Building tomato resistance to insect pests through soil health management

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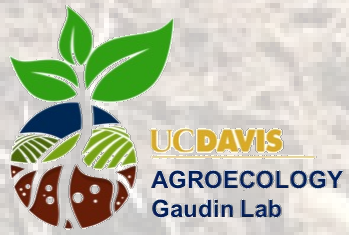


|Meng Li, Leah Renwick, Jen Schmidt, Caitlin Peterson, Gaudin Lab
| Rachel Vannette, UC Davis
| Clare Casteel, Cornell University
| Scott and Brian Park, Organic growers

December 7th 2020| Seed Central Express Online

Soils are foundational for agriculture and (partly) govern …

What is soil health ?

The continued capacity of a soil to function as a *living* ecosystem that sustains plants, animals, and humans

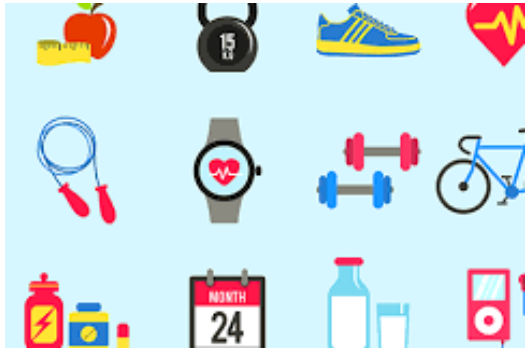
The health *metaphor*

- Our health
  - Parents (genes) x
  - Environment x
  - Actions (Diet, Exercise…)

- Soil Health
  - Parents (rocks) x
  - Environment x
  - Actions (Ag management)







Physical

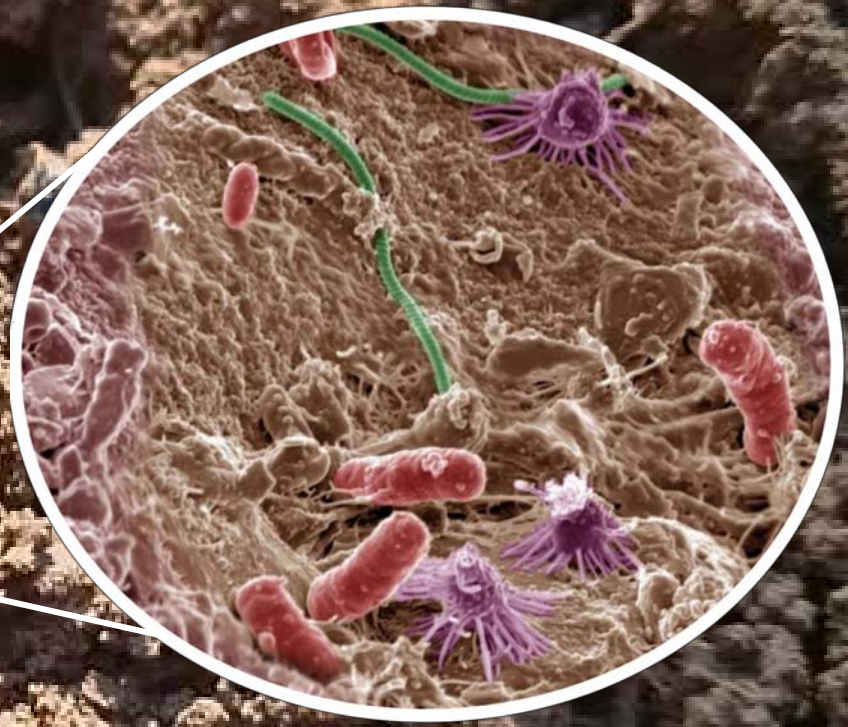
- Aggregation and Structure
- Surface Sealing
- Compaction
- Porosity
- Water Movement and Availability

Chemical

- pH
- Soluble Salts
- Sodium
- Nutrient Holding Capacity
- Nutrient Availability

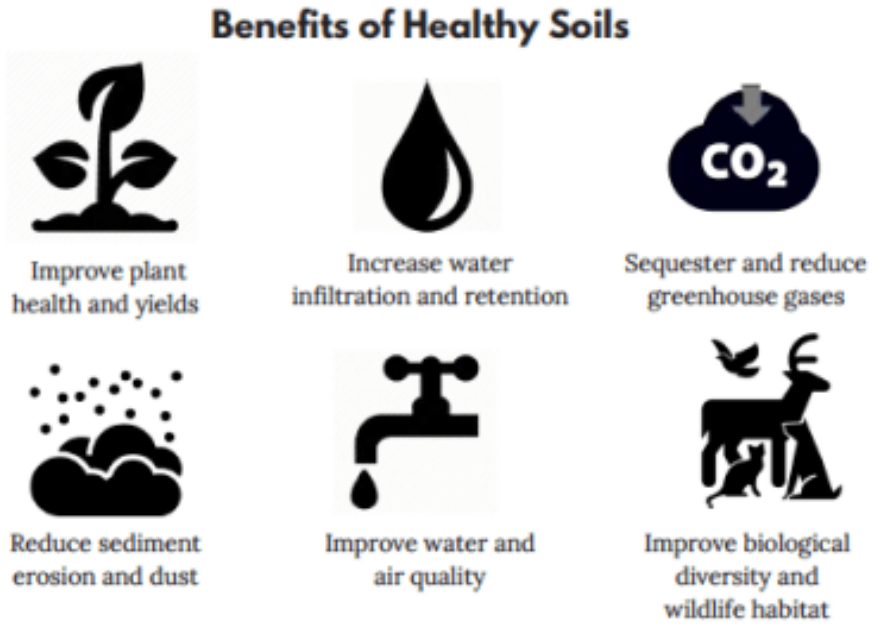
Biological

- Macrofauna
- Microfauna
- Microorganisms
- Roots
- Biological Activity
- Organic Matter



A healthy soil has **adequate physical structure**, is **chemically balanced** and fosters a **diverse and active microbial community**

Soil microbes photo credit
Alice Dohnalkova, PNNL



Some management practices (included for incentives)

- Reduced tillage
- Mulching
- Compost applications
- Cover crops
- Field borders/hedgerow

…

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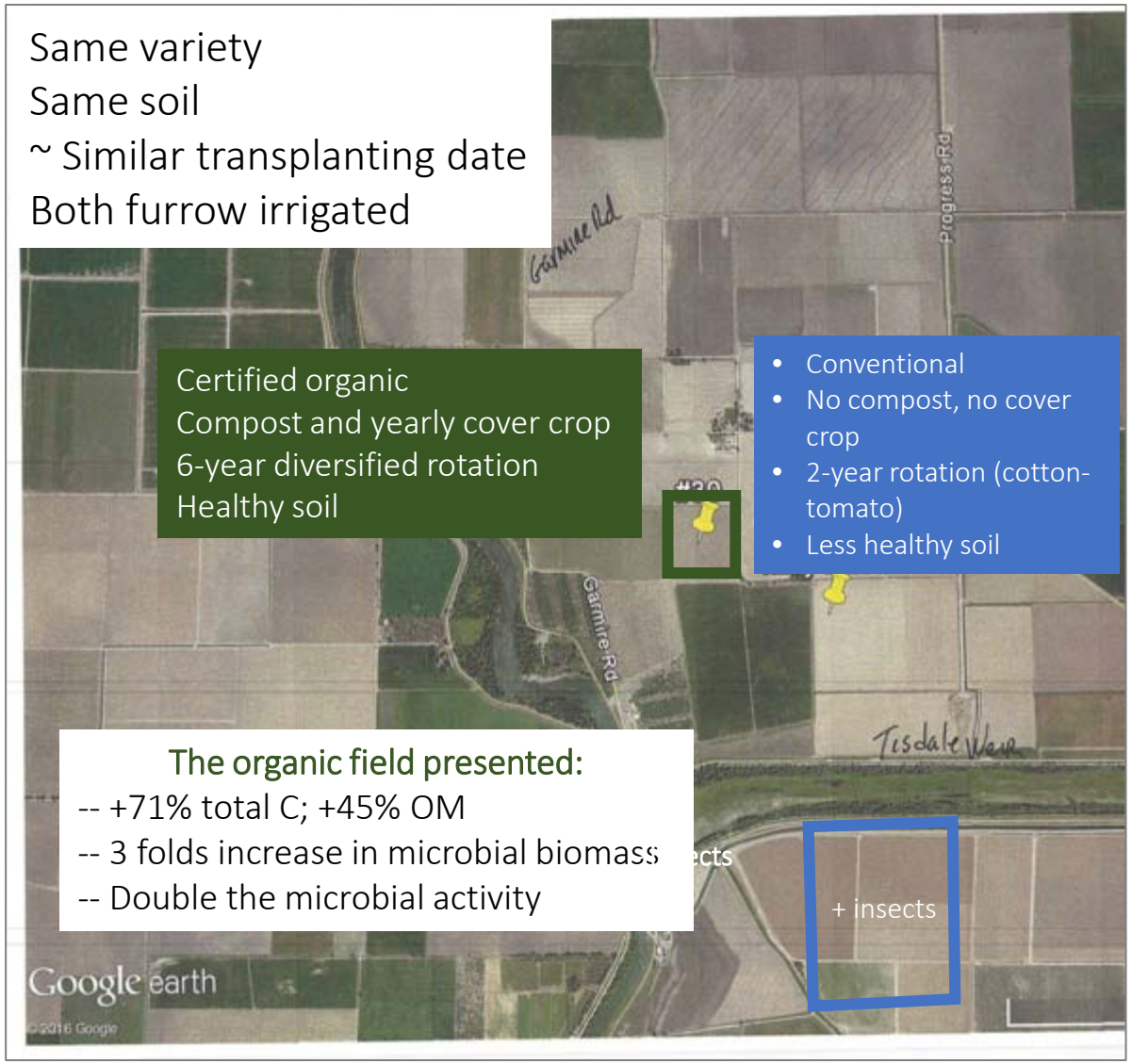
This research started with an observation…

- Very low insect pest pressure, no need for insecticides
- Few beet leafhoppers, vectors of the beet curly top virus

Same variety
Same soil
~ Similar transplanting date
Both furrow irrigated



Certified organic
Compost and yearly cover crop
6-year diversified rotation
Healthy soil

- Conventional
- No compost, no cover crop
- 2-year rotation (cotton-tomato)
- Less healthy soil

The organic field presented:
-- +71% total C; +45% OM
-- 3 folds increase in microbial biomass
-- Double the microbial activity

+ insects

What causes reduction in insect virus vectors of BCTV in this field?

Organic agriculture promotes evenness and natural pest control

David W. Crowder[1], Tobin D. Northfield[1], Michael R. Strand[2] & William E. Snyder[1]

Nature, 2010, Volume 466, Number 7302, Page 109

… and others…

Top down control

Natural enemies

Predation
Antagonisms

- Insect sweeps showed **higher biodiversity**
- But **no significant differences in relative abundance of natural predators** in his field compared to surrounding ones

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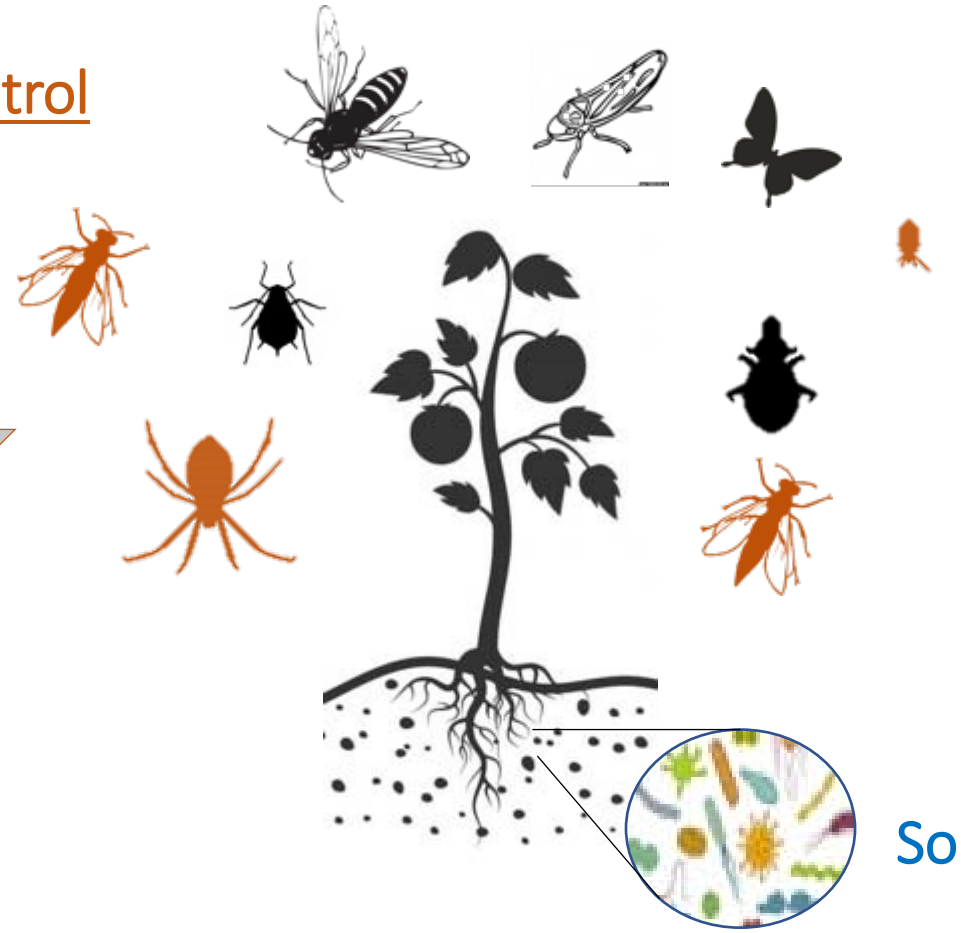


Plant Defense

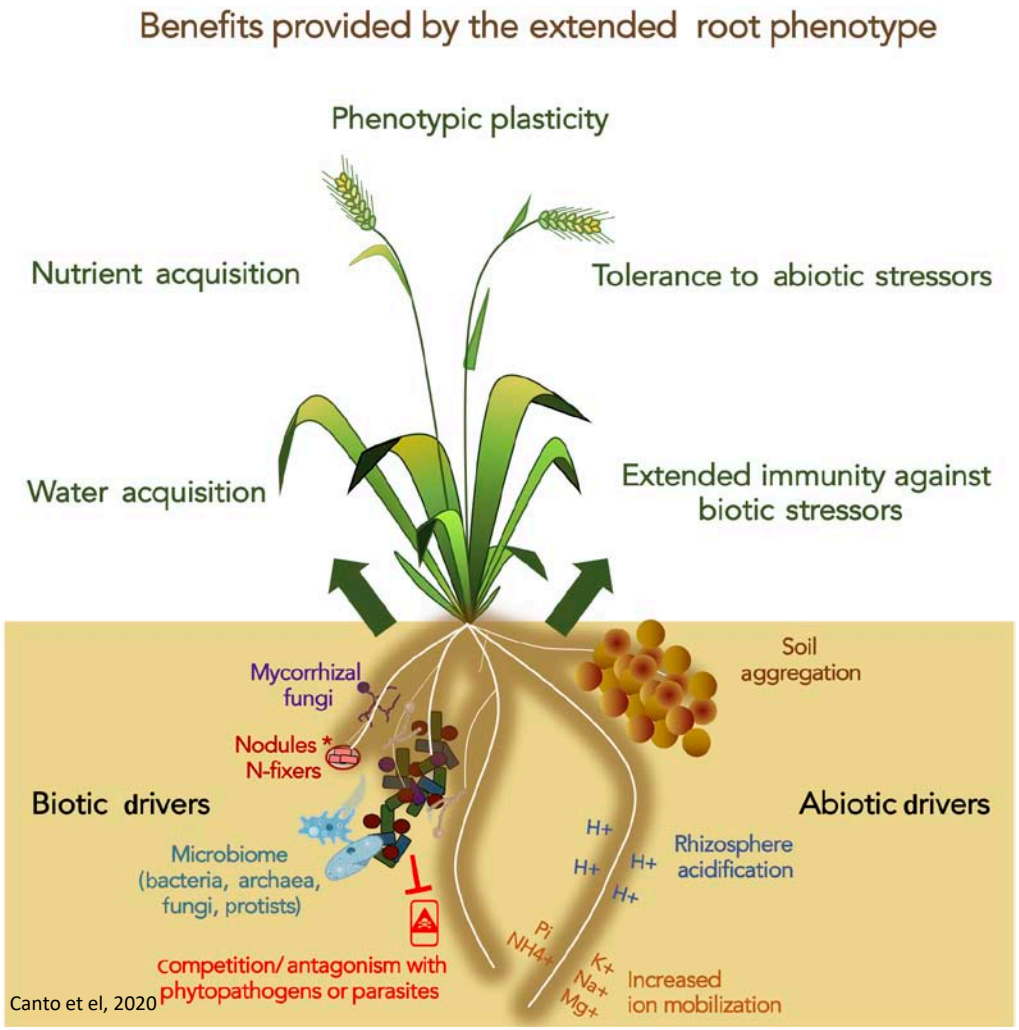
- *Resistance*
- *Attractiveness*

Induced Systemic Resistance

Bottom up control

Soil microbes

The rhizosphere: a unique environment
Could impact above ground pests?

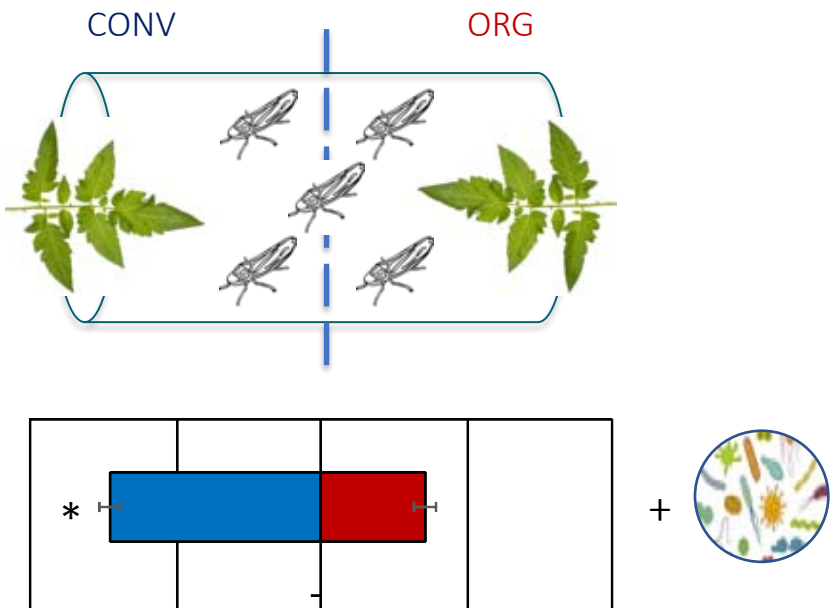


Schmidt, Kent**, Brisson, Gaudin** (2019). *Microbiome*, 7: 146

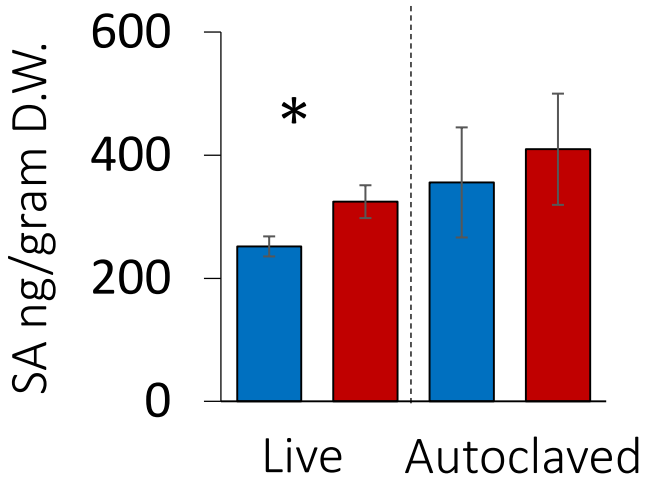
Schmidt, Vannette, Igwe, Blutnell, Castell, **Gaudin** (2019). *Applied and Environmental Microbiology*, 85: e01064-19

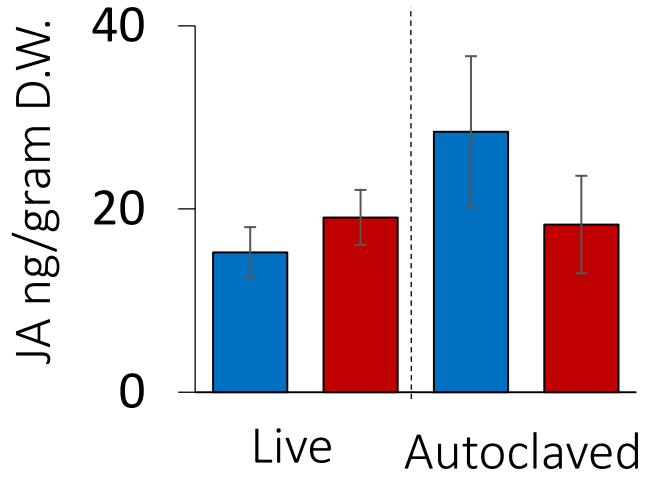
Management has the largest impact on the rhizosphere microbiomes

- Extracted soil slurries (soil + microbes) from conventional and organic replicated field plots
- Inoculated tomato plants growing on sterile soil media in a growth chamber



Live microbes





Confirmed with

- Induction assays
- Salicylic acid and Jasmonic acid induction-deficient mutants

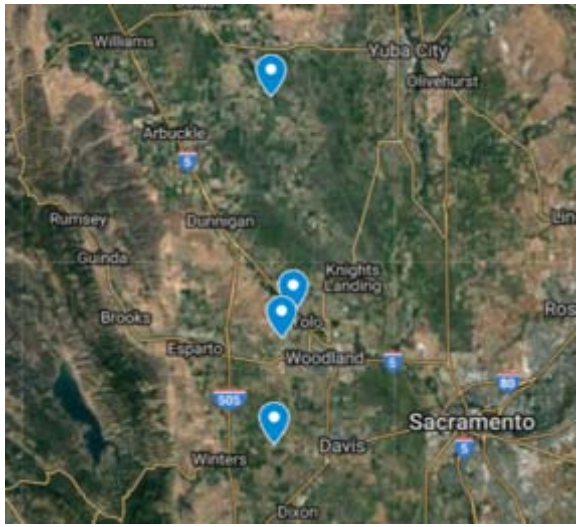
Rhizosphere biota drives differences in leafhopper preference, performance and plant resistance via salicylic acid

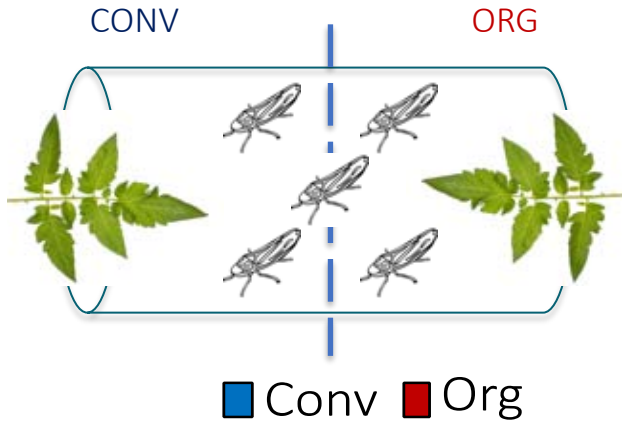
Blutnell , **Schmidt**, Castell, Vannette, **Gaudin** (2020) *Nature Plants, 6:483–491*

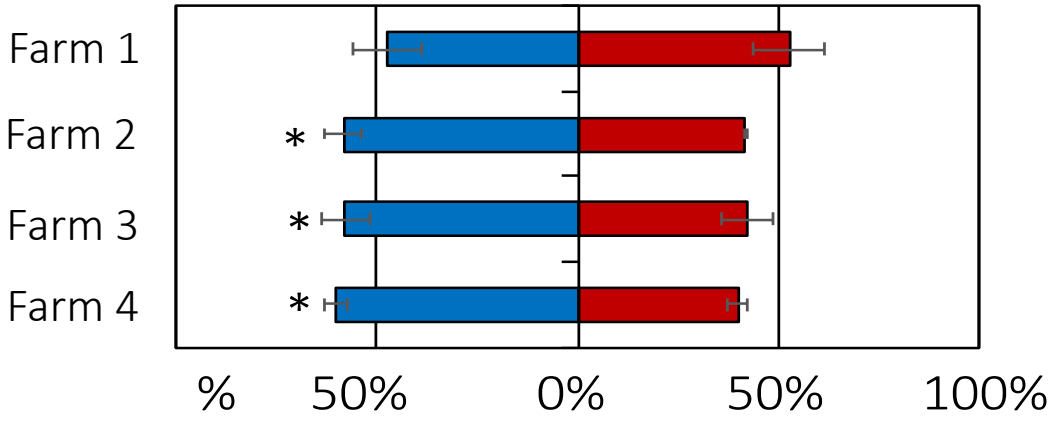
In a growth chamber….how about across diverse agricultural fields?

- 4 paired agricultural fields sites in Yolo county

- Organic and conventional
- Processing tomato
- Same grower, soil type and transplanting dates







Fewer leafhoppers settled on organically managed tomatoes for most farms

Blutnell , **Schmidt**, Castell, Vannette, **Gaudin** (2020) *Nature Plants, 6:483–491*
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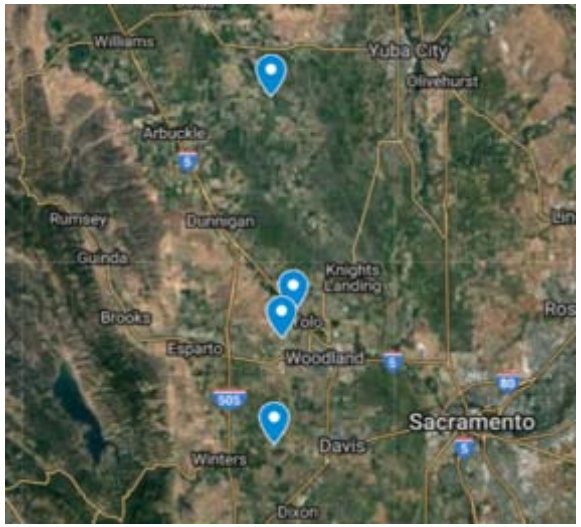

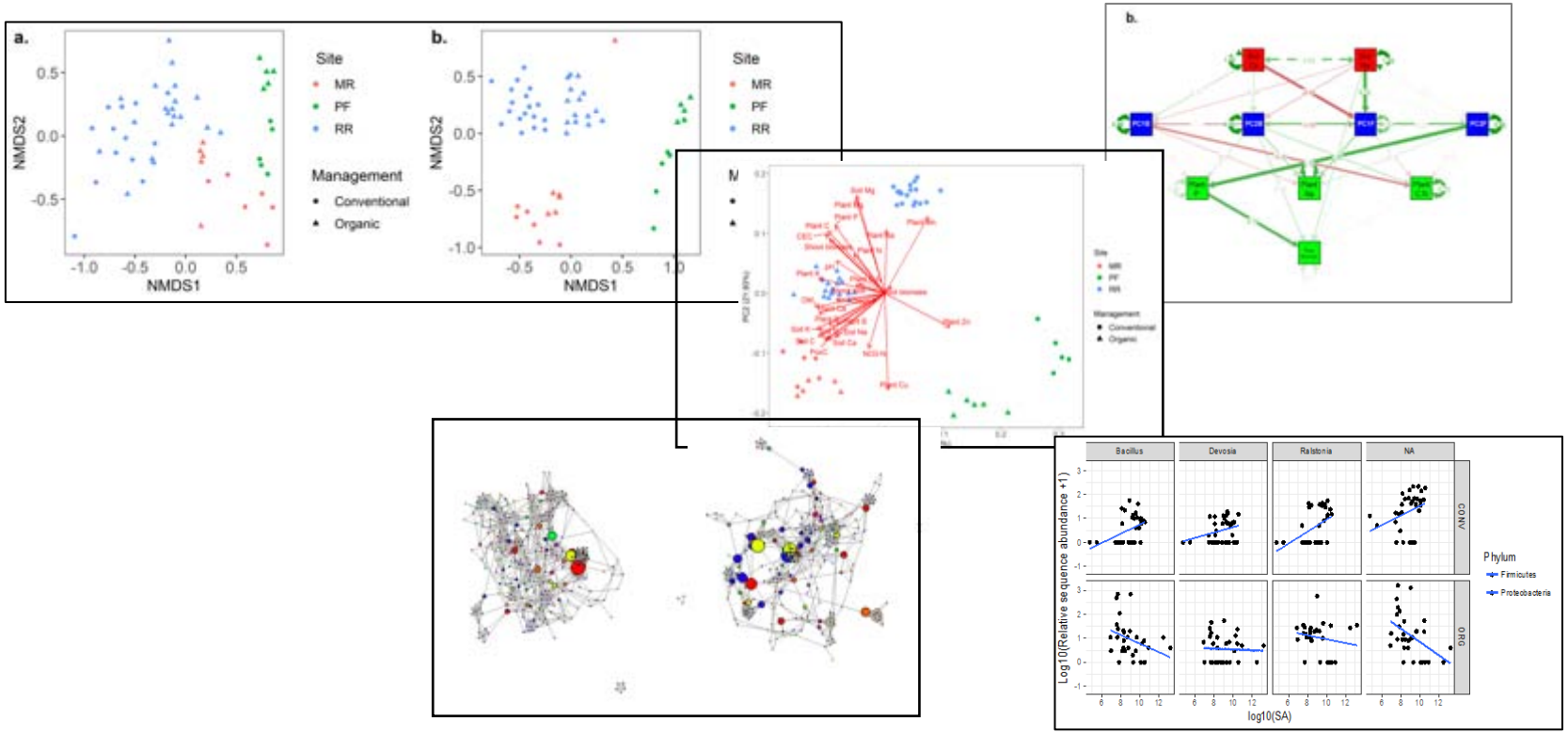

- Leaf nutrient and Salicylic acid were **significantly associated with microbial community composition** and **leafhopper preference**.

- **Identified some microbes which are correlated with SA levels in organic production systems**

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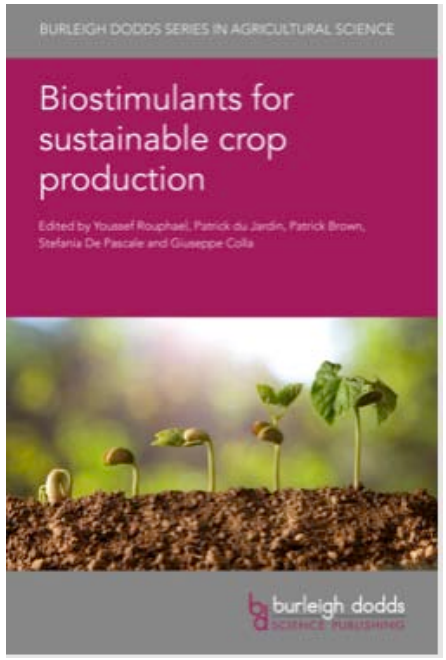
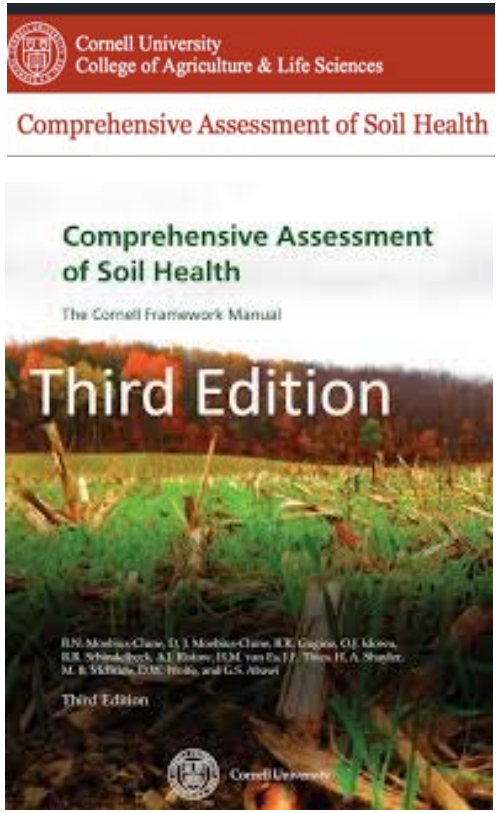
Conclusions

- Mechanisms and key practices ?

- Keeping in tune with *Farmers*
- Soil microbes, key components of healthy soils, play an unappreciated role in depressing herbivores attacks.
- We have an unprecedented opportunity to develop the *next generation of IPM strategies* which integrates soil and fertility management.
- Fostering these beneficial interactions also provides other *co-benefits* for sustainability and resilience of farming systems.





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- Tools
- Technical Assistance
- Incentive program

Picture credit| Scow Lab

Thank you

UC Davis- Plant Pathology, Entomology & Nematology
Rachael Vannette, Clare Casteel
Grower partners, thank you
My lab and all people who gave us a hand !

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