Bacteriomes of Peaches and Cover Crops

By Derek Newberger

Ph.D. Candidate

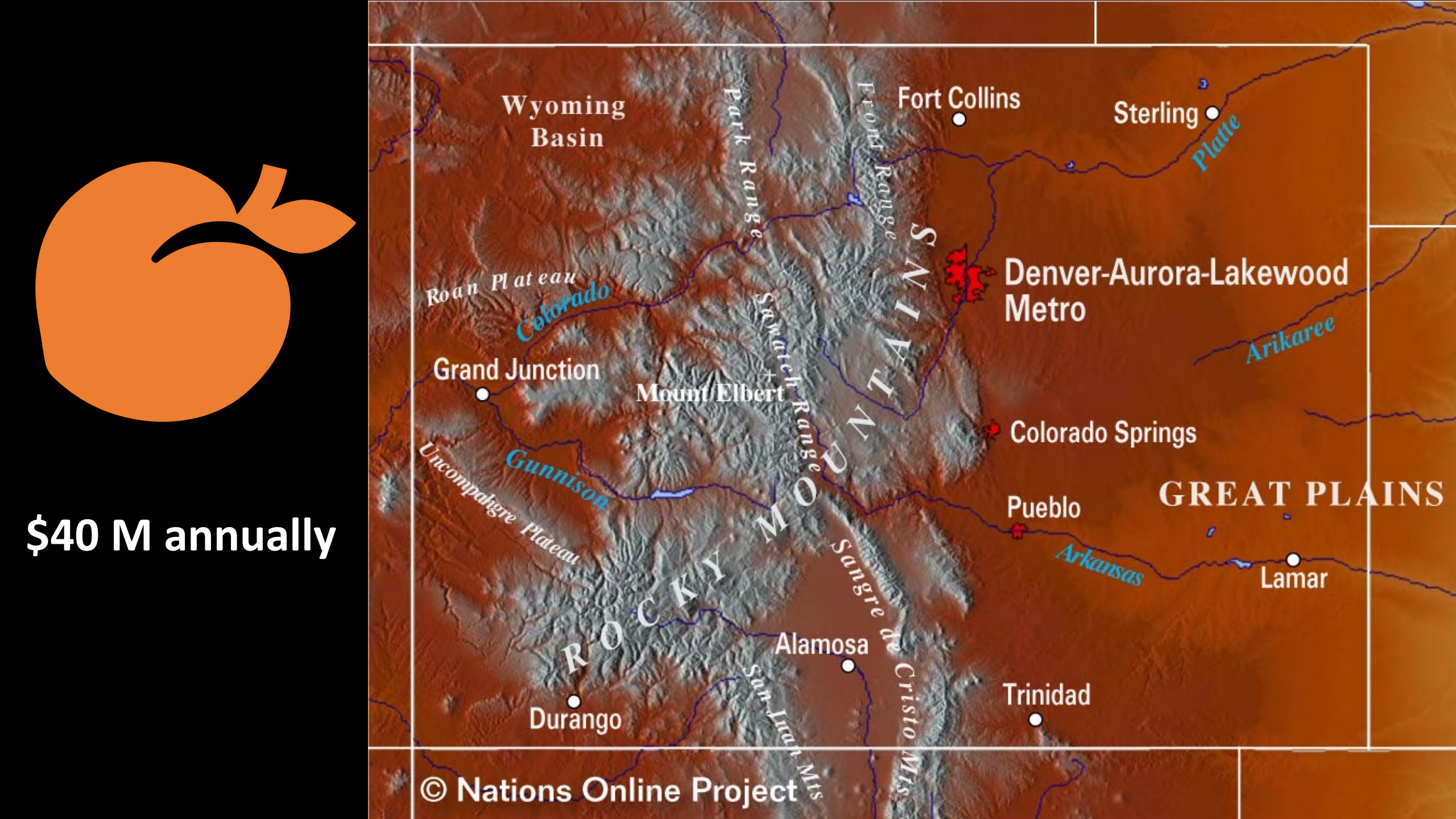
Acknowledgements

- CSU: Minas and Vivanco Lab Collaboration
- USDA: Dr. Daniel Manter, Soil Management and Sugarbeet Research
- Producer Representative: Bruce Talbott, Talbott Farms, Inc
- Western Sustainable Agriculture Research and Education (SARE) project #SW20-910 with title ‘Developing sustainable peach orchard soil microbiome management practices to control replant disease syndrome’

Talbott FARMS

USDA United States Department of Agriculture

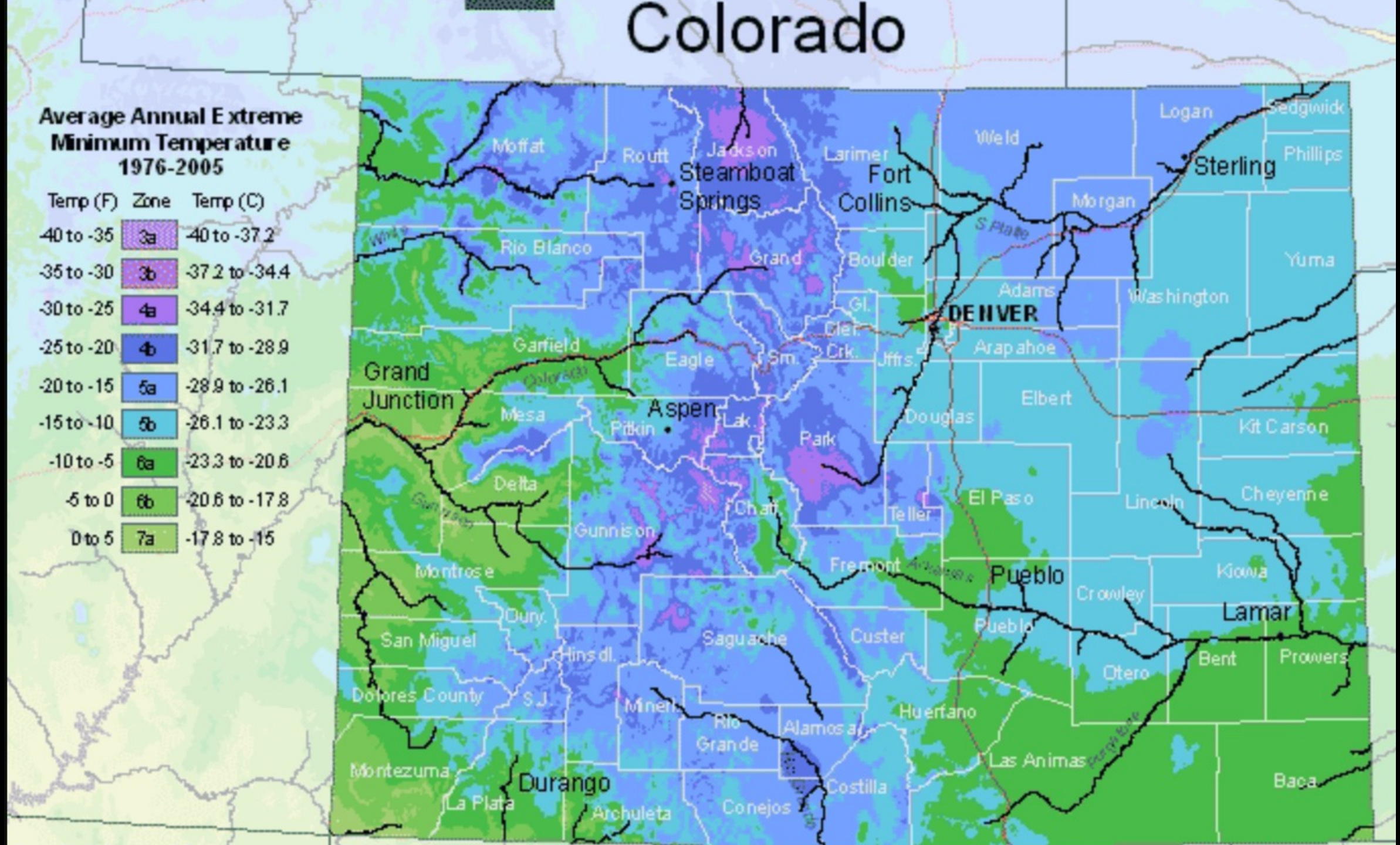
WESTERN SARE Sustainable Agriculture Research & Education



$40 M annually

The problem

Colorado

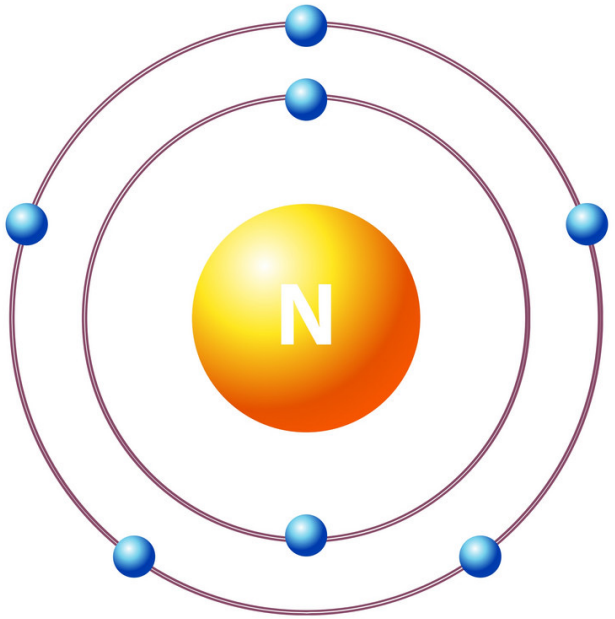

Average Annual Extreme Minimum Temperature 1976-2005
Temp (F) Zone Temp (C)
-40 to -35 3a -40 to -37.2
-35 to -30 3b -37.2 to -34.4
-30 to -25 4a -34.4 to -31.7
-25 to -20 4b -31.7 to -28.9
-20 to -15 5a -28.9 to -26.1
-15 to -10 5b -26.1 to -23.3
-10 to -5 6a -23.3 to -20.6
-5 to 0 6b -20.6 to -17.8
0 to 5 7a -17.8 to -15
Moffat
Routt
Jackson
Steamboat Springs
Larimer
Fort Collins
Weld
Logan
Sedgwick
Phillips
Sterling
Morgan
Rio Blanco
Grand
Boulder
Yuma
Adams
Washington
DENVER
Garfield
Eagle
Arapahoe
Grand Junction
Mesa
Aspen
Pitkin
Douglas
Elbert
Park
Kit Carson
Delta
El Paso
Lincoln
Cheyenne
Gunnison
Teller
Montrose
Fremont
Pueblo
Crowley
Kiowa
Lamar
San Miguel
Saguache
Custer
Otero
Bent
Prowers
Dolores County
Huerfano
Las Animas
Montezuma
Durango
La Plata
Archuleta
Conejos
Costilla
Baca

Peach Replant Syndrome

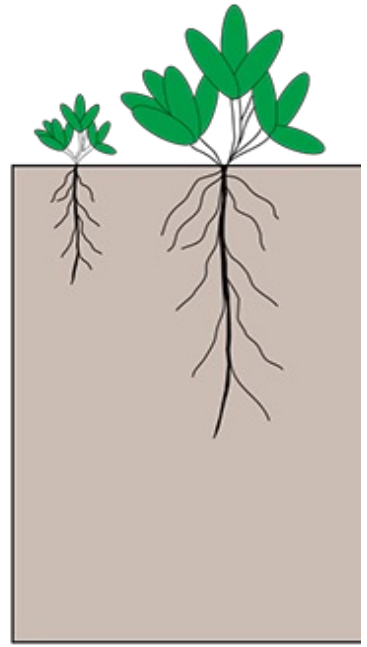
CSU_Pomology

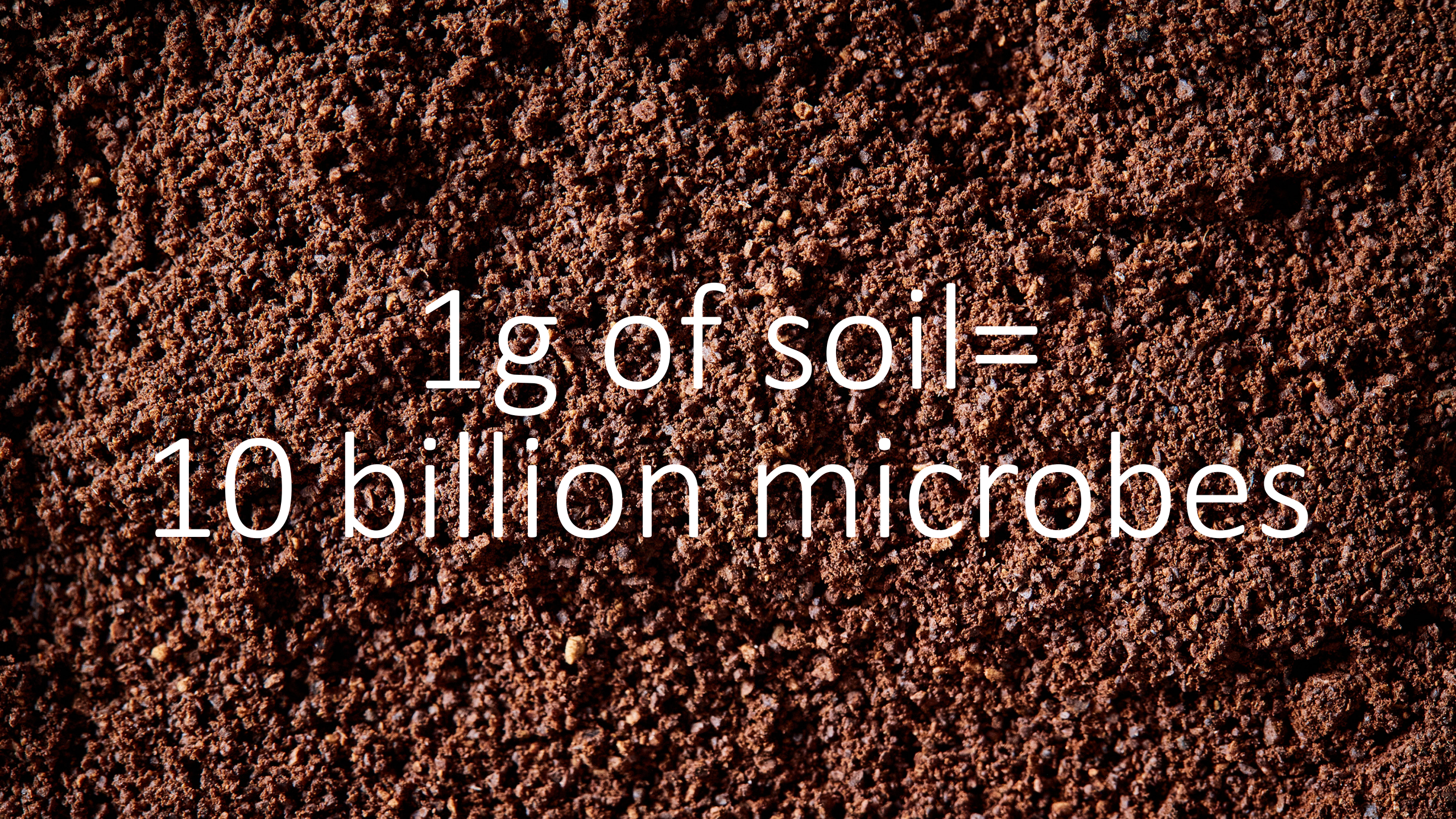
Monocropping:
Orchard: 15 years

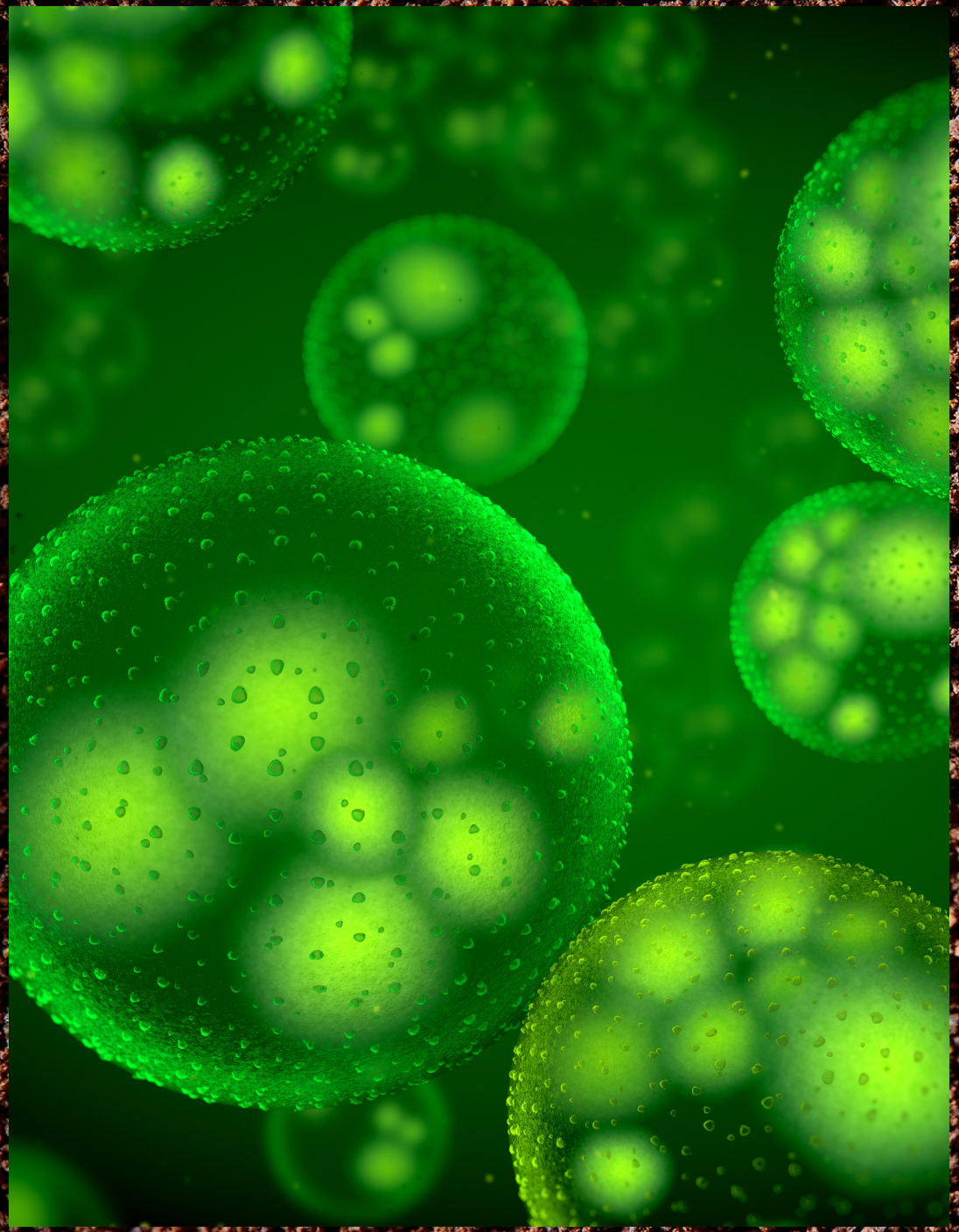
Abiotic Factors:
Soil Nutrients



Intraspecific Allelopathy:
Autotoxicity




1g of soil=
10 billion microbes



PGPR

vs

Pathogen

Our Study

Issue	Remedy
Monocropping	**Genetically different cover crops**
Nutrient depletion	**Cover Crop reincorporation**
Pathogen buildup	

We hypothesize that these sustainable practices could beneficially alter the microbiome of replant soils and empower peaches to recruit beneficial bacteria

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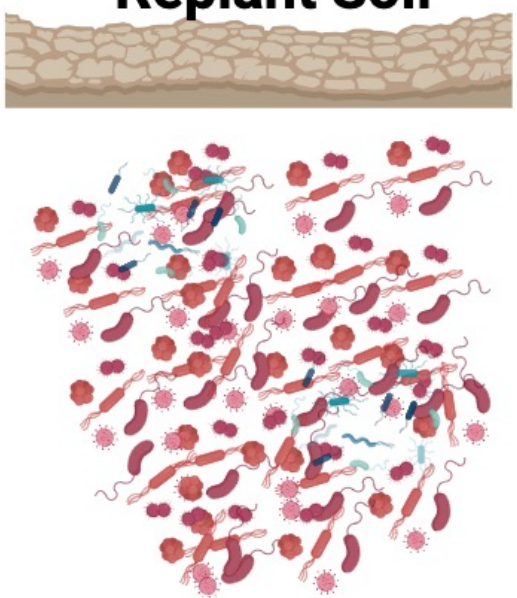
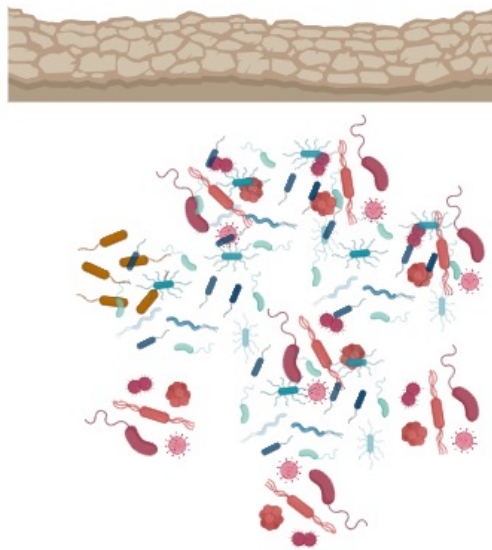
Conceptual Replant Syndrome Solution

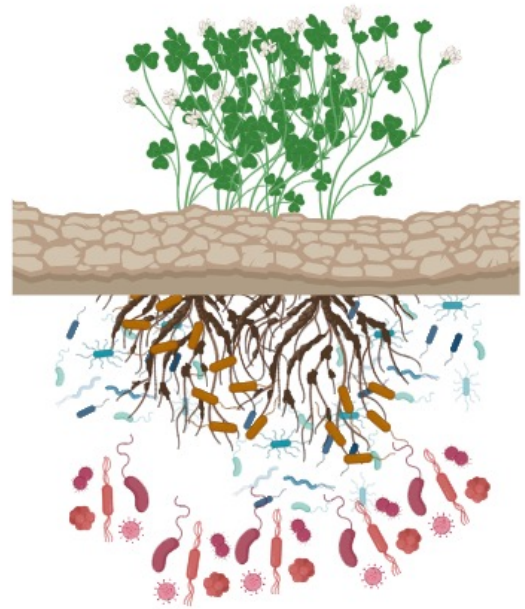
Replant Soil



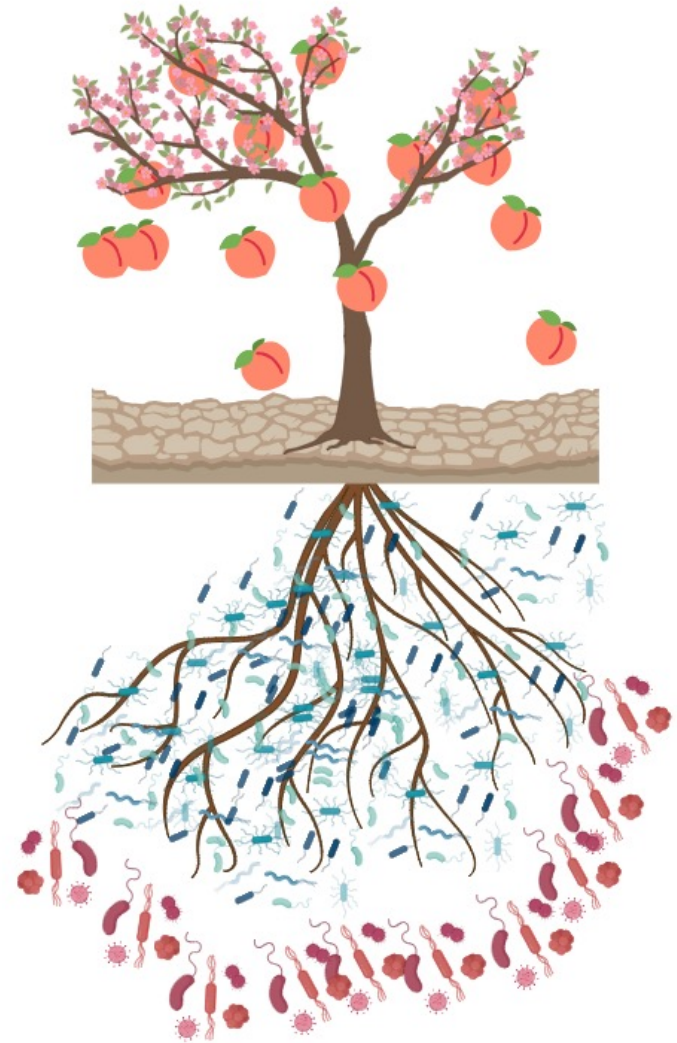
Step 1: Disinfect Soil



Step 2: Cover Crop



Step 3: Plant Tree



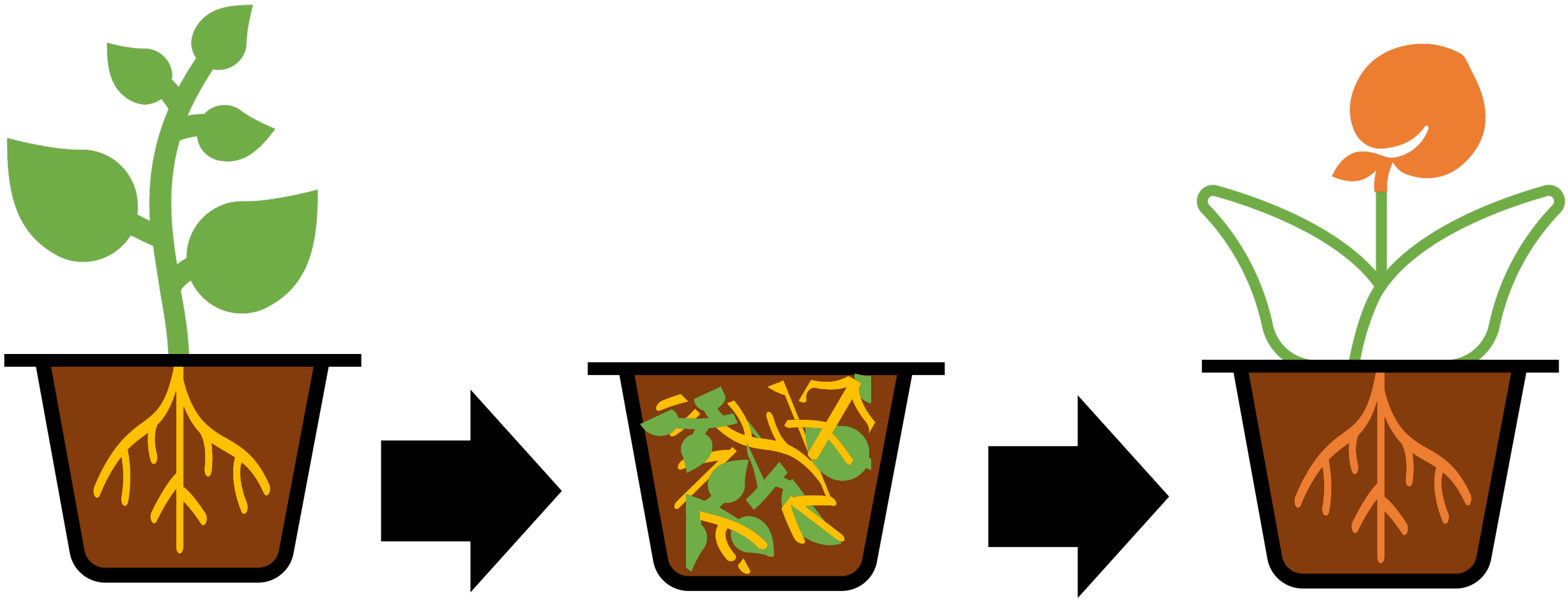




4 Cover Crops in Peach Orchard Soil


BASIC 9-32
LAB/SCI
RH
45053320
Aaron Stock # 45053320


BASIC 9-32
LAB/SCI
RH
45053320
Aaron Stock # 45053320

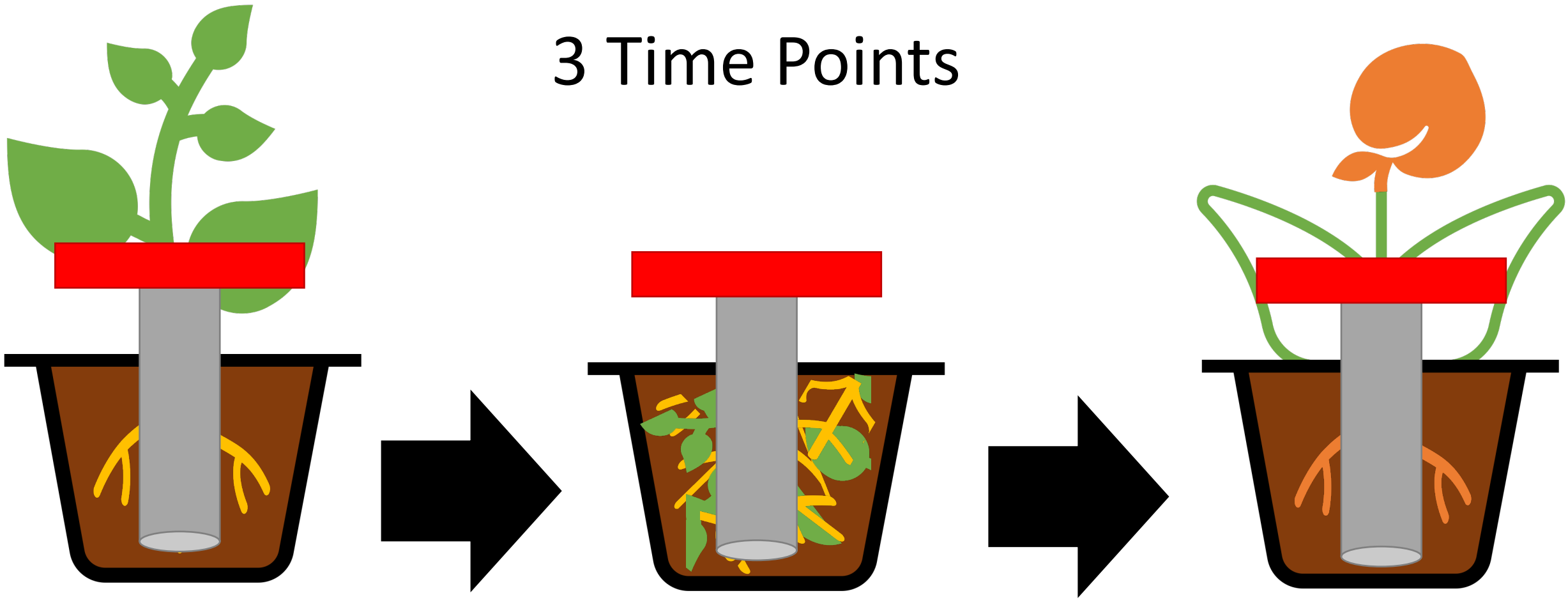


12 Weeks

2 Weeks

22 Weeks

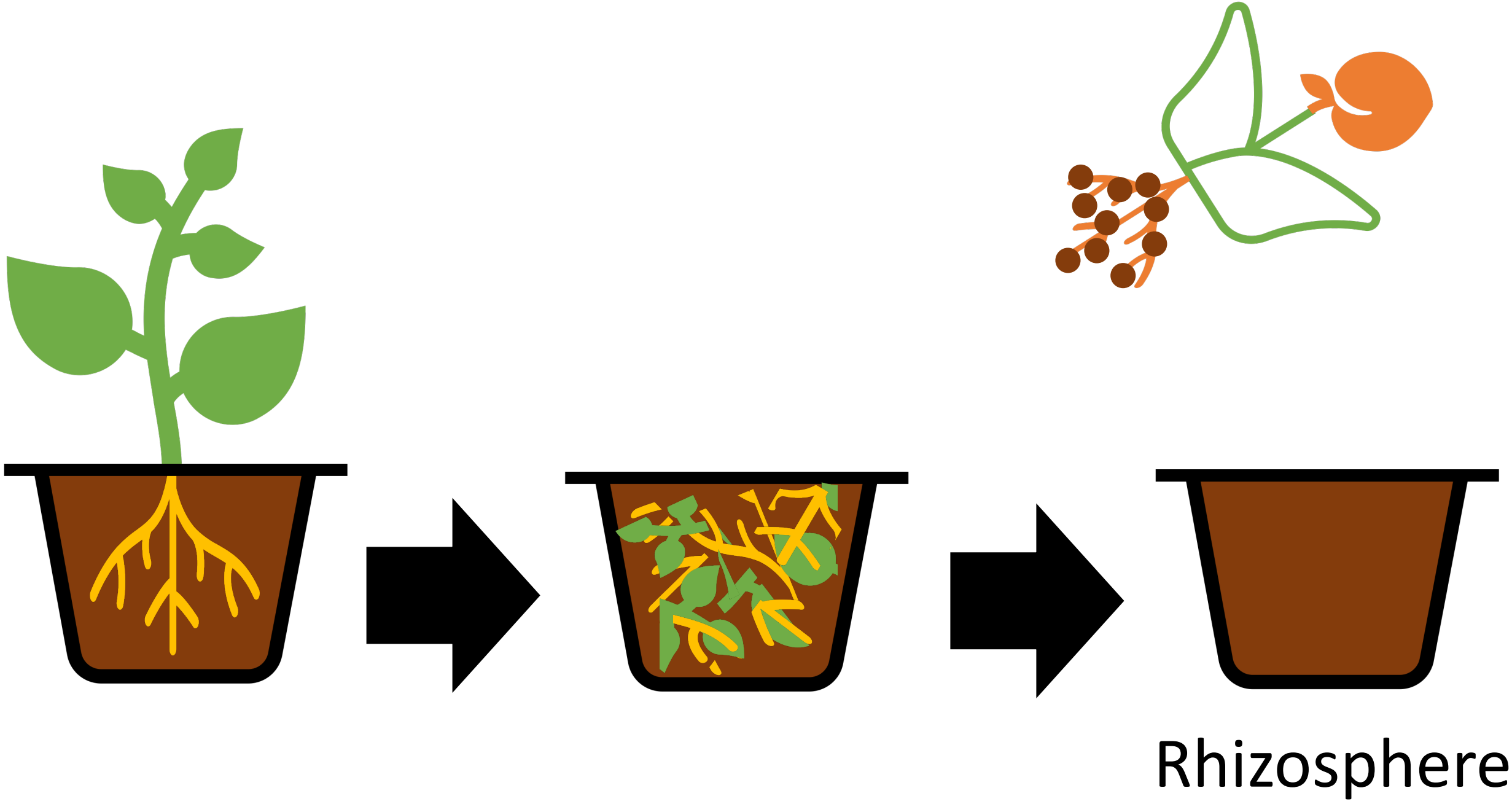
Bulk Soil
3 Time Points



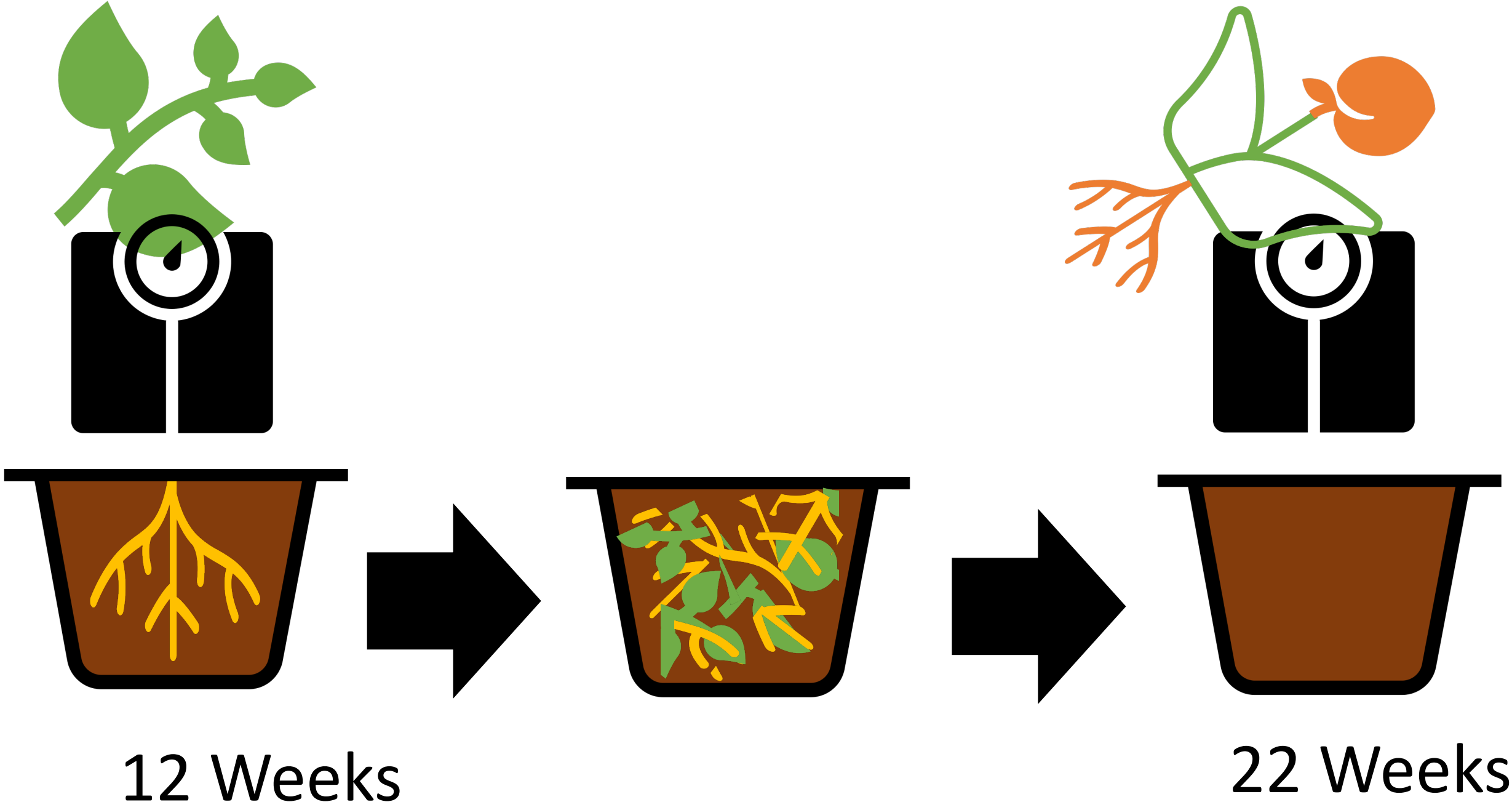
Cover Crop

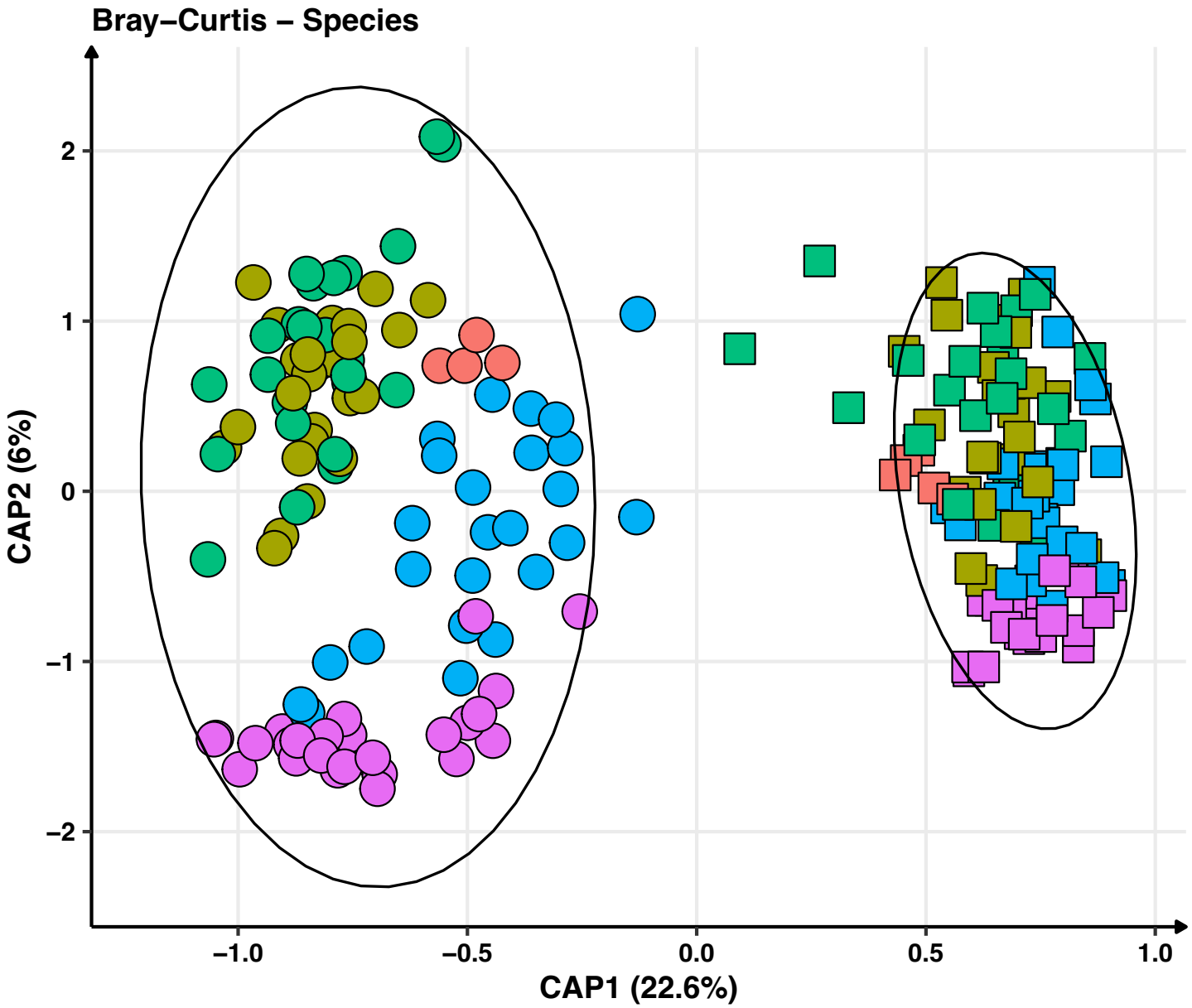
Incorporated

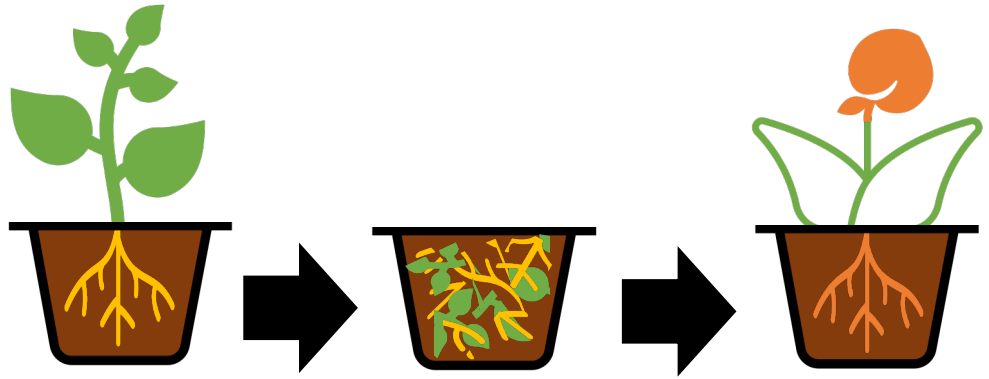
Peach



Rhizosphere


12 Weeks
22 Weeks





Soil Treatment

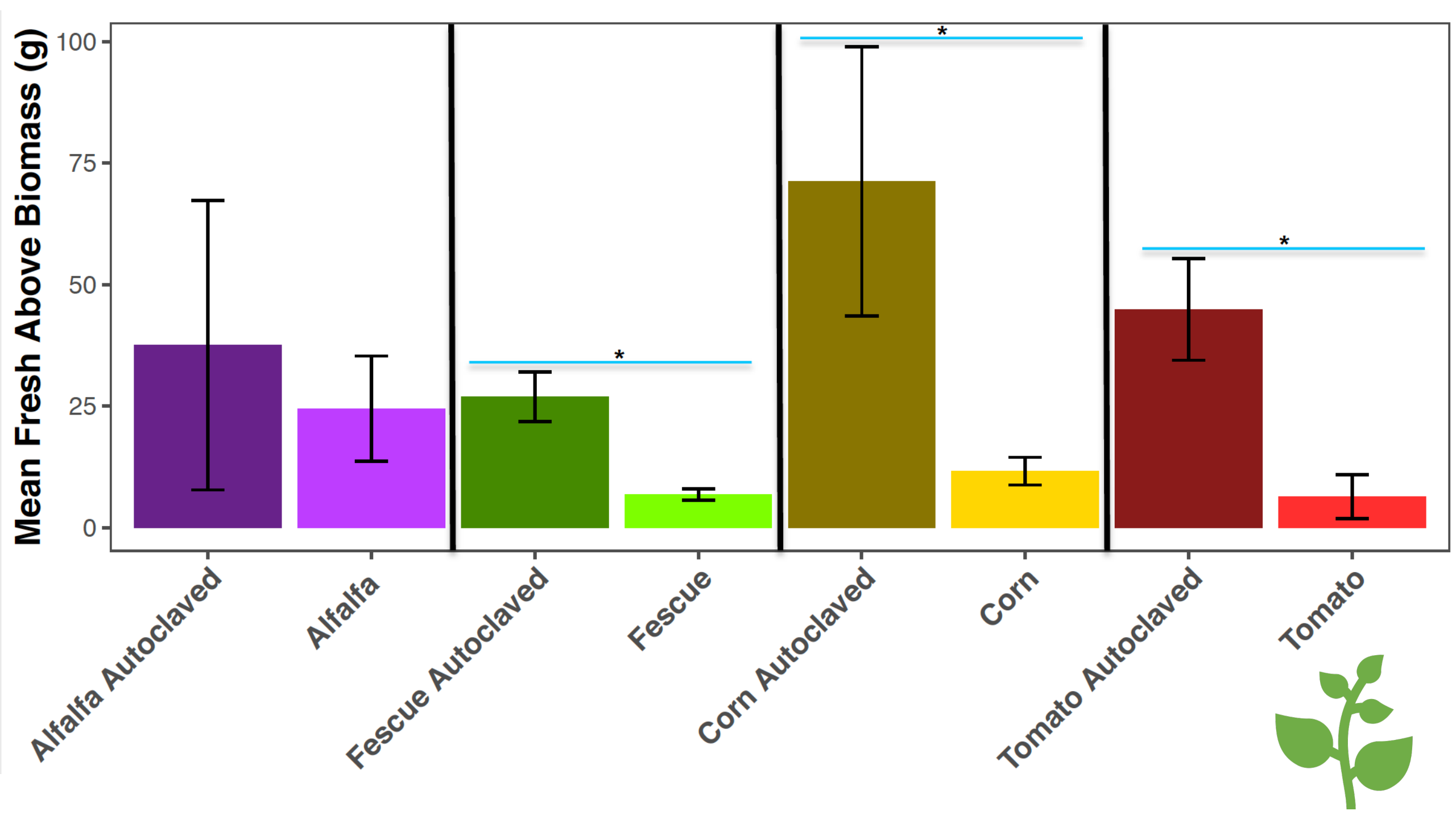
- Autoclaved
- Non–Autoclaved

Crop Phase

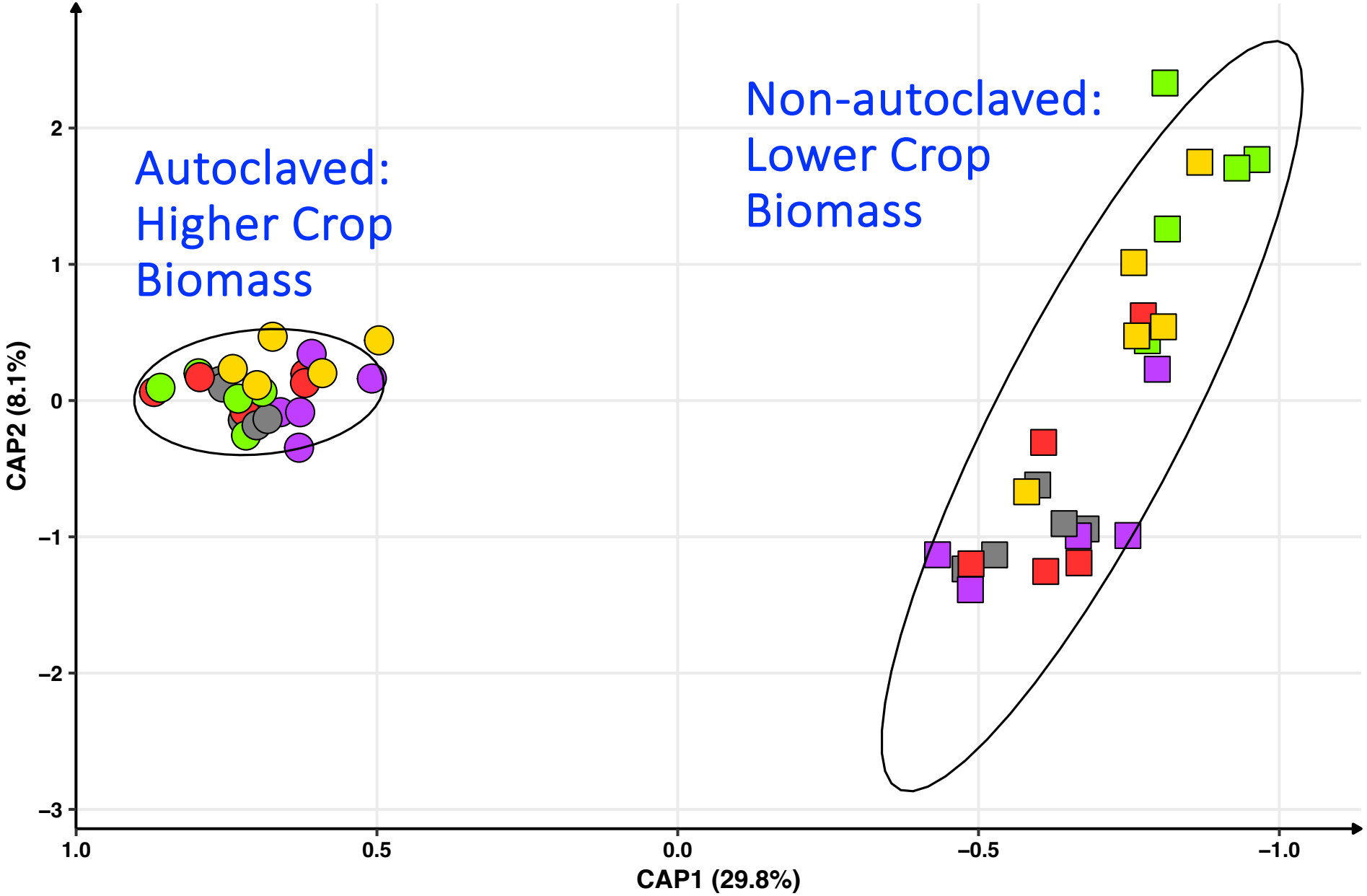
- Bulk Soil Control
- Rotation Crop
- Rotation Crop Incorporated
- Peach
- Peach Rhizosphere

Non-autoclaved

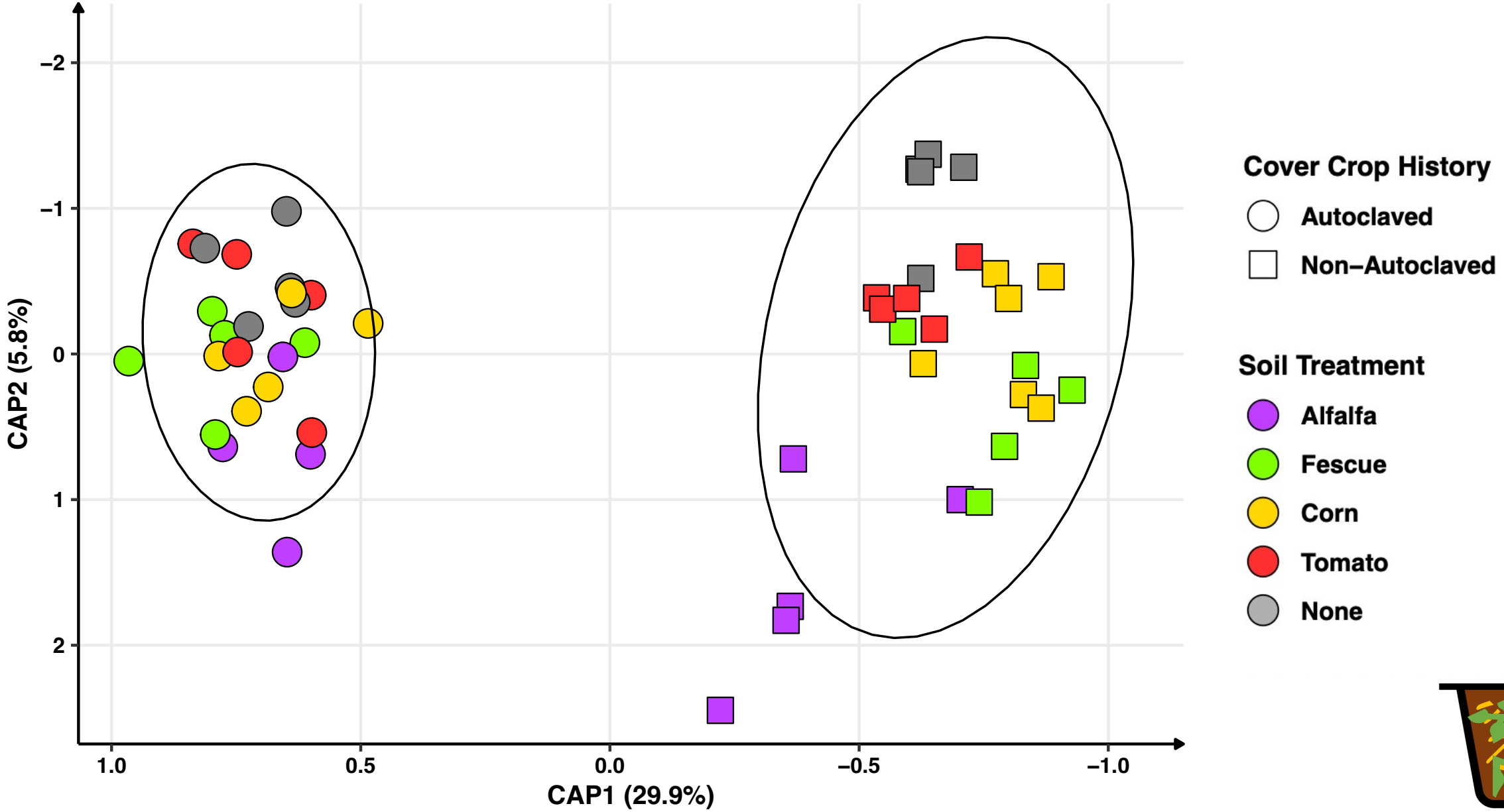
Autoclaved


Mean Fresh Above Biomass (g)
100
75
50
25
0
*
*
*
Alfalfa Autoclaved
Alfalfa
Fescue Autoclaved
Fescue
Corn Autoclaved
Corn
Tomato Autoclaved
Tomato

Cover crop bulk soil microbiomes

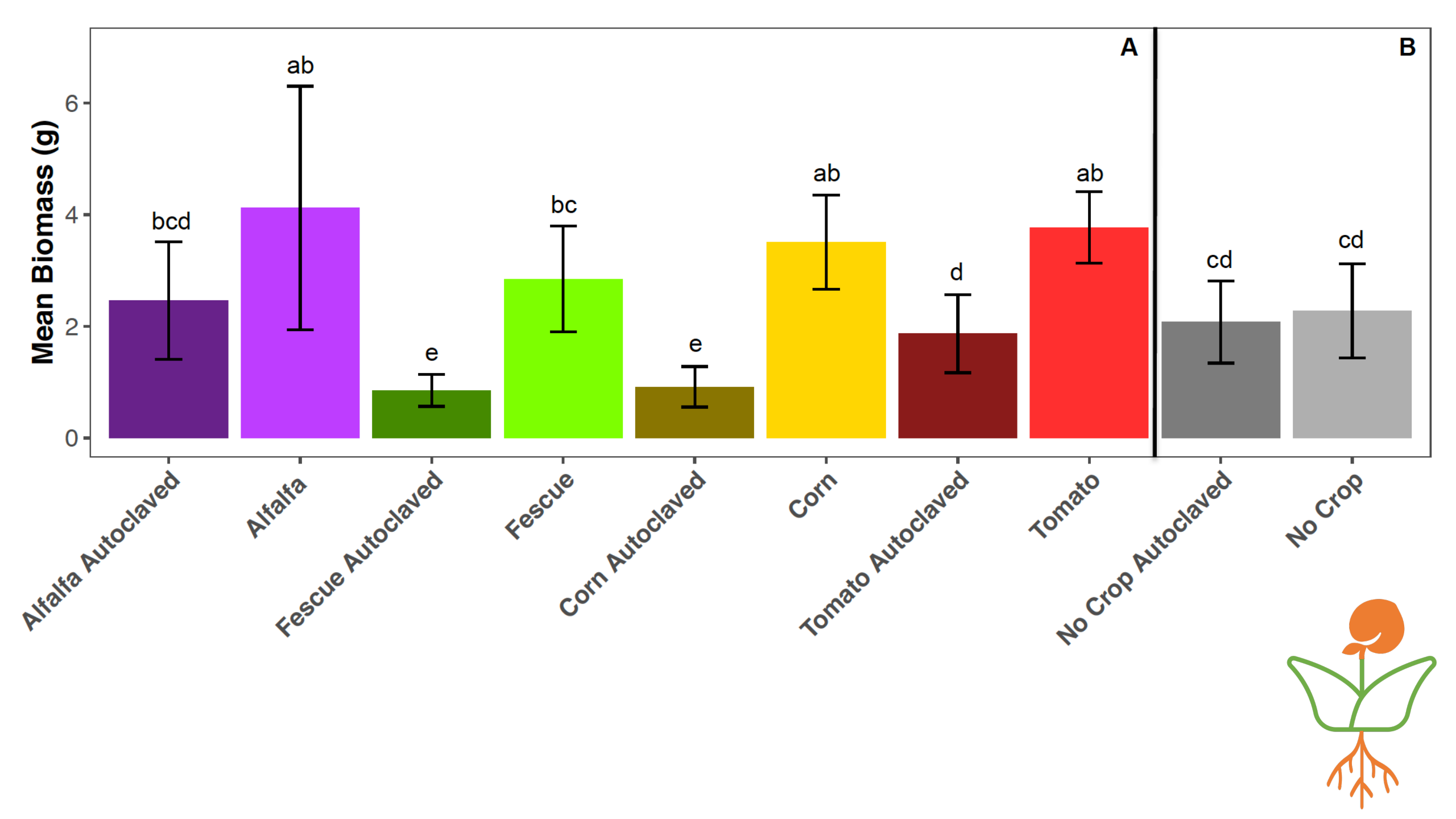


Cover crop incorporated bulk soil microbiomes



Autoclaved and Alfalfa Cover Crop

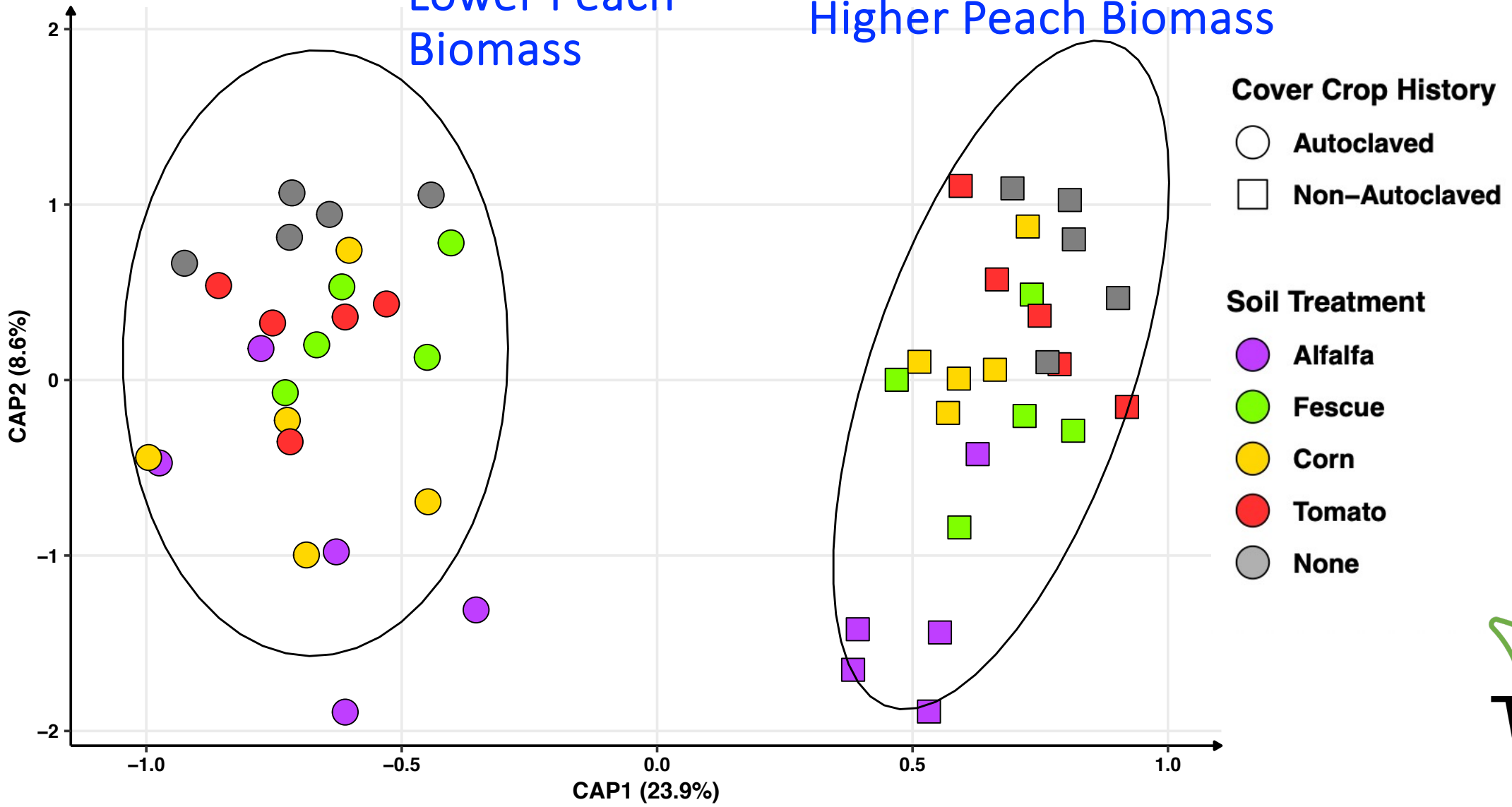
Non-Autoclaved and Alfalfa Cover Crop

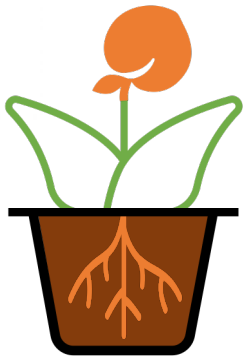

A
B
Mean Biomass (g)
0
2
4
6
bcd
ab
e
bc
e
ab
d
ab
cd
cd
Alfalfa Autoclaved
Alfalfa
Fescue Autoclaved
Fescue
Corn Autoclaved
Corn
Tomato Autoclaved
Tomato
No Crop Autoclaved
No Crop

Peach bulk soil bacterial microbiomes (22 weeks)

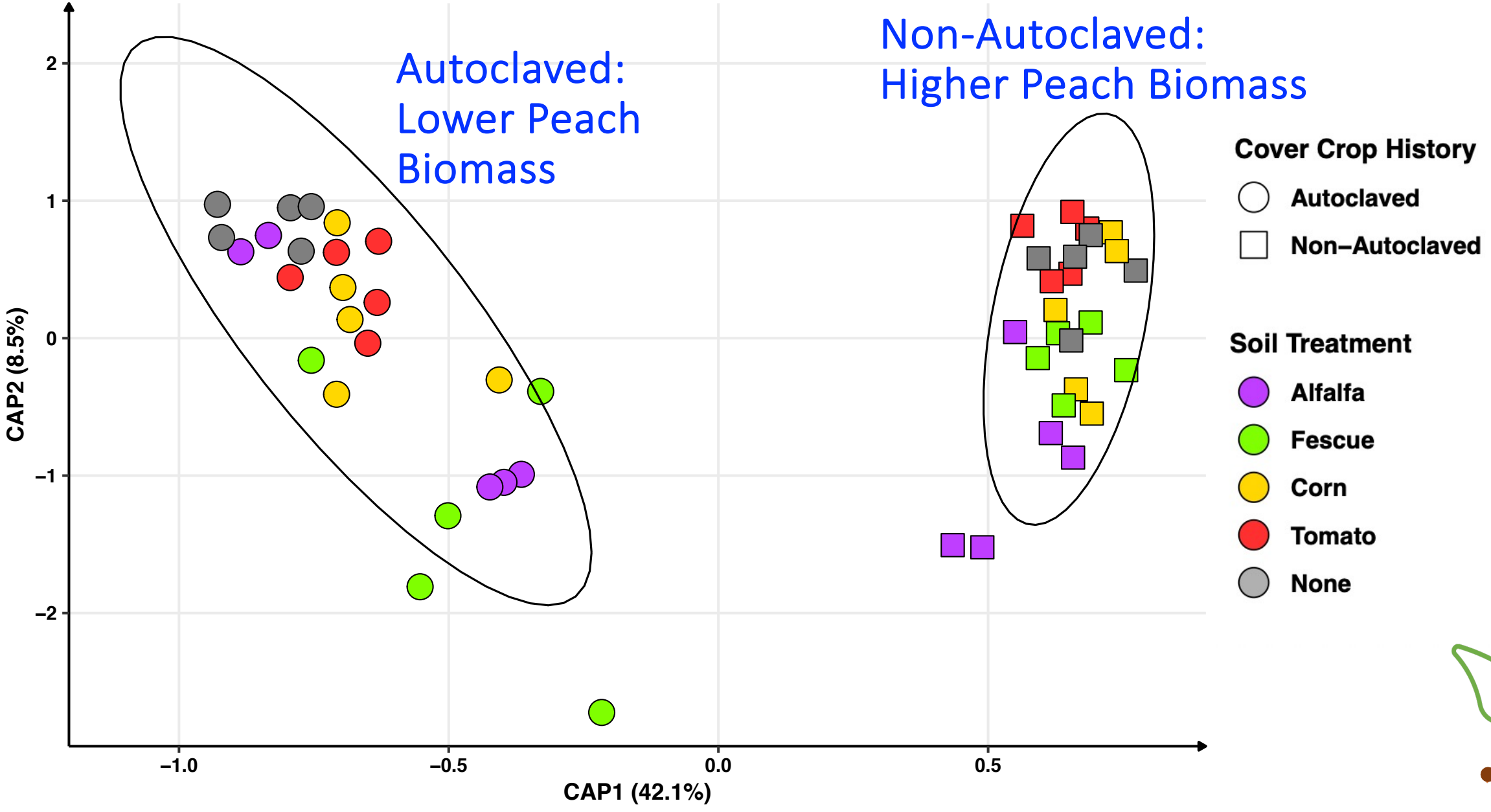
Autoclaved:
Lower Peach Biomass

Non-Autoclaved:
Higher Peach Biomass

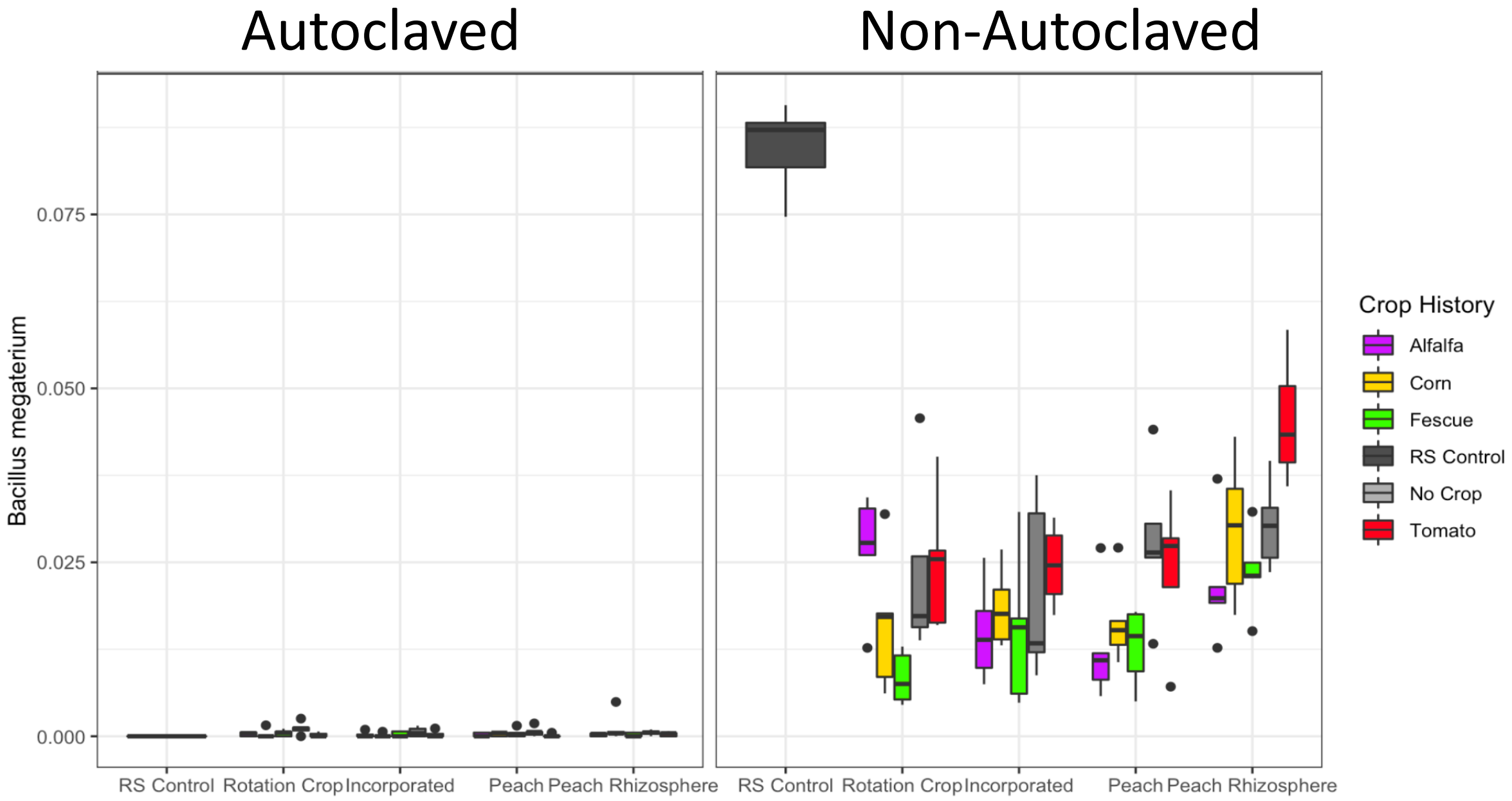




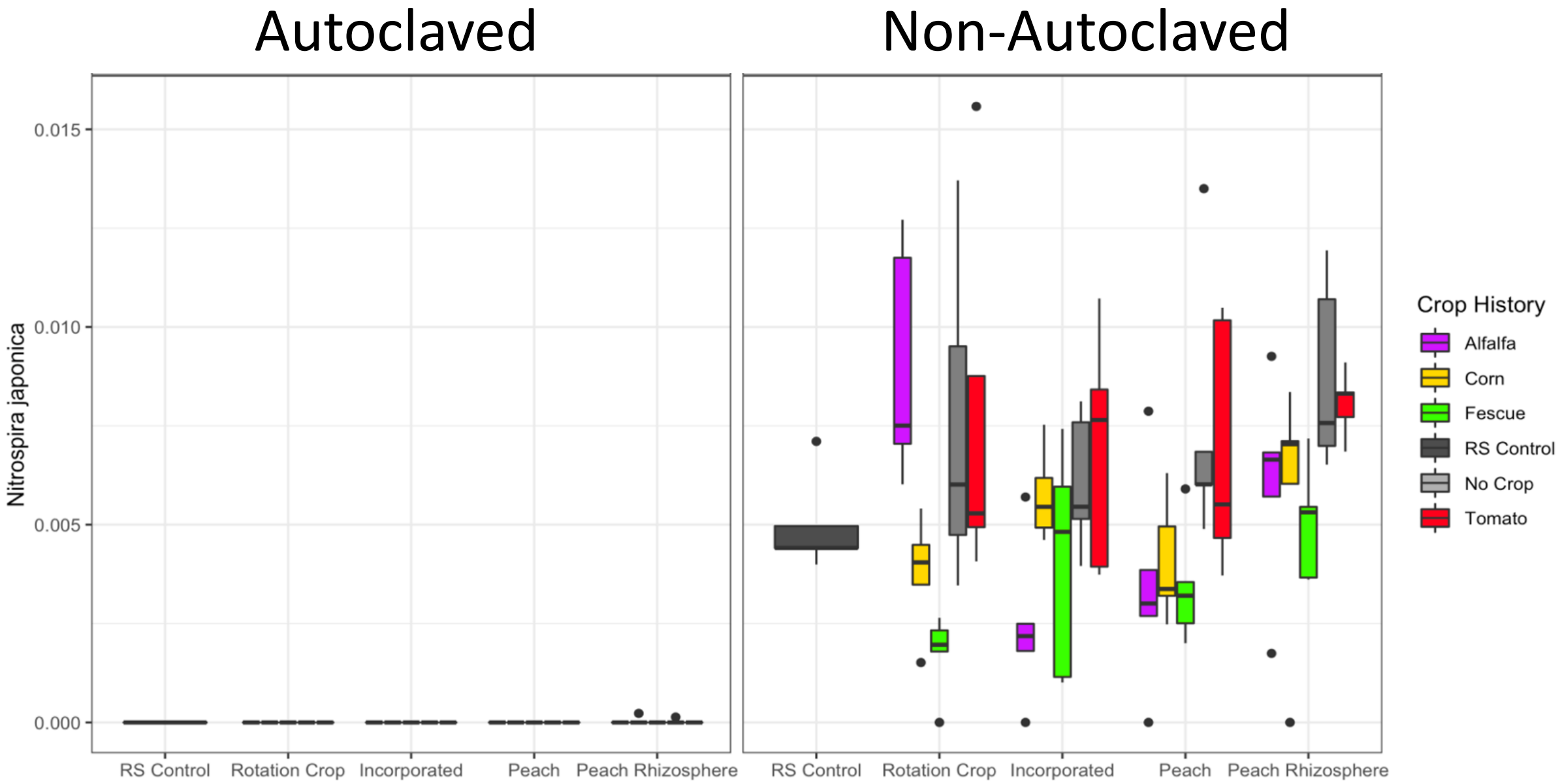
Peach rhizosphere bacterial microbiomes (22 weeks)



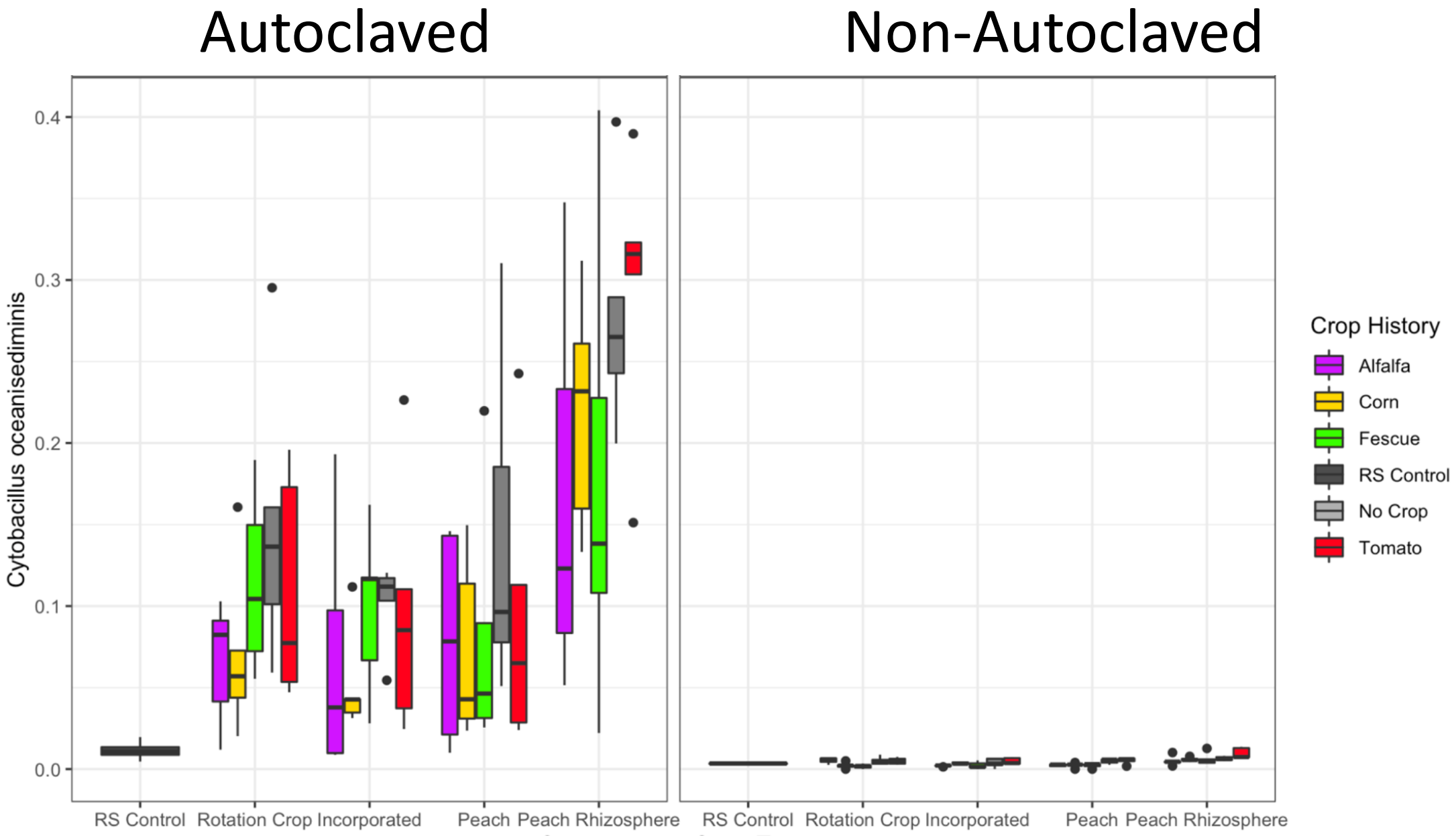
Bacillus megaterium



Nitrospira japonica



Cytobacillus oceanisediminis



Summary

Cover crop biomass was higher in autoclaved soils

Peach tree biomass was higher in non-autoclaved soils

Non-/autoclaved no plant controls show no biomass difference

Autoclaved and non-autoclaved bacterial microbiomes remained separated

Using genetically different crops worked- not all CC were equal
Beneficial bacteria were lost due to autoclaving soils: moderate disinfection technique
***Paenibacillus castaneae* and *Bellilinea caldifistulae:* Beneficial bacterial species that were cultivated exclusively in the peach rhizosphere of non-autoclaved soils with a cover crop history**
Only see part of the picture

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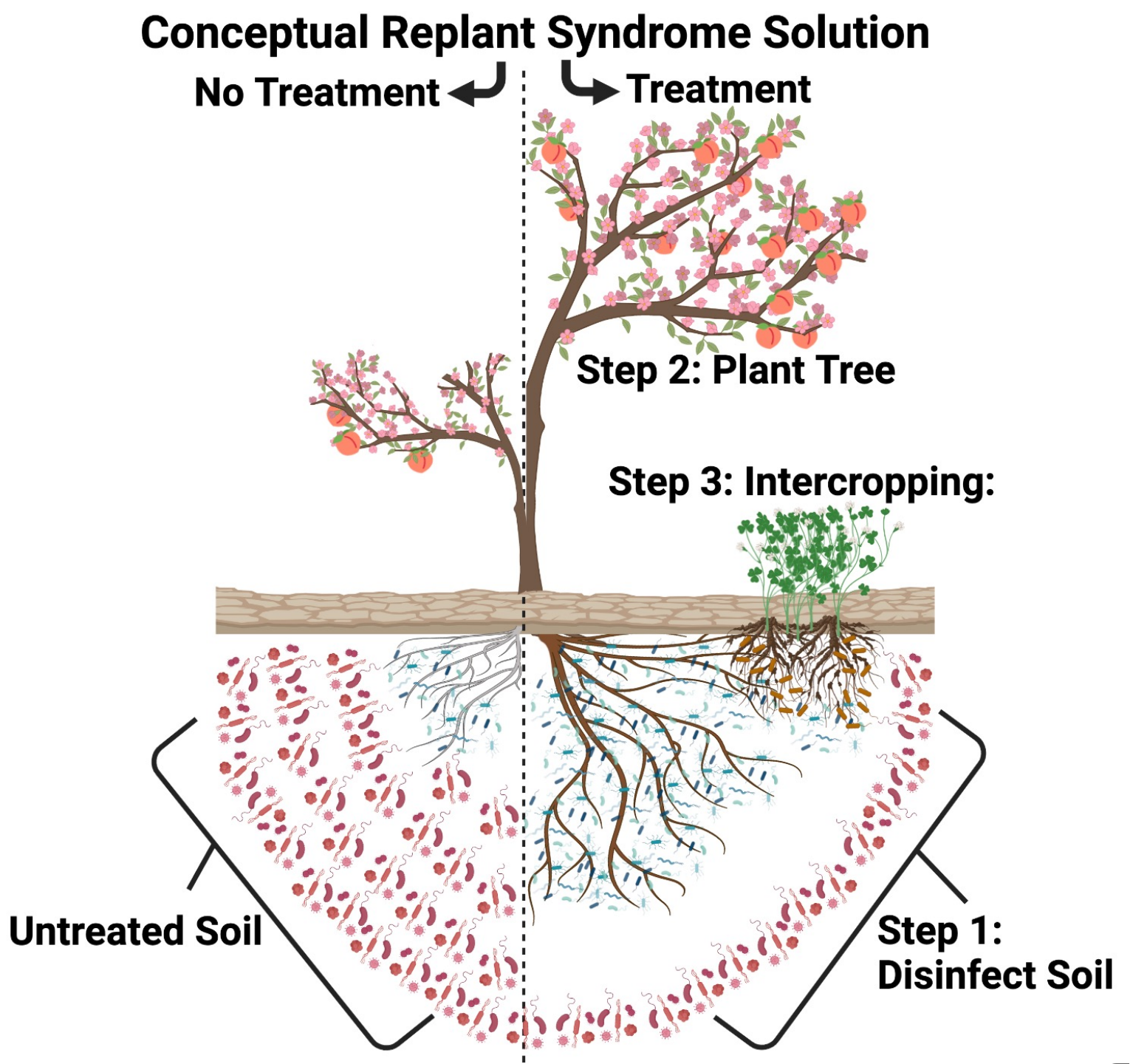
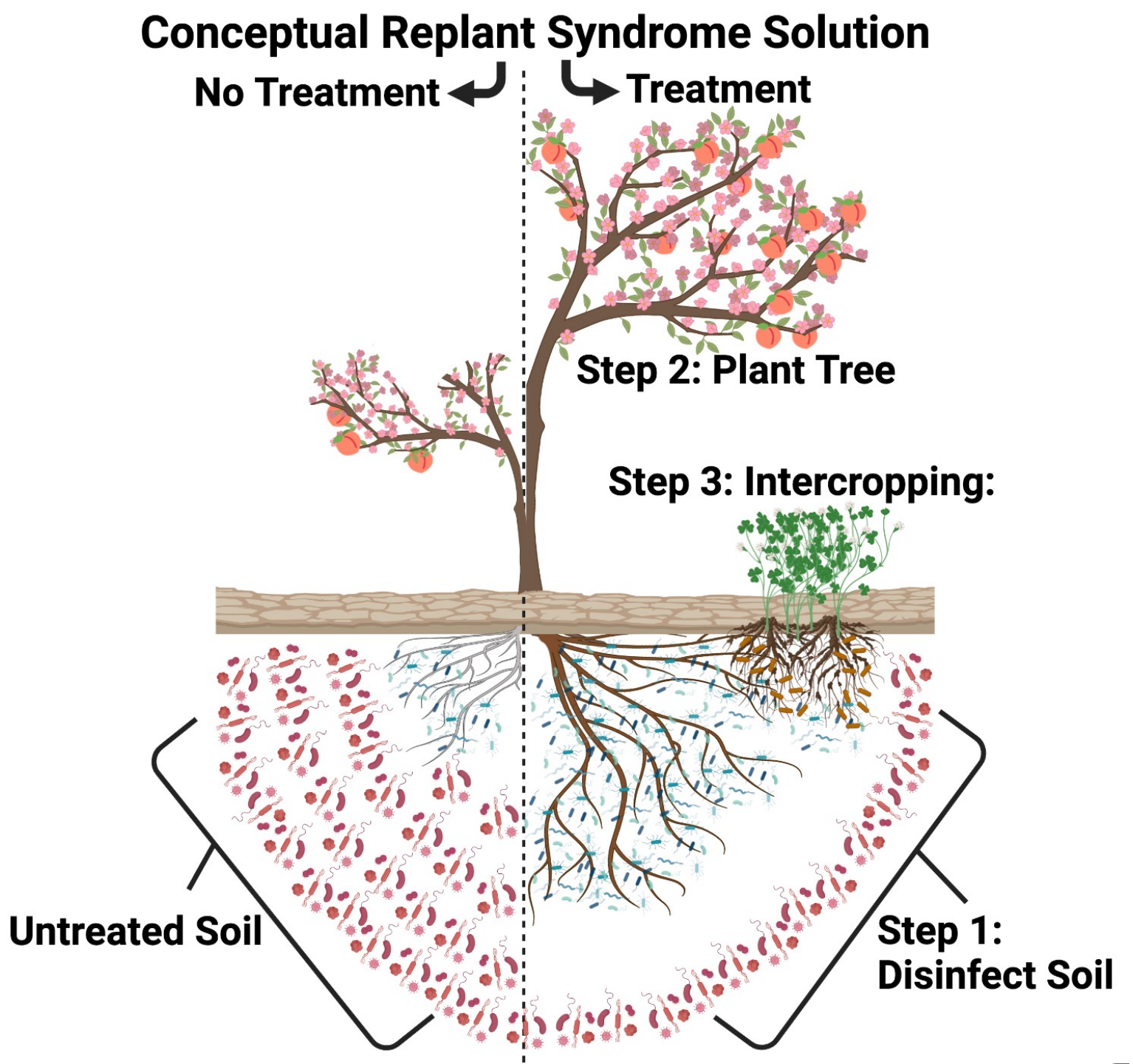
SCAN ME


Conceptual Replant Syndrome Solution
No Treatment
Treatment
Step 2: Plant Tree
Step 3: Intercropping:
Untreated Soil
Step 1:
Disinfect Soil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No Treatment
Treatment
Step 2: Plant Tree
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Step 1:
Disinfect Soil

SCAN ME

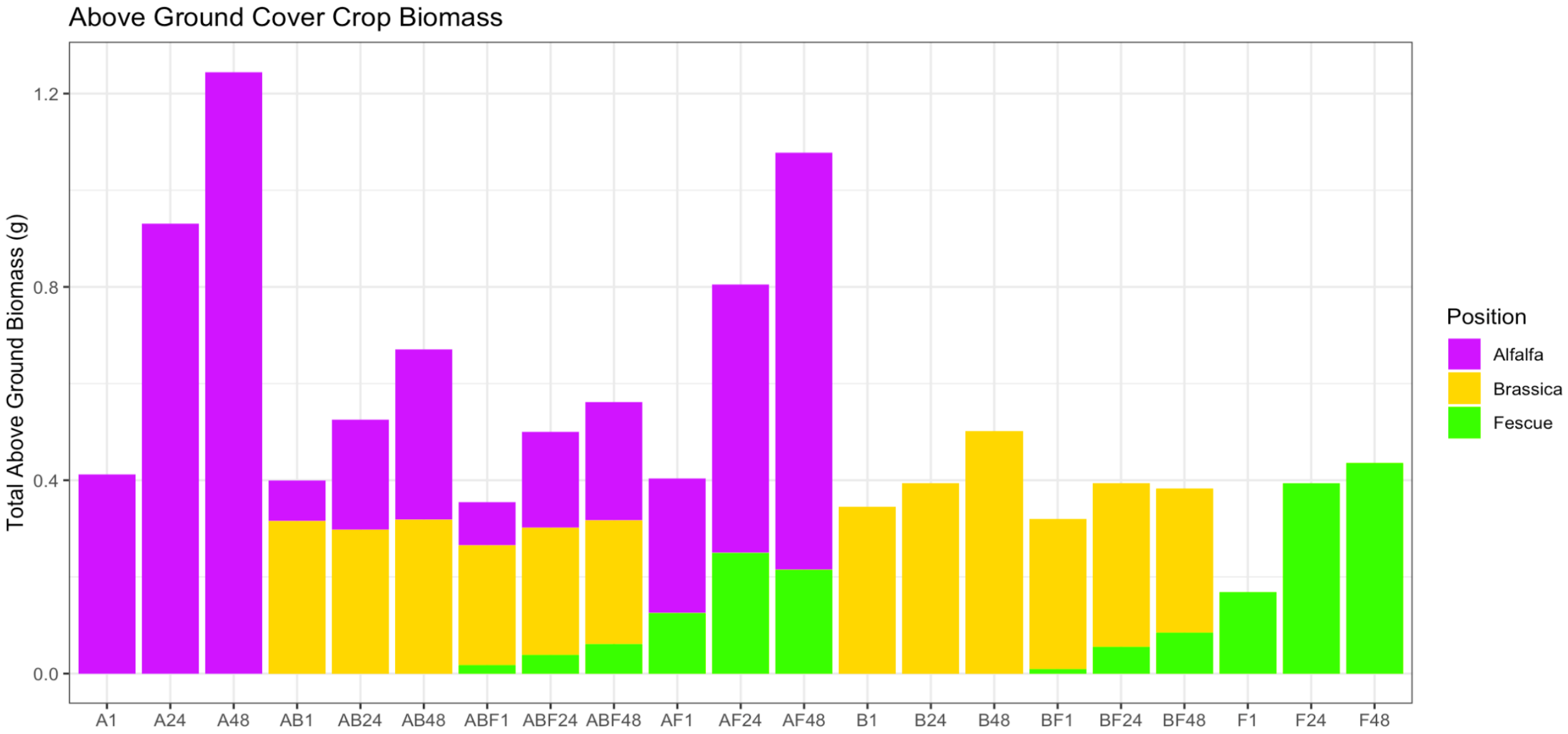
Bulk Soil

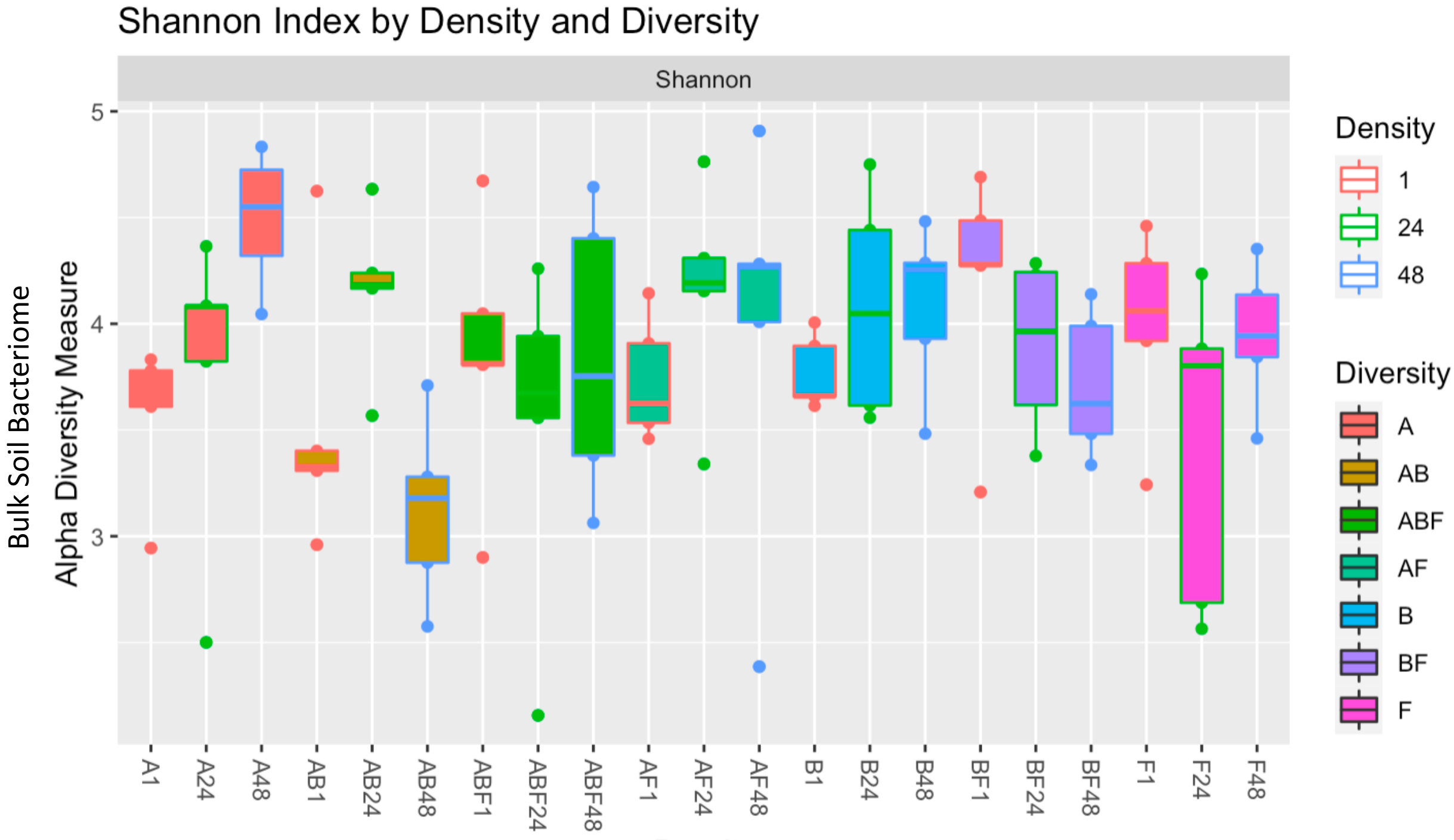
Bulk Soil

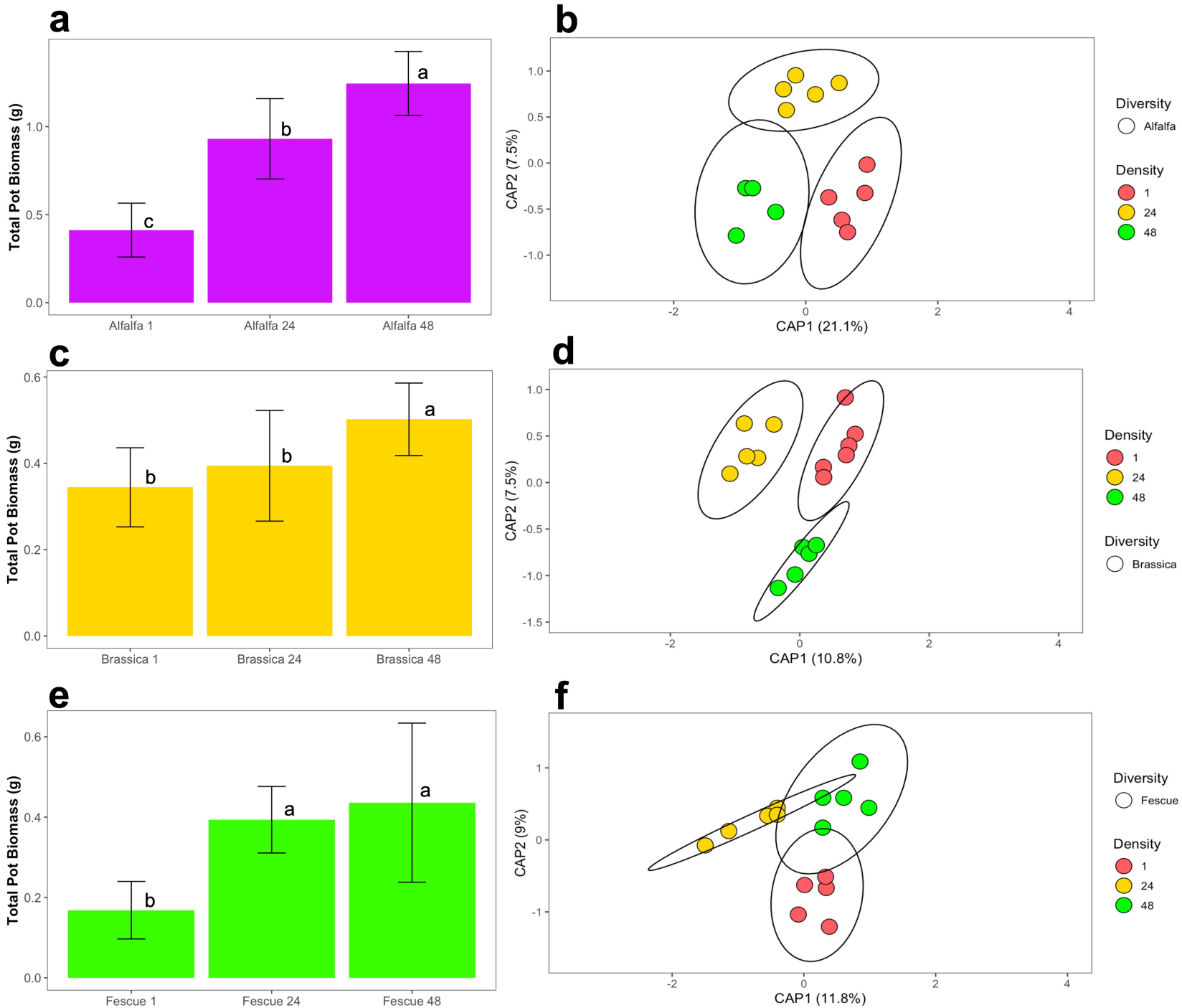
Microcosm Competition Experiment Set Up

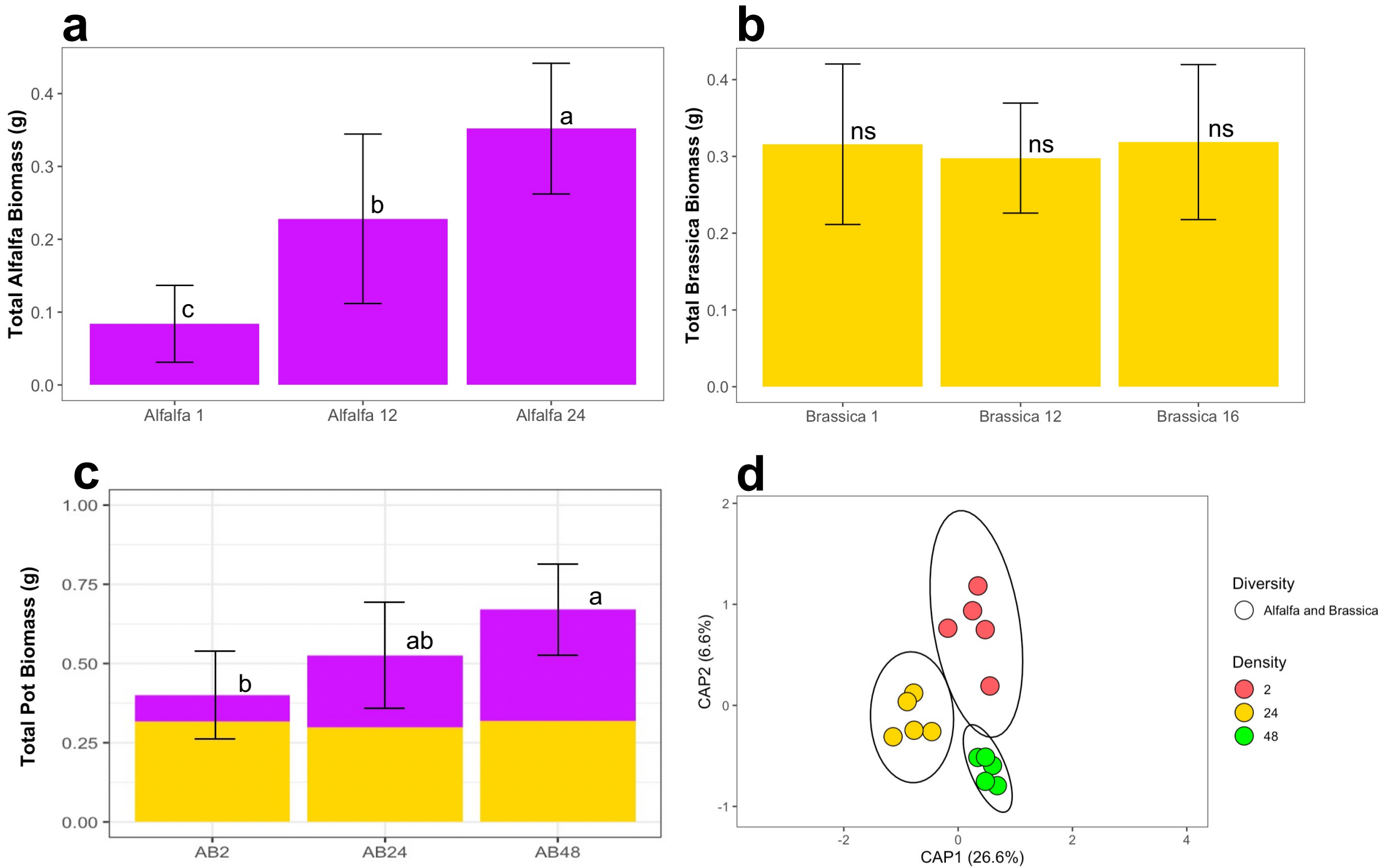
- 7 diversity treatments (1. alfalfa, 2. brassica, 3. fescue, 4. alfalfa-brassica, 5. alfalfa-fescue, 6. brassica-fescue, 7. alfalfa-brassica-fescue)
- 3 density treatments (low: 1-3 plants, medium: 24 plants, and high: 48 plants)
- 21 treatments total

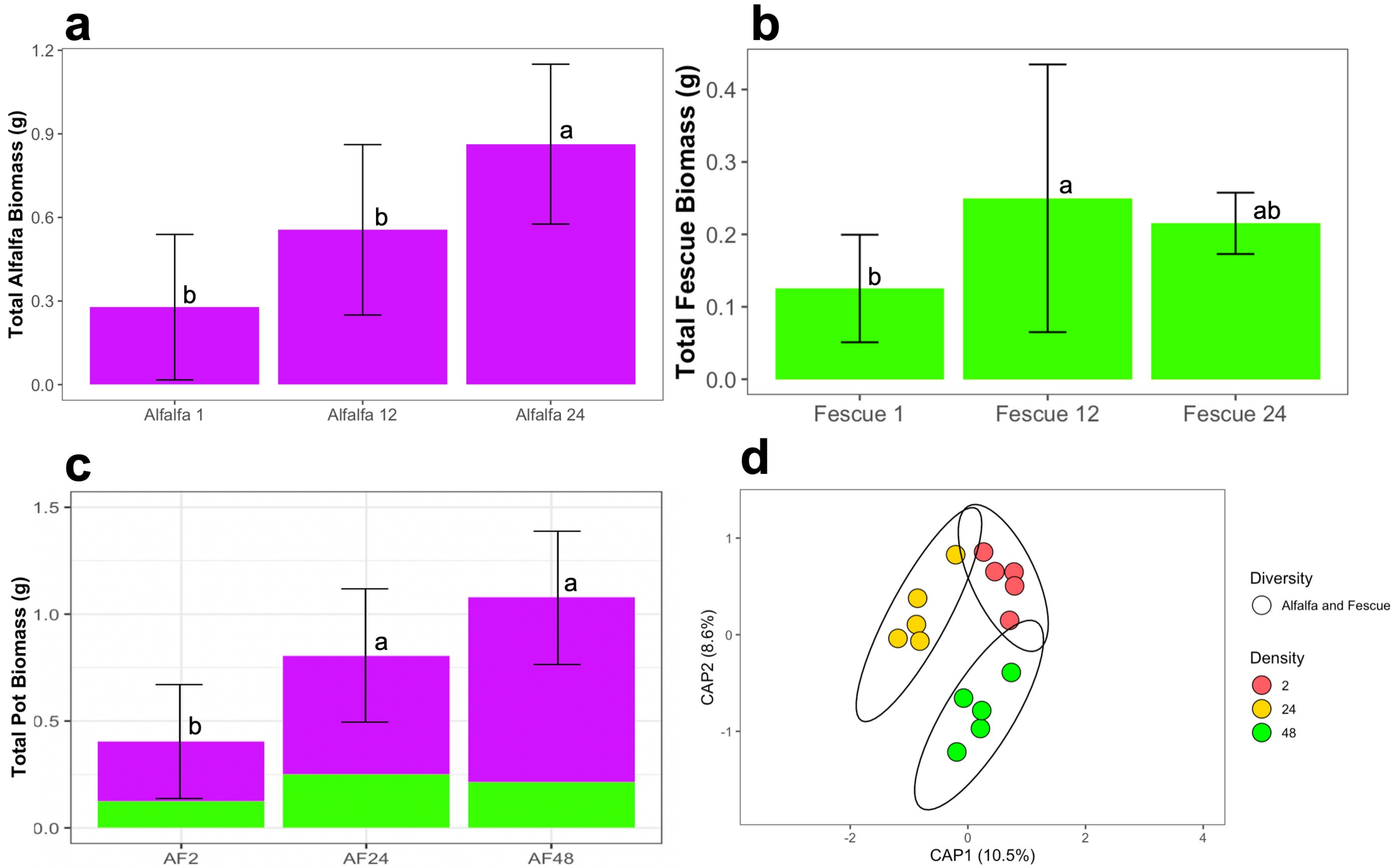
	Monoculture	Polyculture
Low Density (1-3 Plants per microcosm)	1. Alfalfa (1 Plant)	10. Alfalfa (1 Plant) and Brassica (1 Plant)
	2. Brassica (1 Plant)	11. Alfalfa (1 Plant) and Fescue (1 Plant)
	3. Fescue (1 Plant)	12. Brassica (1 Plant) and Fescue (1 Plant)
		13. Alfalfa (1 Plant), Brassica (1 Plant), and Fescue (1 Plant)
Medium Density (24 Plants per microcosm)	4. Alfalfa (24 Plants)	14. Alfalfa (12 Plants) and Brassica (12 Plants)
	5. Brassica (24 Plants)	15. Alfalfa (12 Plants) and Fescue (12 Plants)
	6. Fescue (24 Plants)	16. Brassica (12 Plants) and Fescue (12 Plants)
		17. Alfalfa (8 Plants), Brassica (8 Plants), and Fescue (8 Plants)
High Density (48 Plants per microcosm)	7. Alfalfa (48 Plants)	18. Alfalfa (24 Plants) and Brassica (24 Plants)
	8. Brassica (48 Plants)	19. Alfalfa (24 Plants) and Fescue (24 Plants)
	9. Fescue (48 Plants)	20. Brassica (24 Plants) and Fescue (24 Plants)
		21. Alfalfa (16 Plants), Brassica (16 Plants), and Fescue (16 Plants)

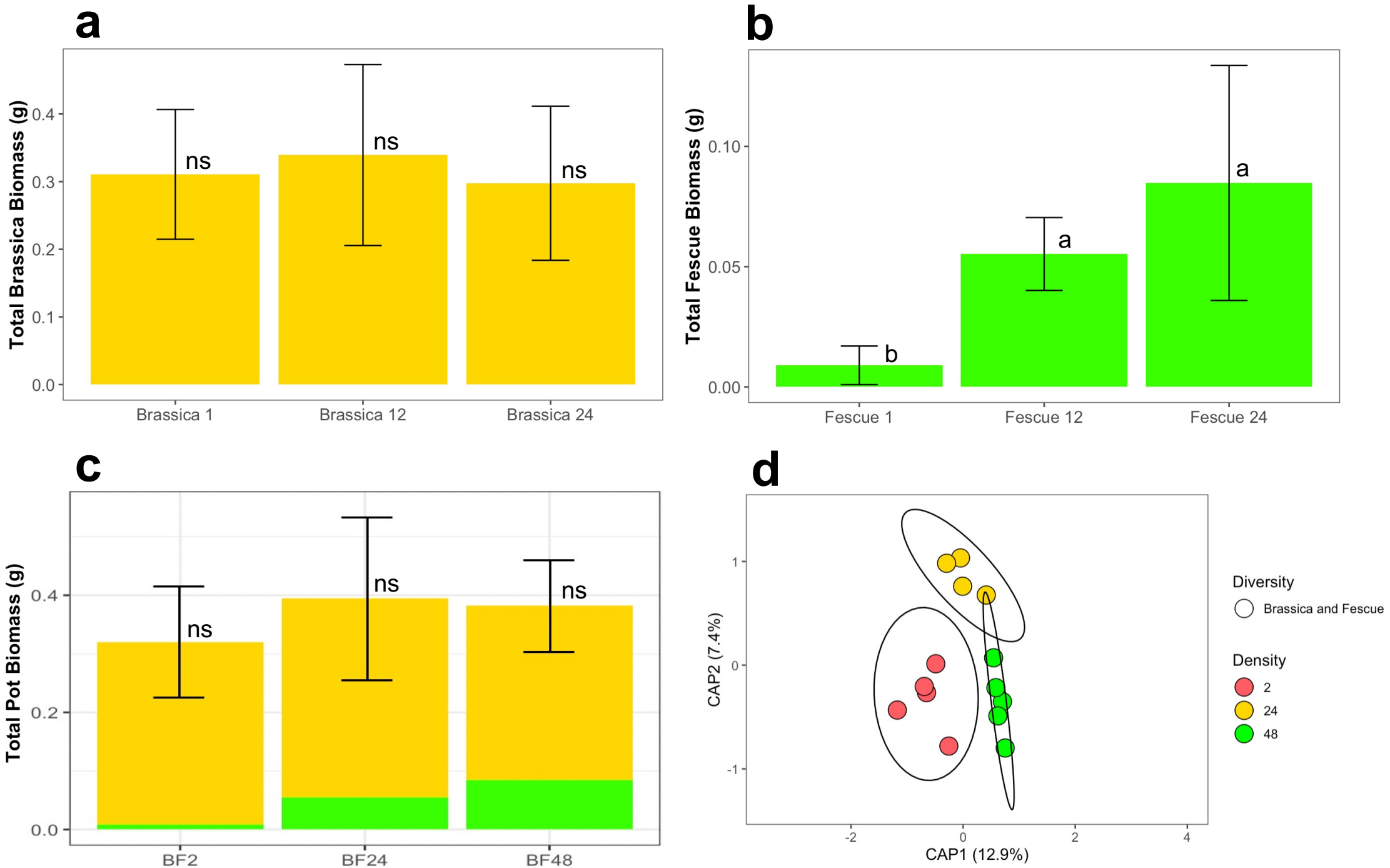

Above Ground Cover Crop Biomass
Total Above Ground Biomass (g)
1.2
0.8
0.4
0.0
A1
A24
A48
AB1
AB24
AB48
ABF1
ABF24
ABF48
AF1
AF24
AF48
B1
B24
B48
BF1
BF24
BF48
F1
F24
F48
Position
Alfalfa
Brassica
Fescue

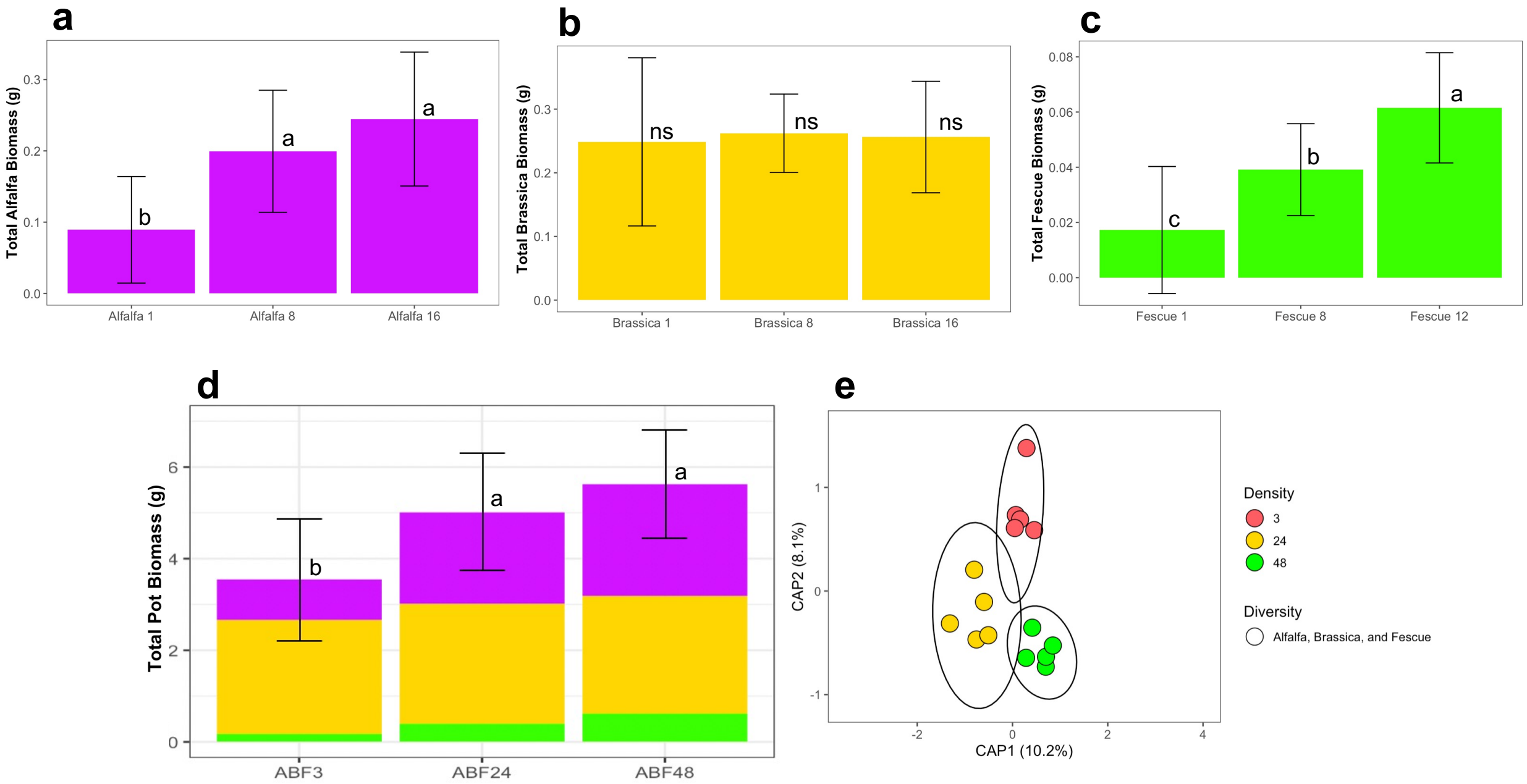

Shannon Index by Density and Diversity
Shannon
Bulk Soil Bacteriome
Alpha Diversity Measure
5
4
3
A1
A24
A48
AB1
AB24
AB48
ABF1
ABF24
ABF48
AF1
AF24
AF48
B1
B24
B48
BF1
BF24
BF48
F1
F24
F48
Density
1
24
48
Diversity
A
AB
ABF
AF
B
BF
F


a
Total Pot Biomass (g)
0.0
0.5
1.0
c
b
a
Alfalfa 1
Alfalfa 24
Alfalfa 48
b
CAP2 (7.5%)
1.0
0.5
0.0
-0.5
-1.0
-2
0
2
4
CAP1 (21.1%)
Diversity
Alfalfa
Density
1
24
48
c
Total Pot Biomass (g)
0.0
0.2
0.4
0.6
b
b
a
Brassica 1
Brassica 24
Brassica 48
d
CAP2 (7.5%)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2
0
2
4
CAP1 (10.8%)
Density
1
24
48
Diversity
Brassica
e
Total Pot Biomass (g)
0.0
0.2
0.4
0.6
b
a
a
Fescue 1
Fescue 24
Fescue 48
f
CAP2 (9%)
1
0
-1
-2
0
2
4
CAP1 (11.8%)
Diversity
Fescue
Density
1
24
48


a
Total Alfalfa Biomass (g)
0.0
0.1
0.2
0.3
0.4
c
b
a
Alfalfa 1
Alfalfa 12
Alfalfa 24
b
Total Brassica Biomass (g)
0.0
0.1
0.2
0.3
0.4
ns
ns
ns
Brassica 1
Brassica 12
Brassica 16
c
Total Pot Biomass (g)
0.00
0.25
0.50
0.75
1.00
b
ab
a
AB2
AB24
AB48
d
CAP2 (6.6%)
-1
0
1
2
CAP1 (26.6%)
-2
0
2
4
Diversity
Alfalfa and Brassica
Density
2
24
48


a
Total Alfalfa Biomass (g)
1.2
0.9
0.6
0.3
0.0
b
b
a
Alfalfa 1
Alfalfa 12
Alfalfa 24
b
Total Fescue Biomass (g)
0.4
0.3
0.2
0.1
0.0
b
a
ab
Fescue 1
Fescue 12
Fescue 24
c
Total Pot Biomass (g)
1.5
1.0
0.5
0.0
b
a
a
AF2
AF24
AF48
d
CAP2 (8.6%)
1
0
-1
-2
0
2
4
CAP1 (10.5%)
Diversity
Alfalfa and Fescue
Density
2
24
48


a
Total Brassica Biomass (g)
0.0
0.1
0.2
0.3
0.4
ns
ns
ns
Brassica 1
Brassica 12
Brassica 24
b
Total Fescue Biomass (g)
0.00
0.05
0.10
b
a
a
Fescue 1
Fescue 12
Fescue 24
c
Total Pot Biomass (g)
0.0
0.2
0.4
ns
ns
ns
BF2
BF24
BF48
d
CAP2 (7.4%)
-1
0
1
CAP1 (12.9%)
-2
0
2
4
Diversity
Brassica and Fescue
Density
2
24
48


a
Total Alfalfa Biomass (g)
0.0
0.1
0.2
0.3
b
a
a
Alfalfa 1
Alfalfa 8
Alfalfa 16
b
Total Brassica Biomass (g)
ns
ns
ns
Brassica 1
Brassica 8
Brassica 16
c
Total Fescue Biomass (g)
0.00
0.02
0.04
0.06
0.08
c
b
a
Fescue 1
Fescue 8
Fescue 12
d
Total Pot Biomass (g)
0
2
4
6
b
a
a
ABF3
ABF24
ABF48
e
CAP2 (8.1%)
-1
0
1
CAP1 (10.2%)
-2
0
2
4
Density
3
24
48
Diversity
Alfalfa, Brassica, and Fescue

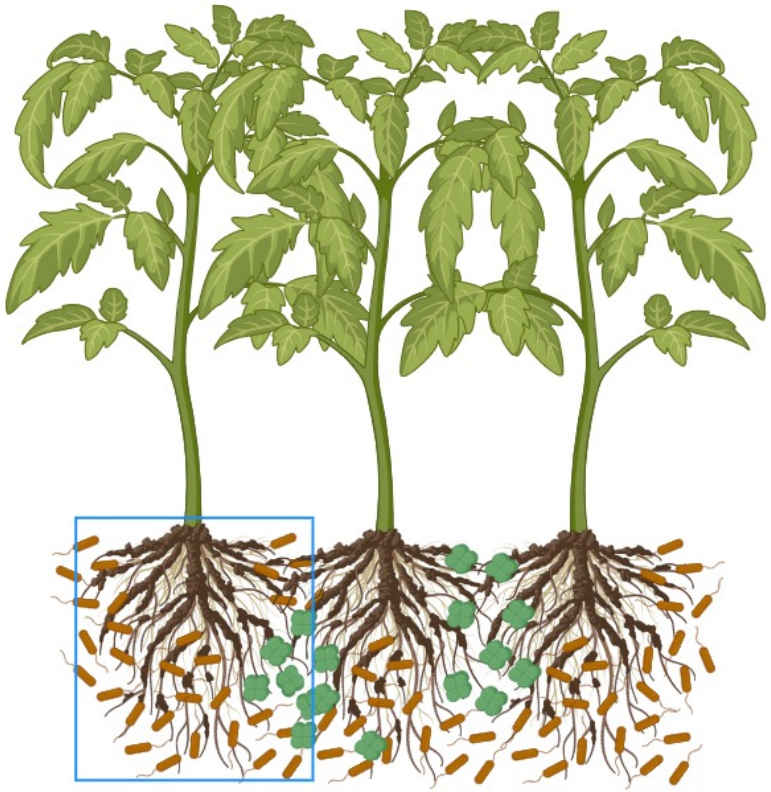
Overall Summary for the Bulk Soil Bacteriome

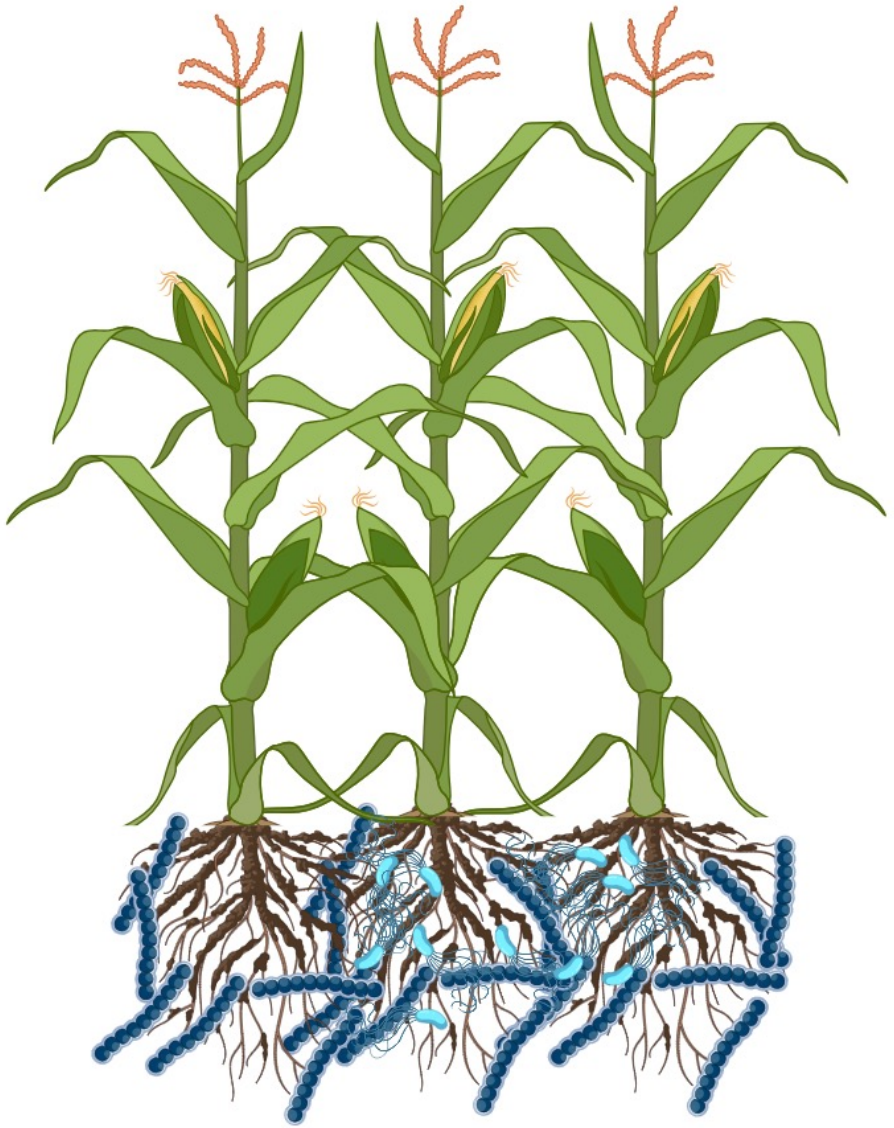
SCAN ME

- Bulk Soil of Alfalfa 48 exhibited the least dispersion, suggesting that the surrounding bulk soil bacteriome can progress towards a tailored microbiome for alfalfa as intraspecific competition increases
- Trade off: Different plant combinations enriched different (beneficial) bacteria
  - Even in high plant competition plant mixtures and densities
- *Azospirillum* spp. enriched in alfalfa and brassica monocultures
  - Not enriched in alfalfa-brassica bulk soil
  - *Pseudarthrobacter phenanthrenivorans*- phytohormone producer

Plant Neighbor and the Rhizosphere

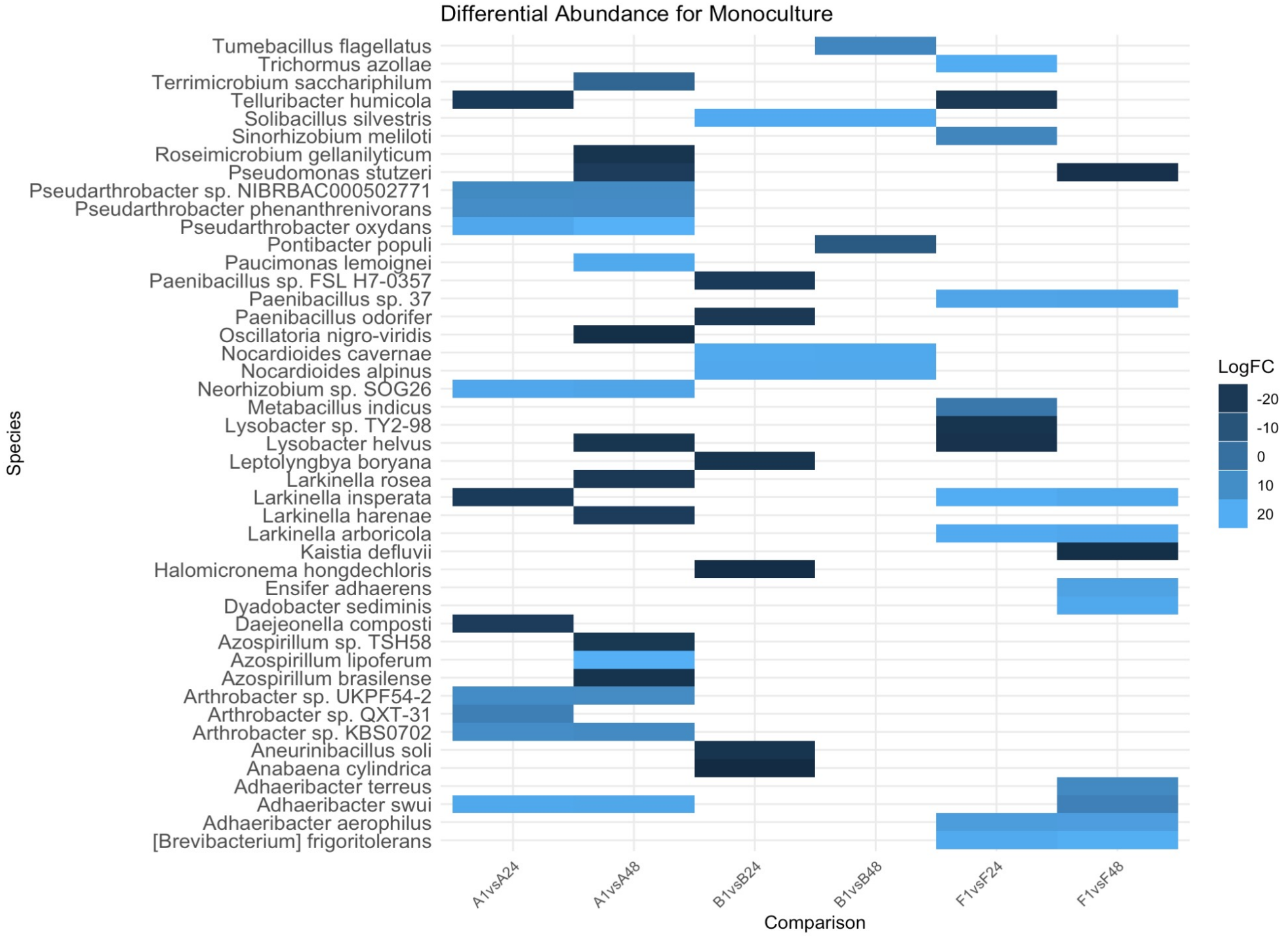
Plant Neighbor and the Rhizosphere: Density





Plant Neighbor and the Rhizosphere: Density &Diversity

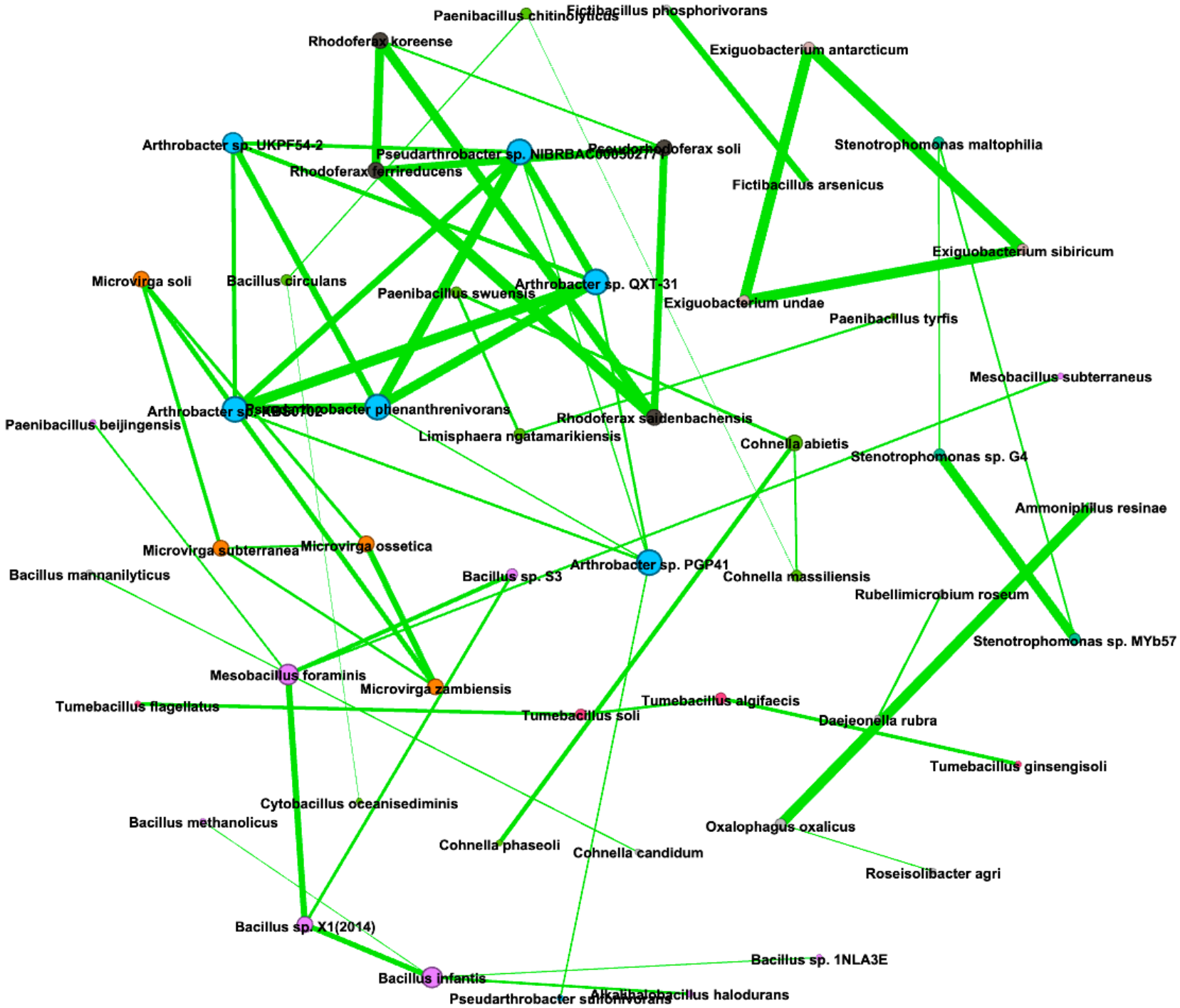
Rhizosphere: Monoculture



Rhizosphere: Monoculture Alfalfa

Differential Abundance:
Pseudarthrobacter sp. NIBRBAC000502771
Pseudarthrobacter phenanthrenivorans
Pseudarthrobacter oxydans
Neorhizobium sp. SOG26
Arthrobacter sp. UKPF54-2
Arthobacter sp. KBS0702
Adhaeribacter swiu

Alfalfa Rhizosphere Monoculture



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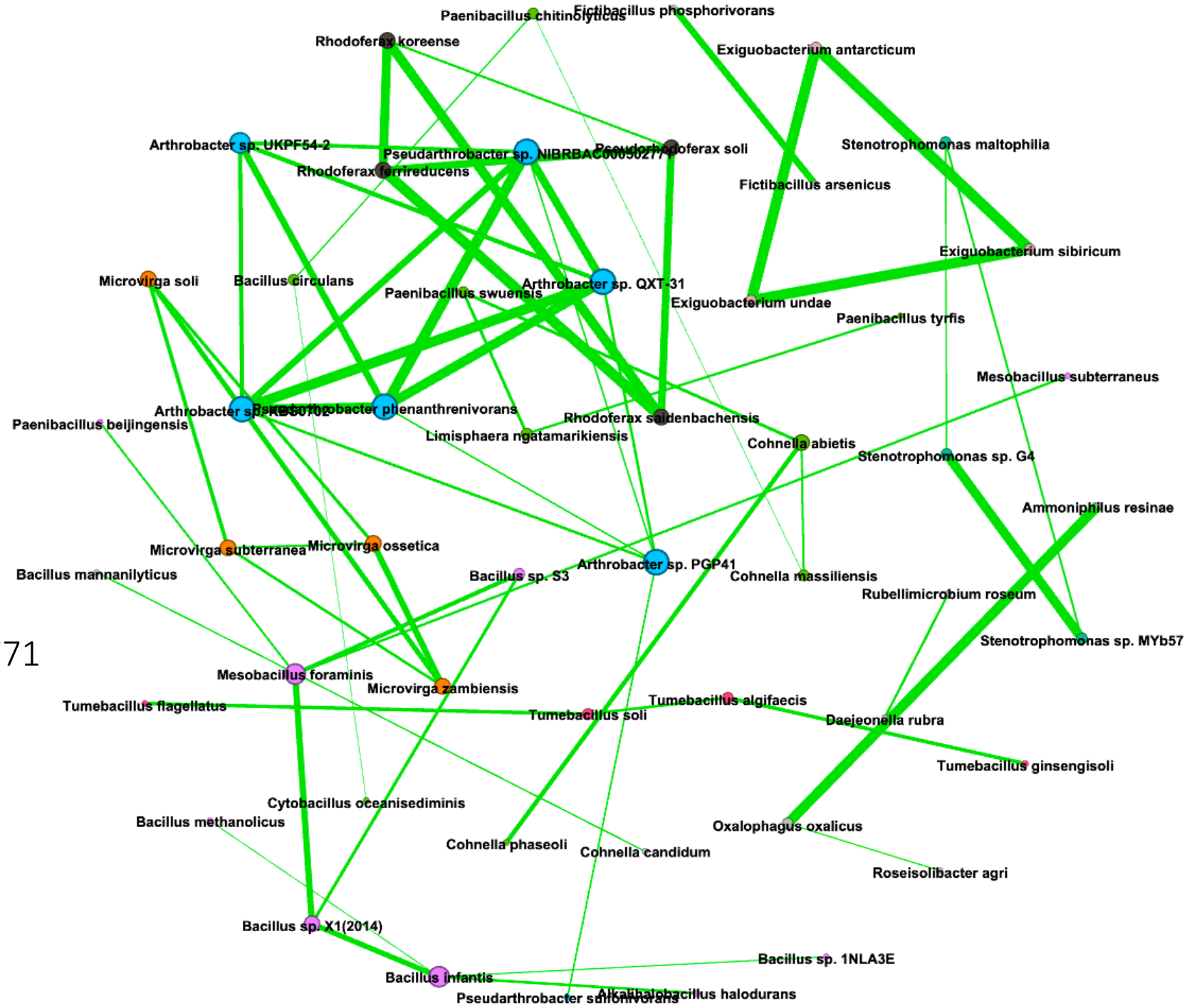

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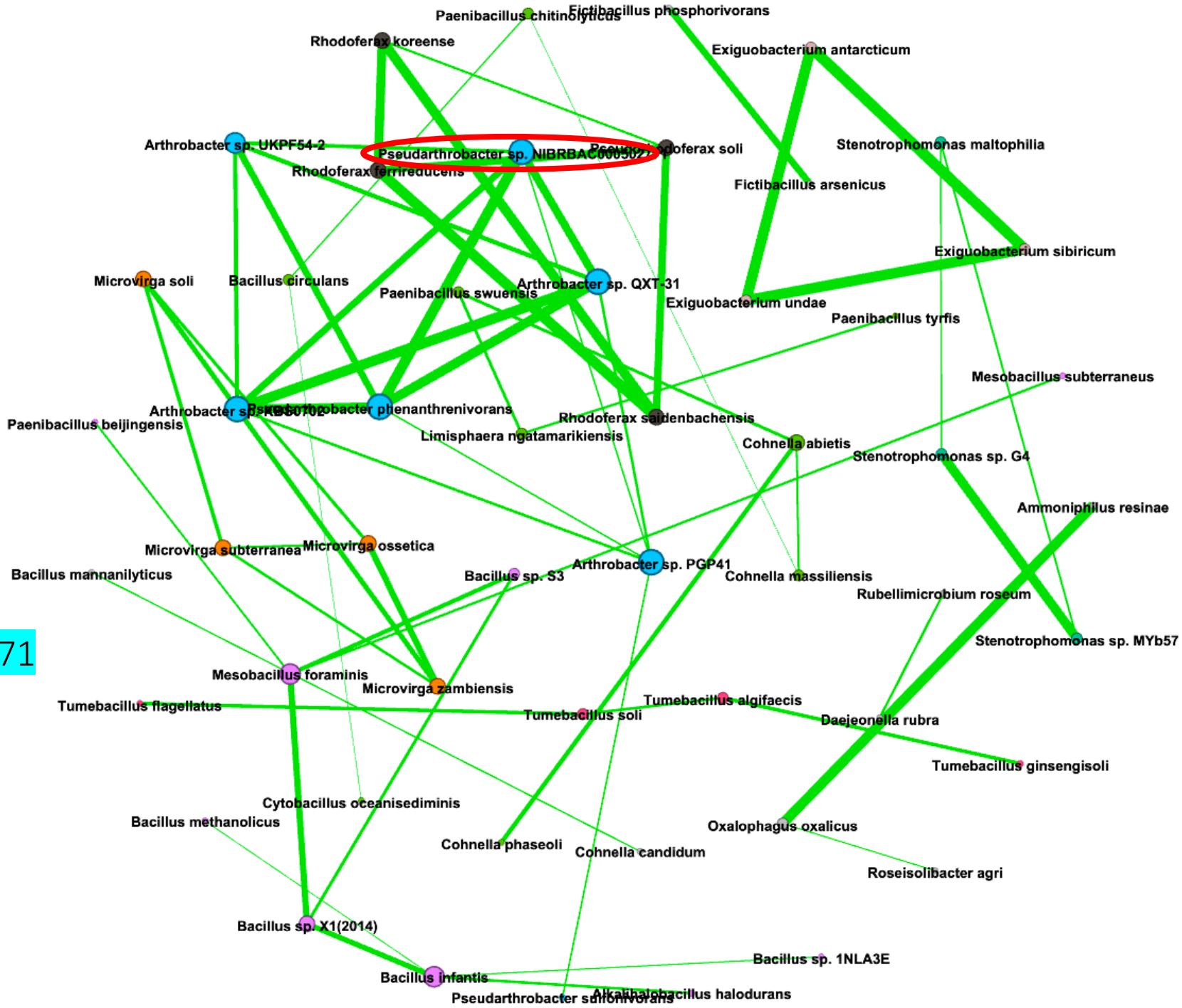

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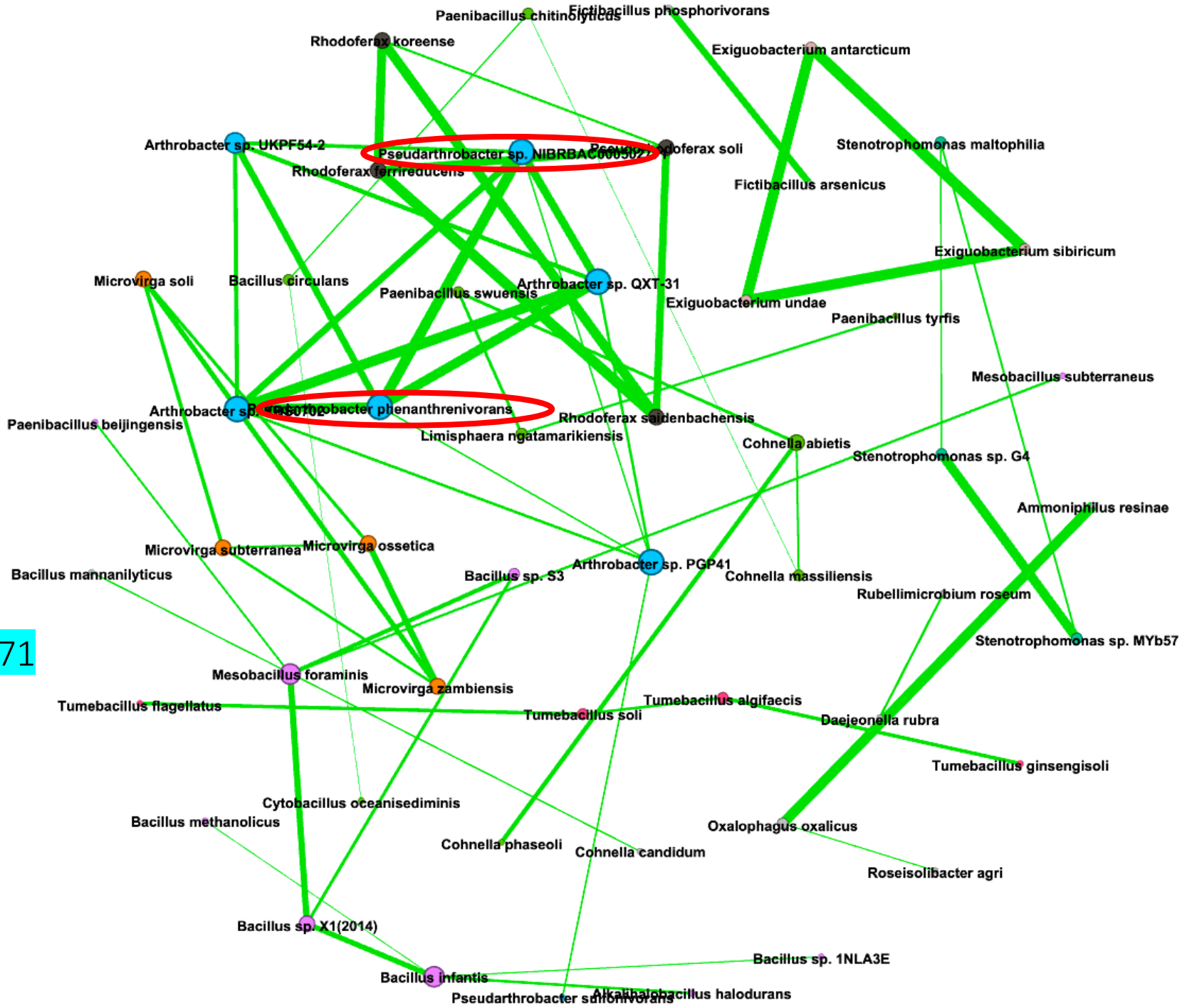

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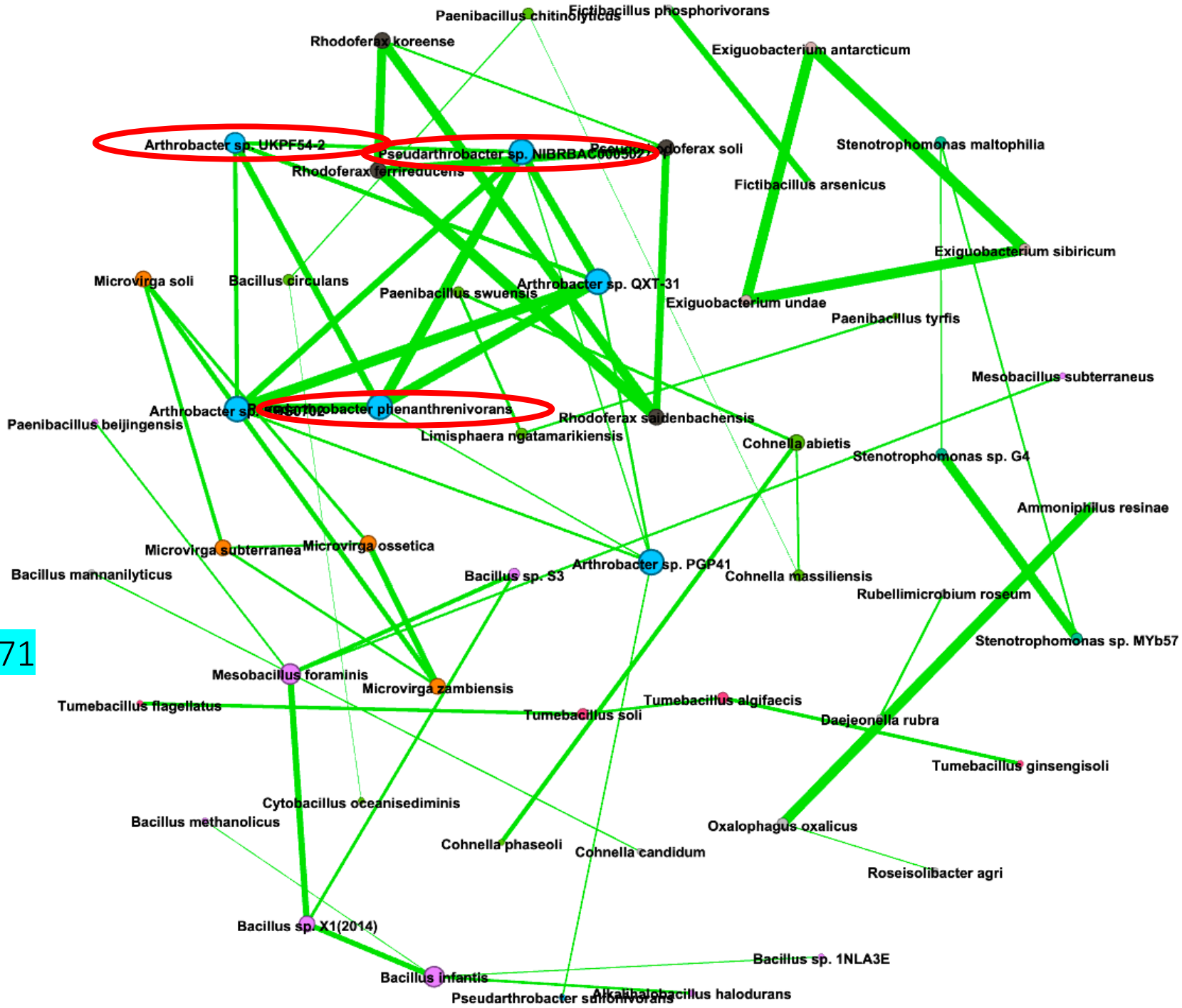
Adhaeribacter swiu



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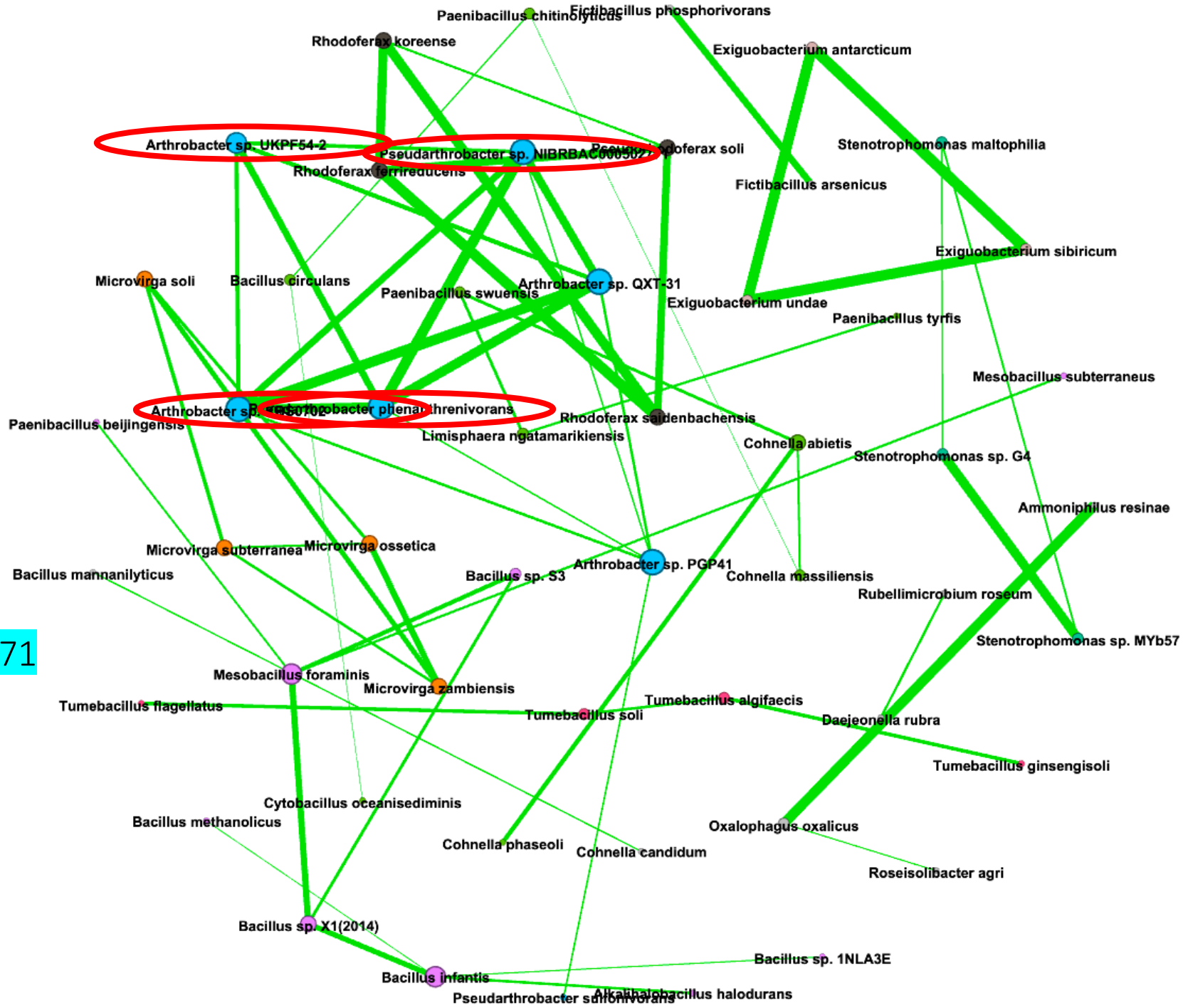
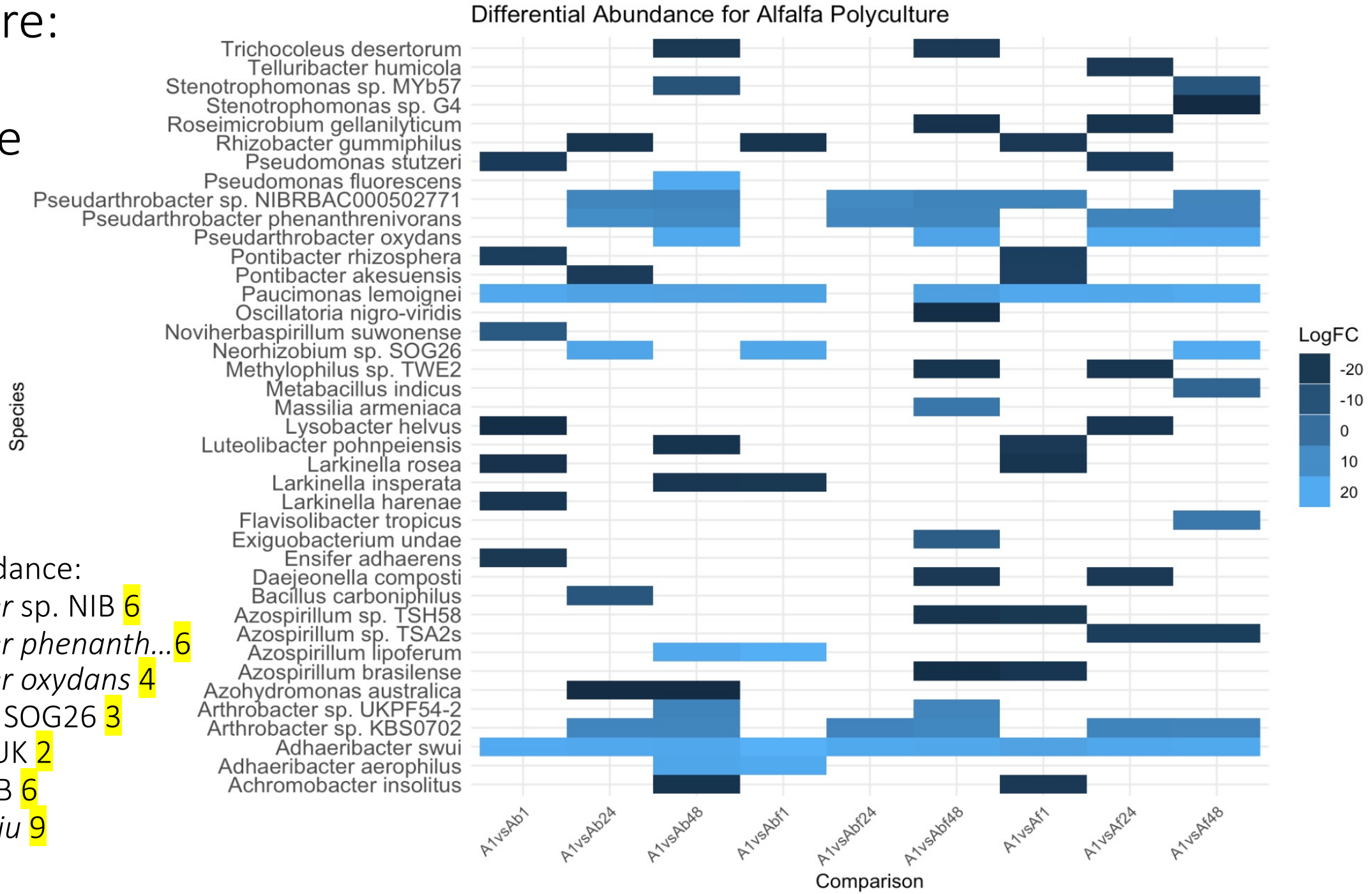


Rhizosphere: Alfalfa Polyculture



Differential Abundance:

Pseudarthrobacter sp. NIB 6

Pseudarthrobacter phenanth… 6

Pseudarthrobacter oxydans 4

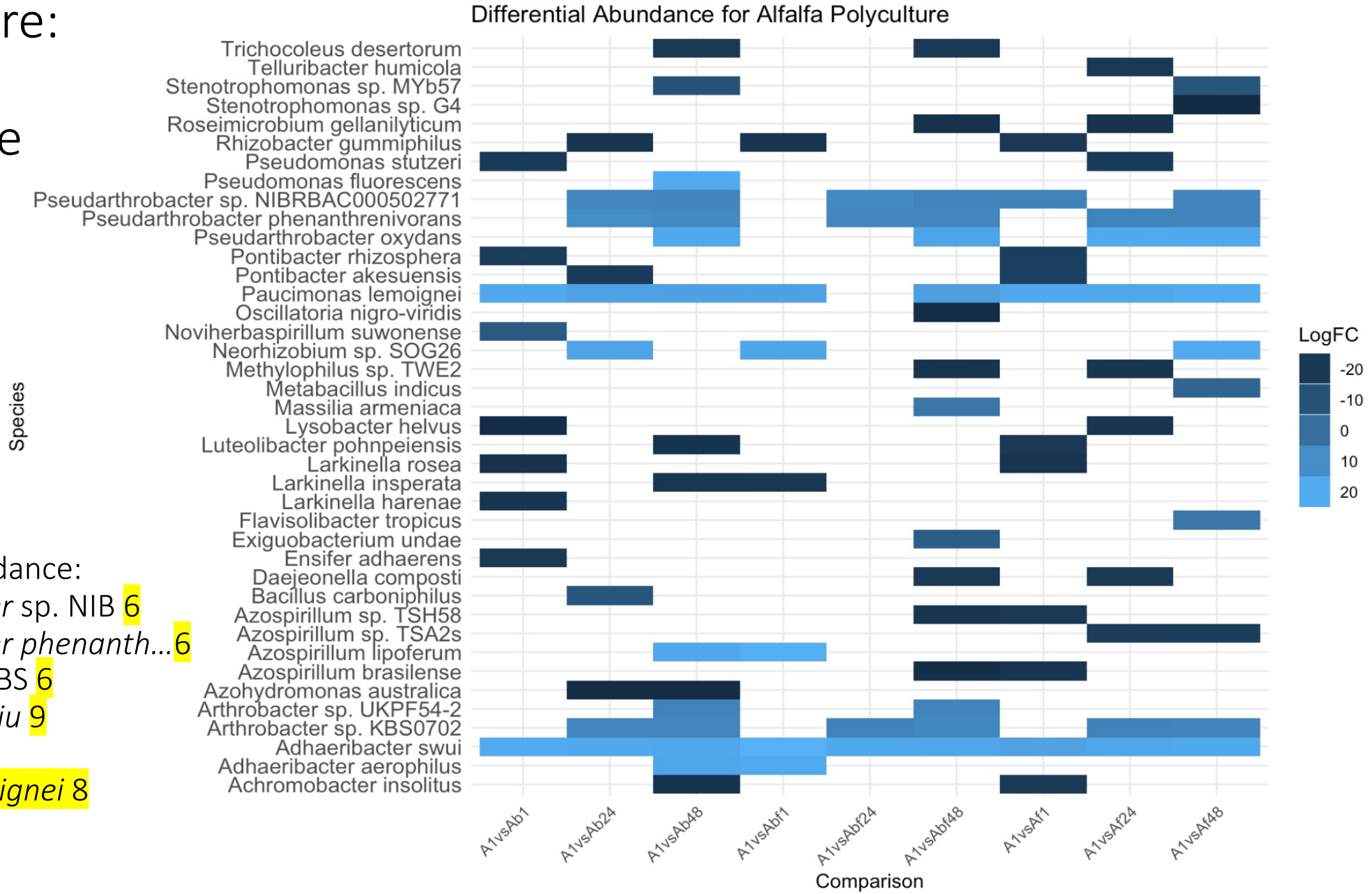
Neorhizobium sp. SOG26 3

Arthrobacter sp. UK 2

Arthobacter sp. KB 6

Adhaeribacter swiu 9

Rhizosphere: Alfalfa Polyculture



Differential Abundance:

Pseudarthrobacter sp. NIB 6

*Pseudarthrobacter phenanth…*6

Arthobacter sp. KBS 6

Adhaeribacter swiu 9

Paucimonas lemoignei 8

Alfalfa Rhizosphere Polyculture

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Pseudarthrobacter sp. NIBRBAC000502771
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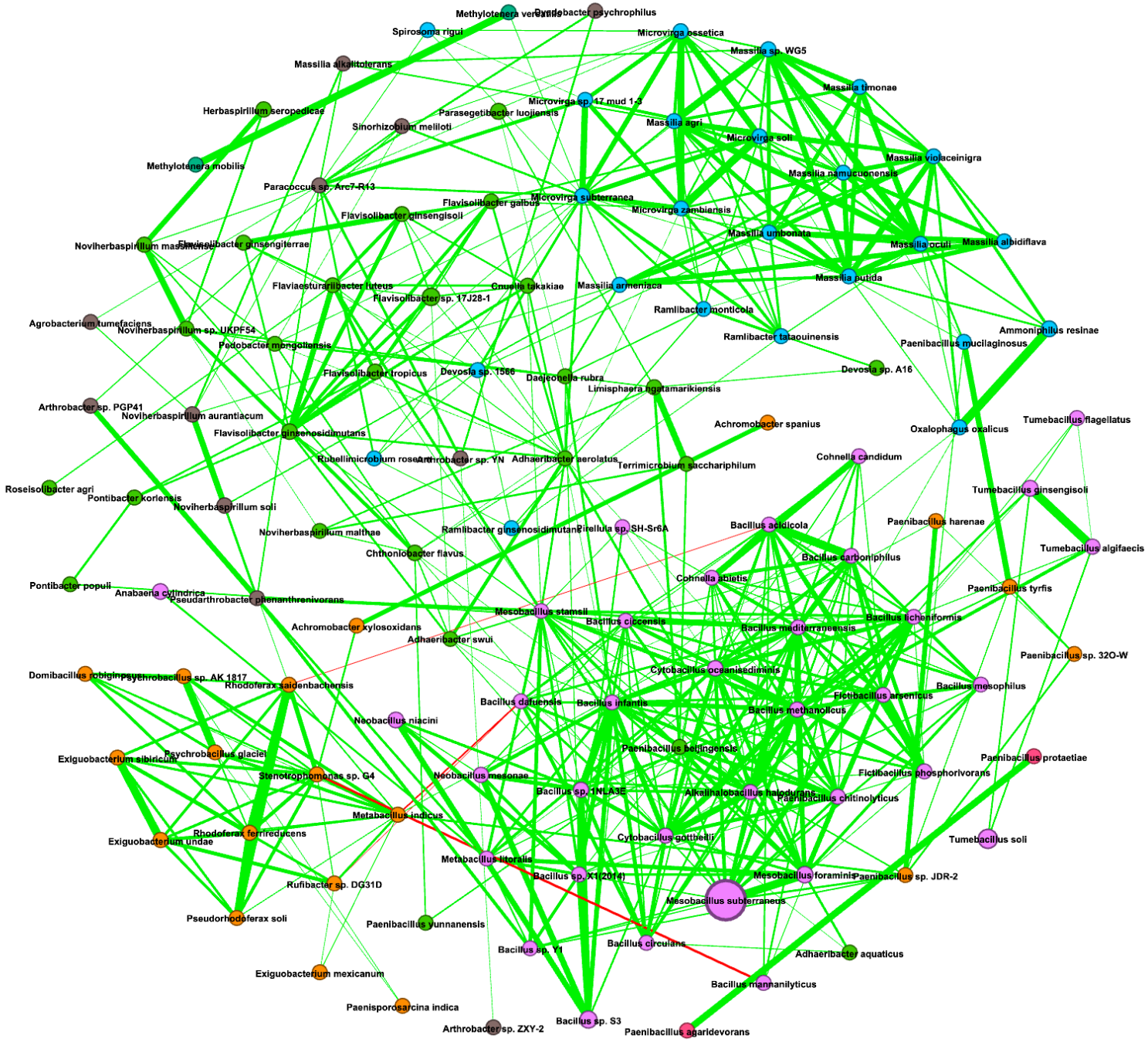
Arthobacter sp. KBS0702
Adhaeribacter swiu

Paucimonas lemoignei



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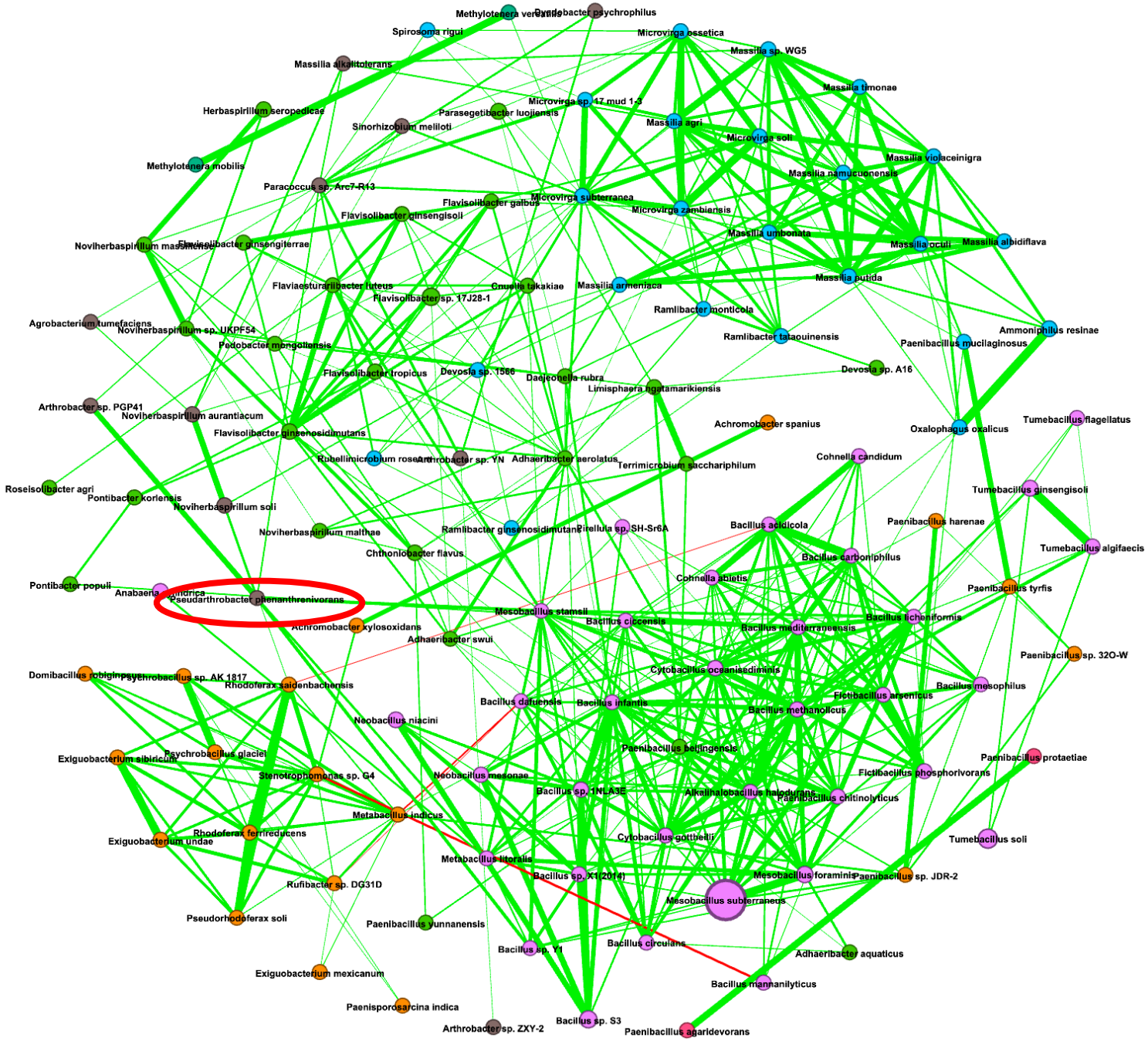

Future Works

- Polyculture Networks
- Hub Species functionality using Picrust2

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