Benefits of Microbial Inoculation of Native Plants During Nursery Culture and Field Performances: Lessons Learned from Other Countries

Ali M Quoreshi
Environment and Life Sciences Research Center
Kuwait Institute for Scientific Research

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Outline

- An Overview of Microbial Associations
- Microbial Inoculation: An Effective Tools
- Benefits of Mycorrhiza
- Examples from Nursery Inoculation and Field Performance

Overview

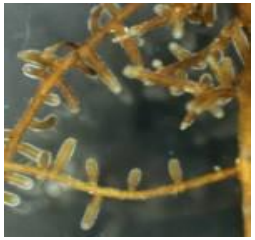
- Soil microbes play a critical roles in ecosystems : nutrient acquisition, nutrient and carbon cycling and soil formation
- The microbial community, distribution, and activity in desert ecosystem are poorly documented compared to others

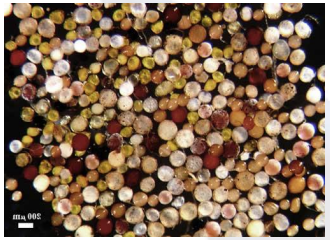
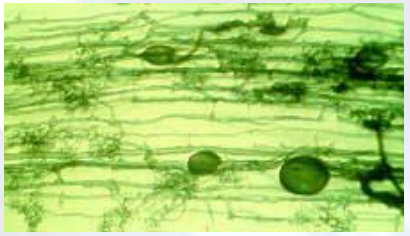
Overview

- Restoration work requires large numbers of native plant species to be planted or seeded
- Mycorrhizal fungal inoculation to nursery plants may improve plant survival and growth, nutrient uptake, and tolerance
- Mycorrhizal fungi are known to facilitate the growth and vigour of many plants

Soil Microbes

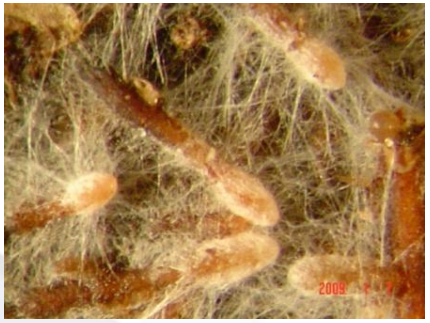
- Among the soil biota, mycorrhizal symbioses are key component of natural systems. In the rhizosphere of desert plants mycorrhiza play a significant role in plant nutrition, drought tolerance and soil stabilization

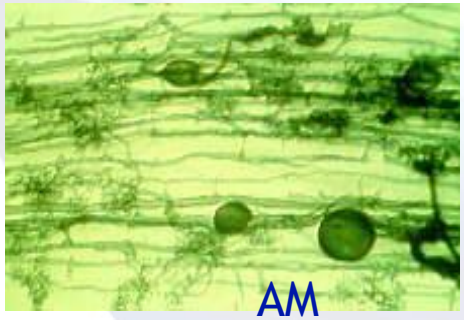



What are Mycorrhizae?

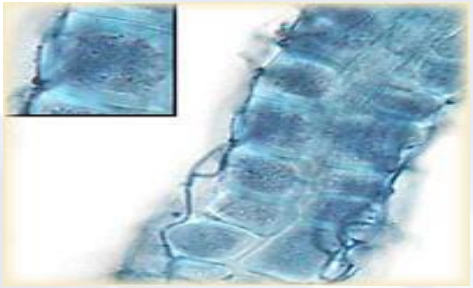
- Mycorrhizae are symbiotic associations that form between the roots of most plant species and fungi
- Plant ⟹ fungi: sugars and other substances
- Fungi ⟹ plants: nutrients, water, hormones
- Different types are recognized in an ecosystem



ECM



AM

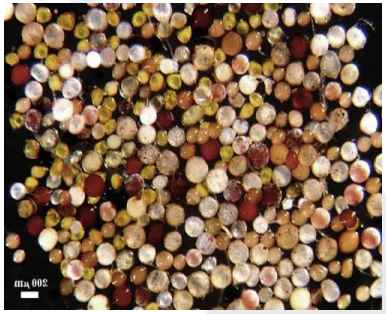


ERM

What are microbial inoculants?

- Beneficial soil microorganisms
- Fungi, actinomycetes, bacteria
- Mycorrhizal fungi and nitrogen fixing rhizobia are considered important soil microbial groups in desert ecosystem.

- DSE – Endophytes associated with desert plant roots



Mycorrhizal fungi & their Importance

- Soil microbes play a critical roles in ecosystems : nutrient acquisition, nutrient and carbon cycling and soil formation
  - Enhance plant efficiency in absorbing nutrients and water
  - Minimizing different plant stresses, increase drought resistance
  - Improve seedling growth and survival
  - Improve soil structure and contribute to nutrient cycling processes

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Desert Ecosystem

- Almost 90 % of crop plants are mycorrhizal mostly of AM type
- Some desert plant roots are also associated with both AM fungi and DSE

- In the rhizosphere of desert plants, mycorrhizae and other endophytes play a significant role in drought resistance, improve stomatal conductance, plant nutrition and photosynthesis

Inoculation Potential for Native Species and Agricultural Crops

- *Panicum turgidum*
- *Rhanterium epapposum*
- *Acacia pachyceras*
- *Stipagrostis plumosa*
- *Centrapodia forsskalii*
- *Pennisetum divisum*
- *Farsetia aegyptia*
- *Haloxylon salicornicum*
- *Calligonum comosum*
- *Lycium shawii*
- *Nitraria retusa*

- *Hordeum vulgare*
- *Zea mays*
- *Medicago sativa*
- *Sorghum vulgare*

Inoculation to native tree species

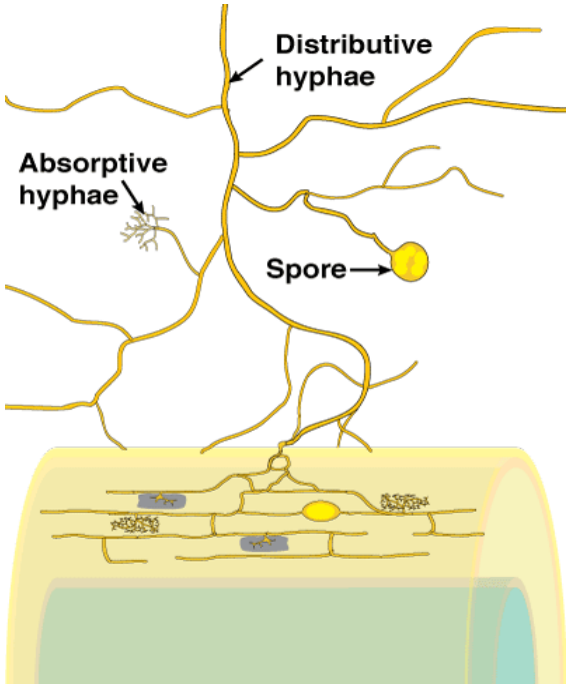
- Can form symbiotic association with N_2 –fixing rhizobium species, ectomycorrhizal fungi (ECM), and arbuscular mycorrhizal fungi (AM).

Microbial biotechnology

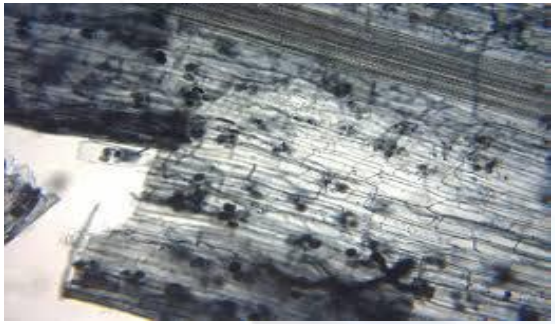
- Microbial inoculation to nursery plants help plants to cope with stress conditions, such as nutrient deficiencies, drought, salinity, high temperature, contamination and soil disturbances

- Therefore, inoculation at nursery culture period may be a simple technique for improving the success of plants in arid zones

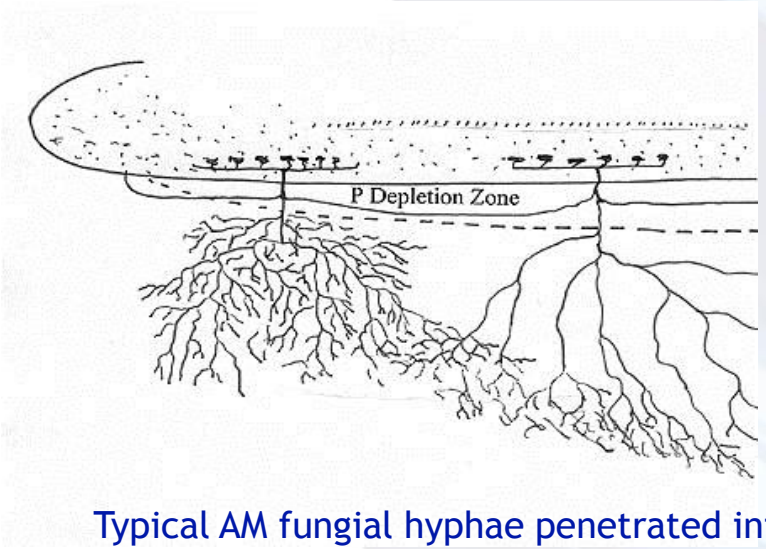
Typical AM Fungi in Roots



Diagrammatic representation of AM hyphae

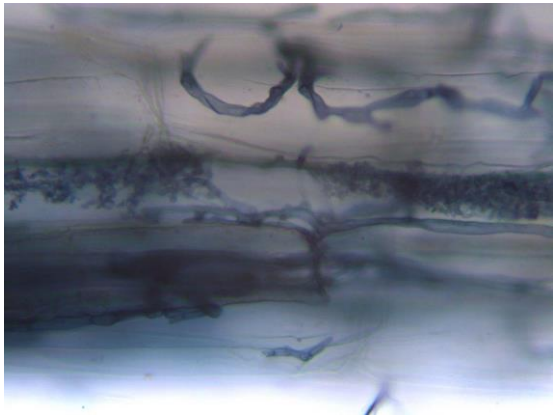


Typical vesicle and arbuscule of AM fungi in a root cortex of AM hyphae

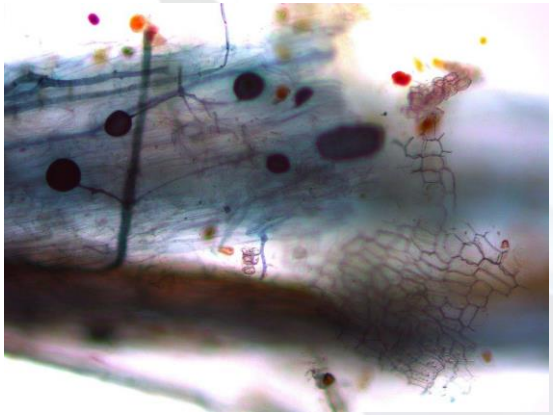


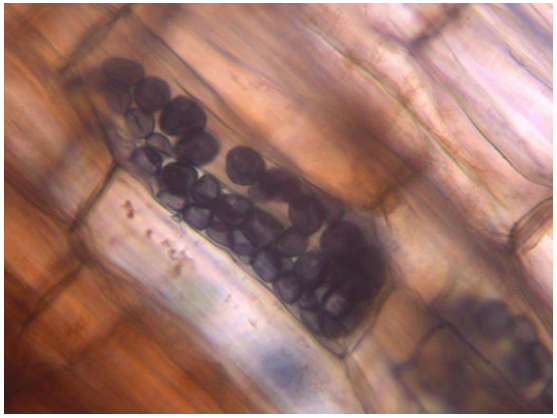
Typical AM fungial hyphae penetrated into rhizosphere

AM fungal association in roots of native plants from Kuwait

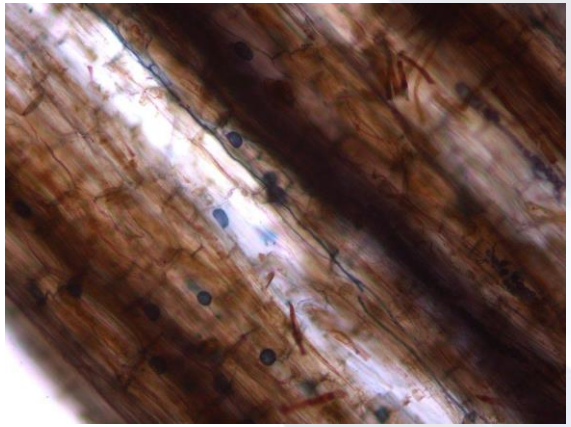


Arbuscule of AM fungi in a root cortex of AM hyphae





DSE in a root cortex of AM hyphae



Vesicle of AM fungi in a root cortex of AM hyphae

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Example from Nursery Inoculation and Field Performance evaluated in Canada

Canadian Oil sand operation and disturbed lands

Mining oil sands for oil extraction

After mining landforms with tailing sands

Re-constructed Mined land ready for revegetation

Seedling production at Bonnyville Forest Nursery

White spruce and jack pine inoculated with ECM fungi

Frankia inoculated alder seedlings

Example of *Frankia* inoculation success

Re-construction of Oil sands mine lands for revegetation

Root nodule

Frankia inoculated alder seedlings Used for revegetation

Frankia inoculated Alders

Non-inoculated Alders

Outplanting performance of alders on oil sands reclamation site

Photo showing *Frankia* inoculated Alder seedlings (A) and non-inoculated control (B) alder seedlings after two growing season on Suncor Energy Inc. reclamation site. Photo taken September, 2010.

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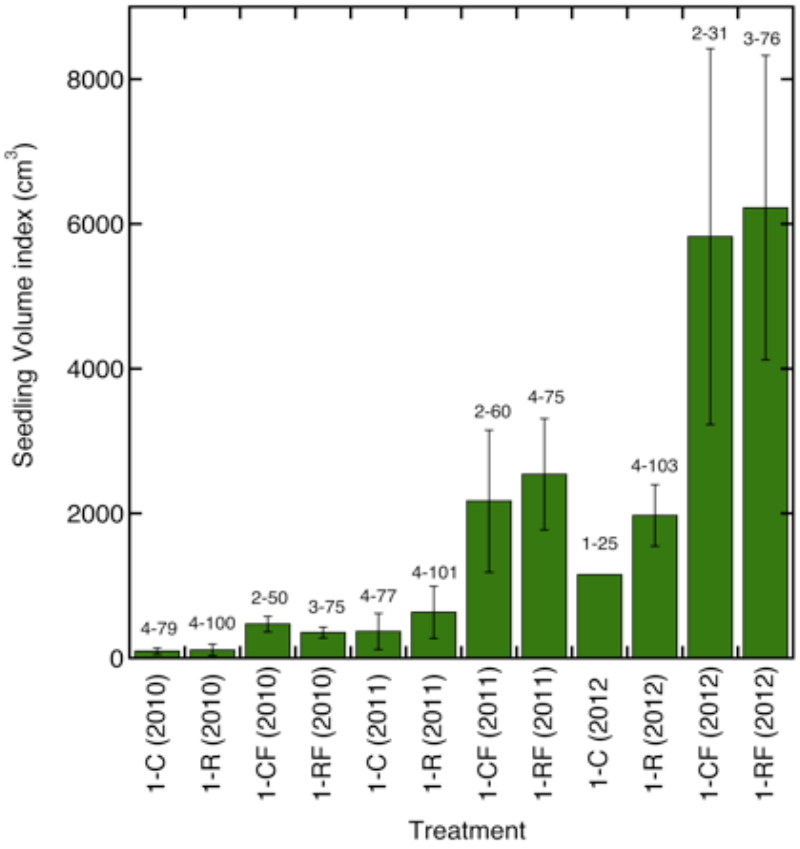
Inoculation of alders with *Frankia* resulted in huge formation of root nodules in the reclamation site:

Application of Actinorhizal alder technology to enhance Reclamation success

Objectives: Improve plant performance via greenhouse inoculation with *Frankia*



ed alder plantation

ECM Field trials: Photo taken in fall 2008

Seedling growth performance after four growing seasons

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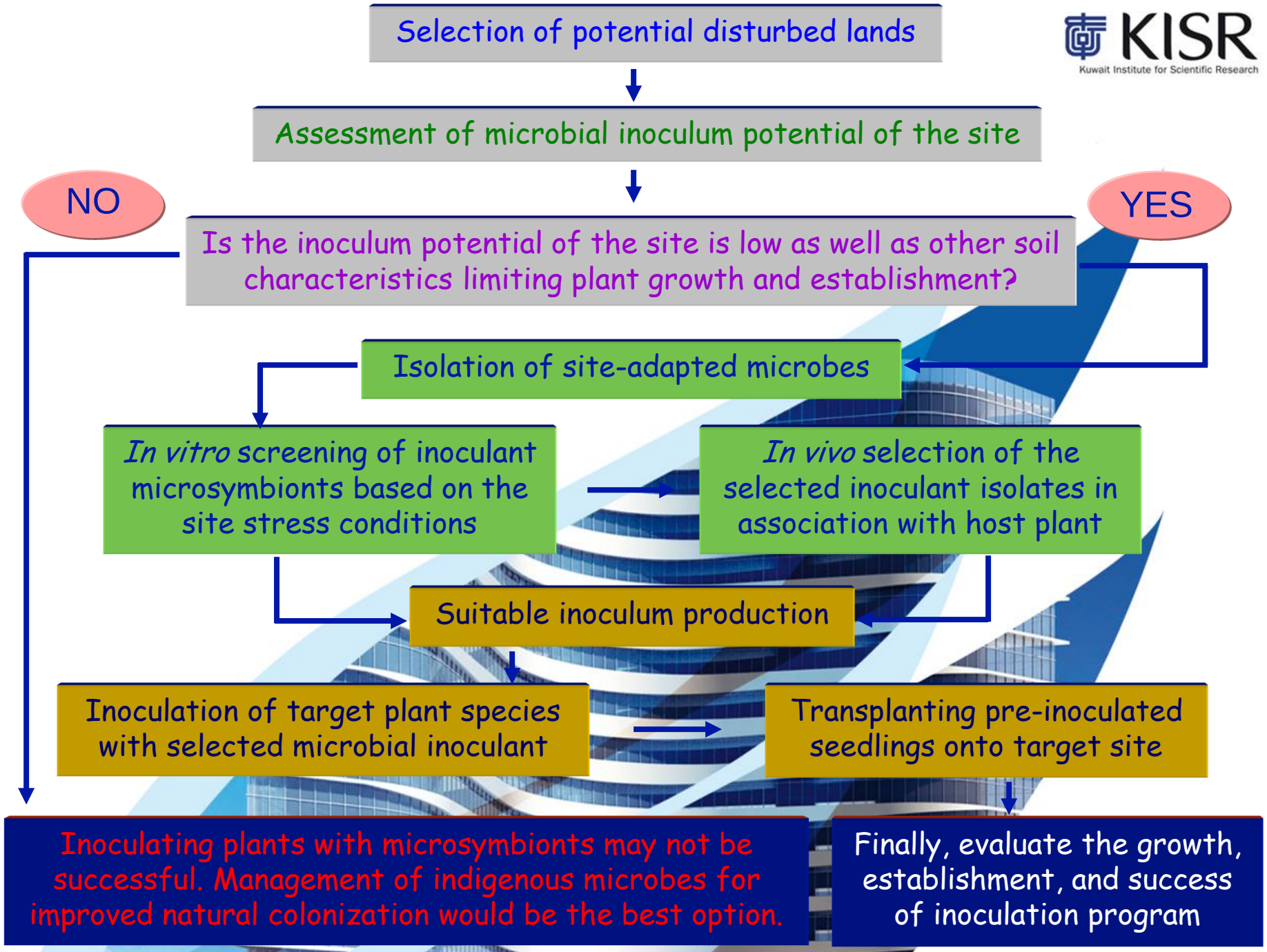
Approach

- Investigating potential site
- Inoculum potential study
- Isolation of ecologically adapted strains
- screening
- Inoculation of seedlings
- Field trials
- Monitoring growth performance
- Persistence of inoculum by molecular method


Selection of potential disturbed lands
Assessment of microbial inoculum potential of the site
NO
YES
Is the inoculum potential of the site is low as well as other soil characteristics limiting plant growth and establishment?
Isolation of site-adapted microbes
In vitro screening of inoculant microsymbionts based on the site stress conditions
In vivo selection of the selected inoculant isolates in association with host plant
Suitable inoculum production
Inoculation of target plant species with selected microbial inoculant
Transplanting pre-inoculated seedlings onto target site
Inoculating plants with microsymbionts may not be successful. Management of indigenous microbes for improved natural colonization would be the best option.
Finally, evaluate the growth, establishment, and success of inoculation program

Conclusions

- Inoculation at nursery culture period may be an essential approach for improving the success of plants in arid zones
- There is a strong need for basic research regarding extreme arid environment microbes and their functional characterization as well as for applied research in view of use of mycorrhizae and other microbes to promote sustainable vegetation establishment and agriculture in this arid region.
- I expect scientists from GCC countries should come forward and establish a collaborative effort on establishing some sort of mycorrhizal research consortium for arid regions
- KISR can lead on this type of effort

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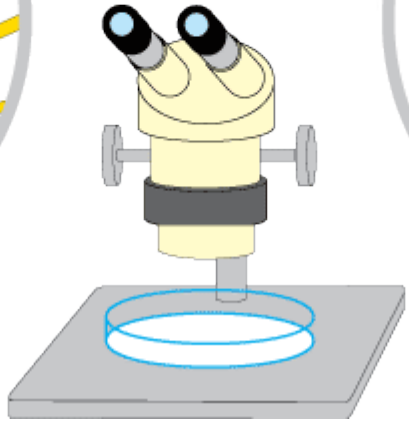
Roots



Spores

Thank You