Mycorrhizal Symbiosis

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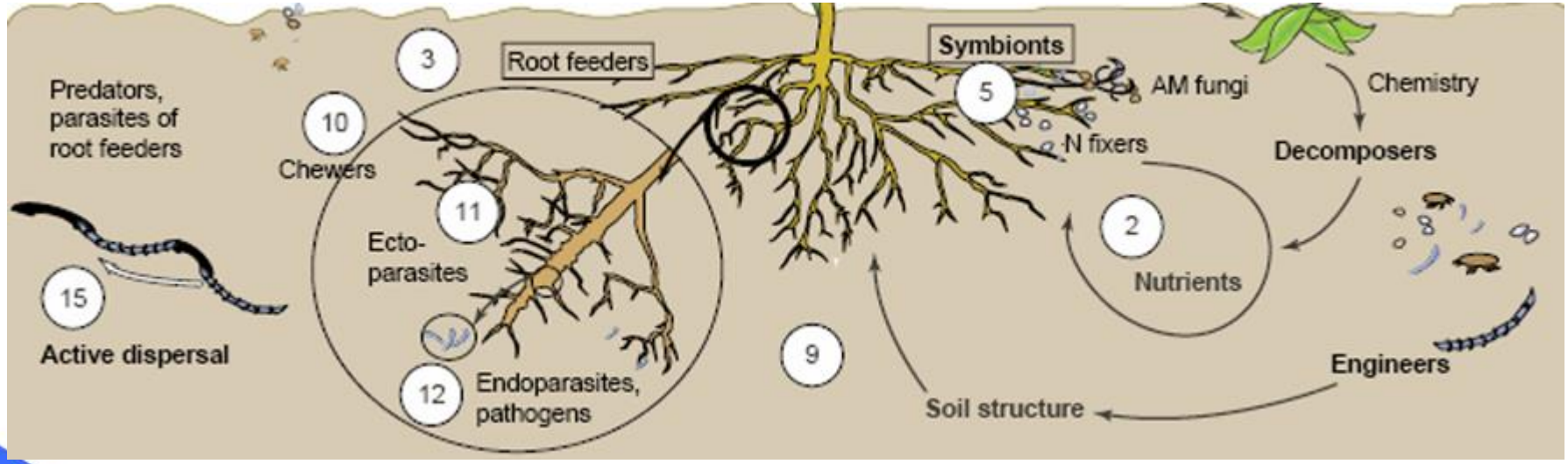
Outline

- An overview of Mycorrhizal Associations
- Soil and Plant Sampling Techniques for Mycorrhizal Study
- Benefits of Mycorrhiza

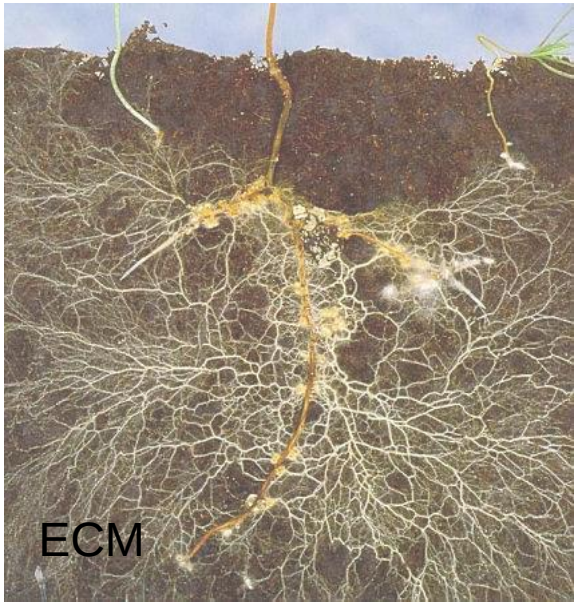
Belowground Ecosystem

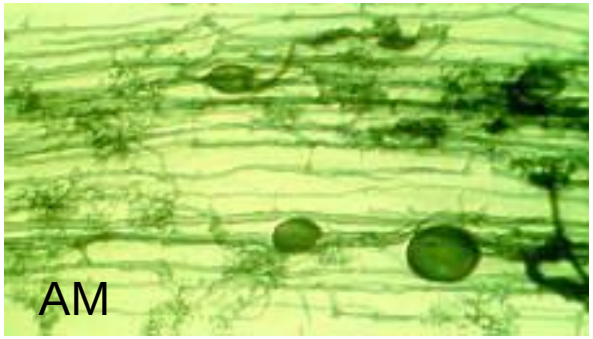


De Deyn & van der Putten, *Trends in Ecology & Evolution*, 2005, 20:625-633

What is Mycorrhizae?

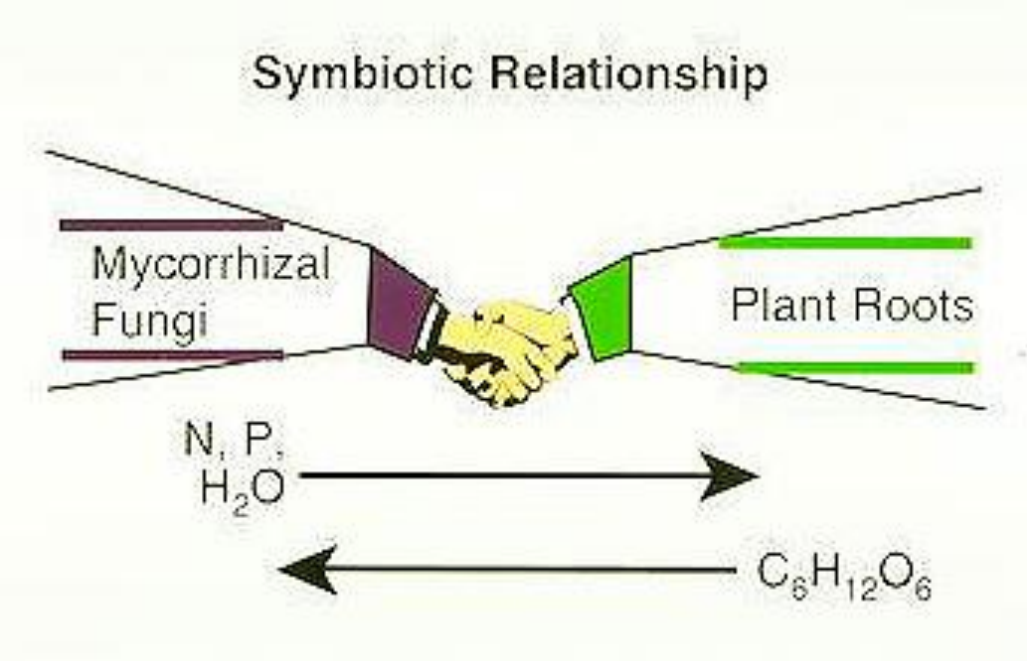
- Mycorrhizae are symbiotic associations that form between the roots of most plant species and fungi
- Different types are recognized
- An ecosystem normally contains a mixture of types of mycorrhizal associations





Symbiotic Relationship

- Hyphae increase surface area of roots for increased absorption of soil nutrients: Nitrogen, Phosphorus



Type of Mycorrhizae

- **There are at least seven major types of mycorrhizal associations, arbuscular mycorrhizae (AM), ectomycrorrhizae, ectendomycorrhizae, ericoid mycorrhizae, orchid mycorrhizae, arbutoid mycorrhizae, and monotropoid mycorrhizae**

- **Most common association is the arbuscular mycorrhizae (AM) and ectomycorrhizae (ECM) are probably the next most common type symbiosis**
- **Ericoid mycorrhizae (EM)**

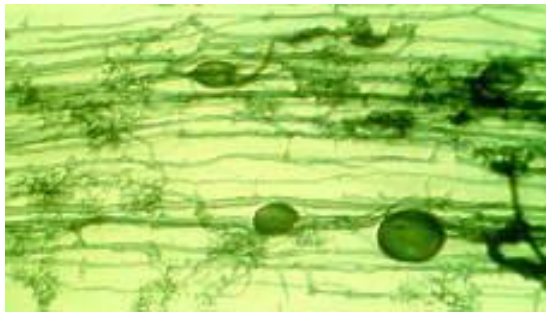
Mycorrhiza

= plant roots + fungi

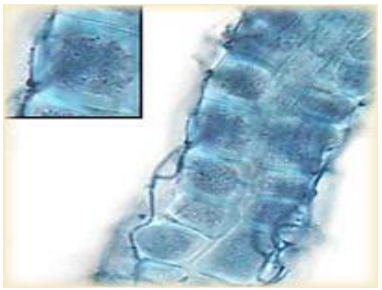
The most Important associations are:

- Ectomycorrhizas (ECM)
- Arbuscular mycorrhizas (AM)
- Ericoid mycorrhizas (EM)

ECM



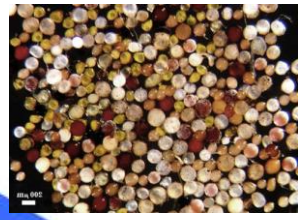
AM

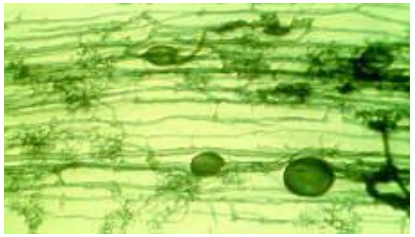


EM

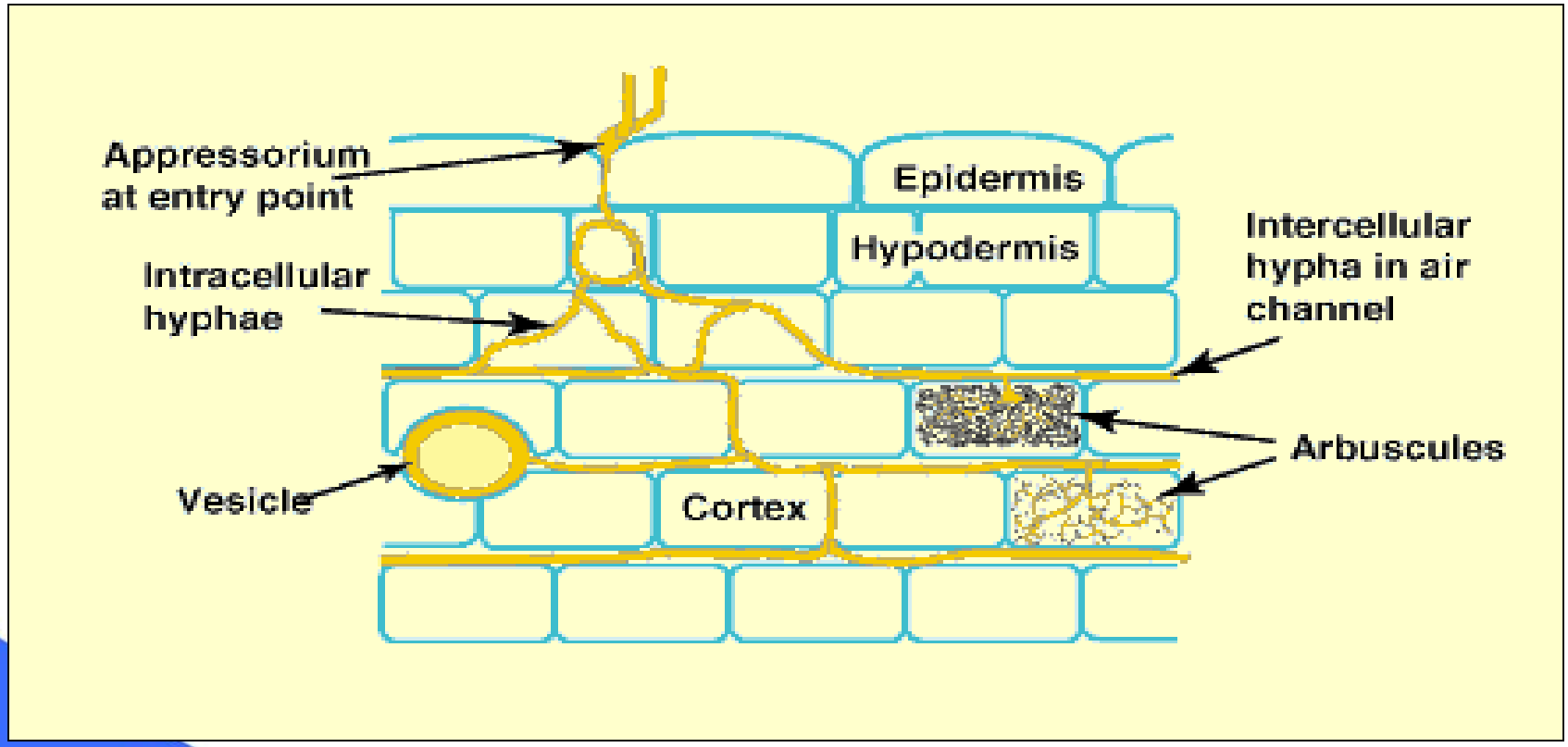
Mycorrhizae

- Are crucial components in plant systems and known to facilitate plants with nutrients and water in exchange of carbohydrates

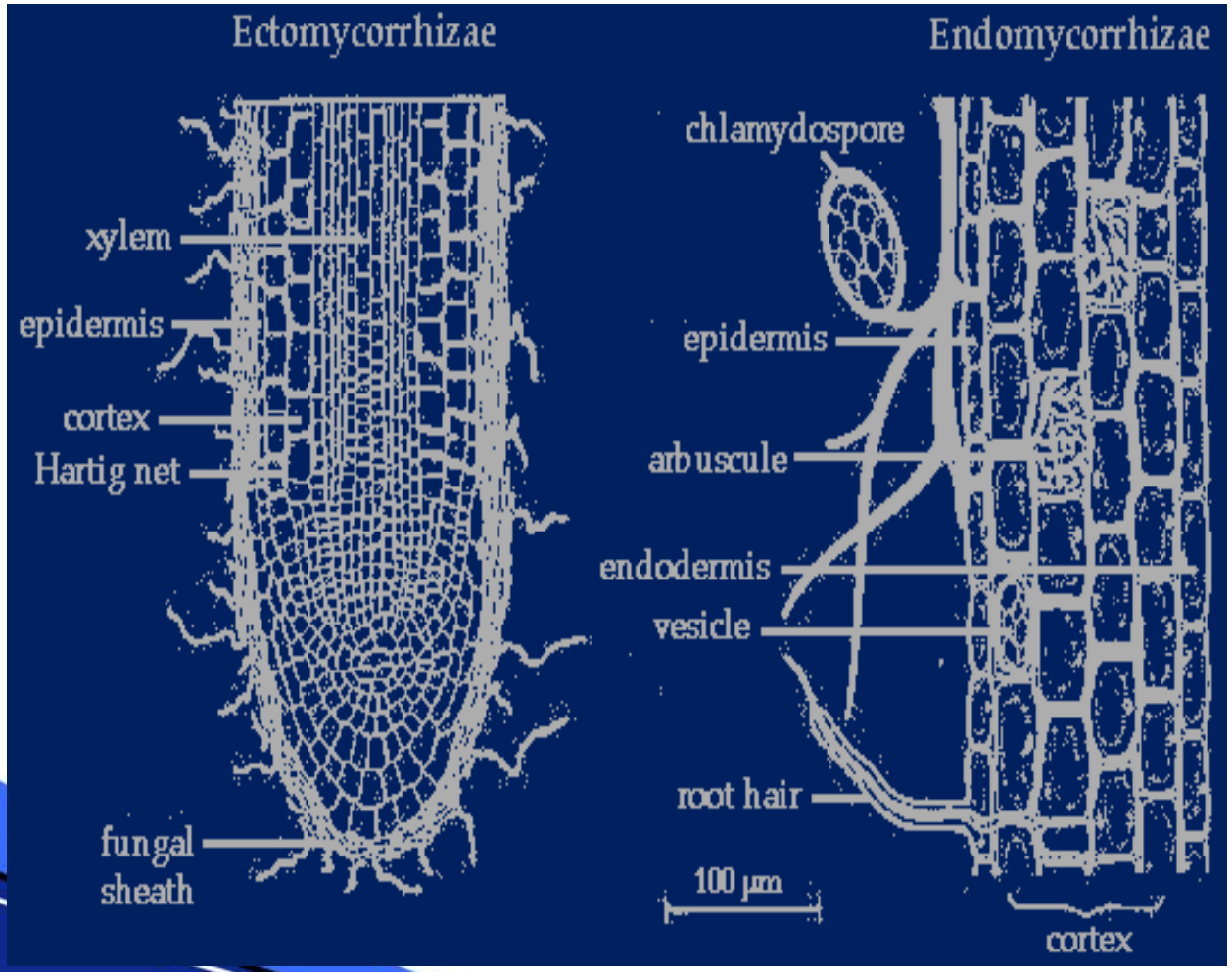




AM Fungal Association



ECM and AM Fungal Associations



Classical Example of Effectiveness of ECM Association

The main role of mycorrhizal associations is to acquire nutrients by exploring the soil volume with hyphae that are both more responsive and more extensive than the roots themselves.

Desert Ecosystem

- **Almost 90 % of crop plants are mycorrhizal mostly of AM type**
- **In the rhizosphere of desert plants, mostly arbuscular mycorrhizae (AM) play a significant role in plant nutrition and soil stabilization**

MYCORRHIZAE

- In nature approximately 90% of plants are infected with micorrhizae.

- 83% Dicots
- 79% Monocots
- 100% Gymnosperms

Soil Sampling Equipment

Sampling Tools:

- Shovel
- Push soil probe
- Auger
- Use clean tools
- Sample from the proper depth and location
- Place samples in clean bucket for mixing

When to Take Soil Samples?

- **Soil samples may be taken anytime of the year, but….**
  - **Depending on the objective of the study**
  - **Considering seasonal variations**
  - **At least twice a year**

How to Get a Good Soil Sample ?

- **Sample Soil at the Right Time**
- **Sample at Proper Depth**
- **Collect a Representative Sample**

Use of proper tools

- **A soil probe is a good tool for obtaining soil samples. Push the tube to the six-inch depth and remove the core**

- Get soil sample information sheets and cartons.
- Clean tools and containers.
  - Plastic bucket.
  - Soil tube or auger.
- Take one composite sample from each uniform area.

For General Field Sampling

- Identify fields or sampling areas
- Use proper sampling tools
- Collect 15 to 20 soil cores at random over the field to provide a single composite sample
- Fill out required information on the sample bag completely
- Deliver samples to the laboratory as soon as possible

INSTRUCTIONS FOR ROOT SAMPLING

Tools

You will need the following tools:

- Soil probe
- Clippers
- Tape measure
- Plastic baggies
- Permanent marker
- Rubber gloves (optional)

PLANT ROOT SAMPLING

Single root auger

•The single root auger is used to take undisturbed samples for root investigations in soils with low penetration resistance

• Samples with a length of 15 cm can be taken to a depth of max. 1 m.

Bi-partite root auger, standard set for sampling to a depth of 2 m

• By applying the bi-partite root auger almost undisturbed, uniform soil samples can be taken in layers of maximal 15 cm.

Soil Sampling Procedure

- The primary objective when collecting a soil sample for laboratory analysis is that its composition be representative of the conditions that exist in the field

- The general procedure involves the random collection of several individual soil cores over the designated area and combining them to forma a composite sample for analysis

- If soil samples are carefully collected and processed, the test result will be very useful. The following guidelines are suggested

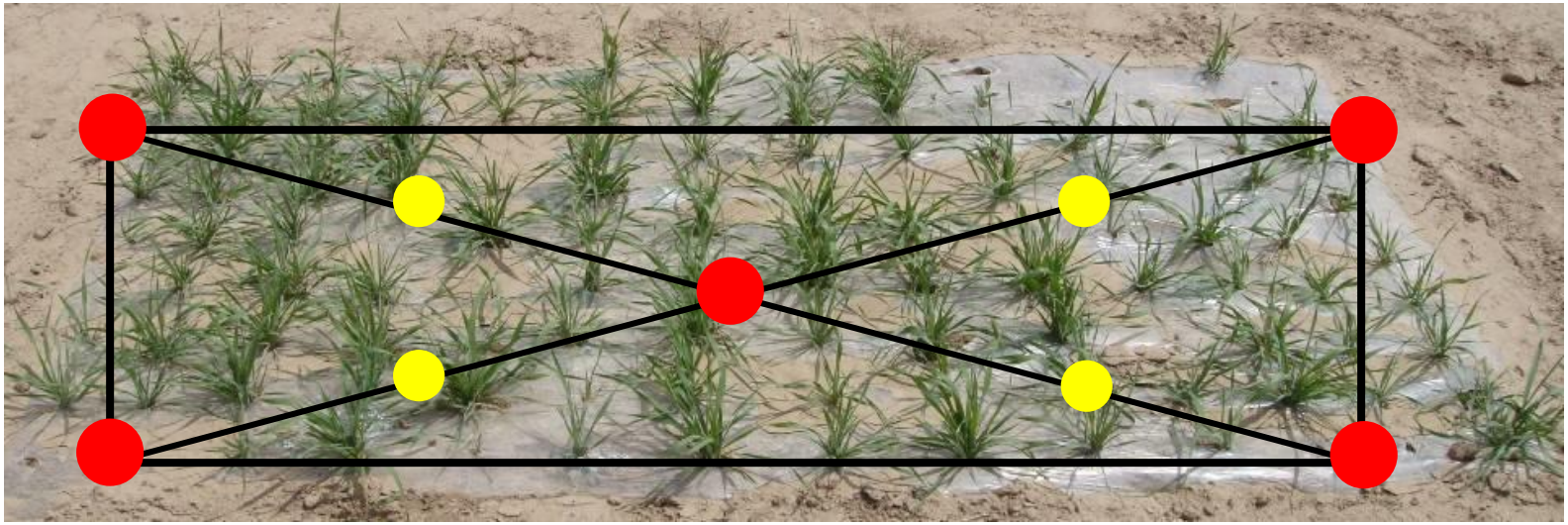
Sampling Strategy

- Roots
- Rhizosphere soils
- Bulk Soils
- Other samples (spores, mushrooms)

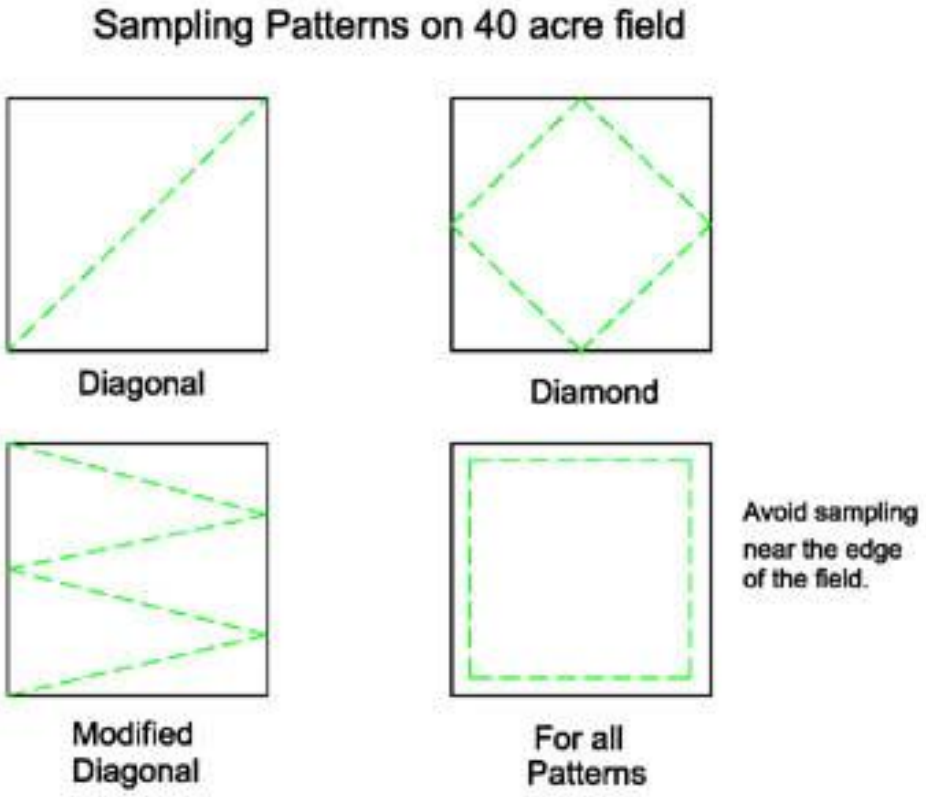
Mycorrhizal root sampling can be obtain by the following methods:

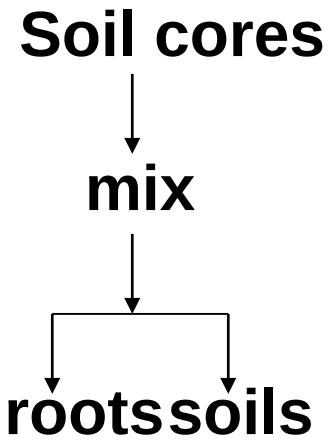
- By destructive sampling
- Non-destructive sampling
- Soil spore sampling

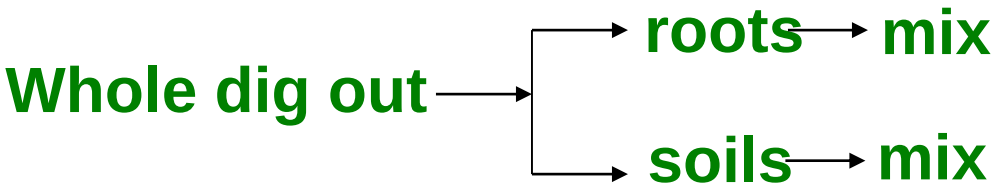
Sampling strategy in each plot



Patterns Model




Soil cores
mix
roots
soils


Whole dig out
roots
mix
soils
mix

Non-destructive sampling

1. Collect three soil cores (subsamples) from each tree. Select roots from different sides of the tree (e.g., North, South, etc.). Fragments of finer roots that can be found close to the soil surface that can be unearthed manually should be added to the core.

2. Use a soil probe to collect root samples from the tree for analysis and evaluation of mycorrhization.

Soil plugs

3. You should see roots in the sample

Roots

4. Place soil sample in plastic bag

Bagging sample

5. Each subsample should be placed in a clearly labeled ziplock bag. SEAL THE BAG COMPLETELY

Bagged sample

Mycorrhizae inoculum

- Mycorrhizal inoculum is material that carries mycorrhizal fungi in a usable form to the intended host plants.

- In the case of VAM fungi, inoculum may be spores, hyphae, and colonized root fragments.

- The quality of mycorrhizal inoculum is not easy to assess, but the best way is an expression of the number of propagules per unit volume of material. Propagules include spores, hyphae, and root fragments.

Functions of Mycorrhizal fungi

- Fungus uses organic nutrients (including sugars) produced by plant

  ECM are not obligate mutualists but VAM are.

- Fungi impart benefits to plant by increasing: nutrient absorption, especially phosphorus, water uptake, tolerance of harsh environmental conditions, including polluted environments (e.g. acts as shield against acidity, elemental toxicity and pathogens).

Function of Mycorrhizae: Benefits to Plant

- Accelerates tree growth rates
- Increases nutrients and water uptakes
- Improves resistance of trees to environmental stresses and diseases
- Reduces need for fertilizer and fungicides
- Increases drought resistance
- Increase plant tolerance to soil temperature extremes
- Deals with different salt stresses
- Improves soil conditions and nutrient cycling

The protocol will follow the typical tasks for assessing microbial structure and diversity is as follows:

- **Selection of the sampling site according to the project strategy**
- **Establishment of soil and root sample collection system**
- **Assessment of Rhizospheric Microbial Symbioses**
- **Characterization and identification of soil microflora in Kuwaiti desert**
- **Molecular characterization**

Factors that can affect of mycorrhizal formation

- > pH of soil----------(-)
- > soil moisture----------(-)
- > soil depth----------(-)
- > amount of above ground plant cover--------(+)
- > grazing----------(-)
- > pesticides----------(-)
- > soil fertility----------(-)

Mycorrhizae and Plant Diversity

- Biodiversity of belowground fungal symbionts increases biodiversity of above ground plants
- Increased access to nutrients becomes restricted under competitive conditions
- Differences in functional capacity of a specific fungus-plant combination appear to explain the effect
- In ecosystems, increased functional capacity allows one plant species to perform better than others
- Restored plant communities have been found to be more diverse when mycorrhizal fungi are present when both inoculated and uninoculated areas receive the same seed mix.

Mycorrhizae and Plant diversity

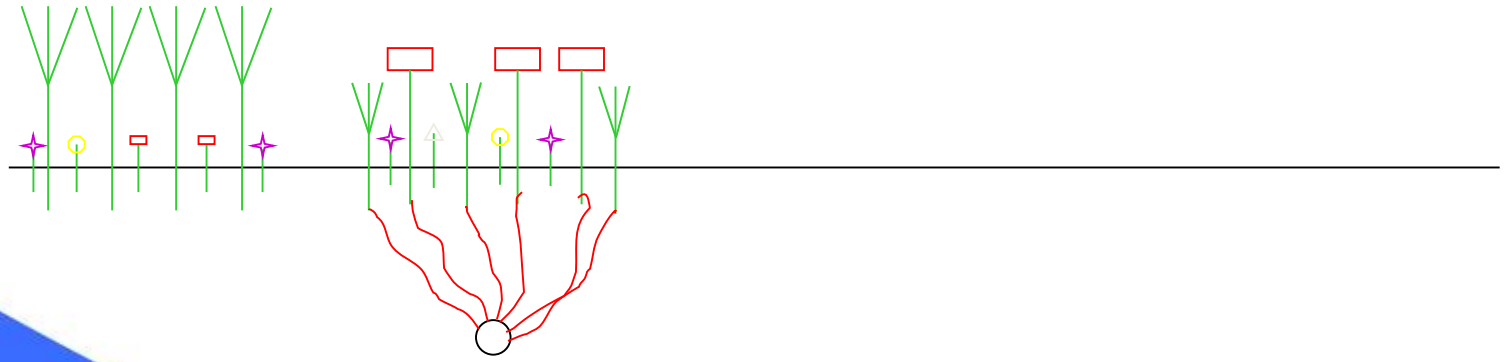
Basis for fungal species richness on plant biodiversity and production

No symbionts

Mycorrhizae and Plant diversity

Basis for fungal species richness on plant biodiversity and production

No symbionts One symbiont

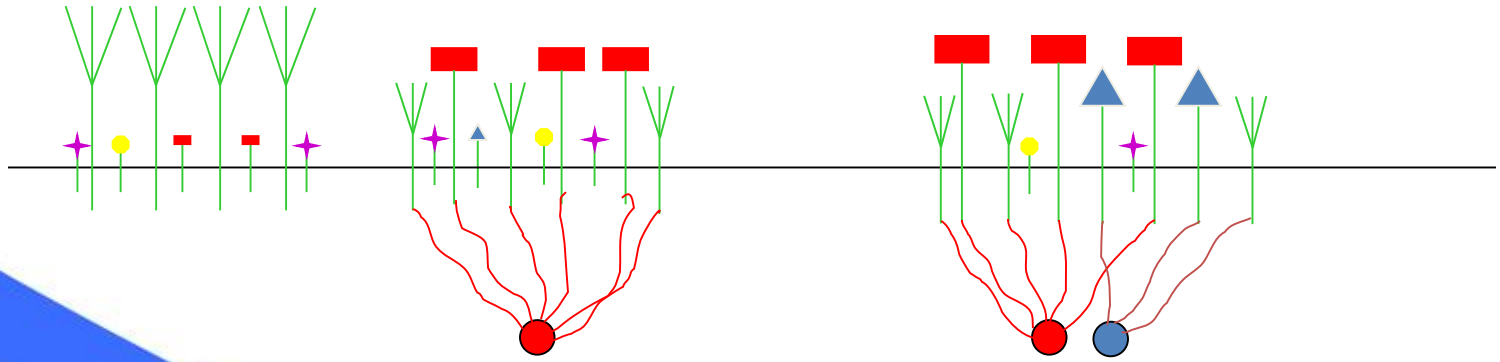


Increasing diversity

Mycorrhizae and Plant diversity

Basis for fungal species richness on plant biodiversity and production

No symbionts One symbiont Two symbionts



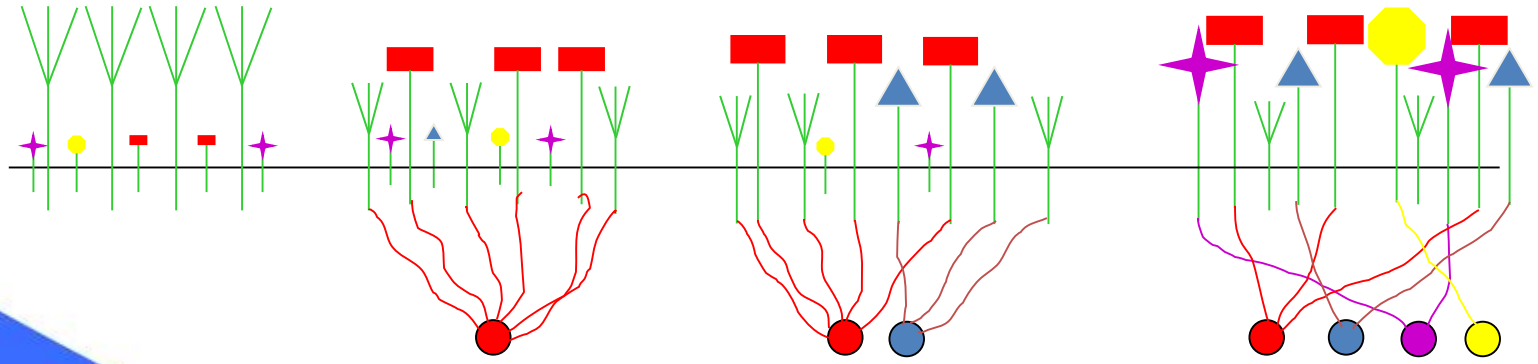
Increasing diversity

Increasing productivity

Mycorrhizae and Plant diversity

Basis for fungal species richness on plant biodiversity and production

No symbionts One symbiont Two symbionts Four symbionts



Increasing diversity

Increasing productivity

Management of Mycorrhizae

- Most of the mycorrhizal fungi are in the top 15 cm of the soil
- Preserve topsoil and microbial activity
- Do not use chemicals that kill fungi
- Do not over-fertilize
- Keep native plants

THANK YOU