Desert Plants and Mycorrhizae: Need for Mycorrhizal Research in Kuwait Desert Ecosystem

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Background

Kuwait is a small desert country situated in the north-eastern part of the Arabian Peninsula. Kuwait's desert land is characterized by extremely hot weather conditions with scarce precipitation, dry extended summer and mild winter, and minimal density of vegetation cover. The native vegetation of Kuwait includes scant herbaceous perennials, woody shrubs, herbs and spring ephemerals. In arid environments, mycorrhizal associations are common and crucial for the survival of plants and may play an essential role in ecosystem dynamics and productivity. Among the soil microbes, arbuscular mycorrhizal (AM) fungi are recognized as an essential component of plant-soil systems of deserts and can survive in harsh and limiting environments because of their role in stress alleviation. However, very little attention has been paid in Kuwait to investigate a comprehensive determination of soil microbial communities, particularly mycorrhizal fungal associations to link biodiversity, ecological processes and structure, and functions. In recent decades, land degradation and desertification have become a severe problem in Kuwait. Due to extreme weather conditions, many of Kuwait's native plants are threatened and very difficult to propagate. An understanding of land reclamation, revegetation and plant growth and survival might be better attained if knowledge of the presence arbuscular mycorrhizal propagules in soil and association of AM fungi on these native desert plants could be determined. Therefore, we initiated a comprehensive research program at Kuwait Institute for Scientific Research for investigation of the relationship between biodiversity, soil properties, soil and rhizospheric microbial populations, particularly AM fungi and the other components of Kuwaiti climatic fluctuations to sustainable ecosystem functioning.

Objectives

The current research focuses on investigating the status and identifying the soil microbial community structure, particularly mycorrhizal fungal species richness, spore density and diversity in relation to annual and seasonal variations in soil moisture, temperature, and nutrient availability in Kuwait desert lands.

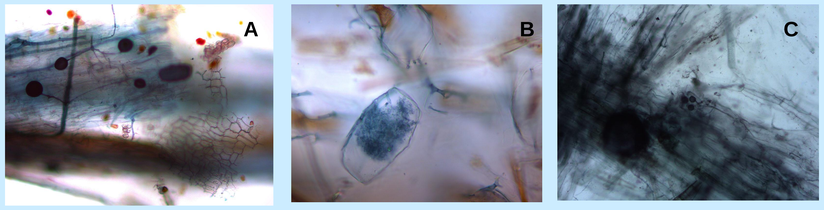


Photo 1. Preliminary assessment of AM association revealed presence of vesicles and arbuscules with root samples stained with 0.1% chlorazol black E from *Acacia* sp. growing in desert soils (A), *Acacia* sp. growing in nursery (B), and *Panicum turgidum* (C).

Methodology and Work Plan

The research project has been undertaken to establish a three-year research for a baseline database development for soil microbial community structure and diversity and also to obtain systematic vegetation data on the key native plant communities that are part of desert plant communities in Kuwait.

Sampling Sites and Data Collection

The sampling sites were established for data collection under desert conditions, namely at KISR's research station, ARS, Kabad (N 29^0 10' 447: E 047^0 42' 239), KISR's research site in northern Kuwait, Al-Liyah (N 29^0 35' 516: E 047^0 37' 120), Mina Abdallah area (N 28^0 57' 753: E 048^0 10' 294) near the oil refinery of Kuwait National Petroleum Company (KNPC), and Umm Qasir (N 29^0 57' 522: E 047^0 57' 369), north of Kuwait, representing both protected and unprotected areas as shown in Plate 1.

- ARS, Kabad site represents the community dominated by *Rhanterium epapposum*;
- Al-Liyah site represents the *Stipagrostis plumose* community;
- Mina Abdallah Area represents the community dominated by *Panicum turgidum*;
- Umm Qasir site represents the community dominated by *Haloxylon salicornicum*.

These communities account for most of the plant communities of the country and cover the greatest proportion of perennial vegetation in Kuwait.

- The soil and plant samples will be collected annually and seasonally (summer and winter) in both protected and unprotected desert ecosystems.
- Two types (rhizosperic and non-rhizospheric bulk) of soil samples from the selected permanent monitoring plots from all sites will be collected.
- The soil substrate and plant root samples will be collected from both the protected and unprotected (disturbed) areas from selected site locations.
- Study approach considered both conventional, biochemical and molecular techniques for plant-root-soil-microbial community association and diversity analyses.

Vegetation in Kuwait:

- **There are 374 species belonging to 55 families that have been identified in Kuwait**
- **256 annuals**
- **83 herbaceous perennials,**
- **34 shrubs and under-shrub species,**
- **one native tree species, locally known as "Talha" (*Acacia pachyceras*).**

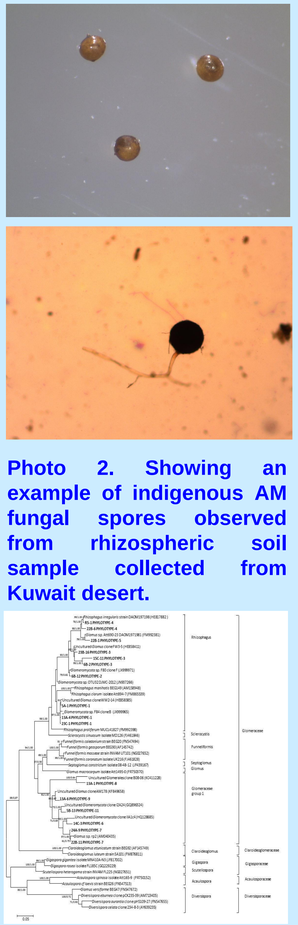


Photo 2. Showing an example of indigenous AM fungal spores observed from rhizospheric soil sample collected from Kuwait desert.

Fig. 1. Maximum likehood analysis of arbuscular mycorrhizal fungi from roots of *Acacia* sp.

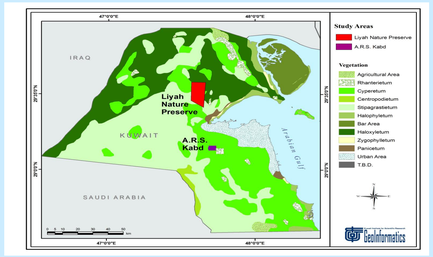


Plate 1. Satellite image showing the vegetation map of Kuwait.

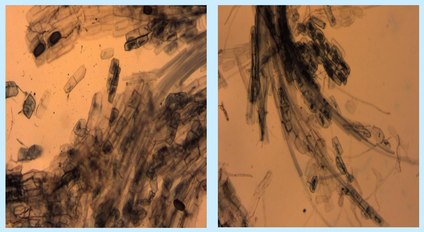
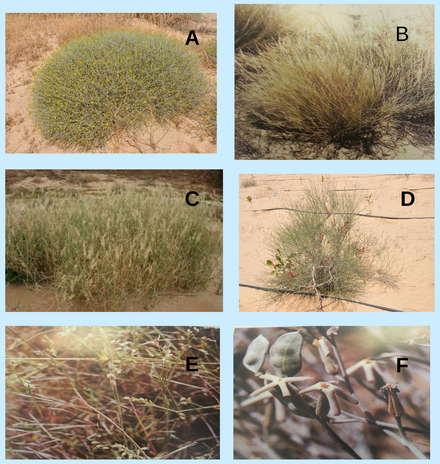


Photo 3. Trap cultures corn plant roots show presence of well developed arbuscules and few vesicles.



Example of key native plant species in Kuwait:*Rhanterium epapposum* (A), *Stipagrostis plumosa* (B), *Pennisetum divisum* (C), *Calligonum polygonoides* (D), *Panicum turgidum* (E), and *Panicum tergidum* (F).

Acknowledgement

We thank Ms. Anitha Jasmine and Ms. Mini T. Sivadasan for their assistance in mycorrhizal analysis.

Photo 4. General view of ARS protected area with *Rhanterium* community.

Photo 5. Degraded desert lands in Kuwait (unprotented).

Preliminary observation of AM fungal association in Kuwait desert ecosystems

- Mean spore density observed per 100g of rhizospheric soils from *Acacia* tree and desert bulk soils were 64 ± 8.2 and 24 ± 0, respectively (Photo 2).
- Assessment of AM colonization in the roots of *Acacia* sp., *Panicum turgidum, Pennisetum divisum, and Polypogon monspeliensis* growing in Kuwait desert soils demonstrate the presence of vesicles and arbuscules (Photo 1) and confirmed that all above plants observed were colonized by AM fungi with varied degree of colonization.
- Trap cultures were established using soil samples collected from rhizosphere of Kuwait's 6 keystone native plant species. Corn (*Zea mays*) seeds were planted using rhizospheric soils and grown in a greenhouse for inoculum production. Roots of corn plants when stained with 0.1% chlorazol black E, show well developed arbuscules and few vesicles (Photo 3).
- The preliminary results from molecular analysis for AM fungal association with *Acacia* root system demonstrate that the most abundant and diverse group is among the family Glomrraceae (Fig 1), where genus Rhizophagus (5 phylotypes) and another unclassified group (5 phylotypes) present.

Conclusion

Preliminary assessment indicates that a considerable level of AM fungal inoculum present in the Kuwait desert ecosystem and probably AM fungi have adapted to extreme weather conditions in Kuwait desert. Further investigations on belowground diversity of AM fungal association with Kuwait's desert ecosystems are in progress that may be contributing to desert plant biodiversity and functioning.

Reference: Al-Awadhi et al. 2003; Jeffries and Barea 2001; Requena et al., 1996; Smith and Read 1997; Sylvia and Williams, 1992.