Mycorrhizae of red raspberry

and potential influence on root-rot and root-lesion nematodes

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September 20 (Week 24)

Ample AMF in raspberry field soil

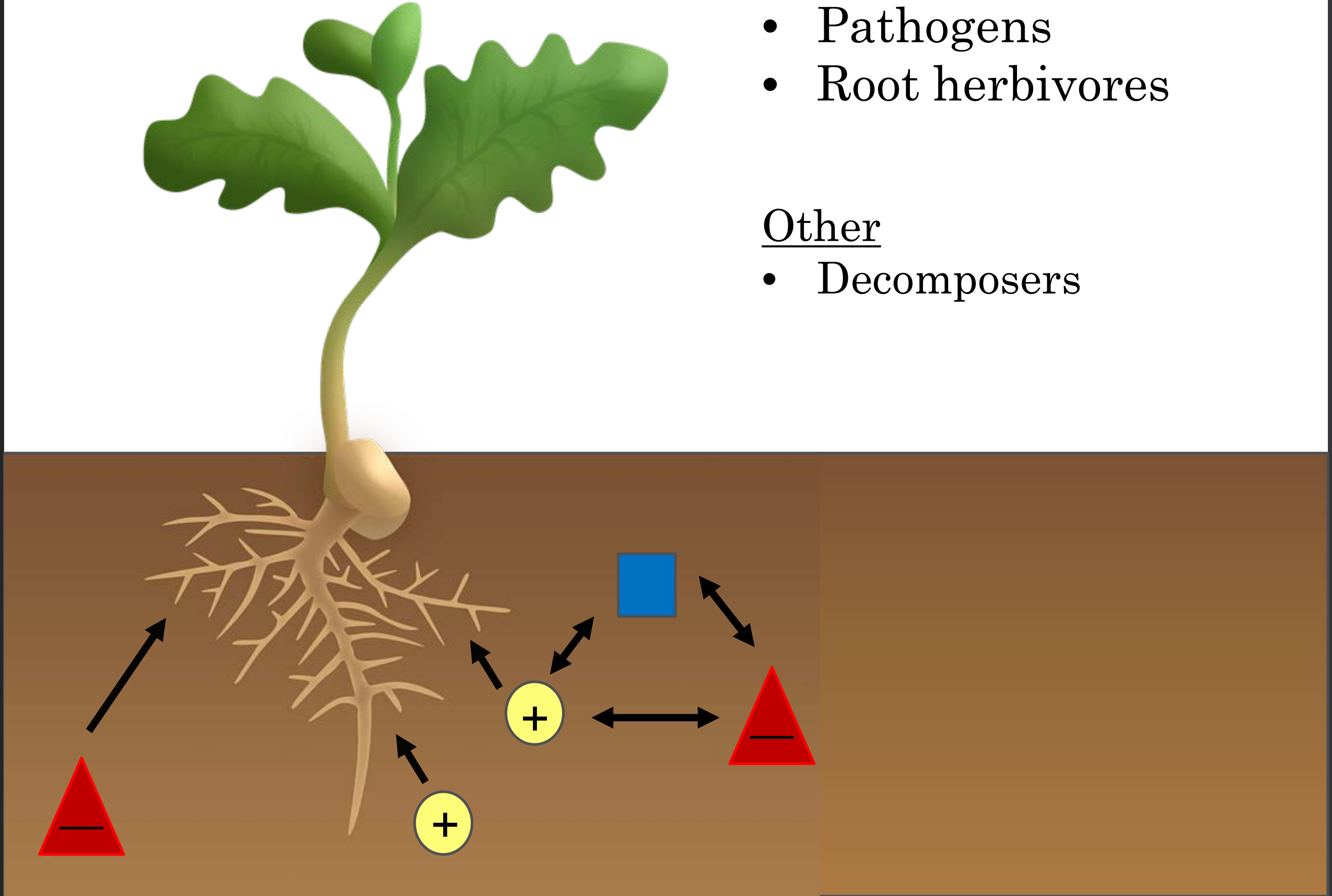
Mycorrhizal fungi:

- Increased leaf nitrogen
- Reduced or similar height/biomass

Pest treatments:

- No effect on plant biomass (with or without mycorrhizal fungi)
- More to come

Microbial Communities in Agroecosystems



<u>Plant-beneficial biota</u>
- Mycorrhizal fungi
- Plant growth promoting bacteria

<u>Pests</u>
- Pathogens
- Root herbivores

<u>Other</u>
- Decomposers

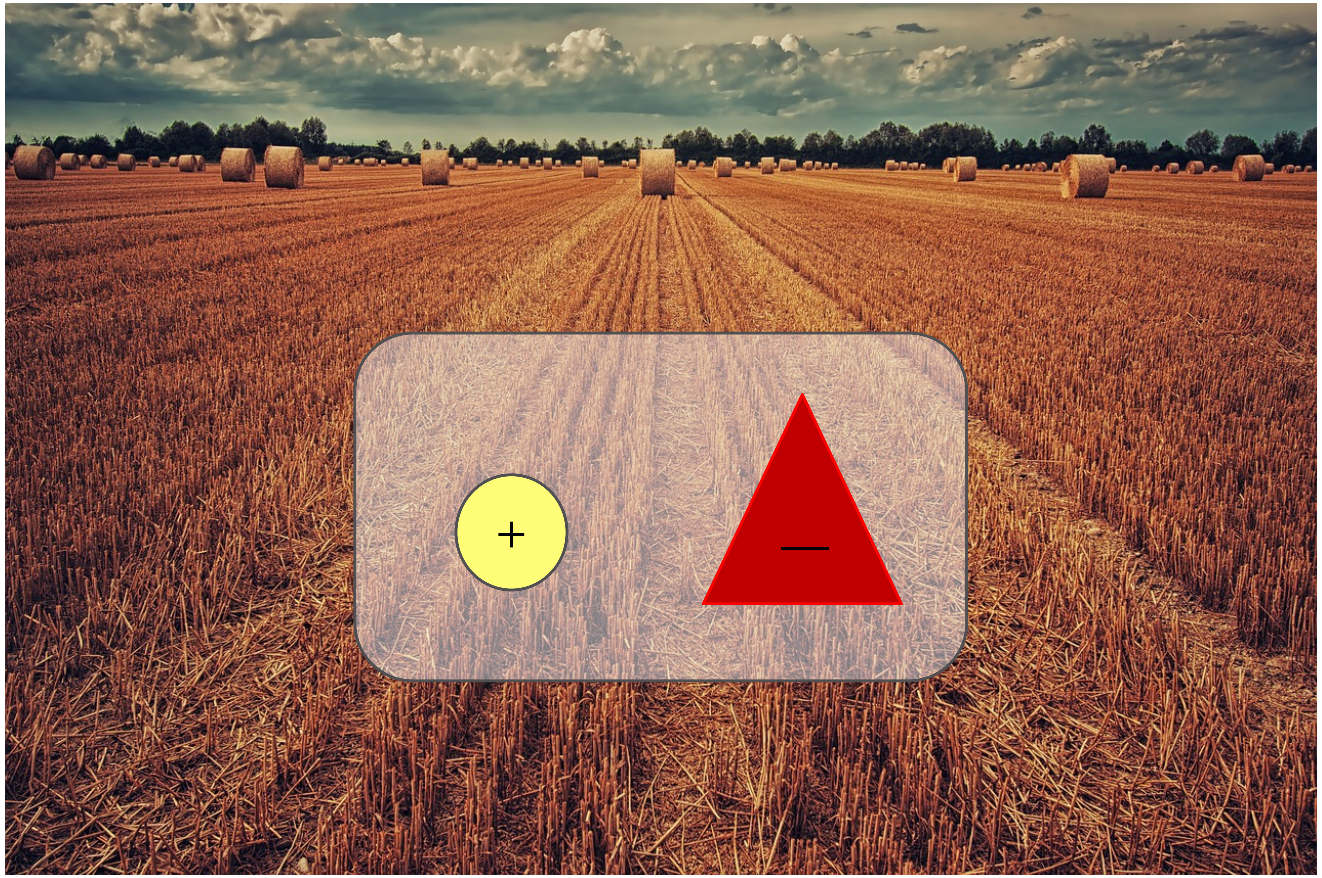
Microbial Communities in Agroecosystems

Methods to improve plant growth using soil ecology:

1. Adoption of cultural strategies that promote soil microbial diversity

2. Re-introduction of key plant-beneficial microbiota

Photo by Johannes Plenio. Retreived from Pixabay

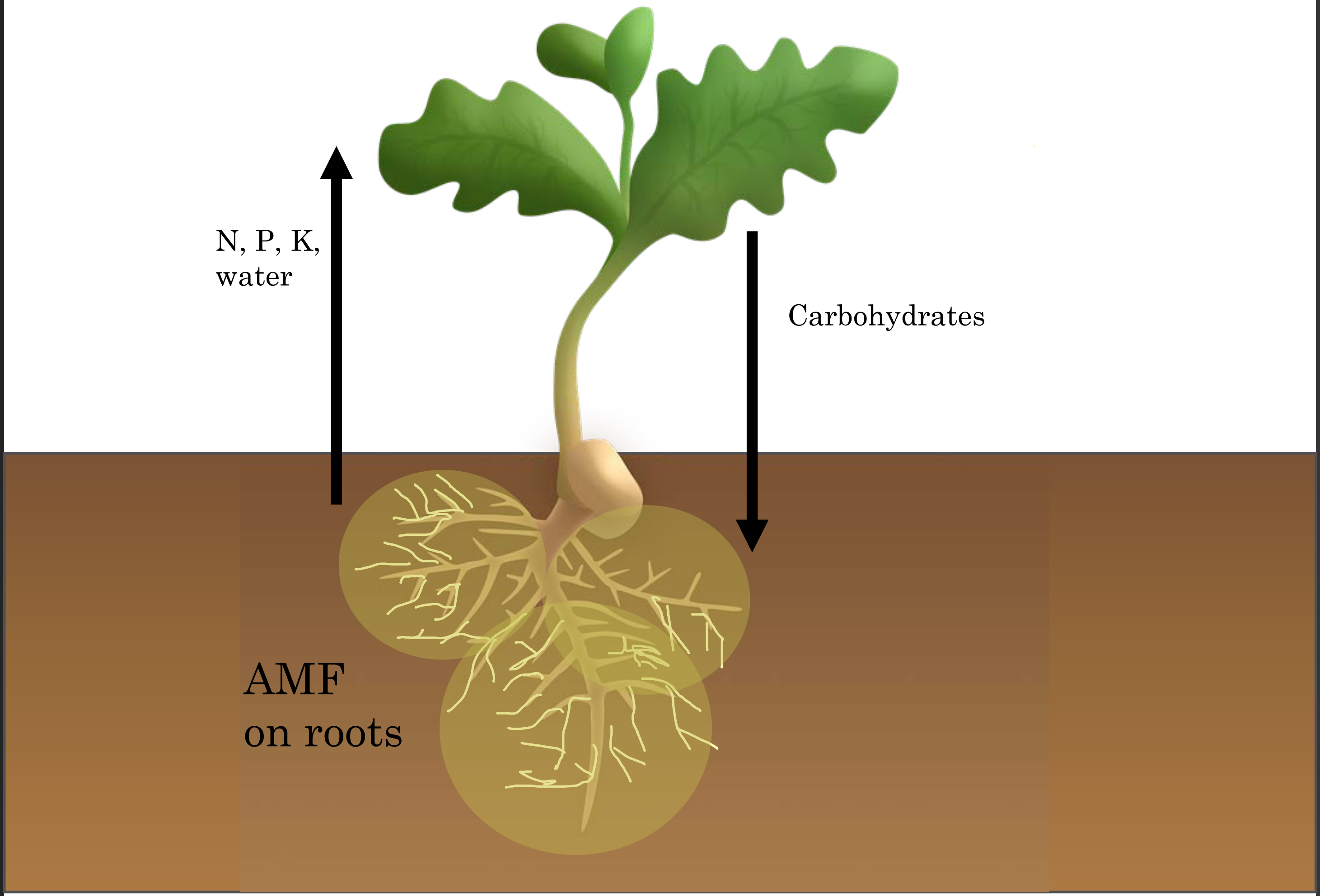


"Research into the role of beneficial microbiota in agroecosystems will offer a suite of tools to improve the security of our food systems, by promoting long term plant health while minimizing environmental impacts"
(Mariotte et al. 2018).

Arbuscular Mycorrhizal Fungi (AMF)

Potential Benefits

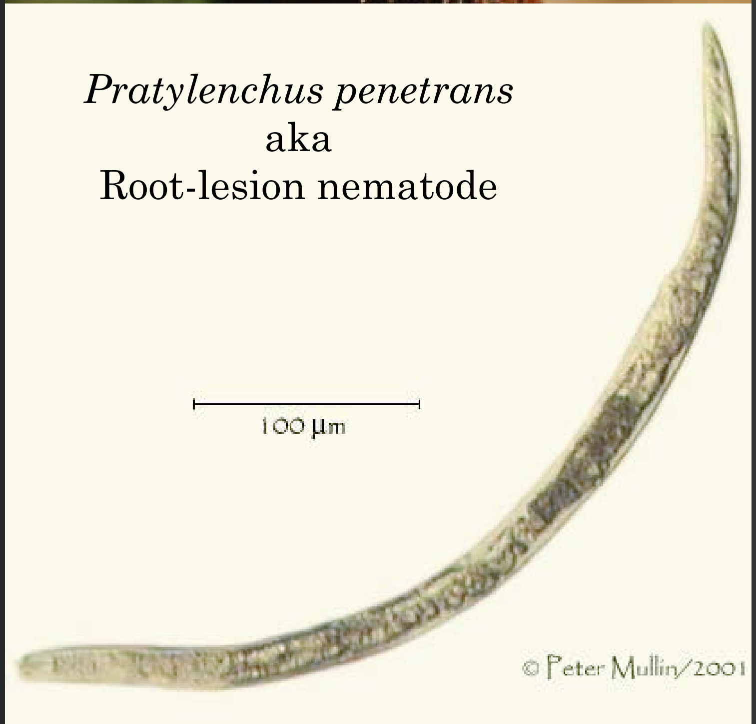
- Improve plant nutrition
- Improve stress tolerance
- Pathogen suppression



Raspberries

- Declining productivity
- Possible contributors:
  - *Phytophthora rubi*
    - Detected in 10/10 fields samples across Skagit and Whatcom (Gigot et al. 2013)
  - *Pratylenchous penetrans*
- Need for management options

P. rubi symptom on raspberry

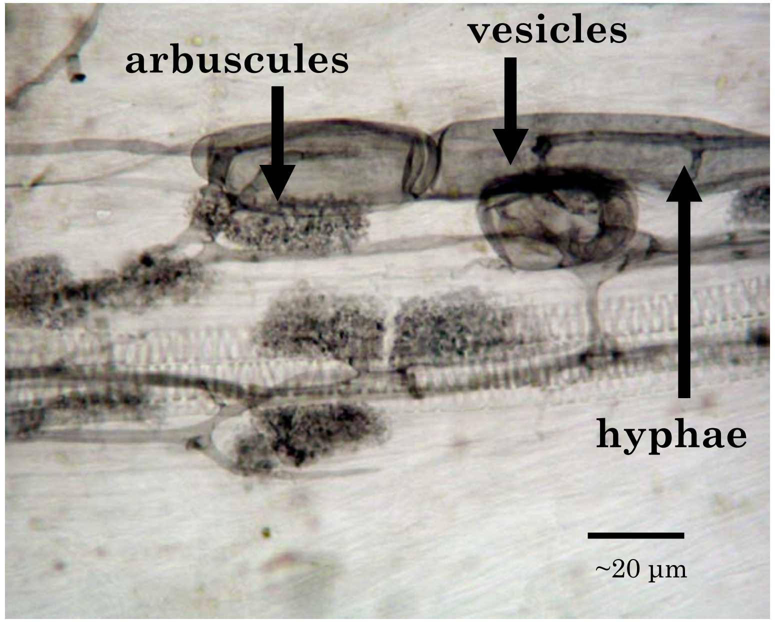


Pratylenchus penetrans
aka
Root-lesion nematode

Preliminary Data

Root samples from a farm which exhibited "Low" and "High" vigor patches

Plant Vigor	No mycorrhizal fungi	Yes mycorrhizal fungi
"Low vigor" (n = 33)	46%	54%
"High vigor" (n=38)	11%	89%



Research Questions

1. How will raspberry plants respond to colonization by different sources of mycorrhizal fungi?

   → AMF available in agricultural (managed) soil vs wild (unmanaged) soils?
   → Other inoculum?

2. How do mycorrhizae affect plant susceptibility and responses to common pathogens?

Research Design

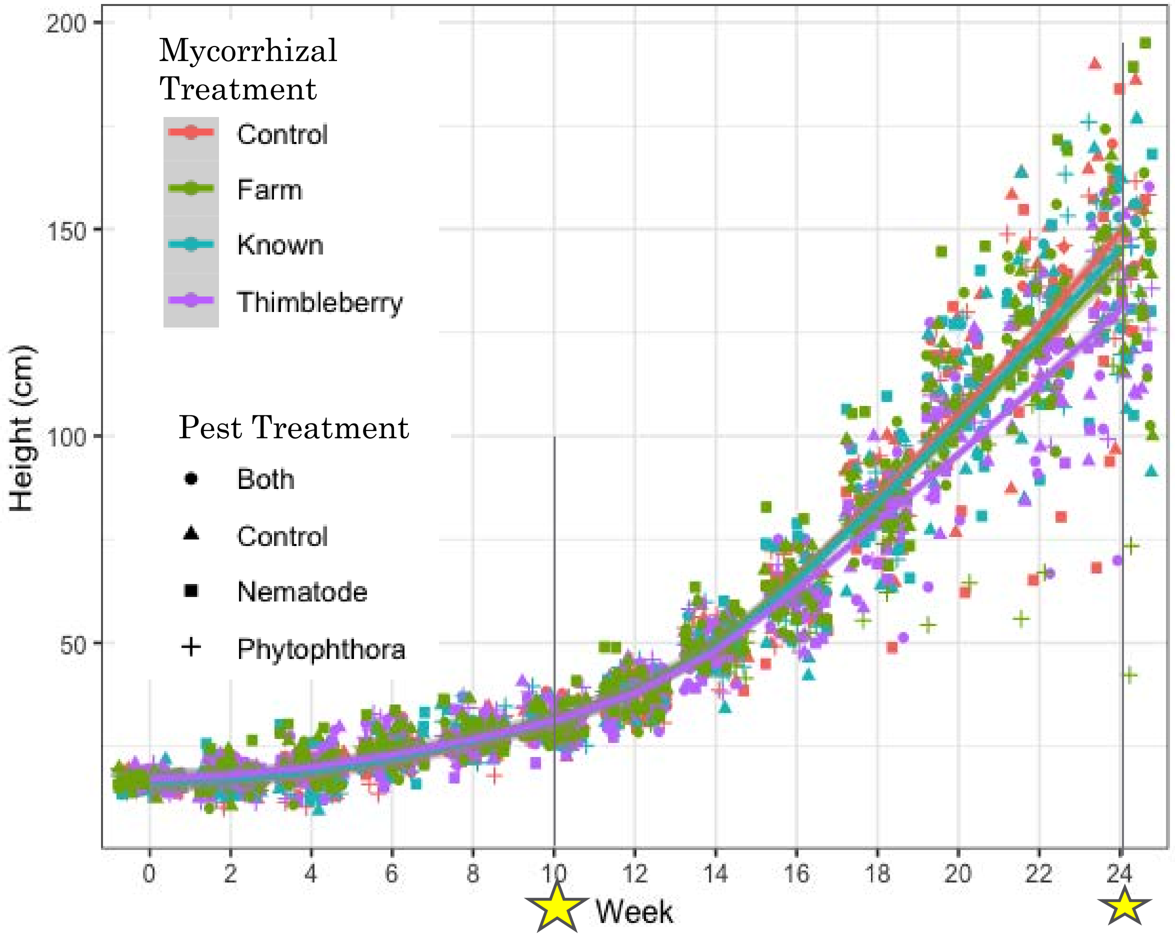
Phase 1: Mycorrhizal Fungi

1. Control (no mycorrhizal inoculum)
2. Farm (agricultural) soil
3. Thimbleberry (unmanaged) soil
4. Known mycorrhizal blend

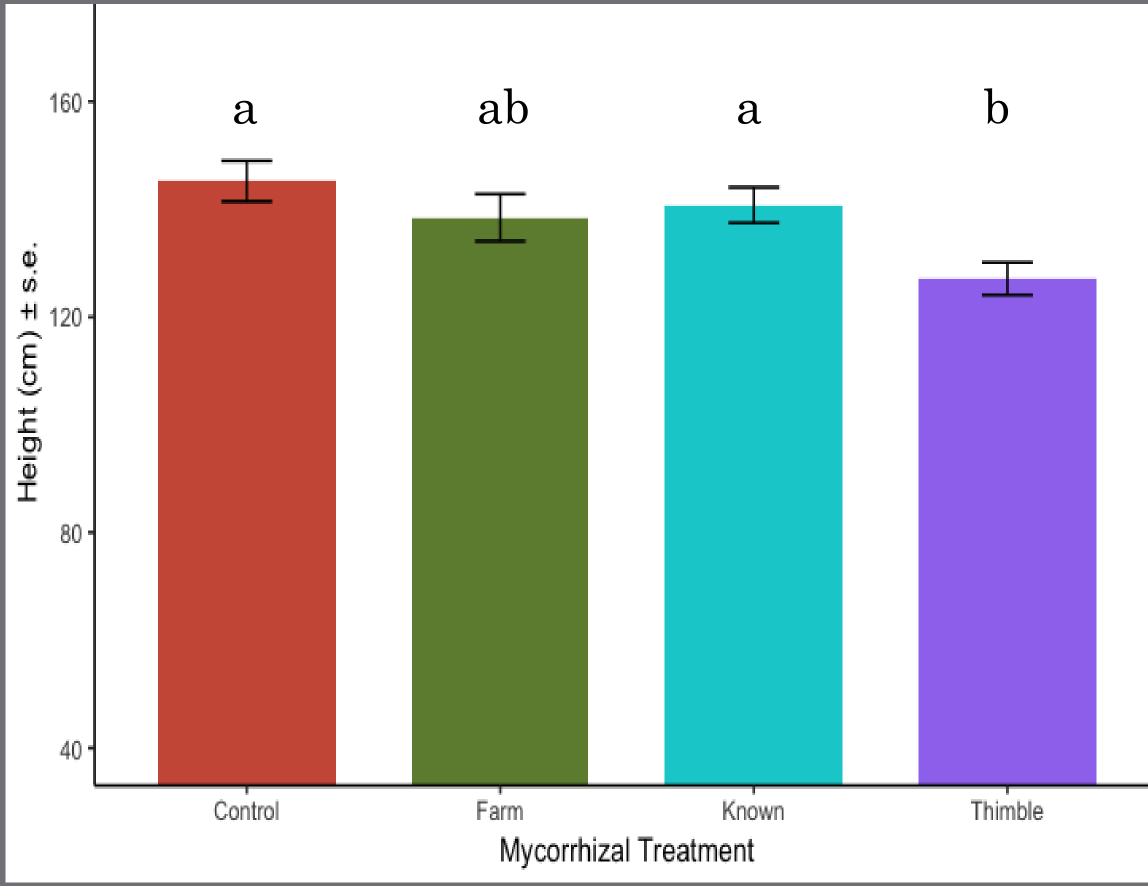
Phase 2: Addition of Pest

1. Control (no pests)
2. *Phytophthora rubi*
   (10% by volume)
3. *Pratylenchus penetrans*
   (1000 nematodes per pot)
4. Both

Height:
Differences increased over time

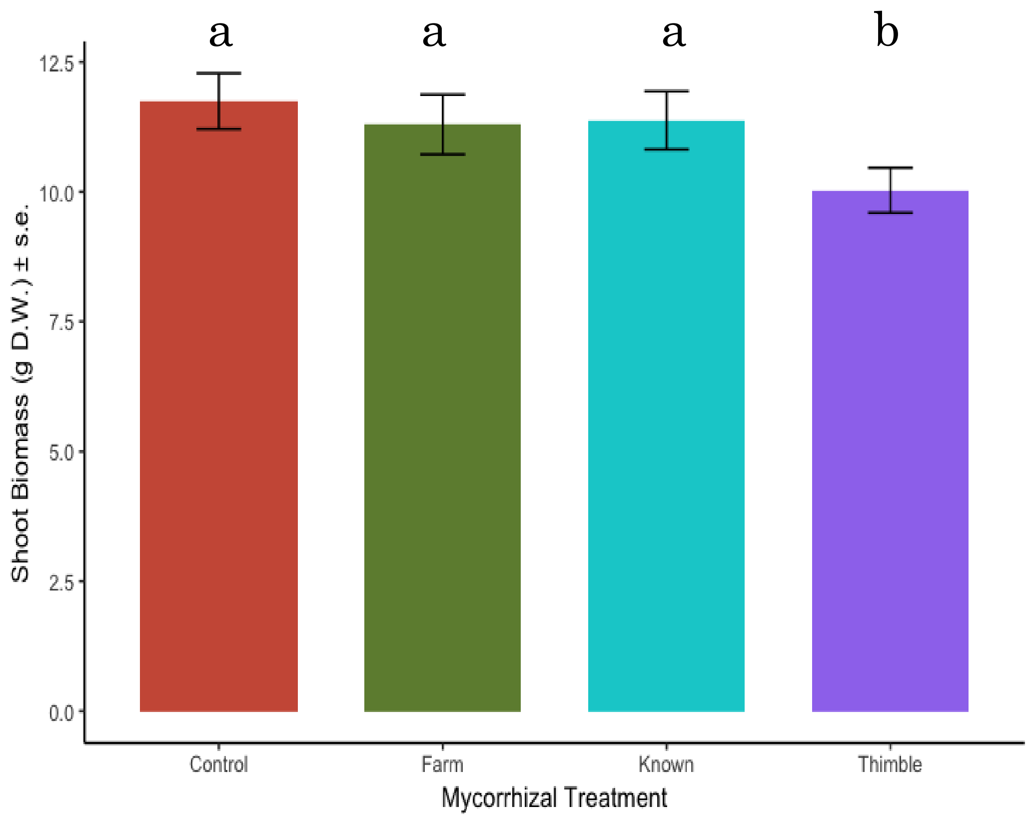


Week 24: Two mycorrhizal treatments heights are similar to control; one treatment shorter than control

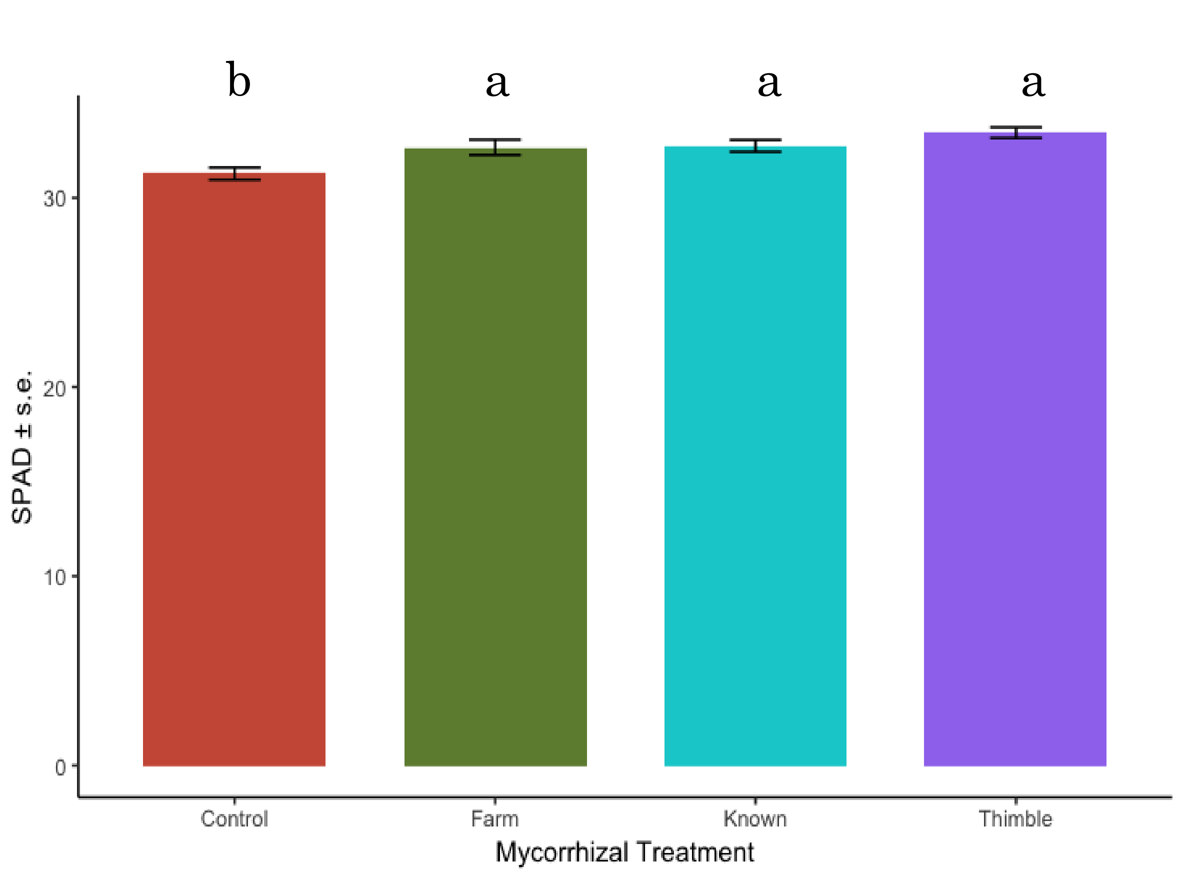


1. How will raspberry respond to colonization by different sources of mycorrhizal fungi?

Shoot biomass:
Not changed or reduced (Week 24)



Leaf nitrogen:
Higher for all (Week 24)



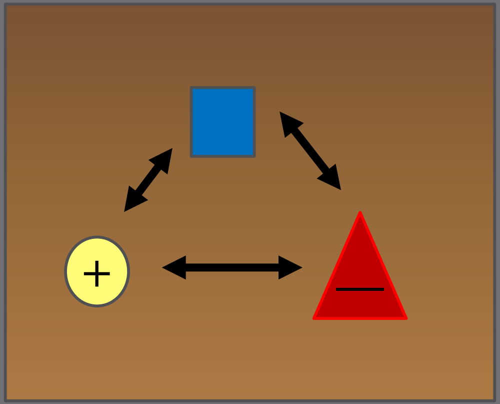
1. How will raspberry respond to colonization by different sources of mycorrhizal fungi?

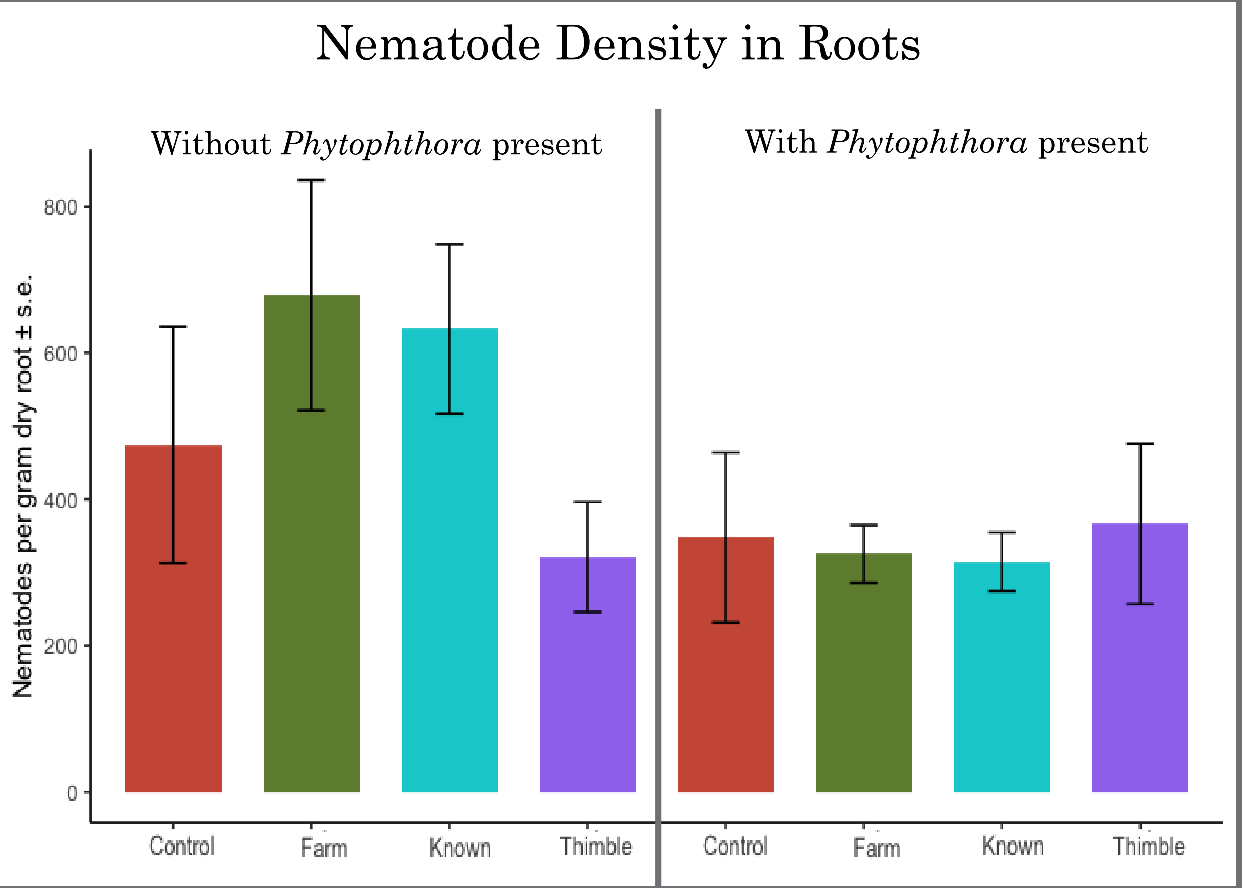
Pest treatments:

- No difference in biomass
- Nematode density

Upcoming:

- Plant nutrient acquisition
- Degree of colonization





2. How do mycorrhizae affect plant susceptibility and responses to common pathogens?

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Pest treatments:

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- More to come

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Questions?

Literature Cited

Artursson, V., R. Finlay, J. Jansson. 2006. Interactions between arbuscular mycorrhizal fungi and bacteria and their potential for stimulating plant growth. Environmental Microbiology 8:1-10.

Bakker, P. A. M., C. M. J. Pieterse, R. de Jonge, and R. L. Berendsen. 2018. The Soil Borne Legacy. Cell 172:1178-1180.

Banerjee, P., and R. C. Anderson. 1992. Long-term effects of soil fumigation and inorganic nutrient addition on the rhizoplane mycoflora of little bluestem (*Schizachyrium scoparium*). Mycologia 84:842-848

Barney, D. L., and C. A. Miles. 2007. Commercial red raspberry production in the Pacific Northwest. PNW 598. OSU Extension, Oregon.

Bonfante, P., and I. Anca. 2009. Plants, mycorrhizal fungi, and bacteria: a network of interactions. Annual Review of Microbiology 63:363–83.

Brussaard, L., T. W. Kuyper, and R. G. M. de Goede. 2001. On the relationships between nematodes, mycorrhizal fungi and plants: functional composition of species and plant performance. Plant and Soil 232:155–165.

de Kroon, H., M. Hendriks, J. van Ruijven, J. Ravenek, F. M. Padilla, E. Jongejans, E. J. W. Visser, and L. Mommer. 2012. Root responses to nutrients and soil biota: drivers of species coexistence and ecosystem productivity. Journal of Ecology 100:6-15

Fester, T., and R. Sawyers. 2011. Progress and challenges in agricultural applications of arbuscular mycorrhizal fungi. Critical Reviews in Plant Sciences 30:459-470.

Fitter, A. H. and J. Garbaye. 1994. Interactions between mycorrhizal fungi and other soil organisms. Plant Soil 159:123–132.

Forge, T., A. Muehlchen, C. Hackenberg, G. Neilsen, and T. Vrain. 2001. Effects of preplant inoculation of apple (*Malus domestica* Borkh.) with arbuscular mycorrhizal fungi on population growth of the root-lesion nematode, *Pratylenchus penetrans*. Plant and Soil 236:185–196.

Forge, T. A., and C. Kempler. 2009. Organic mulches influence population densities of root-lesion nematodes, soil health indicators, and root growth of red raspberry. Canadian Journal of Plant Pathology 31:241-249.

Friesen, M. L., S. S. Porter, S. Stark, E. J. von Wettberg, J. L. Sachs, and E. Martinez-Romero. 2011. Microbially mediated plant functional traits. Annual Review of Ecology, Evolution, and Systematics 42:23-46.

Dangi, S. R., J. S. Gerik, R. Tirado-Corbalá, and H. Ajwa. 2015. Soil microbial community structure and target organisms under different fumigation treatments. Applied and Environmental Soil Science 2015:673264.

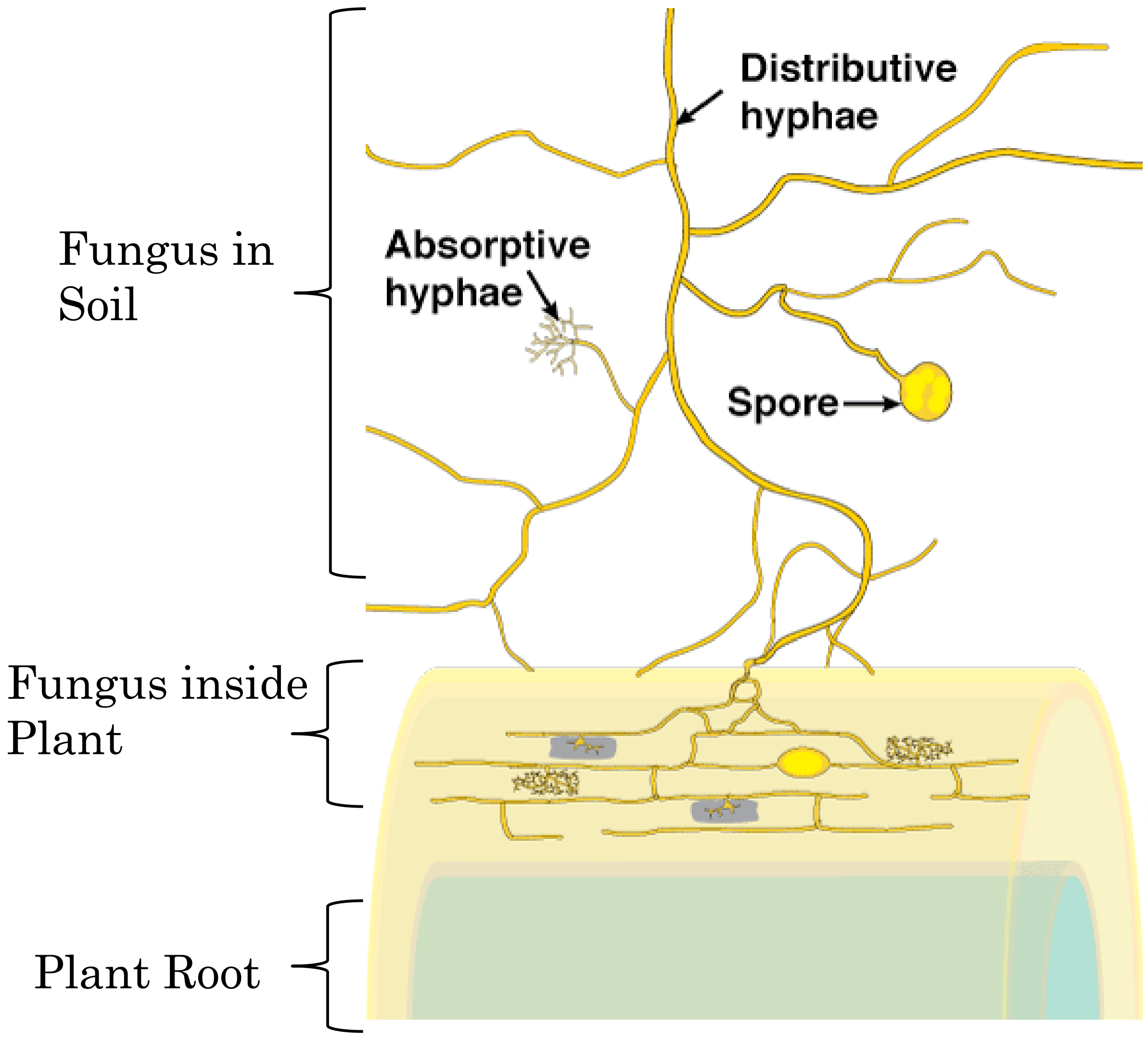
Gigot, J., T. W. Walters, and I. A. Zasada. 2013. Impact and occurrence of *Phytophthora rubi* and *Pratylenchus penetrans* in commercial red raspberry (*Rubus ideaus*) fields in Northwestern Washington. International Journal of Fruit Science 13:357-372.

Hamel, C., Y. Dalpé, and V. Furlan. 1997. Indigenous populations of arbuscular mycorrhizal fungi and soil aggregate stability are major determinants of leek (*Allium porrum* L.) response to inoculation with *Glomus intraradices* Schenck & Smith or *Glomus versiforme* (Karsten) Berch. Mycorrhiza 7:187.

Han, Z., T. W. Walters, and I. A. Zasada, I. A. 2014. Impact of *Pratylenchus penetrans* on established red raspberry productivity. Plant Disease 98:1514-1520.

AMF:

Potential Benefits



- Nutrient Uptake
- Plant Growth and Development
- Altered Soil Microbial Community
- Stress responses
- Pathogen Suppression

Figure from Schouteden et al. 2015. Retrieved from: https://www.researchgate.net/publication/284141850

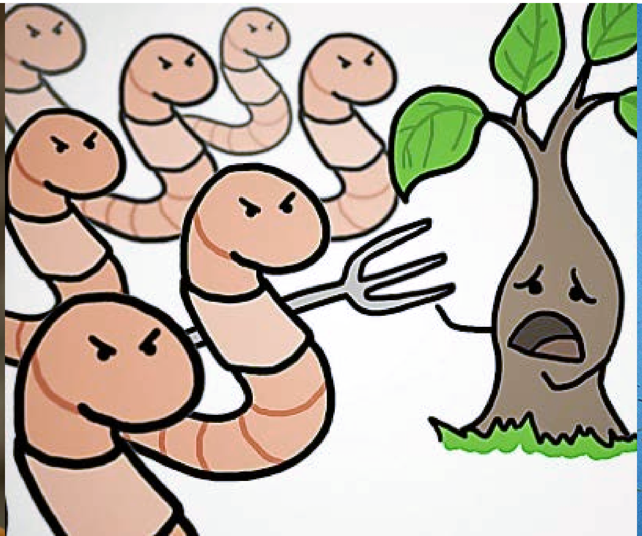
Research Proposal

1. How will raspberry plants respond to colonization by different sources of mycorrhizae?

2. How does mycorrhizal colonization affect plant susceptibility and responses to common pathogens?

	Control	Nematode	P. rubi	Both
Control	10	10	10	10
Farm	10	10	10	10
Thimble	10	10	10	10
Known	10	10	10	10

Photo courtesy of Paolinio Раменское, retrieved from pixabay



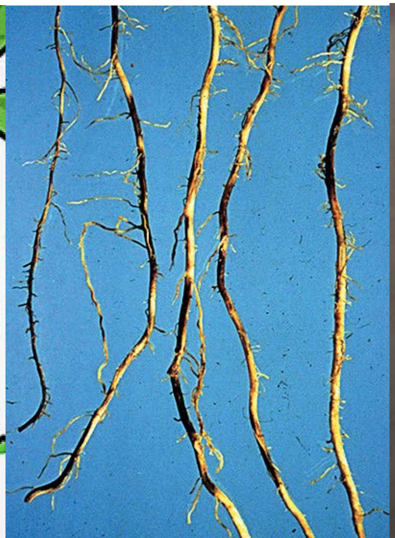


Photo courtesy of Rebecca Bunn

Methods

- Soil medium: Soil, sand, and turfase (1 : 1 : 1)
    - Whole-soil inoculum (50 mL)
    - “Microbial wash” (10 mL)
- Micropropagated *Rubus ideaus* var. Meeker

- Greenhouse set to 60F. Truly ranged 60 – 85F
- 12-h day/night cycle.

- **Nutrients:** Modified Hoagland’s solution (no P).
  Increased in response to signs of nutrient stress:
  Weeks 7-9: 10 mL (2.1 mg N / plant);
  Weeks 10-12 20 mL (4.2 mg N / plant);
  Weeks 13-14 30 mL (6.3 mg N ;
  Weeks 15-24 30 mL 2X (12.6 mg N / plant).