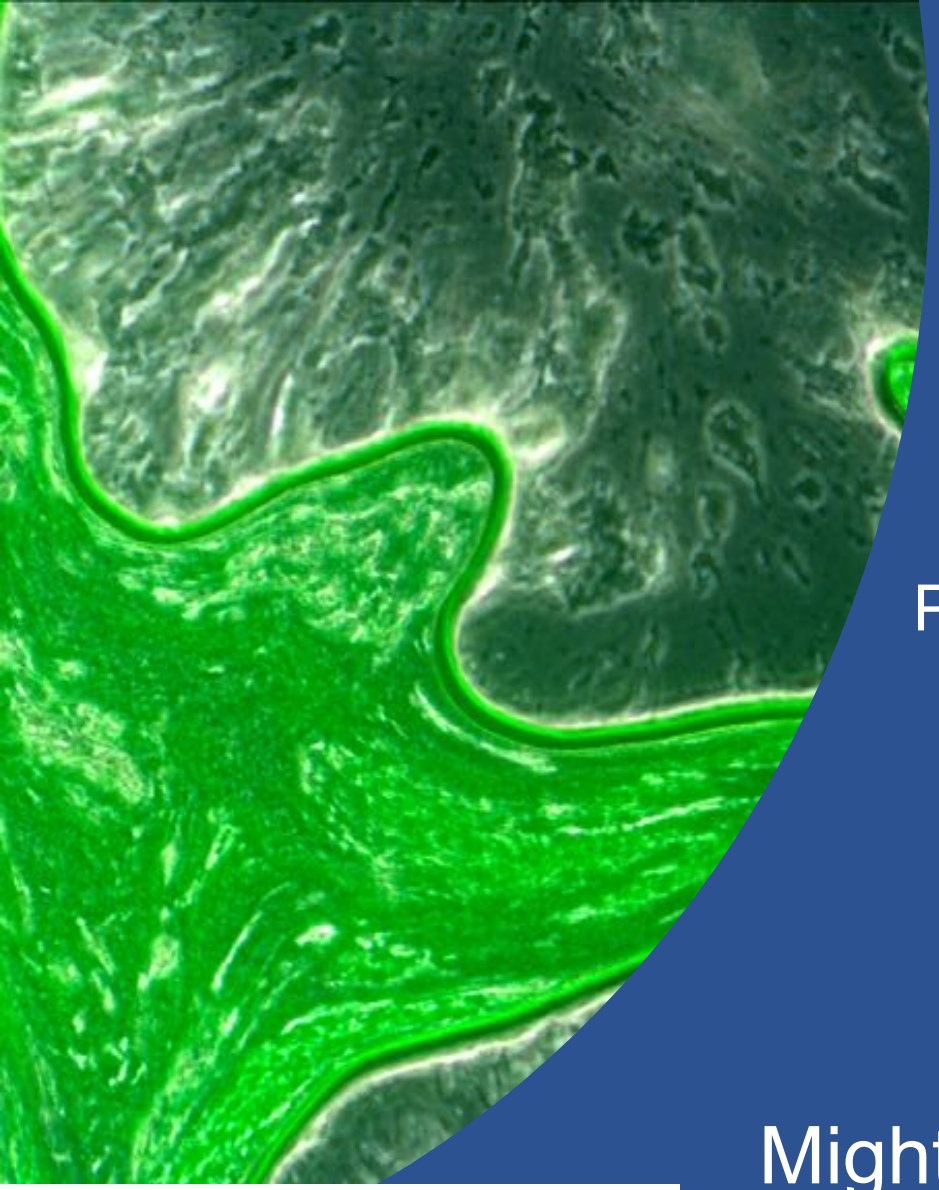

Penn State
Microbiome Center
Presents

Imtiaz Ahmad
Postdoctoral Research Associate
Department of Entomology,
Penn State University, PA, USA.
ixa12@psu.edu

Mighty microbes: The tri-trophic interactions of endophytic *Metarhizium* in maize.

PennState

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Project team

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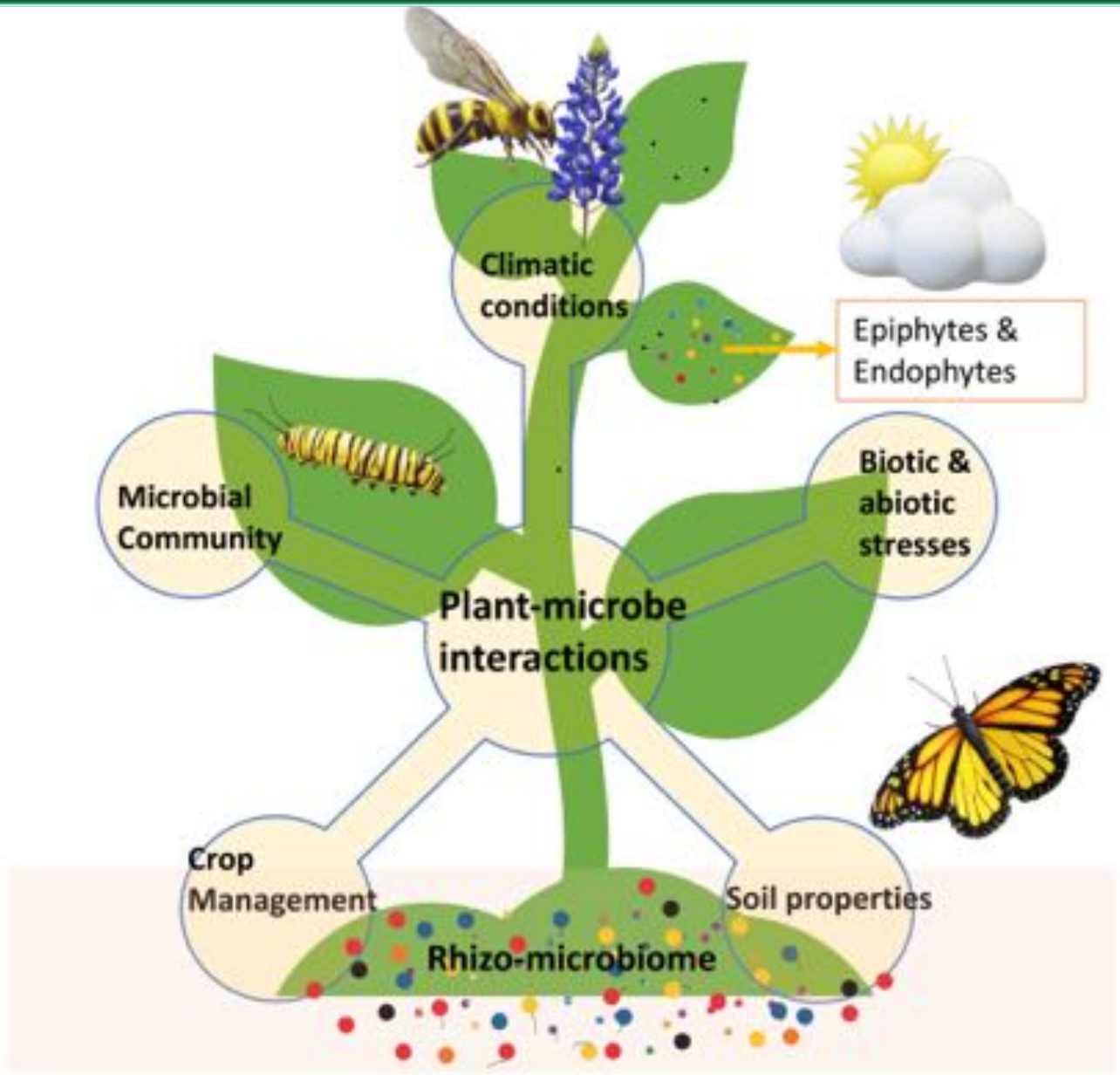
- Jason Kaye
- Barbara Padro
- Dawn Luthe
- Brianna Flonc
- Puneet Randhawa
- Christina Voortman
- Dayton Spackman
- Scott Harkcom
- Many lab assistants

Plants, microbes and beyond!

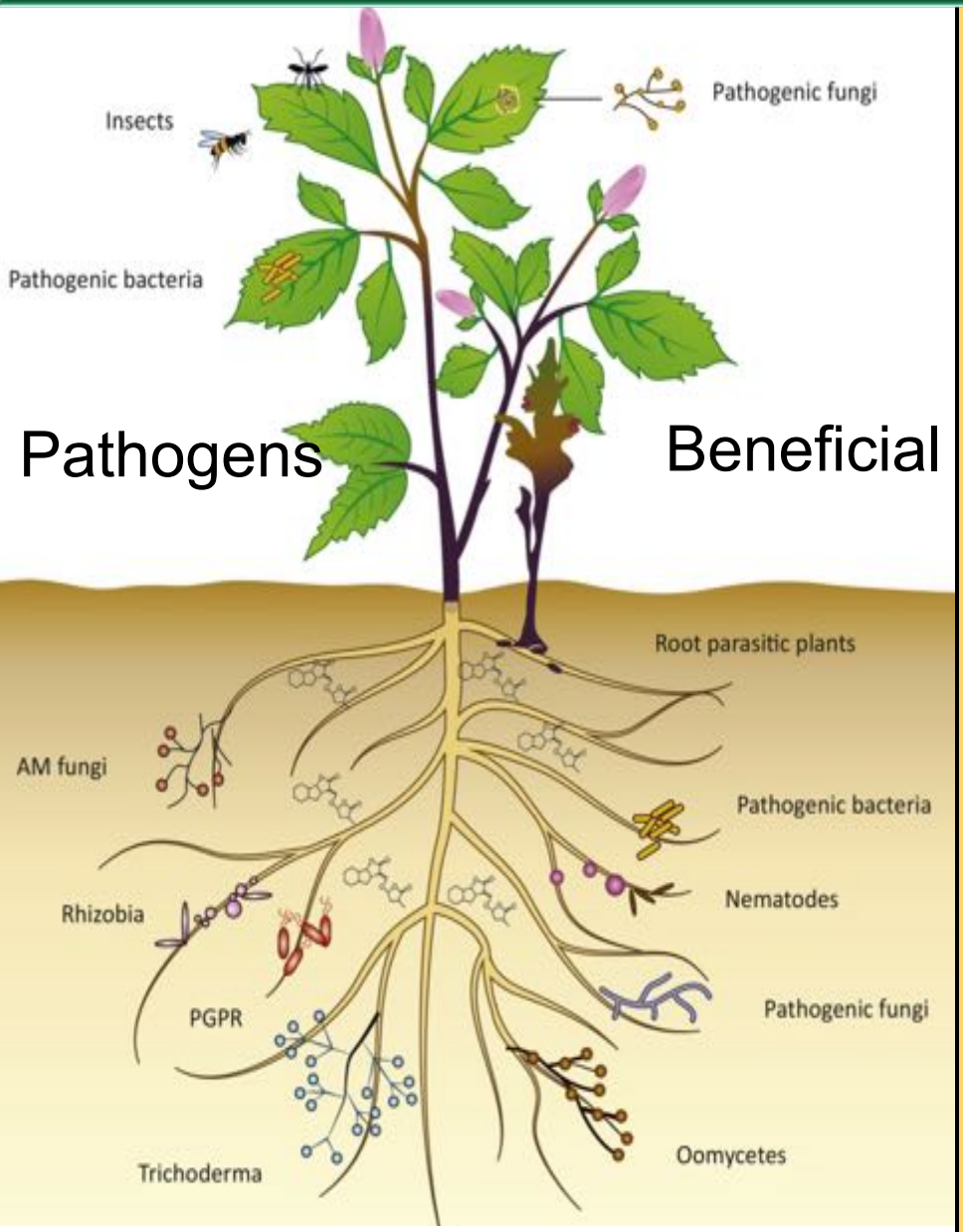


Microbes are mighty!

In 1 teaspoon of soil there are…

Bacteria	100 million to 1 billion
Fungi	6-9 ft fungal strands put end to end
Protozoa	Several thousand flagellates & amoeba One to several hundred ciliates
Nematodes	10 to 20 bacterial feeders and a few fungal feeders
Arthropods	Up to 100
Earthworms	5 or more

Multi-trophic communications

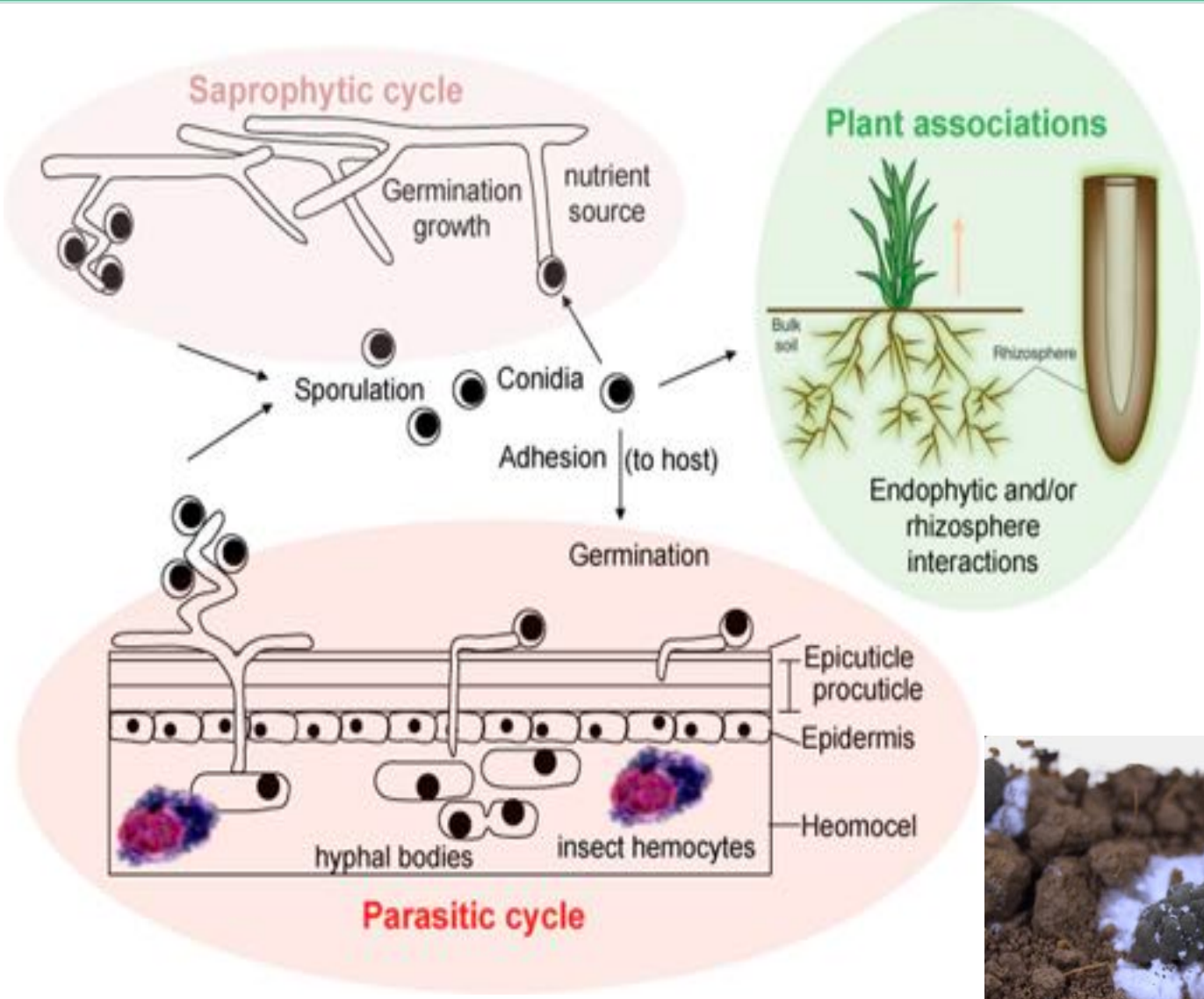


López-Ráez, Juan A. et al.Trends in Plant Science , Volume 22 , Issue 6 , 527 - 537

Metarhizium

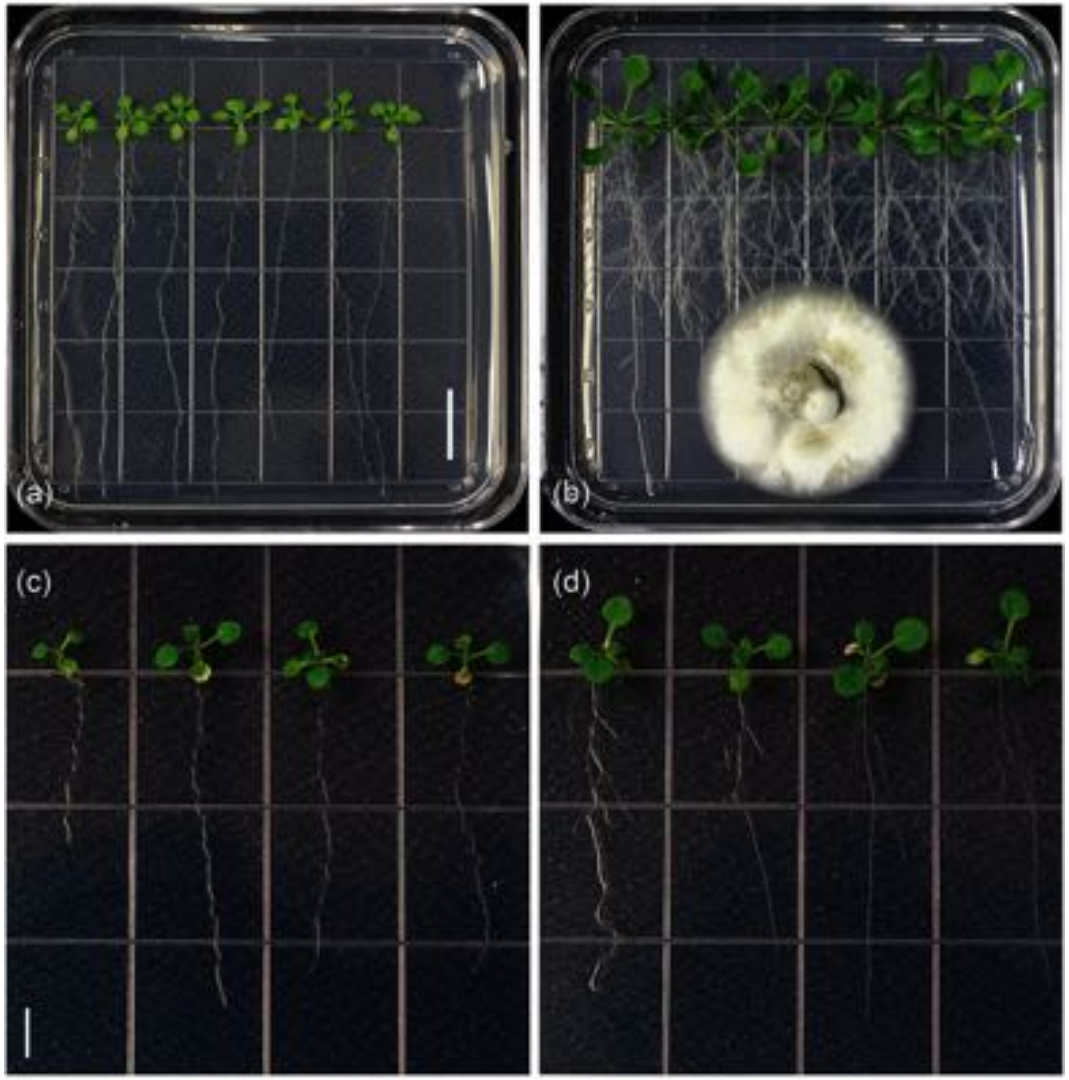
- Hypocreales: Clavicipitaceae
- Insect pathogens
- Plant colonizer
- Broad host range

Life cycle of *Metarhizium*



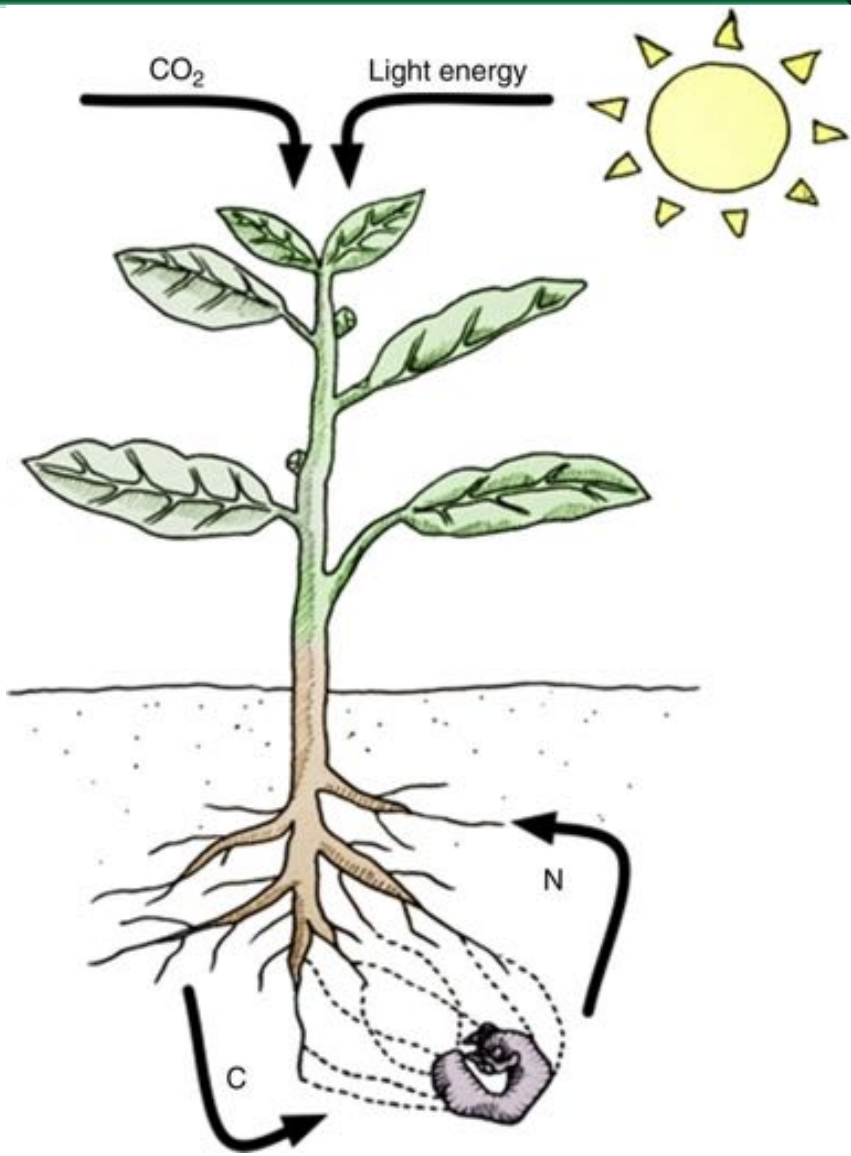
Ortiz-Urquiza, A. et al. (2015). Improving mycoinsecticides for insect biological control. *Applied microbiology and biotechnology*, *99*(3), 1057-1068.

Metarhizium: A multifunctional fungus



- ***Metarhizium***

+ ***Metarhizium***

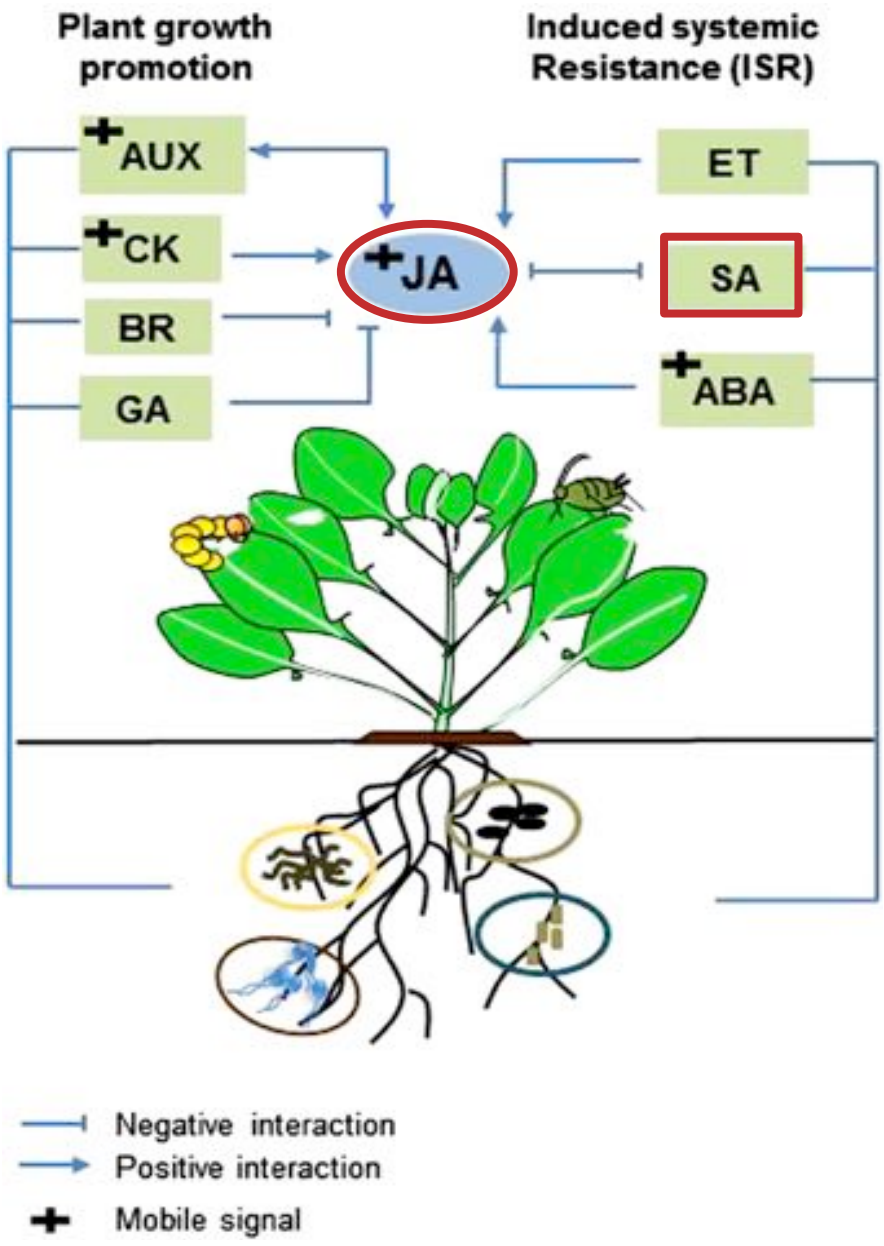


Behie, S. W et al., (2017). Nature communications, 8, 14245. Behie, S. W et al., (2012). Science, 336(6088), 1576-1577. Liao et al., 2017. Microbiology 163: 980-991.

Phytohormone-mediated plant defense

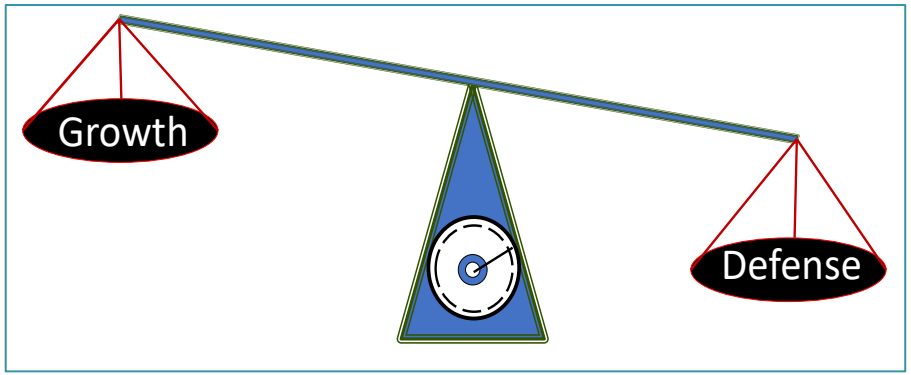
JA: chewing insects, necrotrophic and symbiotic fungi. Growth-defense switch.

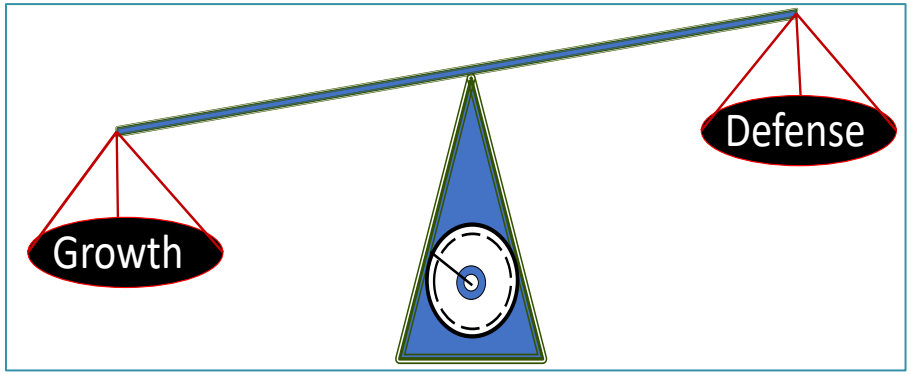
SA: Biotrophic phytopathogens and phloem-feeding insects.

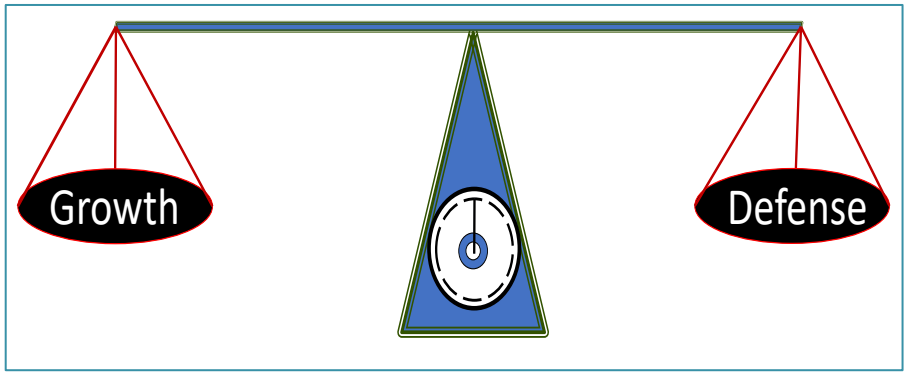


Pangesti et al. 2013. Frontiers Pl. Sci. doi: 10.3389/fpls.2013.00414

Fine-tuning of plant growth and defense







Kliebenstein, 2016. Physiol. Mol. Plant Pathol. 95:55-59.

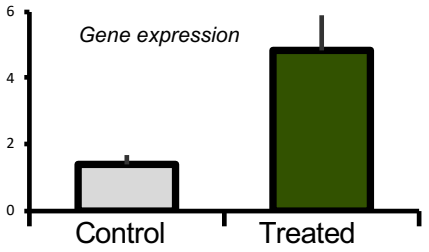
Objectives

- Ability of *M. robertsii* to form endophytic relationship with maize.

- Effects of endophytic *M. robertsii* on maize growth.

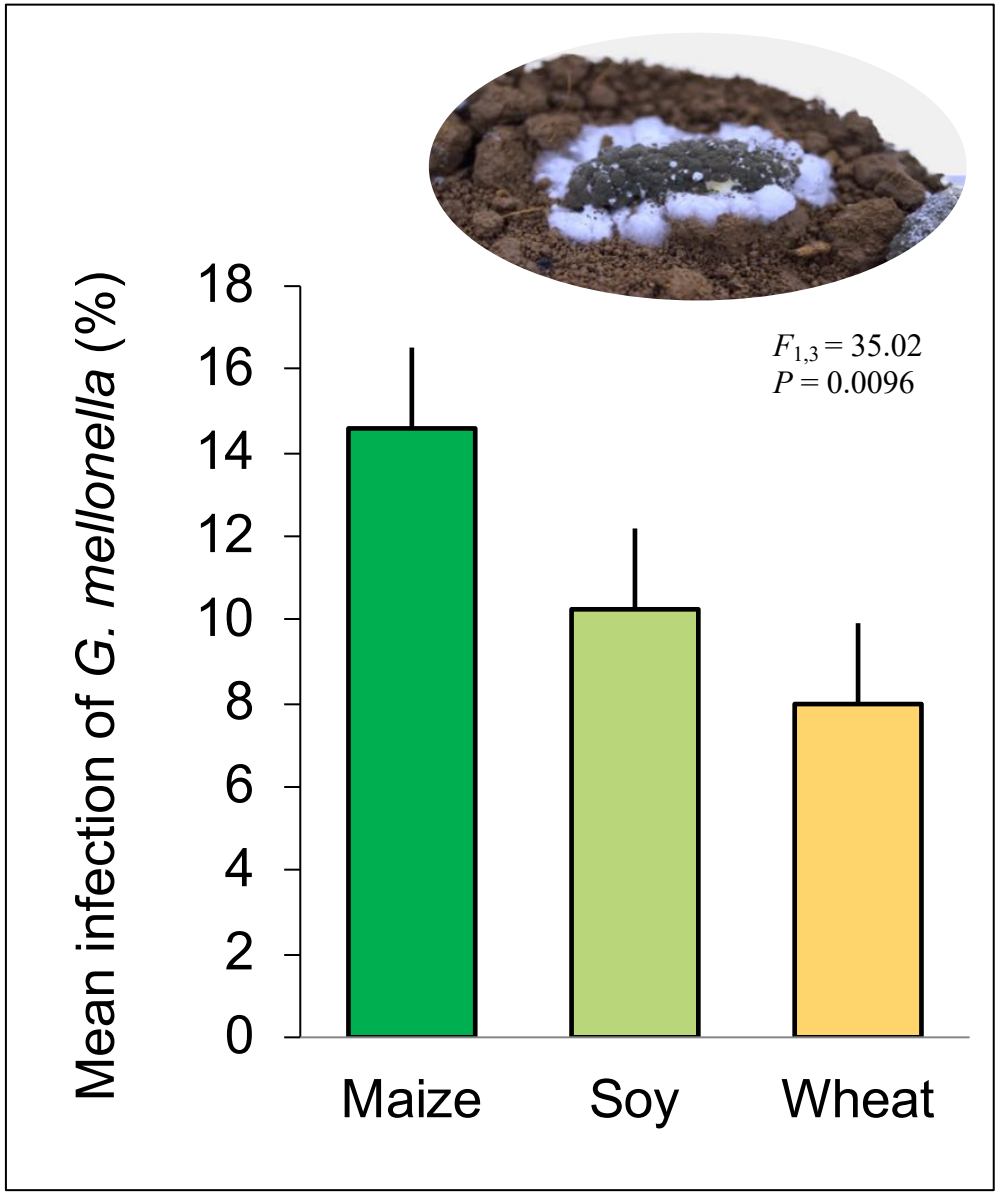
- Effects of endophytic *M. robertsii* on growth of Black Cutworm (BCW).

- Effects of endophytic *M. robertsii* on expression of key plant defense genes.



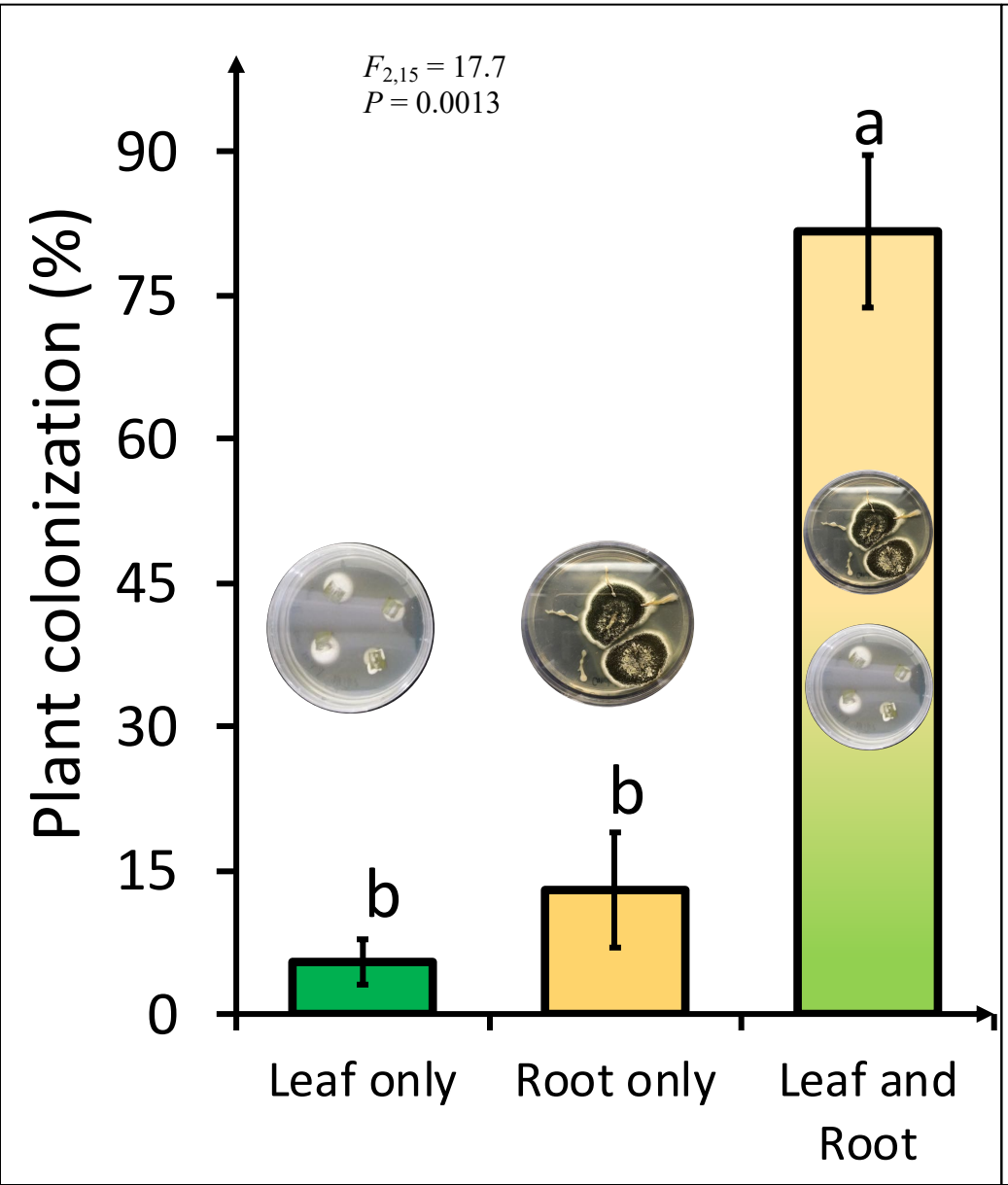
Plant species affect prevalence of *M. robertsii*

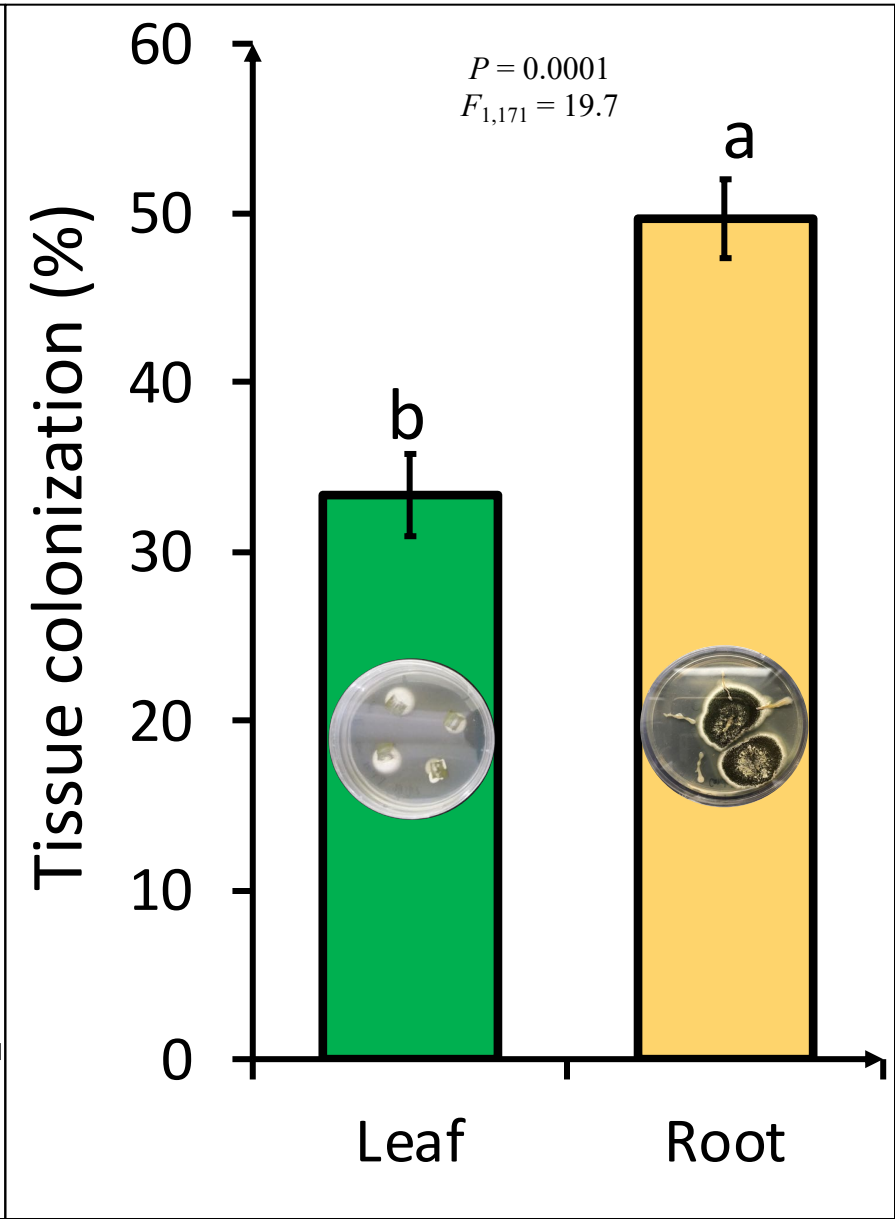
- Detection greatest in maize phase of feed grain rotation.
- Effects on maize growth and defense gene expression, and growth of BCW?



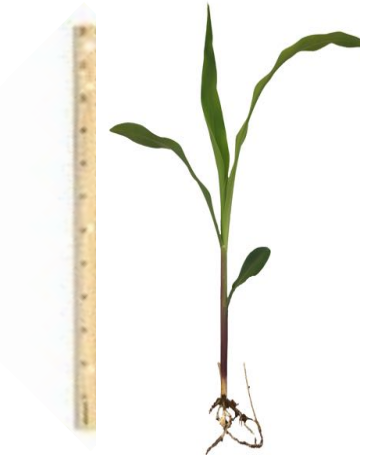
Randhawa et al. 2018. Biological Control

Maize colonization by *M. robertsii*

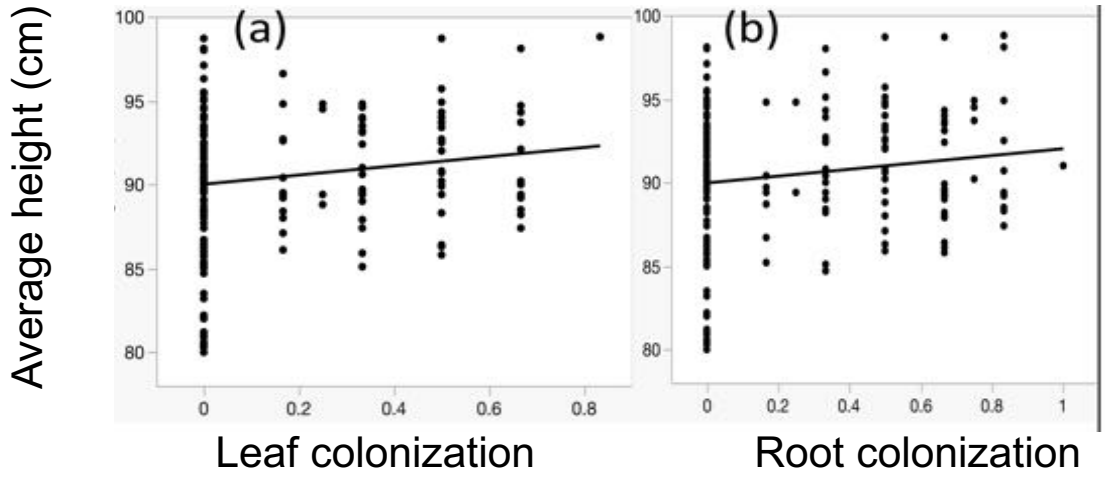




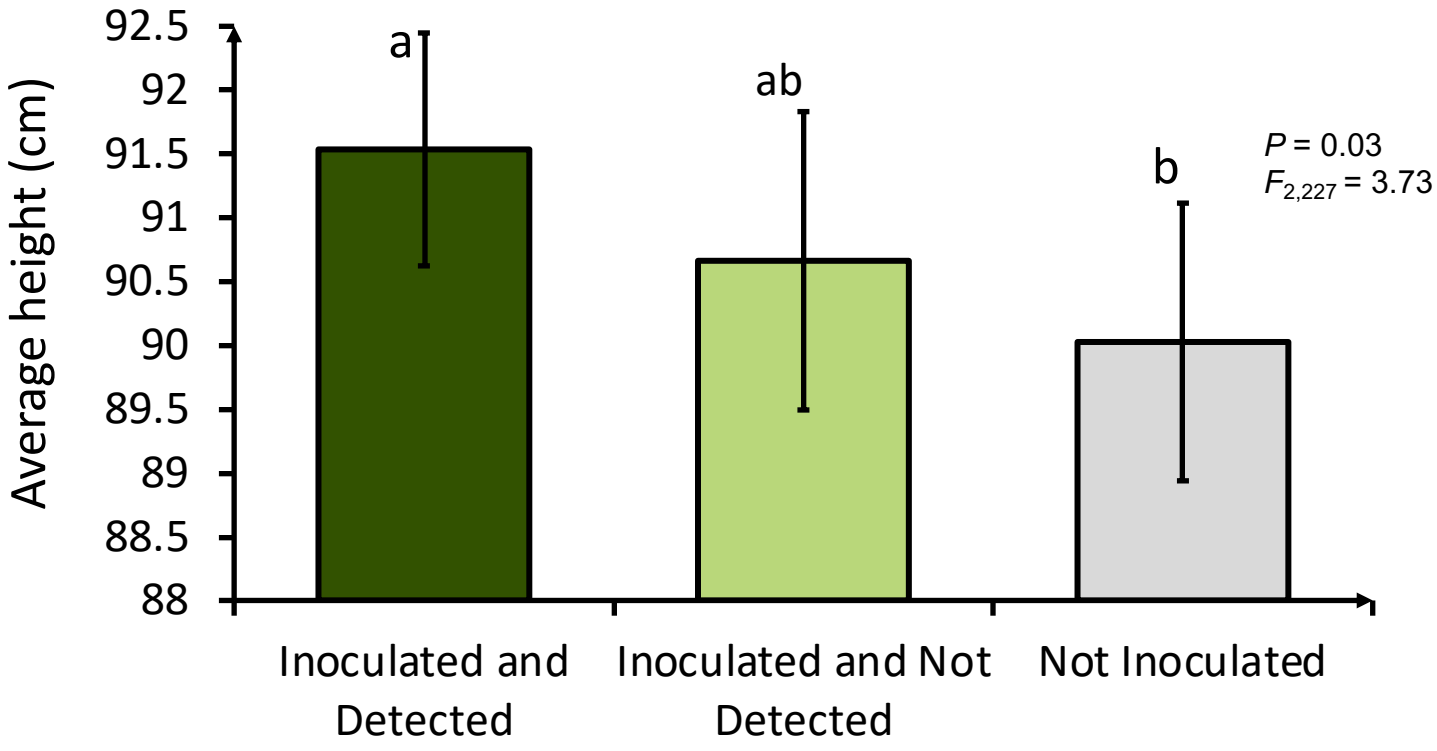
Height is correlated with tissue colonization



$P = 0.02$
Est. =1.87
$R^2_{adj} = 0.02$



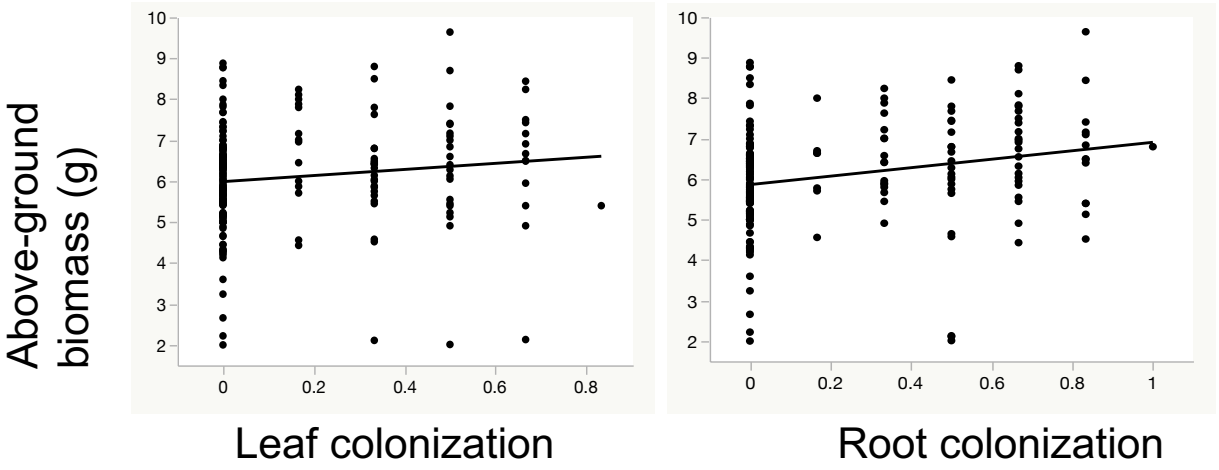
$P = 0.01$
Est. =1.64
$r^2_{adj} = 0.02$



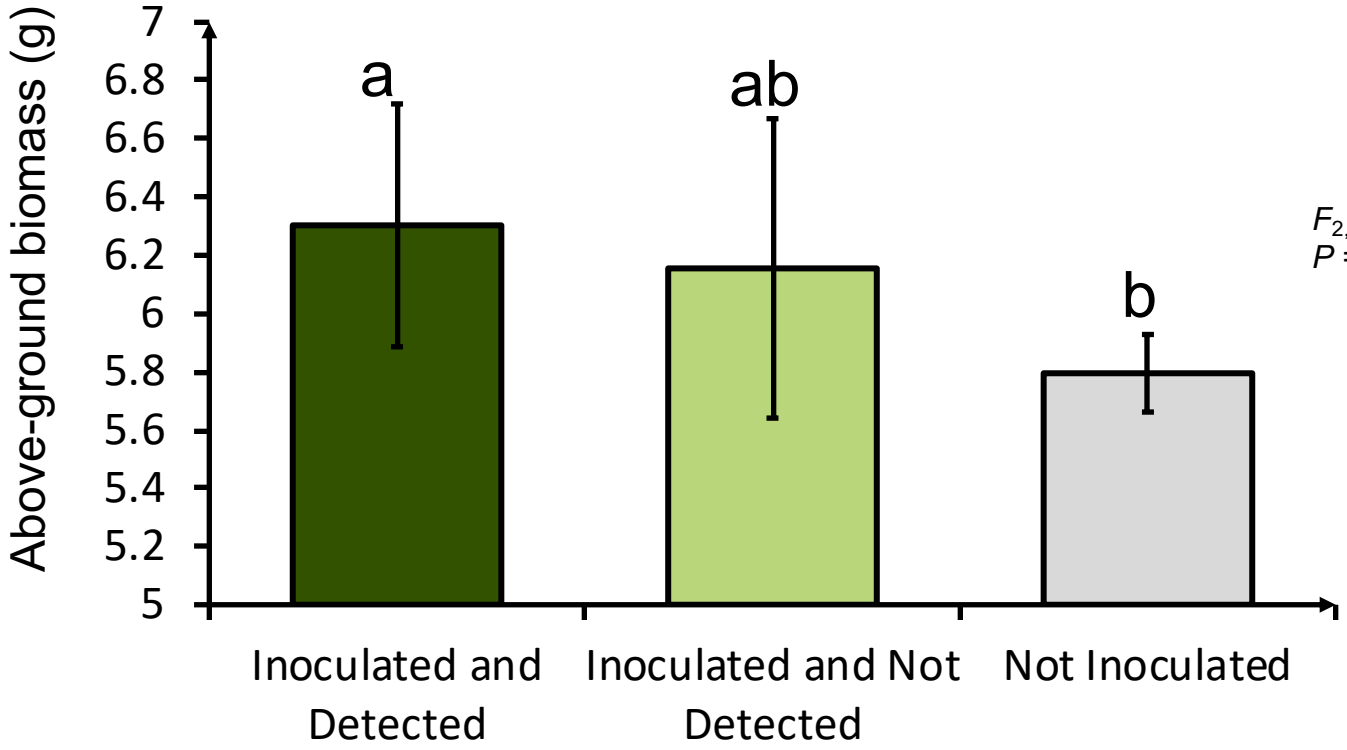
$P = 0.03$
$F_{2,227} = 3.73$

Biomass is correlated with root colonization

r^2_{Adj} = 0.0007
P = 0.16
Est. = 0.41

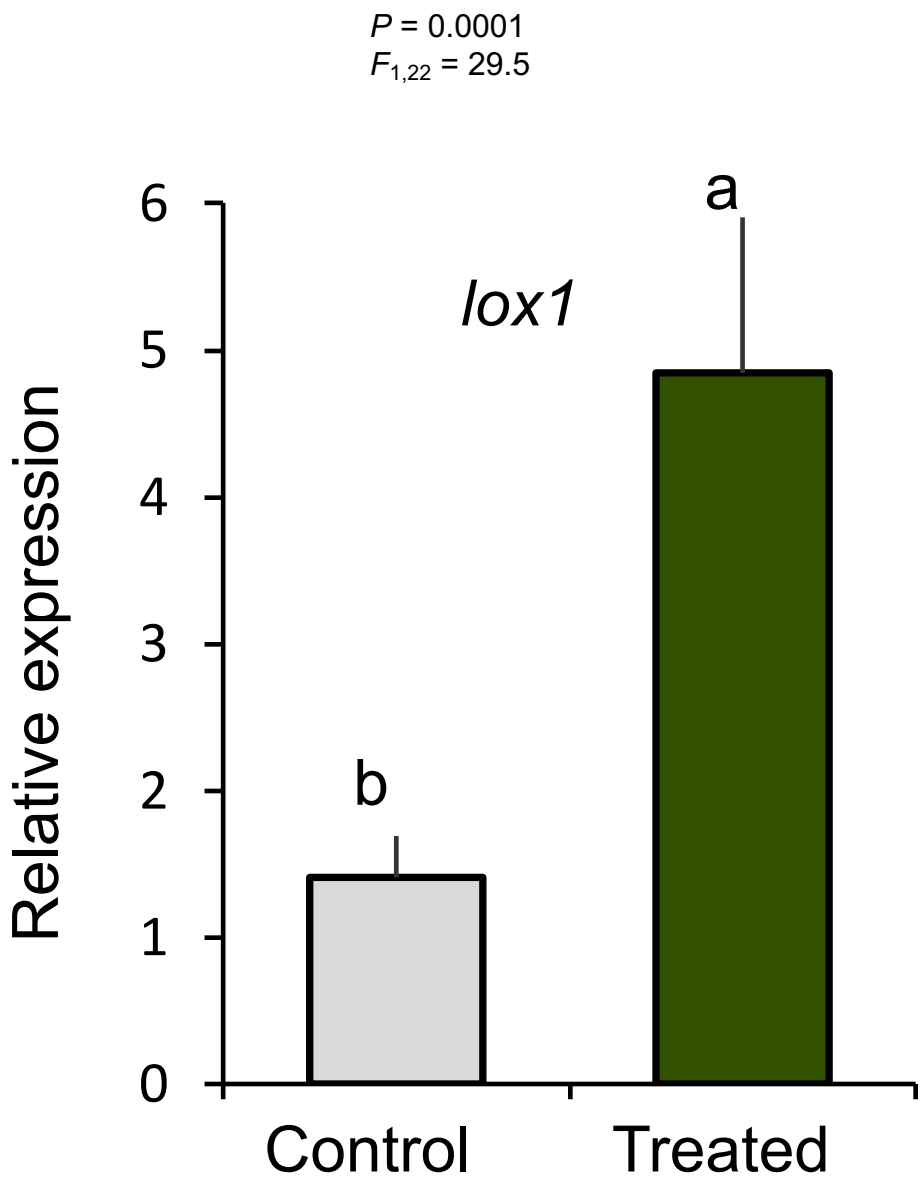


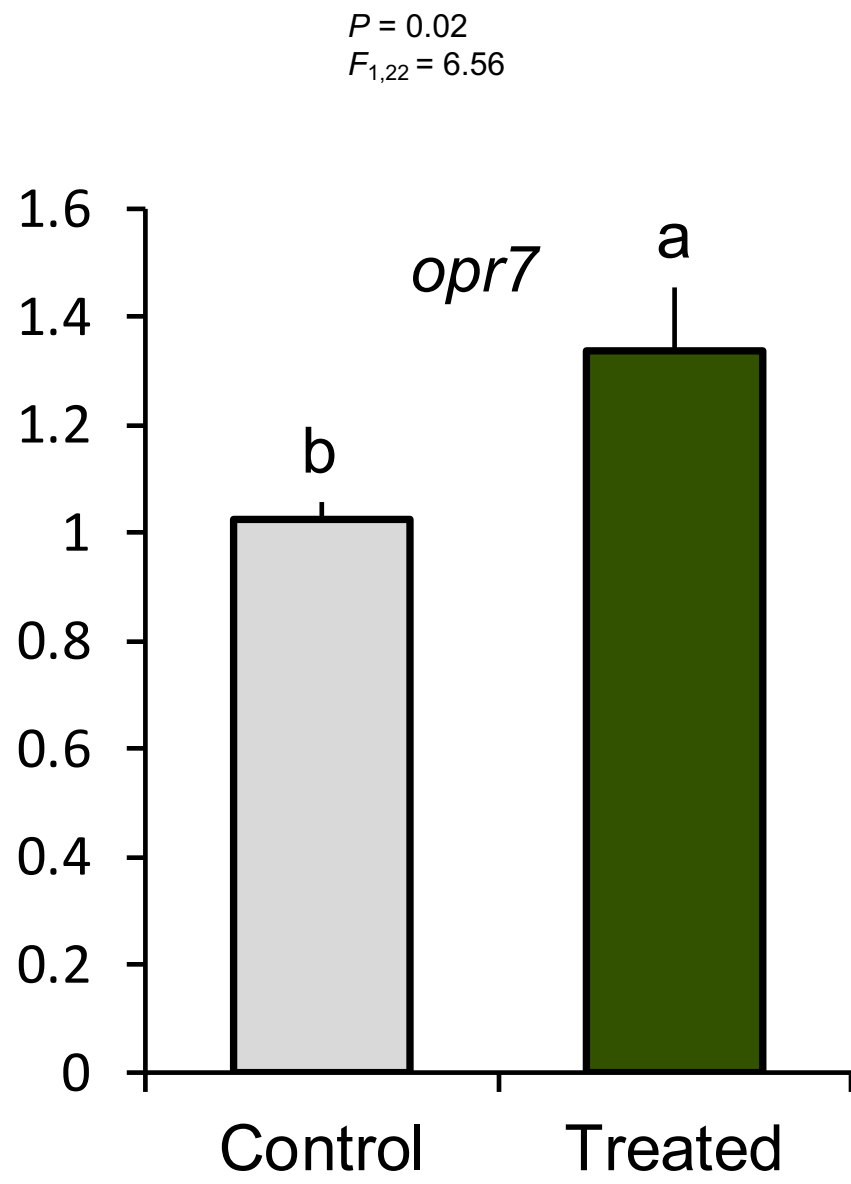
r^2_{Adj} = 0.03
P = 0.006
Est. = 0.67



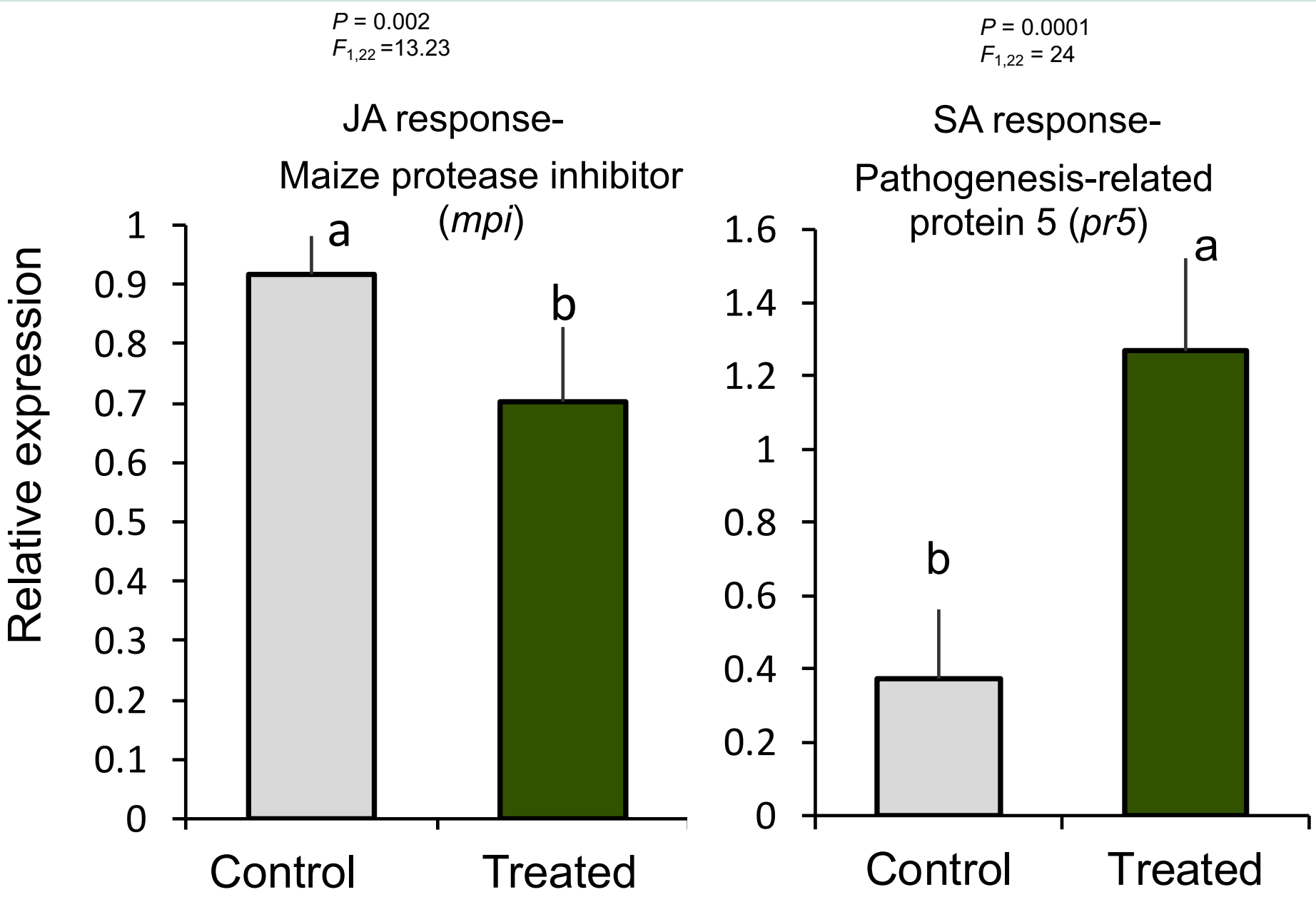
$F_{2,211}$ = 3.78
P = 0.02

Jasmonic acid biosynthesis pathway

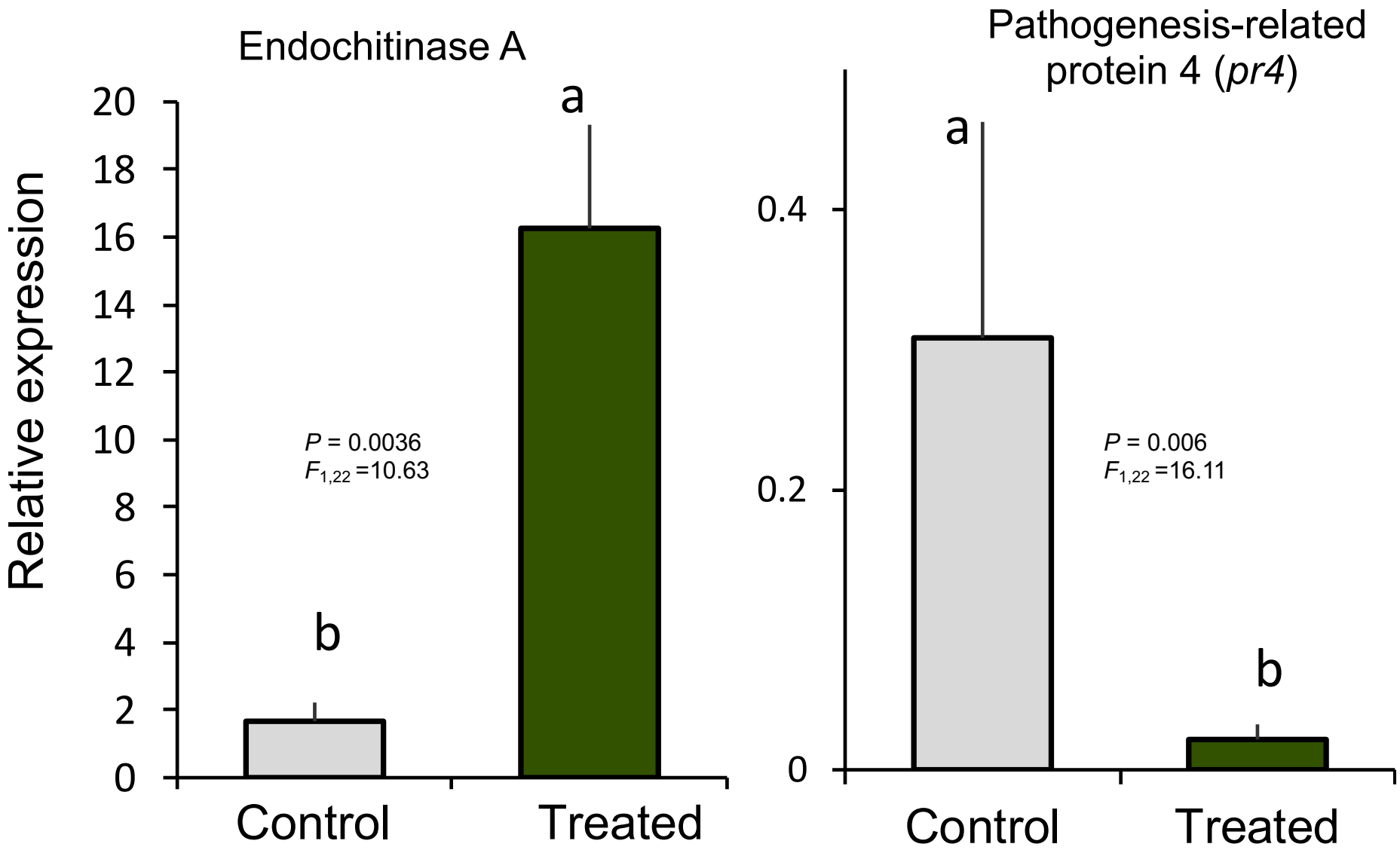




JA and SA response pathways

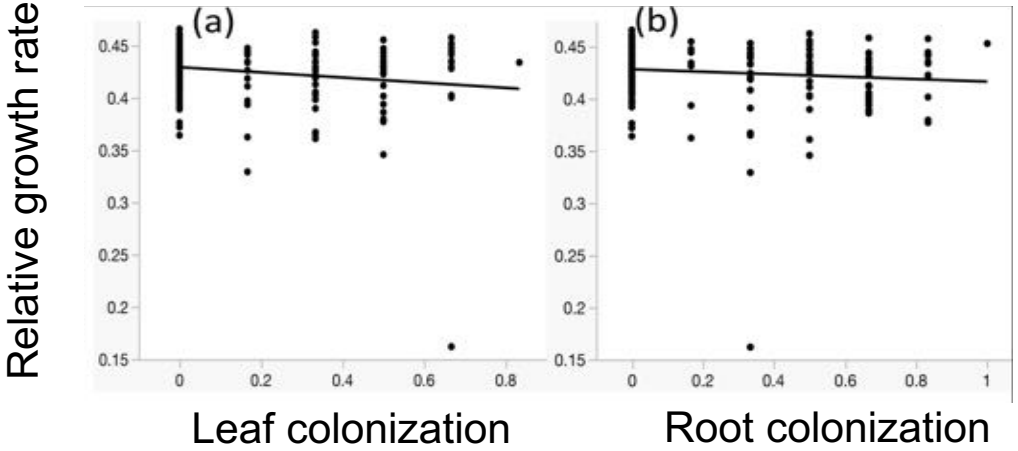


Plant-derived chitinases

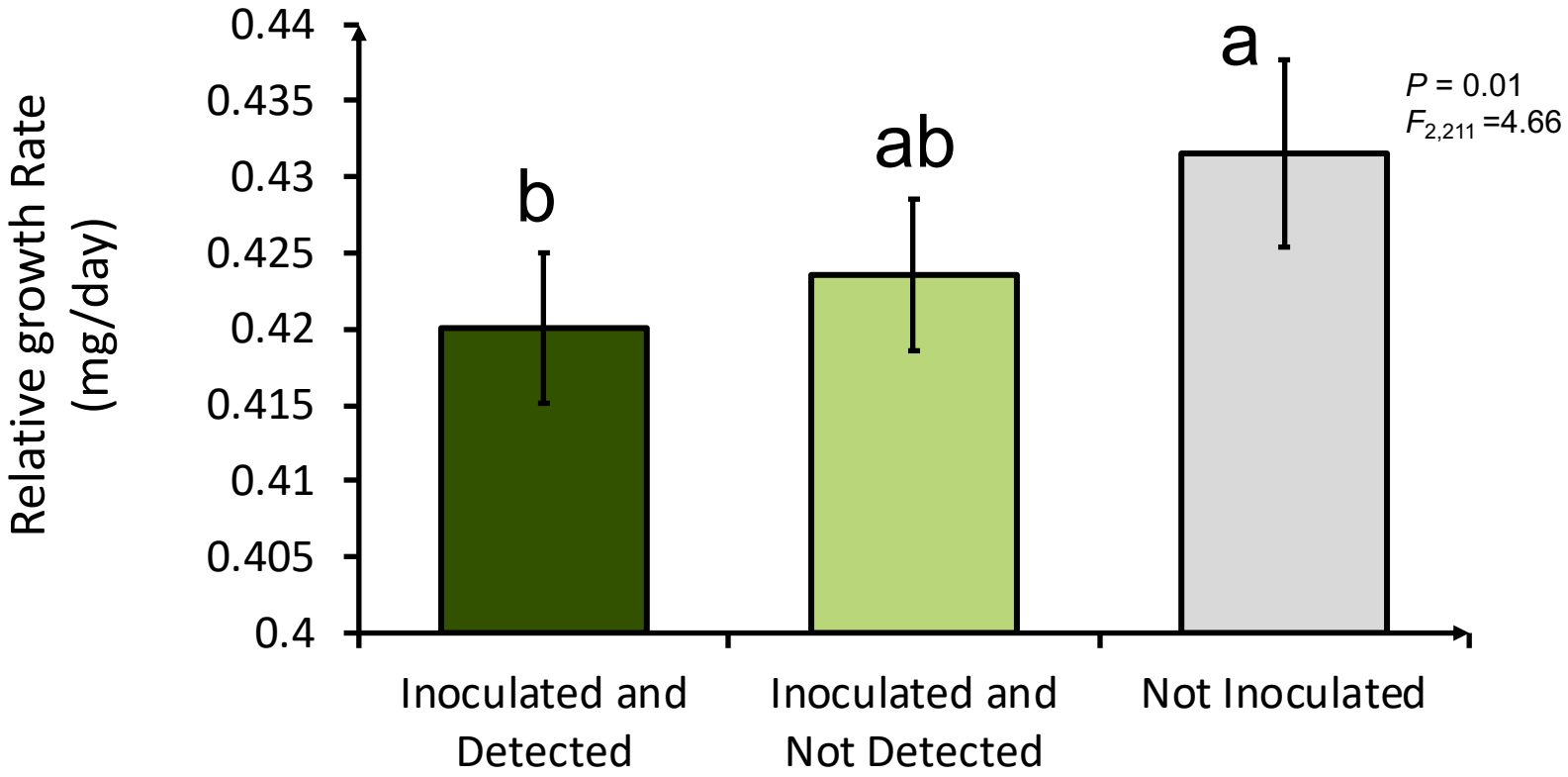


RGR of BCW is correlated with colonization

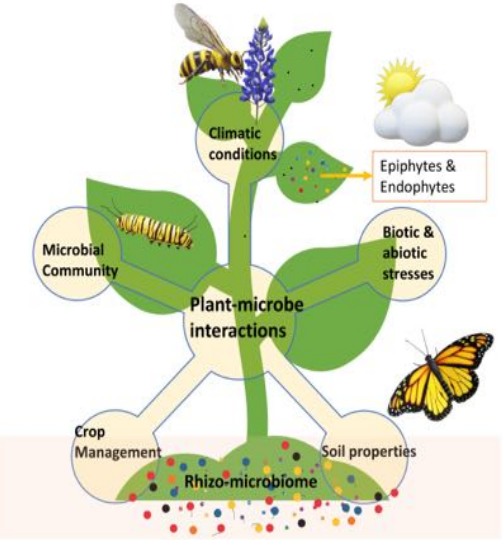
r^2_{Adj} = 0.02
P = 0.03
Est.= -0.01



r^2_{Adj} = 0.02
P = 0.03
Est. = -0.01



Summary



- *M. robertsii* recovered from 91% of treated maize plants. Systemic recovery.
- Endophytic had greater plant height, above-ground biomass and modulated defense gene expression.

- Relative growth rate of black cutworm was lower on leaves from endophytic plants.
- Results support model of integrated response vs. trade-off between plant growth and defense.

Thanks for your attention!