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AM Fungal Spore diversity in different Agroclimatic Zones of Andhra Pradesh, India

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A B S T R A C T

Investigation has been taken up to reveal the spore diversity of Arbuscular Mycorrhizal (AM) fungi in the soils of five different agro-climatic zones of Andhra Pradesh. Maximum AM fungal spore number was recorded in Central Telangana Zone (47) followed by North Telangana Zone (32.4) per 100g of soil. The lowest spore number was recorded in Godavari Zone (31) followed by Krishna Zone (30.6) and North Coastal Zone (30.5) of Andhra Pradesh. Spore diversity study indicated that a total of three genera with nineteen species of AM fungi were recorded in five zones of AP, of which fifteen species were of genus *Glomus*, three species of *Acaulospora* and one species of *Scutellospora*. The highest spore frequency was represented by *G. phansihalos* followed by *G. fasciculatum* and *Scutellospora* in the soils of AP. Among the five Zones spore diversity were found to be greater in Central Telangana Zone soils followed by North Telangana Zone soils. This information provides a clear direction for farmers of AP for going external inoculation of mycorrhizal fungi with the suitable genus at species level selection in each agro-climatic zone and helps in mitigating adverse environmental situations in semi-arid zones of Andhra Pradesh.

Introduction

Arbuscular mycorrhizal fungi (AMF) are obligate symbiotic fungi which colonize the roots of the majority of crop plants. As obligate symbionts, AMF are believed to be dependent upon the host plant for fixed carbon. The plant receives a variety of benefits which may result in increased growth: improved water relations (Davies *et al*., 1993), pest and disease resistance (Hooker *et al*., 1994) and enhanced nutrient uptake over non-mycorrhizal controls (George *et al*., 1995). The most important of these benefits is increased nutrient uptake, notably of immobile nutrients such as P and Zn (Bolan, 1991; Burkert and Robson, 1994). Soil aggregation is an important aspect of soil structure, which determines characteristics such as water inflow rate, pore space, and resistance to erosion which indirectly influence soil health management. These fungi are important in maintaining and enhancing the stability of soil aggregates and soil health (Tang *et al*., 2011; Miller and Jastrow, 1990).

It is evident from their effects upon soil health and host plant growth that AMF are an

important part of sustainable agricultural systems that have low inputs of chemical fertilizers and biocides (Bethlenfalvay and Schuepp, 1994; Brundrett, 2009; Hooker and Black, 1995). Modern, intensive agricultural practices, such as chemical fertilization and pest control, continuous monoculture, and tillage have impact on AMF distribution in agricultural soils. Describing the diversity of the community of AMF and application network theory at a site leads in determining the influence of AMF on agricultural crops and eventually it helps in developing good management regimes for these interacting partners. The present study has taken up to know the status and distribution of AM Fungal species across different soils of Andhra Pradesh(AP) covering agro ecological Zones to understand the species level importance in promoting growth of agricultural crops in AP.

Materials and Methods

Based on the climatic conditions Andhra Pradesh state is broadly divided into nine distinct agro-climatic zones. The present study was undertaken to investigate AM fungal distribution in five different agro-climatic zones, *i.e.,* Krishna, North Telangana, Central Telangana, North Coastal and Godavari. A critical benchmark location has been fixed to collect soil samples, for determining the occurrence and abundance of arbuscular mycorrhizal fungi in existing field crops. The soil samples were collected from benchmark locations considering the predominant crop species in the zone.

A typical survey plan is executed to cover five agro-climatic zones including variety of soils such as Alluvial clay loam, Silty loam, Silty sandy loam, Silty clay loam and Clay loam soil types and different crop species (Table 1). In all the zones, soil samples were collected to a depth of 0-25 cm of the root zone by using soil corer. A total of thirteen random spots were taken in each benchmark location. These thirteen samples were pooled together as one sample, transferred it to a clean polythene bag, labeled and brought to the laboratory and stored in a refrigerator around 4^0C until further processes like to monitoring the AMF spore populations and biodiversity of AM fungi. Air dried soil sample of 100 g was subjected to wet sieving and decanting technique (Gerdemann and Nicolson, 1963) for enumeration AMF spores. In order to separate spores from organic debris, the sieved sample was centrifuged with 55% sucrose solution at 1750 rpm for 5 min. Spore counting was done by preparing a grid of thin layer of spore suspension was spread on this and counted under a stereoscopic binocular microscope. AMF spores were identified with the keys provided by Schenck and Perez (1999). Other physicochemical characters like, pH of the soils was determined by taking (1:2) soil and water suspension, the pH was measured by using pH meter. Electrical conductivity (EC) of the soils was determined by taking (1:2) soil and water suspension. The EC of the soil suspension was measured by using EC meter. Soil organic-carbon was estimated by following the wet-oxidation method as described by Walkley and Black (1934)**.**

Results and Discussion

Occurrence and distribution of AM fungi in the five agro-climatic zones of Andhra Pradesh has been thoroughly monitored in the present investigation. It was observed that the soils of all five climatic zones were supported the occurrence of AM fungal species (Table 2). Irrespective of the crop species grown in the zone, the presence AM fungal spores indicates that they have wide host range along with climatic adoptability (Bethlenfalvay and Schuepp, 1994). It also indicates that AM fungal association with higher plants is

universal as reported by Nicolson (1967). The spore density varied with type of soil present in each zone. The highest AM fungal spore population was recorded in Central Telangana Zone (47/100g soil) where the soil type is Silty sandy loam (Table 1 and Fig. 1) and the lowest spore density was recorded in North Coastal Zone (30.5/100g soil) where the soil type is Silty clay loam. It clearly indicates that type of soil has high influence on the spore production during crop period wherever the soil structure is dominant with either silt or sand the AM fungal populations were high and these fractions might have facilitated the spore production when compared to clay loam soils. The presence of clay may hinder spread of fungal hyphae and indirectly reduce the spore production. These results are in support of the observations reported in Tarai soils of Uttar Pradesh (Trimurtulu and Johri, 1998). The soils which are having more clay content known to have high organic carbon, interestingly in the present study where the soils with more of organic carbon less is the spore production in the case of AM fungal species. This indicates that AM fungi are not more dependent on soil carbon rather than host photosynthate. There are other several factors like intensive cultivation and more of adoption modern agricultural practices like application of weedicides, fungicides, more of chemical fertilizers and deep tillage might be influencing the spore numbers as stated by Abbott and Robson (1991).

AM fungal species distribution was studied in all the five zones and reported a total of 19 species as most common in the soils of Andhra Pradesh (Table 2). By conducting various morphological observations these were identified as *A. lacunosa, A. scrobiculta, A. nicolsoni, G. aggregatum, G. ambisporum, G. fasciculatum, G. fulvum, G. hoi, G. intraradices, G. lacteum, G. leptotichum, G. magnicaulis, G. multicaulis, G. mosseae, G. pachycaulis, G. phansihalos, G. radiatum, G. reticulatum*, and *S. calospora* (Table 2 and Plate 1). These morphological traits were quite identical as reported by Schenck and Perez (1999). In Andhra Pradesh soils *G. phansihalos, G. fasciculatum, G. intraradices, G. lacteum, G. leptotichum, G. magnicaulis, G. multicaulis, G. mosseae, G. pachycaulis, G. phansihalos, G. aggregatum, G. ambisporum, G. fulvum, G. radiatum, G. reticulatum* were detected in all the five Zones.

Table.1 Soil physicochemical properties of agroclimatic zones of Andhra Pradesh

Name of the zone	Existing Cropping system	Soil Characters			
		Soil pH	EC	OC	Soil type
Krishna Zone	Paddy	7.2	0.44	0.73	Alluvial clay loam
North Telangana Zone	Cotton	7.4	0.46	0.68	Silty loam
Central Telangana Zone	Blac kgram	6.7	0.47	0.49	Silty sandy loam
North Coastal Zone	Paddy	7.6	0.97	0.74	Silty clay loam
Godavari Zone	Paddy	7.9	0.78	0.84	Clay loam

Table.2 Diversified distribution of AM fungal spores in Andhra Pradesh soils

Probable species	AMF species spore abundance/ 1.0 kg soil				
	Krishna Zone	North Telangana Zone	Central Telangana Zone	North Coastal Zone	Godavari Zone
A.lacunosa	10	6	25	5	0
A.scrobiculata	6	13	30	5	0
A.nicolsoni	6	6	20	0	0
G.aggregatum	10	10	15	15	10
G.ambisporum	13	10	10	10	10
G.fasciculatum	56	33	55	50	25
G.fulvum	13	23	20	20	10
G.hoi	10	13	20	0	5
G.intraradices	16	16	20	15	20
G.lacteum	16	20	20	10	10
G.leptotichum	13	16	25	20	20
G.magnicaulis	10	13	30	10	20
G.multicaulis	10	13	30	15	20
G.mosseae	6	10	20	5	10
G.pachycaulis	13	20	20	20	15
G.phansihalos	56	70	75	70	85
G.radiatum	16	16	20	15	20
G.reticulatum	16	13	20	20	20
S.calospora	10	3	25	0	10

Fig.1 AM fungal spore occurrence in different climatic zones of AP

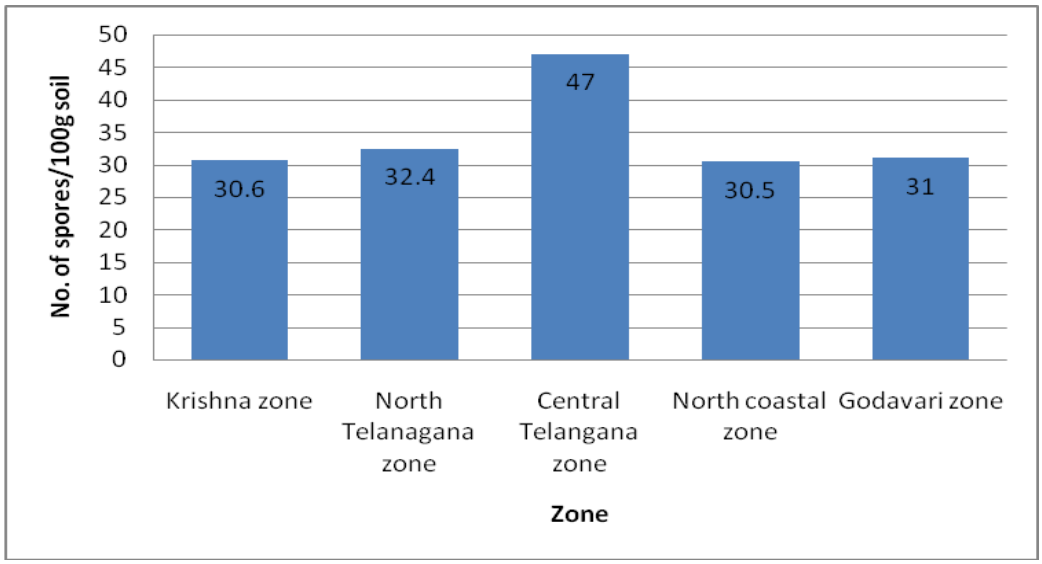


Plate.1 Most predominant AM fungal spore structures in AP soils

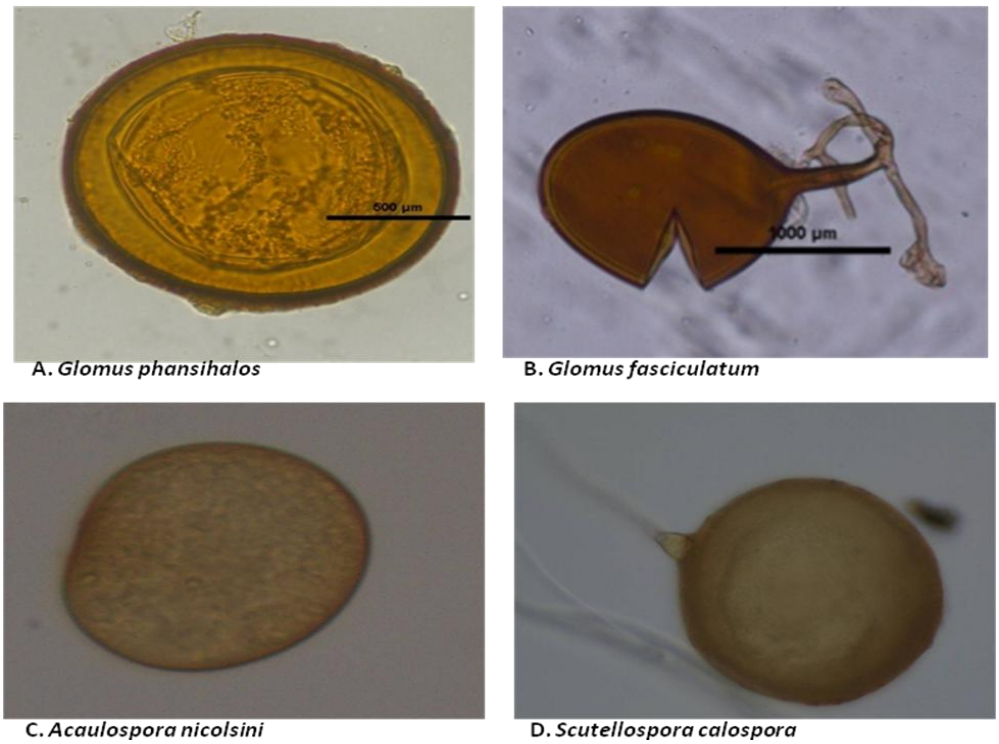


Fig.2 Species level distribution of AM fungi in Krishna Zone

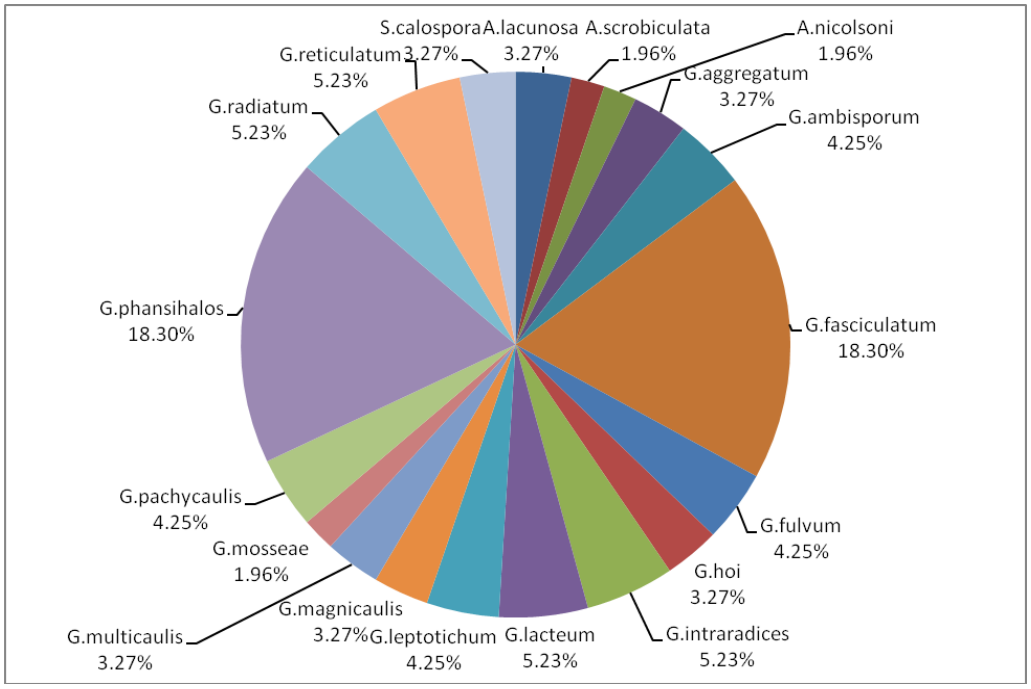


Fig.3 Distribution of AM Fungal species in North Telangana Zone

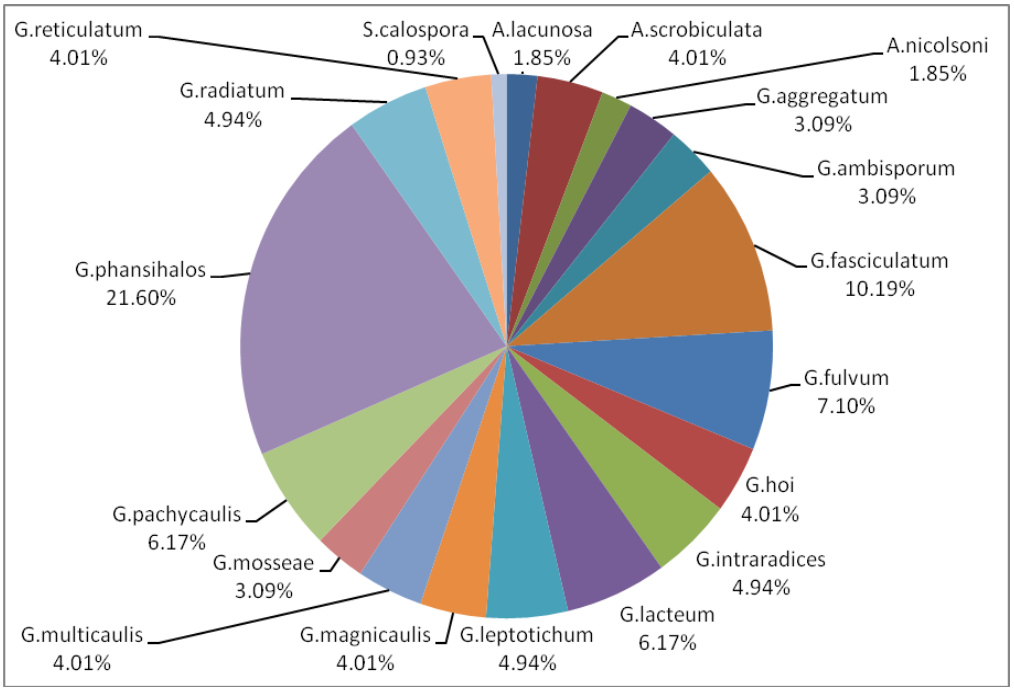


Fig.4 Distribution of AM Fungal species in Central Telangana Zone

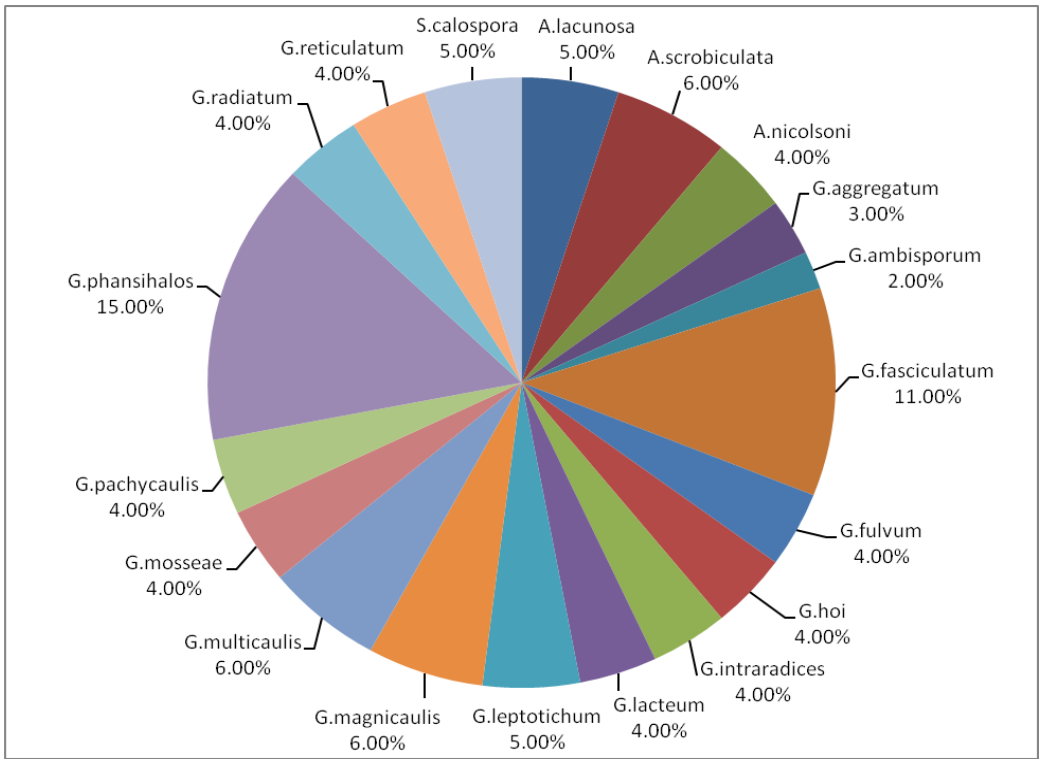


Fig.5 Distribution of AM Fungal species in North Coastal Zone

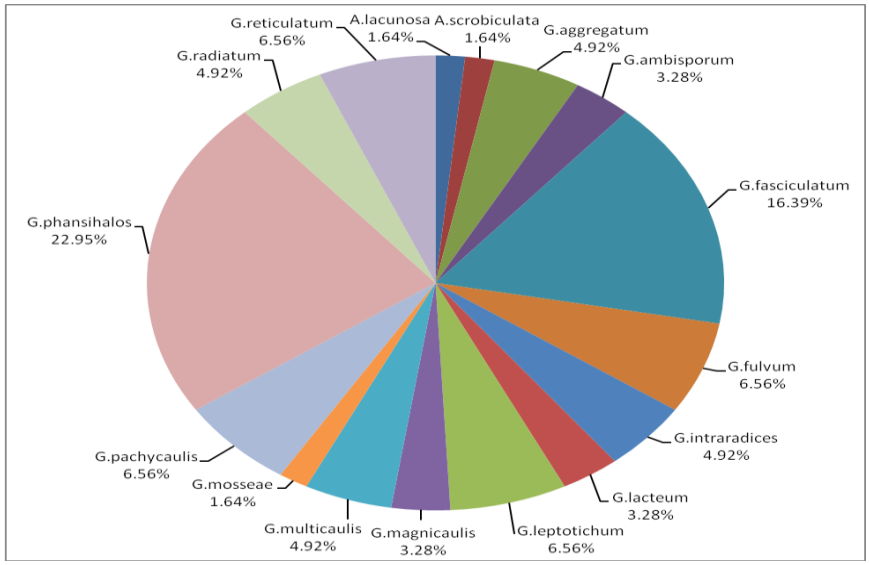
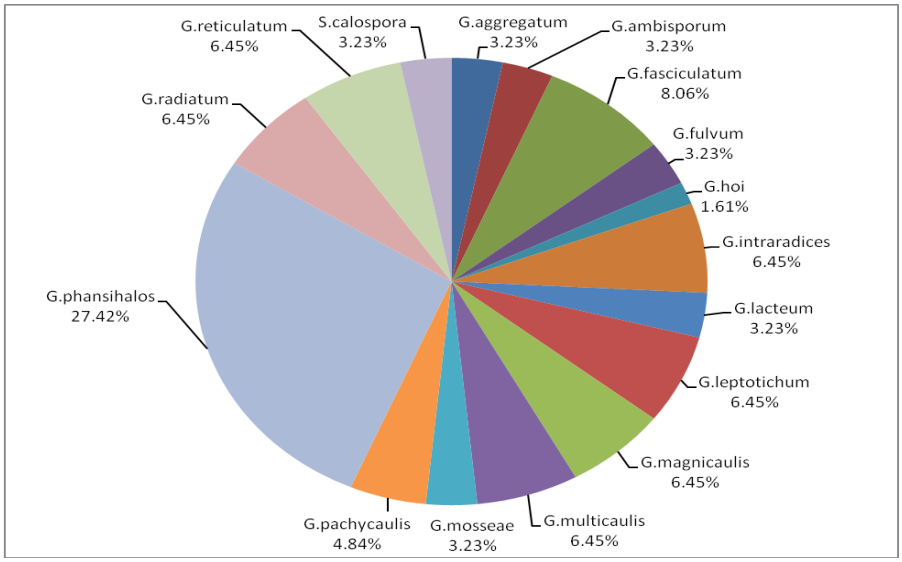


Fig.6 Distribution of AM Fungal species in Godavari Zone



Using morphological characters it was reported that only three genera of AM fungi namely *Glomus*, *Acaulospora* and *Scutellospora* were present in the soils of Andhra Pradesh and this narrow spore diversity may be due to intensive cultivation and more of modern agricultural practices like application of herbicides, fungicides and chemical fertilizers etc. (Abbott and Robson, 1991). In Krishna zone all 19 species were found, *G.fasciculatum* and *G. phansihalos* were equally shared in distribution (18.30%) and were dominant in distribution (Table 2, Fig. 2) among others. In North Telangana Zone soils, even though all the 19 species were recorded, *G. phansihalos* was occupied maximum (21.60%) followed by *G. fasciculatum* of 10.19% (Fig. 3). In Central Telangana Zone soils, *G. phansihalos* occupied 15.0% among all species followed by *G. fasciculatum* of 11.0% (Fig. 4). In North

Coastal Zone, *G. phansihalos* was distributed to an extent of 22.95% among the 16 AMF species reported (Fig. 5) and followed by *G. fasciculatum* (16.39%). In Godavari Zone 16 AMF species were recorded and found *G. phansihalos* occupied to an extent of 27.42% (Fig. 6).

Zhang *et al.,* (2004) surveyed 44 taxa of AM fungi (total species richness) in the deforested and natural forest in sub tropical region of Dujiangyan where as in semi-arid climatic and soil conditions of AP we recorded only 16-19 species of AM fungi. Zhang *et al*., (2004) also reported that *Acaulospora* and *Glomus* were the dominant genera in the study sites. In the present study generic level distribution of VAM spores indicated that *Glomus* species is the most predominant VA mycorrhizal fungus widely distributed in different agroclimatic zones of Andhra Pradesh. This could be due to more survival ability of *Glomus* in different agroclimatic zones of Andhra Pradesh (Plate 1).

Glomus was found dominant genus in all the agro-ecosystems comprising 62.5% of the total species. Predominance of genus *Glomus* may be attributed to the fact that these are the most wide spread VAM fungi (Plate 1). Formation of ellipsoidal and spherical vesicles in the roots indicated the presence of *Glomus* species (Onguene *et al.,* 2001). The genus *Glomus* has been reported to be the most common VAM fungus globally (Stahl and Christensen, 1982) and predominant in the tropical as well as temperate regions (Vestburg, 1995). Genus *Gigaspora, Scutellospora* and *Sclerocystis* might require specific edaphic conditions because of this reason their presence is less in AP soils. Daniell *et al.,* (2001) suggested that genus *Glomus* (unlike *Gigaspora* and *Scutellospora)* may have the ability to recolonize roots from mycelial fragments rapidly.

Many earlier workers (Raghupathy and Mahadevan, 1993; Dalpe and Aiken, 1998) have also reported the predominance of *Glomus fasciculatum* under various climatic conditions. Naik and Lakshman (2009) reported that *Glomus fasciculatum* was the most frequently occurring species in the rhizosphere soil of paddy. Some of AM fungi showed restricted distribution. Such restriction in distribution might be due to the fact that these micro symbionts could not adapt themselves to wide variation in soil pH, moisture contents and temperature (Tables 1 and 2). Identification of some of the AM fungi up to distinct species level was not possible by studying external morphology. It is established that variation in AM fungi distribution is generated by a variety of mechanisms, including variation in host species, mycorrhizal dependency, soil properties, host plant- mediated alteration of the soil microenvironment, or other unknown traits (Eom *et al*., 2000; Wang *et al.,* 2004). Physico-chemical parameters of the soil seemed to play an important role in the AM fungal spore population, root colonization and species diversity (Trimurtulu and Johri, 1998).

AM fungi alter the kinetic properties of the root, thereby enhancing its nutrient uptake abilities. Hence it is clear that mycorrhizal fungi play a vital role in nutrient cycling and productivity of crops. Through appropriate management of mycorrhizae in agriculture, it is also possible to maintain soil quality and sustainability thereby protecting the environment over long term and also reducing cost of production.

In conclusion, the present study shows good spore density and spore diversity of AM fungi in five different agroclimatic Zones of Andhra Pradesh. *Glomus* species was dominant in all zones which indicate its wide adoptability and survivability among 19 species reported in the study. Further it clearly indicates that under various soil physico-chemical and environmental conditions the genus *Glomus* is the best and potential AM fungal inoculant to the farmers of AP.

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