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Status of mycorrhizal fungi in a saline-alkaline habitat

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ABSTRACT : A study was conducted on mycorrhizal status in plants growing at a saline-alkali site. Plants inhabiting the stressed site showed strong mycorrhizal dependency and the percent root colonization by the fungus was affected by the season.

Keywords : Mycorrhizae, saline-alkali soil, seasonal variation

INTRODUCTION

Arbuscular Mycorrhizae (AM) a key soil fungus, which form a symbiotic association with roots of higher plants are known to have a critical role in improving plant health and their establishment in stress conditions like nutrient deficiency, drought, contamination or soil disturbance. Both fossils and molecular phylogenetic evidence (Jeffries *et al*., 2003) supports the hypothesis that terrestrial plants evolved with the aid of existing arbuscular mycorrhizal relationships. Mycorrhizal associations are found in a broad range of habitats, ranging from aquatic, deserts and low land tropical rain forest to high altitudes. These fungi are found in almost every terrestrial ecosystem. Mycorrhizal fungus have been reported in roots of cultivated and non-cultivated plants growing in disturbed and un-disturbed saline soils, including marshlands, river bank, roadsides, and even on the edges of salt slick. (Aliasgharzadeh *et al*., 2001; Hildebrandt *et al*., 2001; Garcia & Mendoza, 2007). They have been linked with increased plant biomass and plant growth in saline soils (Al-Karaki, 2000; Ruizlozano and Azcon, 2000). Mycorrhizae are of immense importance in maintaining soil fertility and these are influenced by climatic and seasonal changes in the physico-chemical properties of soil. Since mycorrhizal association plays a vital role in plant establishment and nutrient cycling, the present study can be beneficial in reclamation programmes of such stressed habitats. By better understanding the ecology of AM fungi in SA soil one can fully exploit their potential in successful restoration of such soils.

MATERIALS AND METHODS

The saline-alkali site was located in the campus of the Institute of Technology, Banaras Hindu University, Varanasi situated at 25°18' N latitude, 83°1' E longitude and 76.19 m above the mean sea level in the Eastern Gangetic plains of India. The region has a moist, subhumid climate dominated by tropical monsoonic character. The one-year time span can be divided into three distinct seasons, hot summer (April to June), a warm rainy season (July to September) and a cold winter (November to February). October and March constitute transitional months between rainy and winter and winter and summer seasons respectively. During the experimental period the temperature and relative humidity ranged between 22-44°C and 28-78% during summer, 25-34 °C and 73-92% during rainy season and 9-29 °C and 48-90% during winter. The annual precipitation was 1209 mm and 324 mm. The SA soil had a pH of 9.4, bulk density-1.53 g cc^{-1}, 44 % porosity, 0.15 mmho cm^{-1} electrical conductivity, 0.28 % organic carbon and 20.6 (ppm) available phosphorus. The concentration of exchangeable ions (meq 100 g^{-1}) were Na^+ 72.70, K^+ 0.937, Ca^{2+} 189.62 and Mg^{2+} 4.006. A nearby garden soil selected for comparison had a pH of 7.2, bulk density-1.35 g cc^{-1}, 50 % porosity, 0.85 mmho cm^{-1} electrical conductivity, 0.9 % organic carbon and 670 (ppm) available phosphorus. The exchangeable ions (meq $100g^{-1}$) were Na^+ 0. 716, K^+ 0.3414, Ca^{2+} 15.22 and Mg^{2+} 3.817.

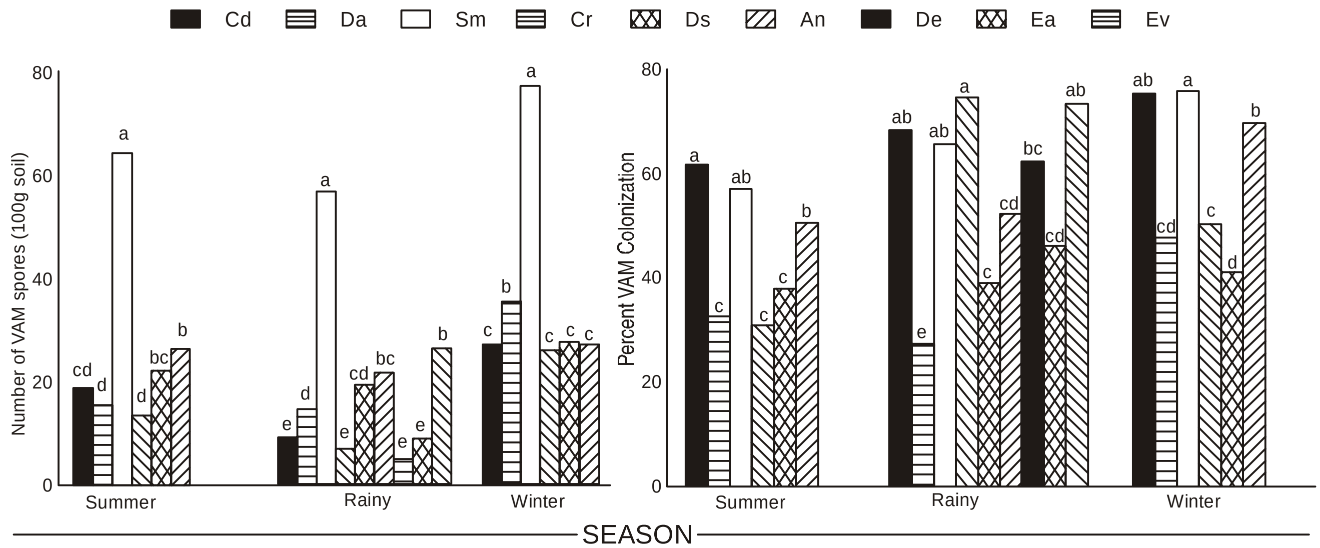
Assessment of AM in soil and plant roots

The assessment of AM fungi in plant growing naturally in SA soil was done during three seasons namely winter, summer and rainy. Estimation and isolation of AM spores in soil was done by wet sieving and decanting method (Gerdemann and Nicolson, 1963) and sucrose centrifugation method of Jenkins (as described in Daniels and Skipper, 1982).

Quantification of AM in plant roots was done following Phillips and Hayman (1970). The indigenous AM fungus was identified as *Glomus* sp. RR1 on the basis of spore size, hyphae, colour, reaction to Melzer's solution and different wall types as described by Walker (1986).

RESULTS AND DISCUSSION

All the native plants growing at the SA site were infected by *Glomus* sp. RR1, showing a strong mycorrhizal dependency. Significant ($p \leq 0.001$) seasonal variation was observed in the AM spore count in the rhizosphere soil and root colonization Fig. 1. Fairly high level of mycorrhizal association was recorded in most of the plant species during winter and rainy seasons (> 50% colonization). Among the plants growing in summer season, *Cynodon dactylon* and *Saccharum munja* possessed high level of AM colonization (> 55%), which was followed by *Accacia nilotica* (50%). Moderate level of colonization was recorded in *Cyperus* *rotendus*, *Dicanthium annulatum* and *Dalbergia sissoo* (<40%). The AM colonization was infrequent in *Cyperus rotendus*. Plants growing during rainy season included *Desmodium* sp., *Eclipta alba* and *Evolvulus* sp. Plants showing high level of colonization (>62%) in rainy season were *C. dactylon, S. munja, C. rotendus*, *Evolvulus* sp. and *Desmodium* sp. Moderate colonization during this season was recorded in *A. nilotica* (52%), *E. alba* (46%), and *D. sissoo* (39%). Least colonization (28%) in rainy season was observed in *D. annulatum*. During winter season the trend observed in the colonization of the plants by AM was similar to that observed in summer season in most of the case. *C. dactylon* and *S. munja* possessed highest level of colonization in all the three seasons and the plant showing least AM colonization varied with the seasons. While maximum AM spore count in rhizospheric soil of the plants was recorded in winter season, lowest was found in rainy season. The plants growing throughout the year showed fairly good number of spores in their rhizosphere, of which, *S. munja* possessed maximum spore count and *C. rotendus* possessed the least count. Except *Evolvulus* sp. the plants which grew only in rainy season showed fewer number of AM spores (<10/100 g of soil). Less number of spores was recorded in grasses growing in summer in SA soil, which



Values not followed by same letter are significantly different at $p < 0.05$ according to Duncan's New Multiple Range Tst (DNM) (Abbreviations : Cd-*Cynodon dactylon;* Da-*Dicanthium annulatum;* Sm-*Saccharum munja;* Cr-*Cypers rotendus*; De-*Desmodium* sp.; Ea-*Eclipta alba*; Ev-*Evolvulus* sp.; Ds-*Dalbergia sissoo*; An-*Acacia nilotica*).

Fig.1. Seasonal variation in AM association in roots and rhizospheric soil of different plant species growing naturally in saline-alkali soil.

included *C. dactylon, C. rotendus* and *D. annulatum.*

All native plants showing strong mycorrhizal dependency supported the ability of mycorrhizal fungi to adapt to salt stresses and play an important role in alleviating the detrimental effects as also observed by Bandau *et. al*., (2006). Plants growing in the SA soil showed a marked seasonal variation in mycorrhizal colonization. These seasonal changes in the AM activity are regulated by the root phenology as AM association is formed only in young roots and it has a limited period of activity (Harley and Smith, 1983). Root growth generally occurs at times when both temperature and soil moisture conditions are favourable (Gregory, 1987). Onset of favourable conditions enhances root growth and mycorrhizal activity. With rain the moisture, nutrient stress and toxic cations of the SA soil get reduced as a consequence of which a high level of AM colonization may arise as observed in the present study. Low AM colonization recorded during summer season might be due to low activity of AM fungi and root senescence during this season. During summer the SA soil is subjected to high pH, osmotic concentration, and temperature coupled with high salt concentration due to evapotranspiration. Colonization of host plant roots and spore production in the host soil vary seasonally as a function of climate and host plant (Giovanetti, 1985).

Spore count of AM fungi did not appear to be affected by salinity supporting Mergulhag *et. al*., (2001) observation. However, soil salinity has been reported (Juniper and Abbott, 2006) to delay germination and limit growth of hyphae from propagules of AM fungi. Spore production is generally thought to coincide with the periods of fungal resource remobilization from senescing roots (Gemma *et. al.,* 1989). In most case spores are less abundant during periods of mycorrhizal formation and they become more numerous during periods of root senescence. This hypothesis is supported by our observation as the spore production increased in winter, which starts after rainy season when root activity starts getting interrupted by a spell of dry season and nutrient stress. In summer the spore count decreased as compared to winter, which might be attributed due to increased rate of root senescence due to harsh soil conditions during summer. Studies done by Escudero and

Mendoza (2005) too show that spore density and AM root colonization when measured at any one time were poorly related to each other. However, spore density was significantly correlated with root colonization 3 months before suggesting that high colonization in one season precedes high sporulation in the next season. AM spores increase as a result of intermittent root growth during seasons of slow root growth and at sites where many rootlets die annually (Mosse, 1973). Spore number is likely to reflect the nutritional status of the host and/or of the soil and the onset of adverse conditions (Mosse, 1973). It can be said that overall trend in mycorrhizal dynamics at the SA soil is regulated by the environmental constraints on root and fungus activity, which vary seasonally. Established mycorrhizal vegetation in such SA stressed conditions can not only extent the infection of seedling and support their growth but may also be of particular ecological interest as this may permit early successional plants to facilitate the establishment of later successional groups (Dickie *et. al*., 2006). Thus AM Fungi can play a remarkable role in the restoration of such stressed lands.

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