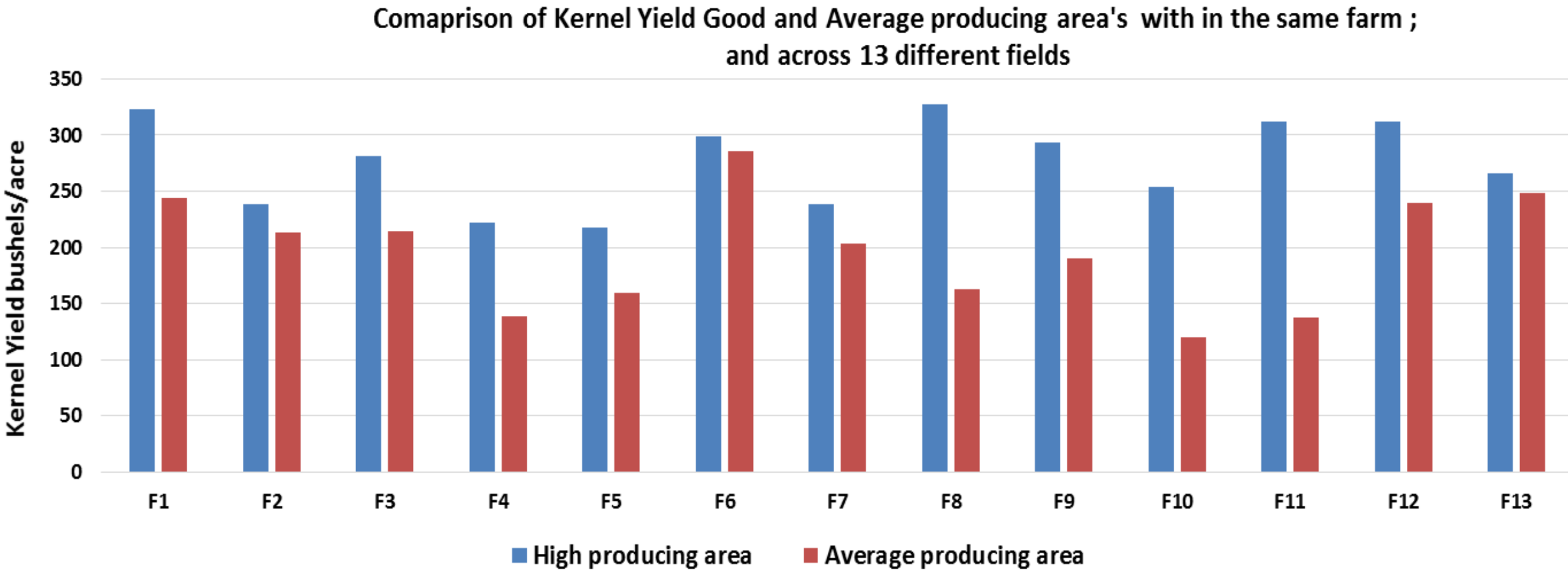
Farm 3 - - Blythe Brae

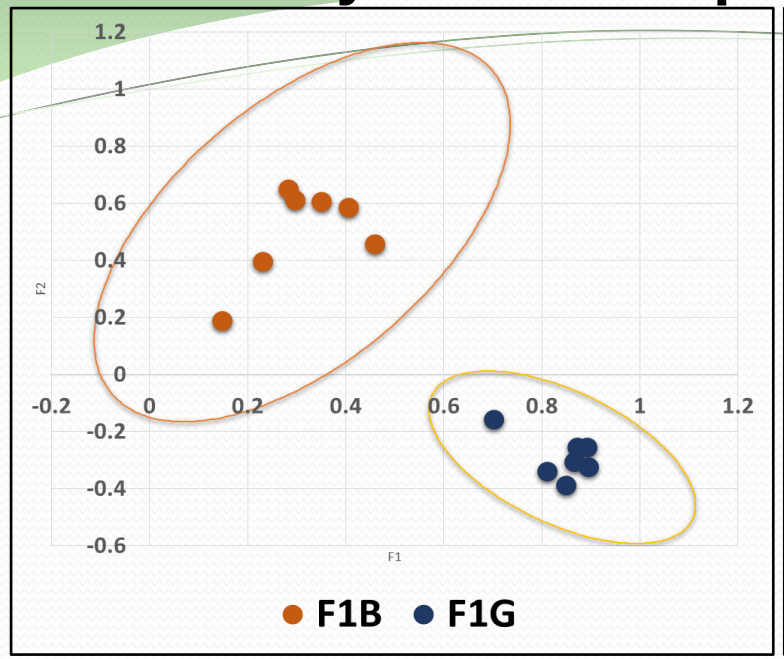


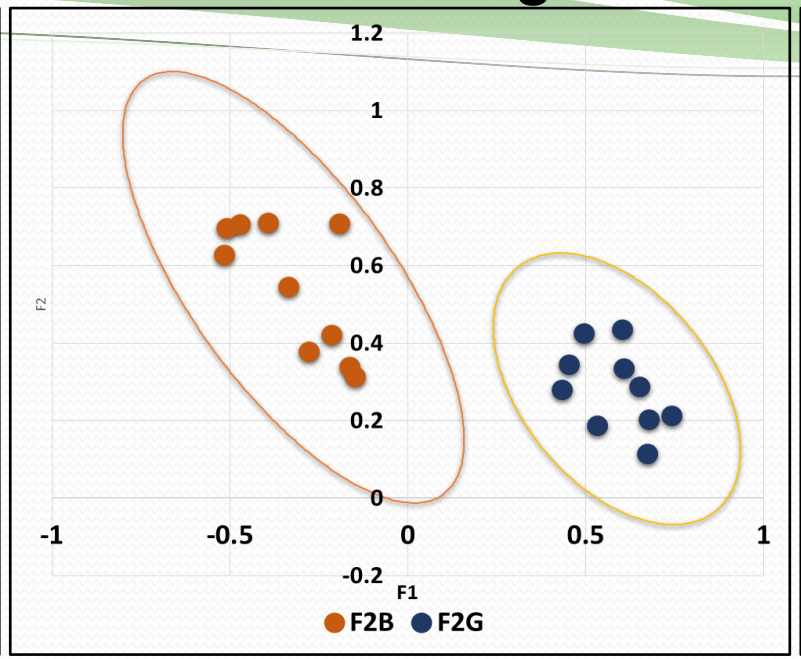


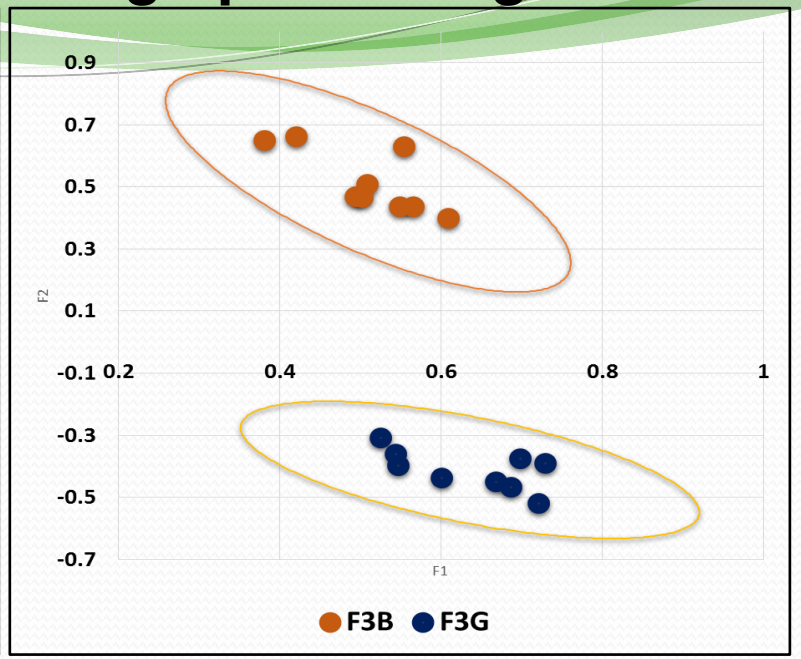
CORN YIELDS FROM 13 FIELDS

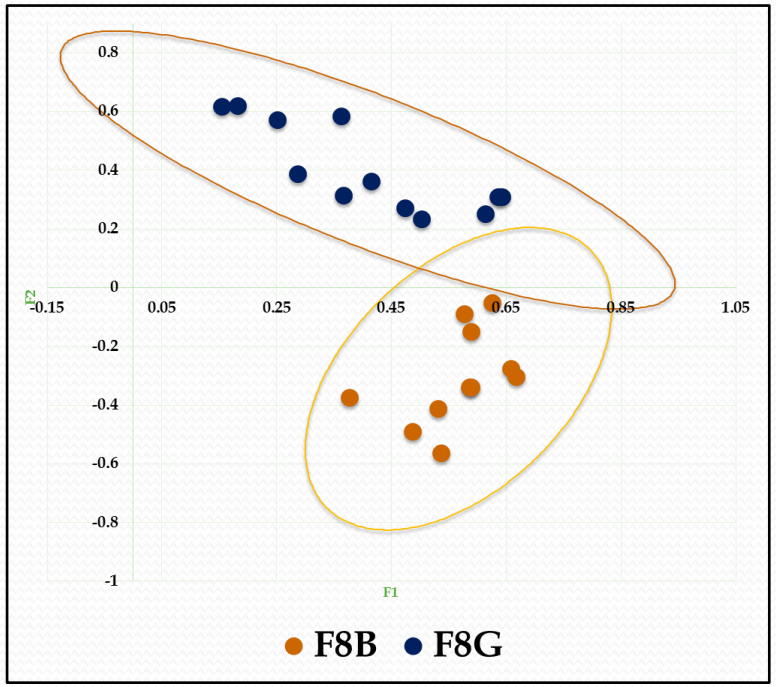


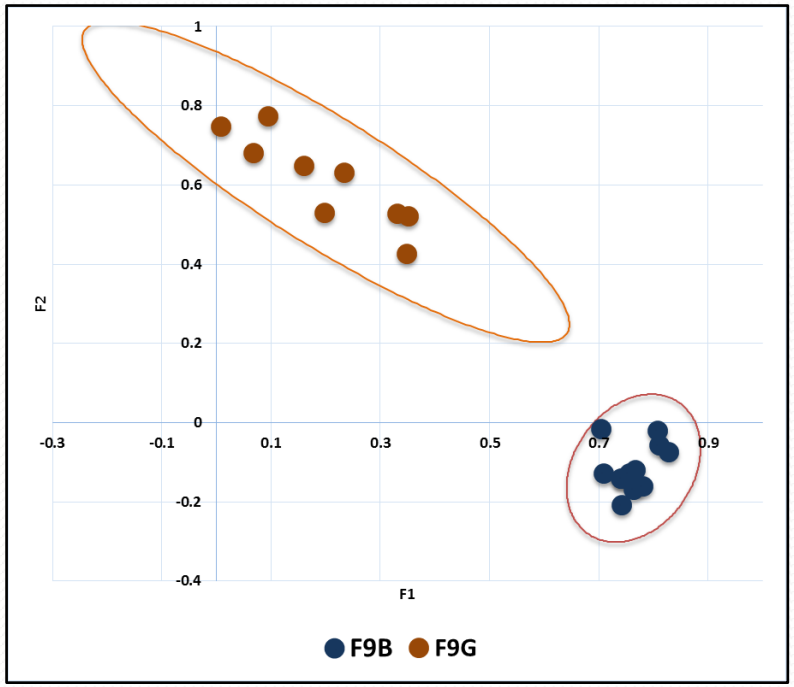
Diversity of Corn Sap microbiome in High and Average producing Sites

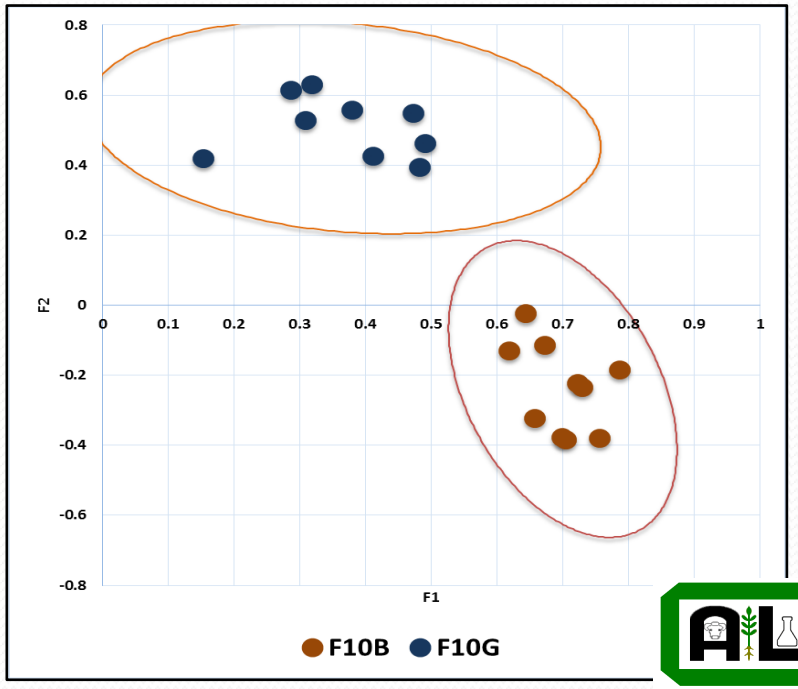


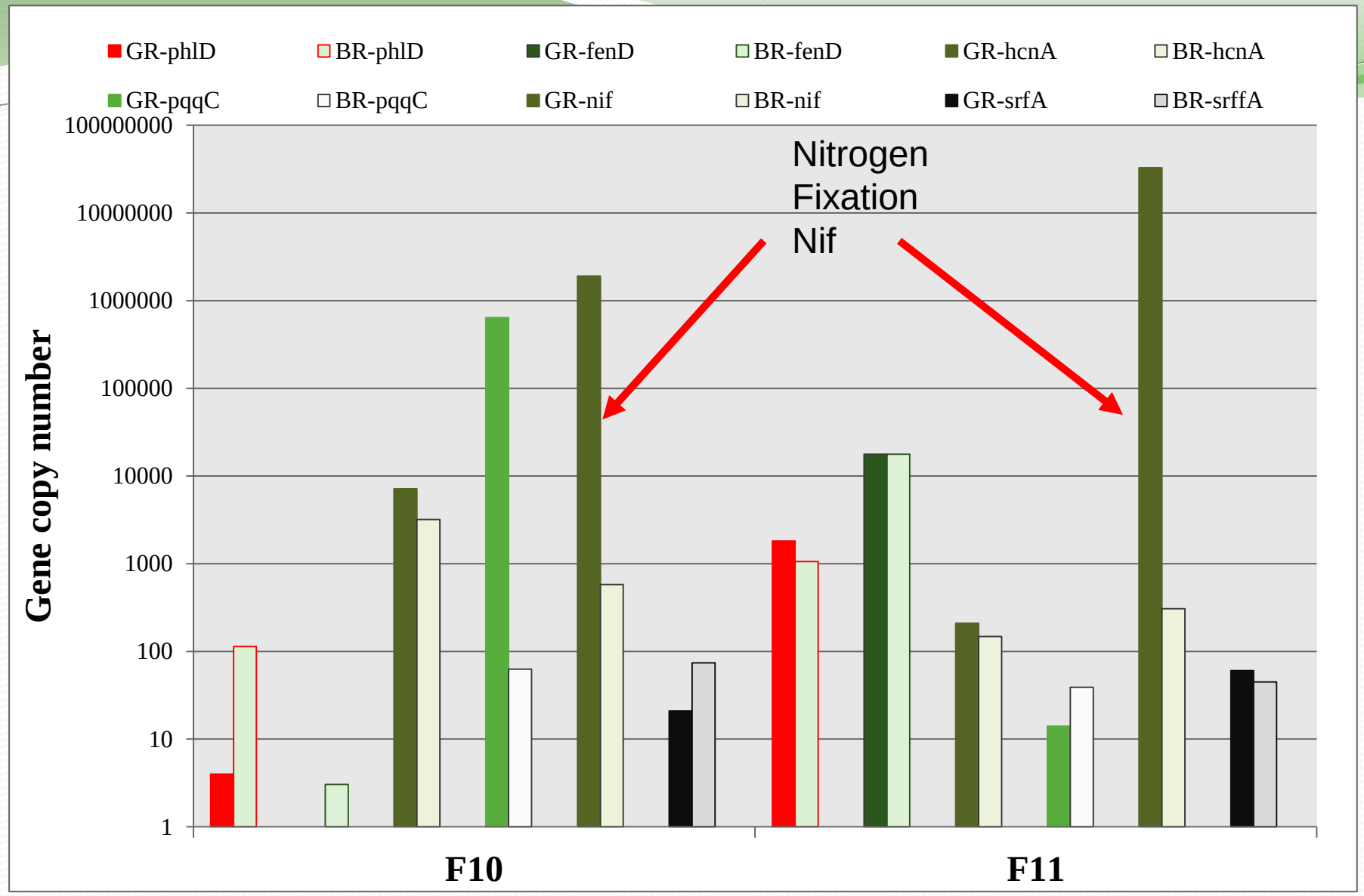






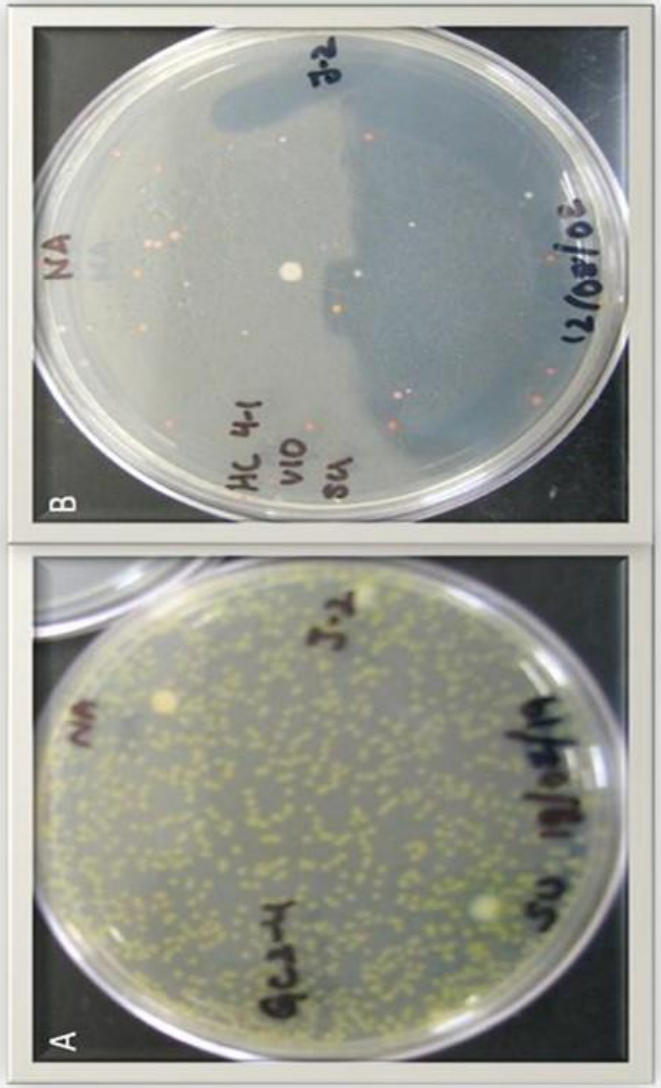


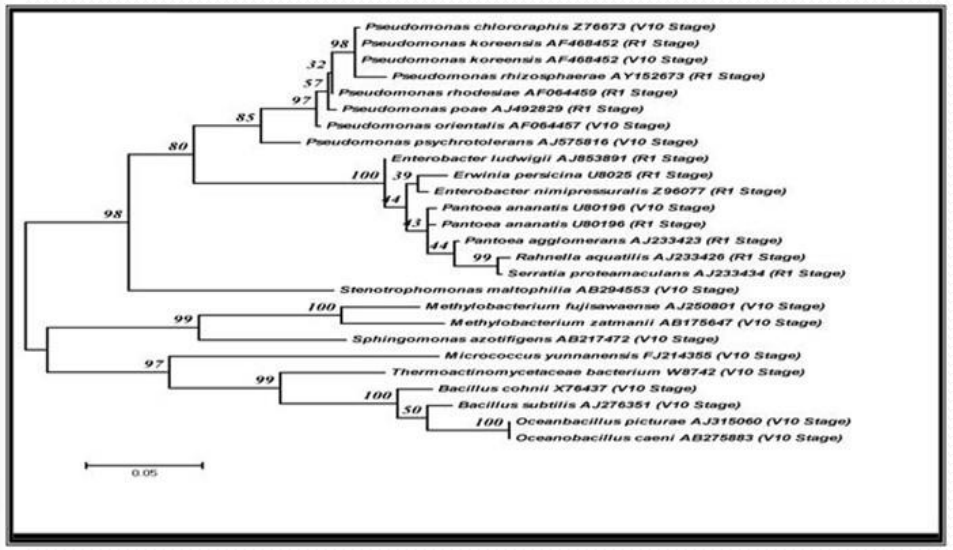


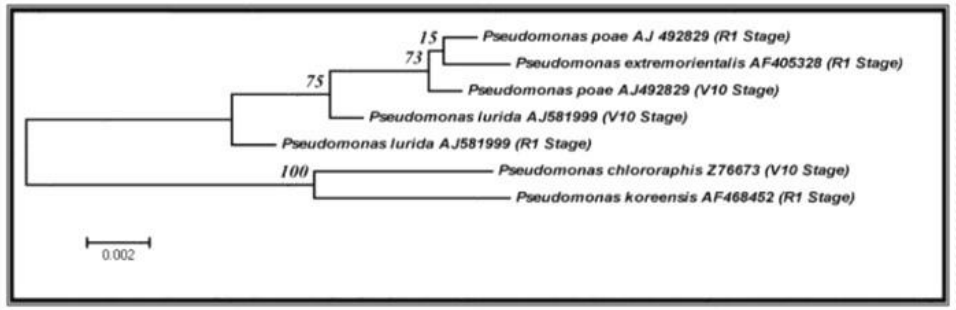


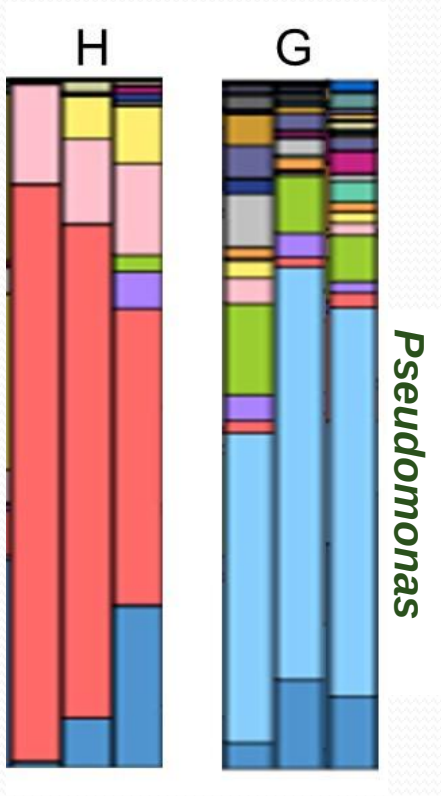
Functional gene analysis on DNA extracted from corn roots from high and average producing sites of two different corn fields

Bacteria isolated from stem sap of corn plants from G and H sites at V10 growth stage.

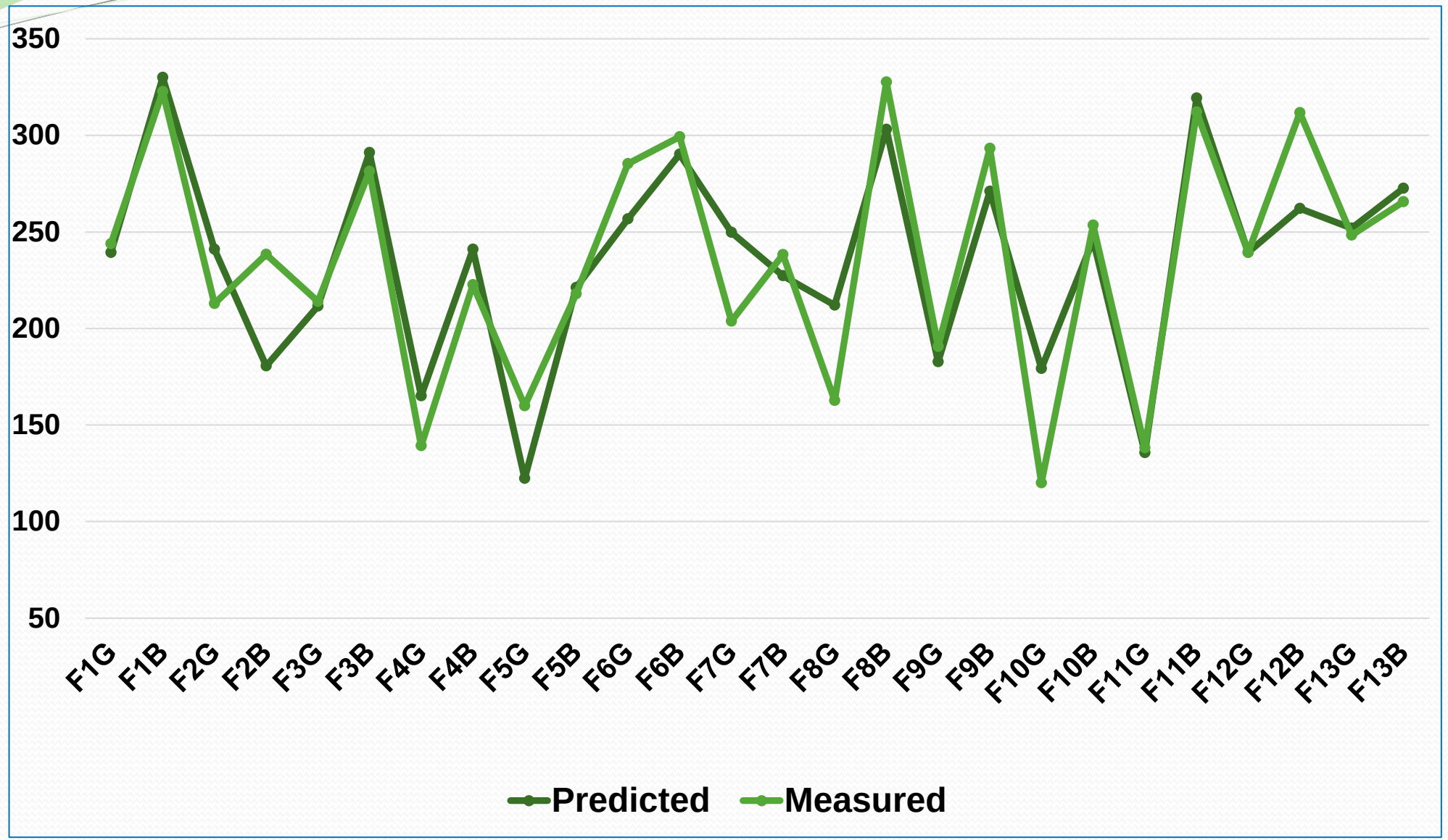




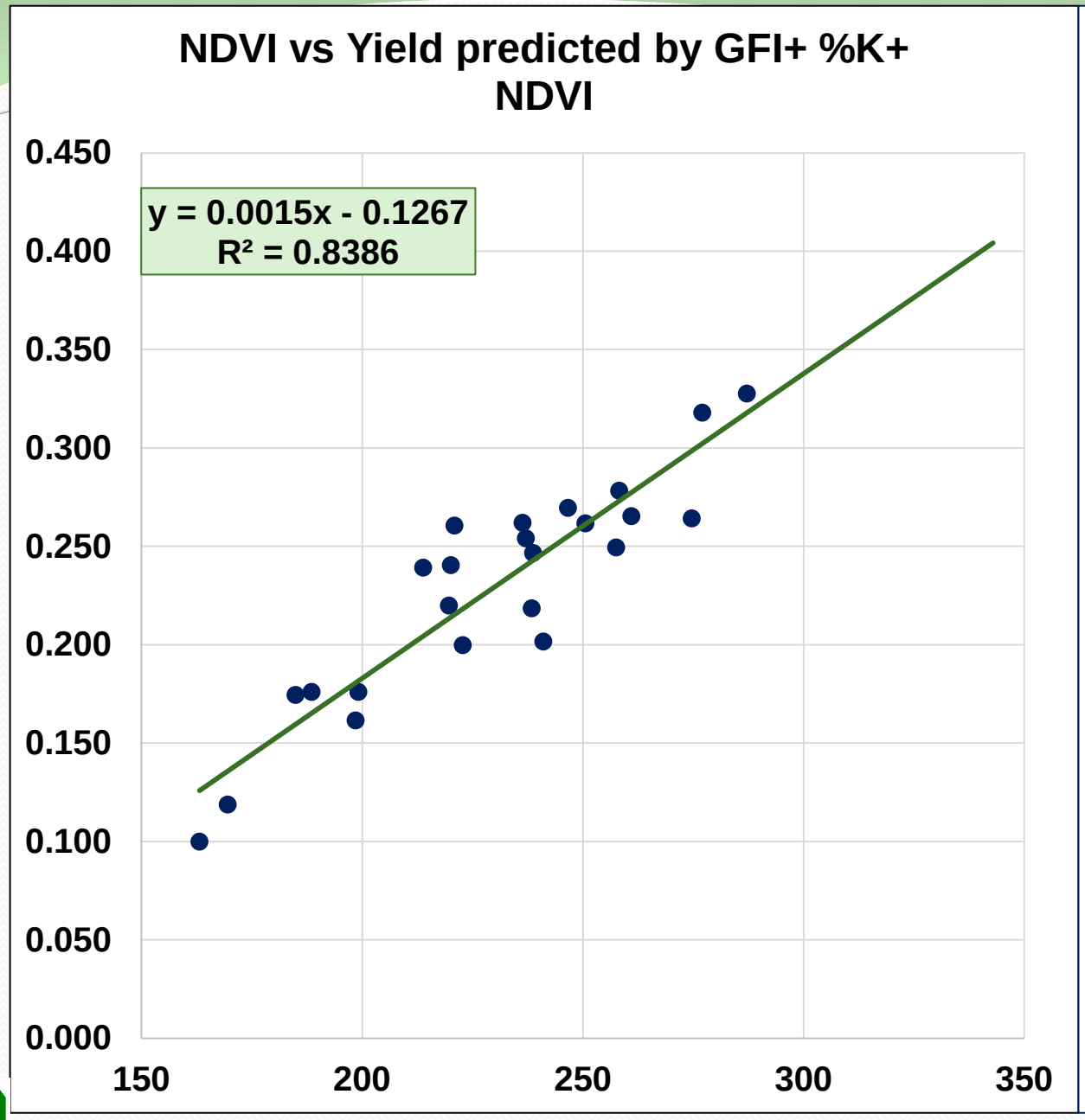


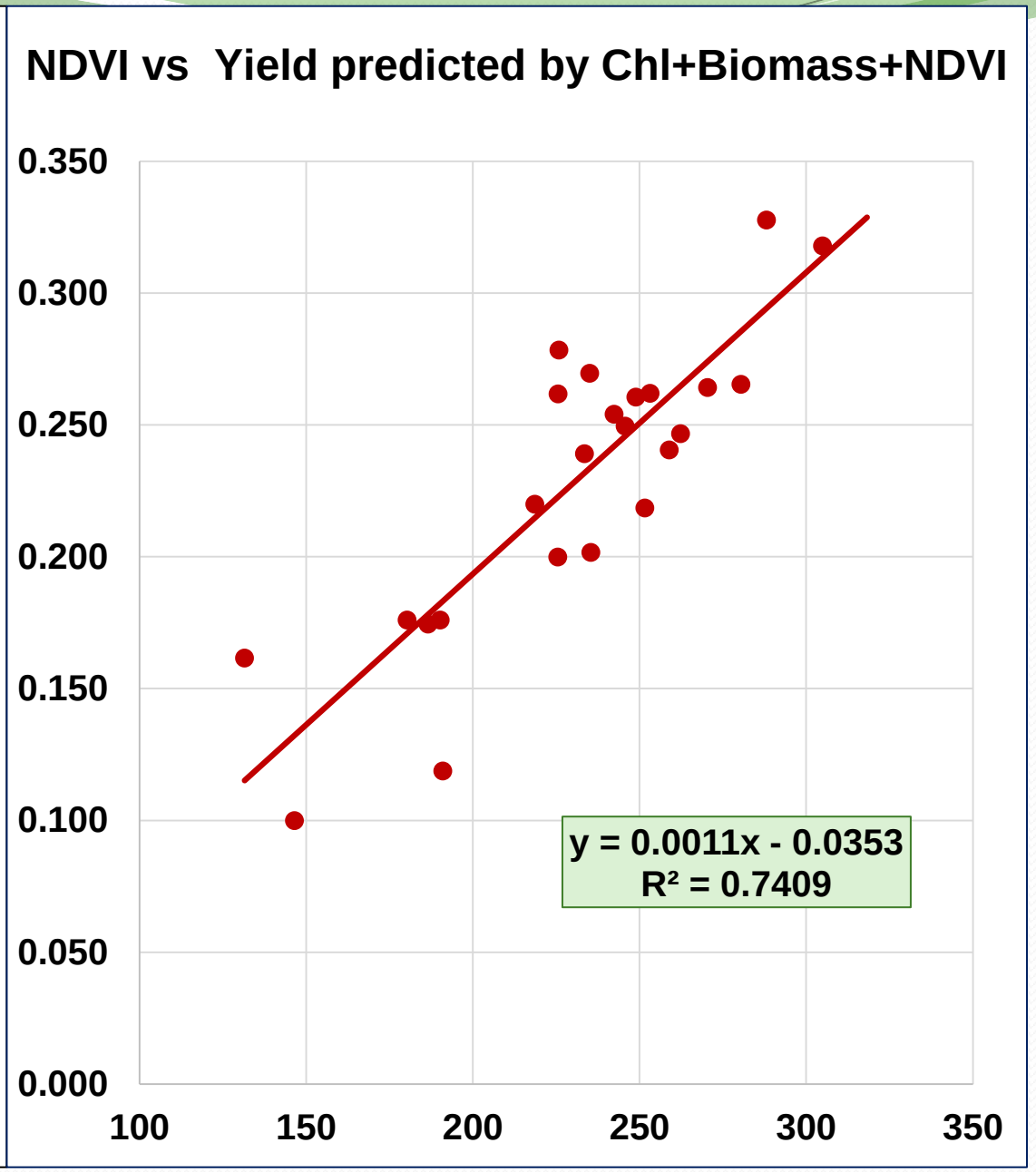


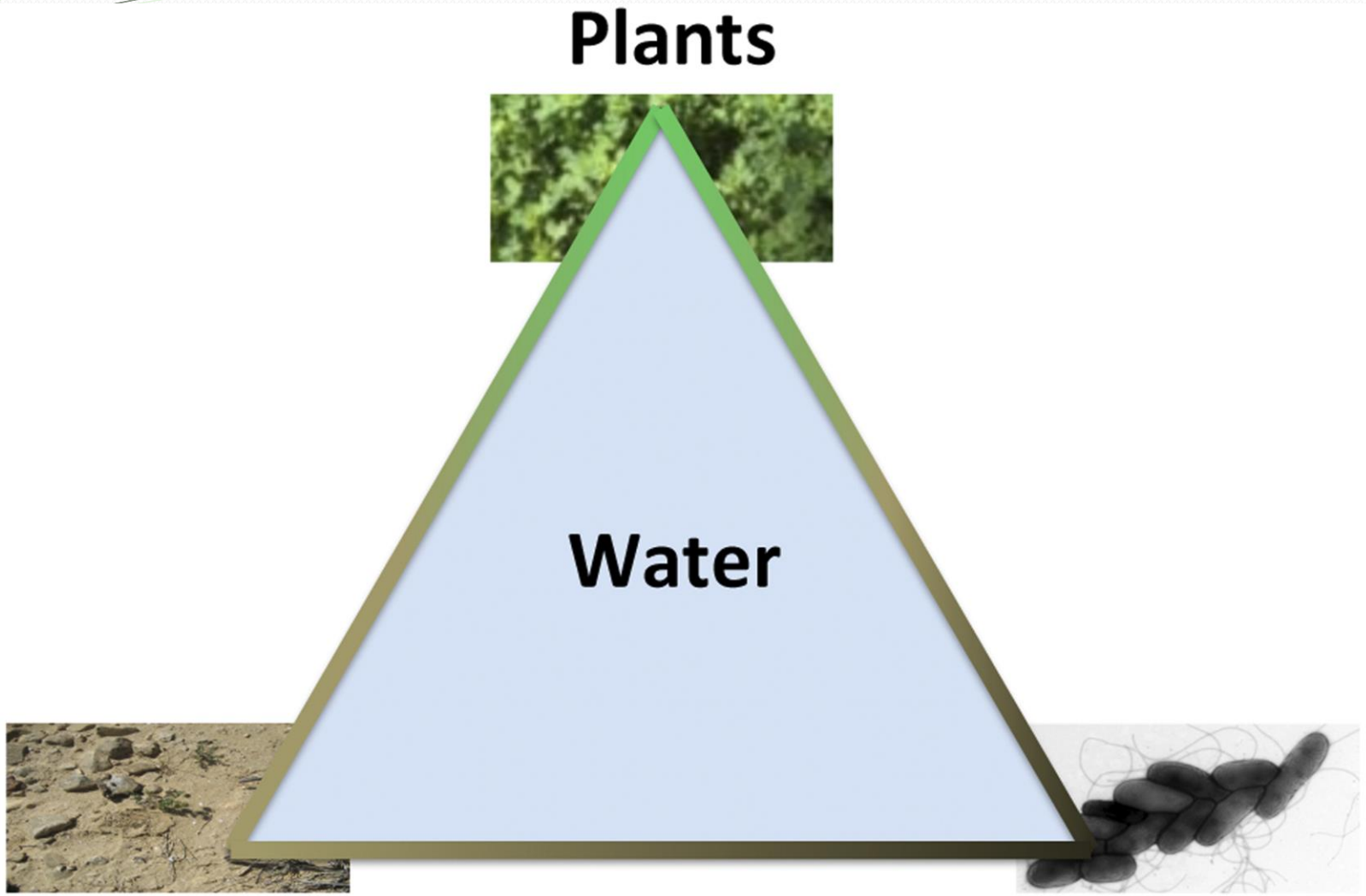
Comparison of Yield : Predicted *vs* Measured



Prediction by
T542.RS
T547.RS
%K.RS
GFI.RS
T641.RS
srffA.RS
T814.RS
T544.RS
NO3.N.RS
T271.RS
T1289.RS
T537.RS
T275.RS
Total.bac.counts.S
T1007.RS


NDVI vs Yield predicted by GFI+ %K+ NDVI
y = 0.0015x - 0.1267
R² = 0.8386
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
150
200
250
300
350


NDVI vs Yield predicted by Chl+Biomass+NDVI
y = 0.0011x - 0.0353
R² = 0.7409
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
100
150
200
250
300
350



The interactions of plants, unconsolidated mineral or organic material, and microbes, all of which require water to form soil, is depicted in this triangle.

Pilar Martínez-Hidalgo; Ann M. Hirsch; *Phytobiomes* **2017,** 1, 70-82. DOI: 10.1094/PBIOMES-12-16-0019-RVW 2017 The American Phytopathological Society

CONCLUSIONS AND SUMMARY

1. Good news - at minimum 1/3 of soils support excellent productivity – 1/3 underperform –WHY? HOW CAN WE FIX IT?

2. **WE ARE LEAVING HALF OF OUR YIELD POTENTIAL IN THE FIELD**

3. Soil Health in agriculture will be crop specific and will be related to crop performance – IS AN UNDERPRORDUCTIVE SITE FOR CORN ALSO A LOW PRODUCTION SITE FOR OTHER CROPS

4. Microbiology has a large role in soil and crop health –We need to measure impact as many factors regulate populations and these we don't yet fully understand

Thank You

and

The Next Green Revolution will Emerge from Underground