

Original Research Article

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Role of the AM Fungi in Physio-chemical Properties of Soil, Study in Sathupally Forest Area, Khammam (District) Telangana State with Reference to *Anogeissus latifolia* and *Bambusa arundinacea*

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ABSTRACT

Keywords

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In the present study, explained about the physio-chemical properties of soil with relation to the AM fungi. Soil was taken from Sathupally forest area of Telangana state. Before and after taken the soil all the properties of soil were taken i.e. p^H, moisture content, Temperature, Water holding capacity. 2 different soil samples were taken from 2 different sites and analyze the soil samples in laboratory which are having 11 species belongs to 2 genera of Combretaceae and Poaceae family. Hence, an attempt has been made to screen the availability of AM fungi from Sathupally forest area of Telangana State by selecting two forest angiosperm species *Anogeissus latifolia* and *Bambusa arundinacea*. The rhizosphere soil of these two species was collected and an attempt has been made to isolate and identify AM fungi from the forest soil of Sathupally forest area. The fungal spore numbers in soil were determined along with the percentage of root colonization.

Introduction

Arbuscular Mycorrhizal (AM) fungi are obligate symbionts distributed abundantly in various soils and helping in nutrients uptake for the sustenance of vegetation. The roots of most plants form VA mycorrhizal associations with a group of soil fungi

belonging to Endogonaceae of Zygomycotina (Gerdemann, 1968; Mallock *et al.*, 1980, Mosse, 1981). Recently the family has been designated as Glomaceae of Glomales (Almeda and Schenck, 1990). They produce specialized structures known as vesicles and arbuscules inside the cortical cells of the roots (Cox and Tinker, 1976; Greny, 1973;

Hayman, 1974; Mosse, 1973; Redhead, 1975; Saif and Khan, 1975; Sutton, 1973).

VA mycorrhizal fungi colonize the fine absorbing roots of the plants, invading only the primary cortex; while vascular tissue and secondary cortex and the thick fleshy roots that develop into main structural roots of perennial plants are not infected. Essentially, therefore, VA infections involve only temporary structures with a limited functional life (Mosse, 1981). In this respect they differ from more pathogenic infections by other fungi that cause lesions, distortion and discoloration of the invaded tissue and often spread into permanent tissues of the stele and beyond.

These fungi produce their hyphae and reproductive structures outside the root system. An important part of the VA mycorrhizal system is the extension of mycelium outside the root. It constitutes a strategically placed network of an additional absorbing surface that enables the plant to tap soil phosphate beyond depleting zone, which is otherwise not accessible to the unaided root (Bevege, *et al.*, 1975; Butler, 1939; Gerdemann, 1955b; Hayman and Mosse, 1971; Mosse, 1956, 1959, 1977; Mosse and Phillips, 1971; Nicolson, 1959, 1960; Tinkler, 1975).

Much work has been done on the physiology of the symbiotic association and it has been established beyond doubt that these VA mycorrhizal roots act as efficient absorbing roots and help in the active uptake of phosphorous and other micro – nutrients (Abbott and Robson, 1979; Asai, 1944; Auge, 1989; Avio and Giovannetti, 1988; Bass and Lambers, 1988; Bass *et al.*, 1989; Barea *et al.*, 1988, 1989; Baylis, 1971, 1975; Miller *et al.*, 1989; Sundaresan *et al.*, 1988). VAM fungi are distributed more abundantly in soils deficient in moisture and phosphorus; as such

semi-arid tropical soils supporting dry deciduous vegetation are nutritionally poor and harbour a greater number of VAM fungal propagules. The VAM fungal propagules vary in soil and their number may be from a few to 800 / g dry soil (Nemec, 1974). It is thought that 95 % of the Angiosperms are mycorrhizal dependent and some Bryophytes (Ligrone and Lopes, 1989) and Pteridophytes (Cooper, 1973; Farmer, 1988; Nair, 1989) do possess VAM associations. The percentage root colonization by these fungi indicates mycorrhizal dependency and efficiency.

AM fungi associated with forest soils are known to help in the establishment of forest seedlings, besides protecting them from forest pests (Bagyaraj *et al.*, 1988, 1989; Borge and Chaney, 1988; Byrareddy and Bagyaraj, 1989; Chaturvedi *et al.*, 1987; Parameswaran and Augustine, 1988; Punj and Gupta, 1988; Warcup, 1986). Recently Mohan Kumar and Mahadevan (1988) have studied the ecology of AM fungi from tropical forests.

Important information on AM fungi have been only summarized into monographs (Hall, 1987; Hall and Fish, 1979; McGee, 1986; Almeda and Schenck, 1990; Schenck and Perez, 1987; Trappe, 1982; and Walker, 1984) of late, VA mycorrhizae have been receiving attention from Indian and Asian workers. National workshop on Mycorrhizae was held at Delhi in 1987 and the first Asian Conference on mycorrhizae took place in Madras in 1988. The status of mycorrhizal research in Asia has been summarized in mycorrhizae Round Table (1988) and mycorrhizae for green Asia (1989). Mosse (1981) in her brilliant review on “VA mycorrhizal research for tropical Agriculture” emphasized the significance of AM fungi in tropical soils. She stated, “It is probable that the endophyte species of tropical soils have not been adequately surveyed and that economically interesting species adapted to

tropical conditions could be found". However, there is no such work on AM fungal flora from Indian forest soils in general and from southern dry deciduous forests of Telangana in particular.

Hence, an attempt has been made to screen the availability of AM fungi from Sathupally forest area of Telangana State by selecting two forest angiosperm species, *Anogeissus latifolia* and *Bambusa arundinacea*. The rhizosphere soils of these two species were collected and an attempt has been made to isolate and identify AM fungi from the forest soils of Sathupally. The fungal spore numbers in soil was determined along with the percentage of root colonization.

Materials and Methods

Collection of samples

Soil samples were collected from Sathupally forest in the month of May, 2018. 50X 50 m area was selected and collections were made by taking composite samples up to a depth of 10 cm, after scrapping off 3 cm of surface soil with a sterile trowel. A pit was dug with the trowel, which was sterilize with 70% alcohol and the root zone soil was collected in fresh polyethylene bag along with root bits. The soil temperature was measured with the help of soil thermometer. The soils were immediately brought to the laboratory and the composite soil samples of each plant species were thoroughly mixed and kept in one big polyethylene bag in refrigerator at 5⁰ C until further study.

Soil reaction

The p^H of the soil was determined as follows:

To 2g of 2 mm sieved soil, 10 ml of glass distilled water was added. The contents were thoroughly shaken and kept undisturbed. The

supernatant was carefully decanted in a wide mouth tube and the same is fed to the calibrated p^H meter and the reading was recorded. Thus, the p^H of the rhizosphere soil supporting the two angiosperm plants under study was individually recorded.

Moisture content

The moisture content of the soil was determined as follows:

10 g of 2 mm sieved soil was taken in a known weight of card board paper boat. The same is kept in hot air oven, adjusted at 105⁰ C, for 11 hours. Next day, the weight of the boat including dry soil was taken, when it was cool. The moisture content in % was determined as follows:

$$\begin{aligned} \text{Weight of empty paper boat} &= W_1 \text{ g} \\ \text{Weight of boat + soil} &= W_2 \text{ g} \\ \text{Weight of boat + soil (after dry)} &= W_3 \text{ g} \\ \text{Weight of soil before dry (} W_2 - W_1 \text{)} &= W_4 \text{ g} \\ \text{Weight of soil after dry (} W_3 - W_1 \text{)} &= W_5 \text{ g} \\ \text{Moisture content (} W_4 - W_5 \text{)} &= W_6 \text{ g} \end{aligned}$$

$$\text{Percentage of moisture content} = \frac{W_6}{W_4} \times 100$$

Likewise, the moisture content (in %) of the rhizosphere soil supporting the two angiosperm plants under study was determined individually.

Water holding capacity

Water holding capacity of the two forest soils was determined by the method recommended by Keen and Raczowski (Piper, 1944).

2 mm sieved soil was taken in a known weight of bottom pored brassbox having Whatman No.1 filter paper distilled water was added till the soil is saturated with soil. The thin film of water on the reverse of bottom was cleaned with the help of a filter paper and

weight was taken. The same was kept in hot air oven at 105^o C for 11 hours. Another Whatman No.1 filter paper of same size was taken and its weight before and after soaking in distilled water was measured. Next day, when the contents became cool the weight of brass box with filter paper and soil was determined. The water holding capacity in percentage was calculated as follows:

$$\begin{aligned} \text{Weight of brass box} &= W_1 \text{ g} \\ \text{Weight of box + filter paper (f.p)} &= W_2 \text{ g} \\ \text{Weight of box + f.p + soil} &= W_3 \text{ g} \\ \text{Weight of box + f.p + soil (wet)} &= W_4 \text{ g} \\ \text{Weight of box + f.p + soil (dry)} &= W_5 \text{ g} \\ \text{Weight of same sized f.p} &= W_6 \text{ g} \\ \text{Weight of same sized f.p. after soaking} &= W_7 \text{ g} \\ \\ \text{Weight of water absorbed by f. p. } &W_7 - W_6 = W_8 \text{ g} \\ \text{Weight of collected soil } &W_3 - W_2 = W_9 \text{ g} \\ \text{Weight of wet soil} &+ W_4 - W_2 = W_{10} \text{ g} \\ \\ \text{Water absorbed by f.p.} & \\ \text{Weight of dry soil } &W_5 - W_2 = W_{11} \text{ g} \\ \text{Weight of water absorbed } &W_{10} - W_{11} = W_{12} \text{ g} \\ \text{by soil + f. p.} & \\ \text{Weight of water absorbed by soil } &W_{12} - W_8 = W_{13} \text{ g} \end{aligned}$$

Water holding capacity in

$$\text{Percentage} = \frac{W_{13}}{W_9} \times 100$$

Thus, the water holding capacity of the two rhizosphere soils was determined individually. Soils were taken from the root zone soils, supporting two Angiosperm plants, viz., *Anogeissus latifolia* Wall, (Combretaceae), and *Bambusa arundinacea* Wild (Poaceae) separately for determining number of AM fungal propagules after removing stones and vegetable debris present. Root bits of each species were fixed separately in 1:3 acetic alcohol.

Isolation and quantitative estimation of AM fungi isolation

For isolation and quantitative estimation of Arbuscular Mycorrhizal fungal propagules, modified method of wet sieving and decanting technique (Gerdemann and Nicolson, 1963) was employed (McKenny and Lindsey, 1987).

100 g of 2.0 mm sieved soil was taken and was made into 4 equal parts and each part was put in 500 ml beaker. A pinch of sodium hexametaphosphate was added to prevent the aggregation of soil particles. 420µm, 250 µm, 105 µm and 45 µm sieves were arranged in the descending order with 45 µm sieve setting at the bottom. The contents of the beaker were thoroughly shaken mechanically for 10 min and were allowed to settle for 15 min. The upper contents were decanted through the sieves.

The debris retained on the sieves was carefully washed into 250 ml beakers separately for each sieve. The debris of 420 µm sieve was first filtered through single synthetic fibred white cloth. The cloth with debris was kept in a glass Petri dish with some water and observed and isolated the AM fungal propagules with the help of a binocular dissecting microscope and injection needle.

The process was repeated for debris of othersieves. Permanent preparations of these propagules were made on slides with polyvinyl lactic acid as mounting medium. The sporocarps and spore aggregations were carefully isolated with microneedles and mounted in the same medium.

Polyvinyl lactic acid preparation

Polyvinyl alcohol – 1.66g
Water – 10 ml
Lactic acid - 10 ml
Glycerol - 1 ml

Method: Polyvinyl alcohol is dissolved in water at 80⁰ C on water bath. Later on, lactic acid is added and stirred with glass rod. Then add glycerin and stirred thoroughly till the glycerin is dissolved.

Identification

There are at present, only six genera in Endogonaceae of mucorales in Zygomycotina (Glomaceae and Glomales of Almeda and Schenck, 1990) viz. *Glomus*, *Acaulospora*, *Entrophosphora*, *Gigaspora*, *Scutellospora* and *Sclerocystis* consisting of about 150 species (Perez and Schenck, 1990). These species form vesicles and arbuscules of same nature in host plant root tissue and cannot be identified on the basis these two structures or mycelium in or outside the host. The vesicles are formed in the host tissue intercellular for probably the store-houses of reserve food material. But it was found that some species are not forming the vesicles. Hence, the name of VAM fungi was modified as AM fungi. The arbuscules are formed in the host tissue intracellular and act ashaustoria.

These AM fungi form Azygospores or chlamydospores outside the host in the rhizosphere soil. These are also generally called as propagules. Based on the nature of these propagules, the species were identified. The characters of these propagules to be studied are colour, size, shape, wall characters (thickness, colour, number of layers and their thickness, inside and outside ornamentations of the wall) presence or absence of subtending hyphae and its nature, nature of pore and the contents are the features specific for each species.

Various keys were taken into account in the identification of AM fungi, such as Hall and Fish (1979), Raman and Mohan Kumar (1988), Schenck and Perez (1988) and Trappe (1982).

Colonization of AM fungi

The magnitude of infection of AM fungi to the host was determined in terms of percentage (Toth and Toth, 1982). The collected and fixed root bits of the two angiosperm host plants were used to determine the percentage infection following the method of Phillips and Hayman (1970).

The fixed root bits were cut into 1 mm pieces. They were autoclaved at 15 lbs for 15 min in 10% KOH solution and rinsed in tap water. Later, they were acidified in dilute HCl for 3 - 4 min and stained.

The percentage of colonization was determined taking into account the number of root bits having vesicles and arbuscules with that of having no such structures, as well as the number of cells with arbuscules with that of non-invaded cells.

% of colonization =

$$\frac{\text{Number of bits (cells) having vesicle}}{\text{Total number of bits (cells)}} \times 100$$

Thus, the percentage of colonization of each of these two angiosperm host plants was determined.

Results and Discussion

Physio-chemical properties

Temperature of the soil

As the soil samples were collected in the month of April, 2018 i.e. in the summer the temperature of the soil slightly higher than the normal. The temperature of rhizosphere soil supporting *Anogeissus latifolia* (soil-1) is 31⁰C, where as that of *Bambusa arundinacea* (Soil-2) is 32⁰C (Table 1).

Moisture content

The moisture content of the soil-1 is 2.55%, where as that of soil-2 is 3.56% (Table-1).

Soil pH

The p^H of the soil were nearly neutral or slightly basic. The p^H of soil-1 is 7.02, where as that of soil-2 is 7.39 (Table-1).

Water holding capacity

The water holding capacity of a soil provides an idea of biota living in that area. The water holding capacity of soil-1 is 38.2 %, where as that of soil-2 is 39.7 % (Table-1).

Quantitative estimation AM fungi

Percentage colonization

The percentage colonization of AM fungi in soil - 1 (supporting *Anogeissus latifolia*) is 73, where as that of soil - 2 (supporting *Bambusa arundinacea*) is 75 (Table-2).

Number of propagules

The number of propagules of AM fungi in soil-1 is 25/50gsoil, where as that of soil-2 is 16/ 50gsoil (Table-2).

Qualitative estimation of AM fungi

Soil-1

Out of the 25 propagules in the soil-1 supporting the Angiosperm plant, *Anogeissus latifolia*, 14 belonging to *Acaulospora*, 2 belongs to *Gigaspora* and 9 belongs to *Glomus* (Table-3) as given below.

1. *Acaulospora appendicula*-3
2. *A. bireticulata* - 1
3. *A. foveata* - 4

4. *A. lacunose* - 3
5. *A. laevis* - 3
6. *Gigaspora gigantean* - 2
7. *Glomus arborence* - 1
8. *G. deserticola* - 5
9. *G. geosporum* - 3

Soil-2

In the soil supporting the Angiosperm plant *Bambusa arundinacea*, a total number of 16 propagules were obtained. Out of this 12 belong to the genus *Acaulospora* and 4 belonging to the genus *Glomus* (Table-3).

1. *Acaulospora appendicula* - 2
2. *A. denticulate* - 2
3. *A. foveata* - 2
4. *A. laevis* - 4
5. *A. scrobiculata* - 2
6. *Glomus arborence* - 2
7. *G. deserticola* - 2

Description of species

Acaulospora appendicula Spain, Sieverding & Schenck

Azygospores formed singly in soil Azygospores globose, 120 - 200 µm diameter, white opaque becoming dull yellow cream to orange when mature. Wall thickness 4 - 6 µm, yellow to brown with age with an irregular reticulate pattern of fine cracks that serve as fracture lines when an azygospore is crushed, sub - tending hyphae not present (Figure 1).

Acaulospora bireticulata Rothwell & Trappe

Sporocarps unknown. Azygospores are formed singly in the soil, sessile, spores globose 170 - 176 µm in diameter, sub - hyaline when young becoming orange and light brown at maturity. Spore surface ornamented with a polygonal reticulum, the ridges 2 x 1.5 - 2 µm with dark grayish - green

sides and a paler depressed central stratum, ridges occasionally branched towards the center of polygons forming irregular, isolated projections at polygon centres, polygons 6 - 18 μ m long, the enclosed spore surface be set with round tipped, 4 - 6 sided processes $\pm 1 \times 1 \mu$ m to give the appearance of an inverted reticulum. Spore wall thickness 3.0 - 7.5 μ m, contents globular (Figure 2).

***Acaulospora denticulate* Sieverding & Toro**

Sporocarps unknown. Azygospores formed singly in soil. Creamy yellow to pale brownish yellow, Globose, 200 - 213.75 μ m in diameter. Spore wall yellow in colour, 4 - 6 μ m in thickness. Irregular ridges are present appearing polygonal in surface view, at the periphery appearing like molar teeth (Figure 3).

***Acaulospora foveata* Trappe & Janos**

Sporocarps unknown. Azygospores formed singly in soil. Spores globose to sub - globose, yellowish brown to dark reddish brown, 161 - 225 μ m in diameter. Spore surface uniformly pitted with round to oblong or occasionally irregular depressions. Spore composite wall thickness is 10 - 12 μ m, dark reddish brown, laminated. Spore contents of small hyaline guttules (Figure 4).

***Acaulospora lacunosa* Morton**

Spores formed singly in soil. Spores are reddish yellow to dull brownish yellow, globose 175.25 - 180 μ m in diameter or sub globose 145 - 150 x 185 - 190 μ m, composite wall thickness is 5.25 - 14 μ m. The surface is ornamented with sausage shaped pits and irregularly arranged ridges but minute pits are not present (Figure 5).

***Acaulospora laevis* Gerdemann & Trappe**

Sporocarps unknown. Spores formed singly in soil. Spores sessile. Vesicle lost in sieving.

Spores smooth, size 116 - 236 μ m in diameter or 391 - 425 μ m. Shape globose to sub globose, colour dull yellow to golden brown to reddish yellow. Spore wall consisting of 3 layers, a rigid yellow brown to red brown outer wall and 2 hyaline inner membranes. Composite wall thick, 4 - 18 μ m, contents globose, spore surface smooth but in older ones minutely perforated (Figure 6).

***Acaulospora scrobiculata* Trappe**

Sporocarps unknown. Azygospores formed singly in soil. Spores are globose 175 - 190 μ m in diameter. Spore surface evenly pitted with depressions which are circular to elliptical. The composite spore wall thickness is 7 - 8.25 μ m. The contents are consisting of small oil guttules (Figure 7).

***Gigaspora gigantea* (Nicol & Gerd) Gerd & Trappe**

Azygospores formed singly in soil. The spores are globose 282 - 290 μ m in diameter or slightly oval 440 - 442 x 455 - 490 μ m in size, pale greenish yellow to golden yellow. The thickness of composite wall is 7.5 - 15 μ m. It has an outer wall layer thin, evanescent or an inner, thick, brown and laminate. The diameter of suspensor at attachment is upto 37.5 μ m and upto 56.25 μ m at its maximum diameter tapering to 10 μ m. The suspensor has one or two hyphal branches. Many protuberances probably germ tubes are present just near suspensor. Rarely, they contain one spore of *Acaulospora* sp. (Figure 8).

***Glomus arboreense* Mc Gee**

Hypogenous spore aggregations upto 1mm size. Chlamydospores formed terminally or sub-terminally. The spores and hyphae are hyaline; globose to sub-globose, rarely irregular; 30 - 30.75 X 52.5 μ m. The

composite wall is very thin, less than 3.75 µm. The surface is smooth to dull roughened, contents hyaline with globular oil drops and are cutoff infrequently by a septum. Hyphae 2.5 - 10.5 µm in diameter at attachment and slightly flared (Figure 9).

***Glomus deserticola* Trappe, Bloss & Menge**

Spores borne singly or in loose fascicles in soil. Spores are globose to slightly sub-globose, 120 - 146 µm in diameter, shiny smooth, reddish brown, with a single, sometimes laminated wall, 2.5 - 10.5 µm in thickness. The attached hypha is 11.25 - 26.25 µm diameter at attachment, cylindrical to occasionally somewhat funnel-shaped, the walls thickened and reddish brown, especially thick adjacent to the spore but not occluding the hypha. Interior of the spore wall at the hyphal attachment thickened at maturity to

form an inner mounded collar, which appears to be closed by a membranous septum (Figure 10).

***Glomus geosporum* (Nicol & Gerd) Walker**

Sporocarps unknown. Chlamydospores formed singly in soil. The spores are globose to sub-globose, 103 - 326 µm in diameter or 105 x 120 µm, smooth and shiny or with a dull appearance or roughened from adherent debris, light yellow - brown to dark red - brown at maturity. Spore walls 3.5 - 15 µm thick, 3 layered with a thin, hyaline, tightly adherent outer wall, most easily observed in young spores and sometimes absent from mature specimens yellow to brown inner wall which forms a septum separating the spore contents from the lumen of the subtending hypha. Walls often becoming perforated with age, probably due to attack of soil microbes.

Table.1 The values of different physio - chemical properties of soils

Soil type	p ^H	Moisture content %	Temperature in °C	Water holding capacity %
Soil - 1	7.02	2.55	31	38.2
Soil - 2	7.39	3.56	32	39.7

Soil-1=*Anogeissus latifolia*. Soil-2=*Bambusa arundinacea*.

Table.2 The values of % colonization and the number of propagules

Soil type	% colonization	Number of fungal spores
Soil-1	73	25/50 g soil
Soil-2	75	16/50g soil

Soil-1=*Anogeissus latifolia*. Soil -2: *Bambusa arundinacea*.

Table.3 Qualitative data of AM propagules

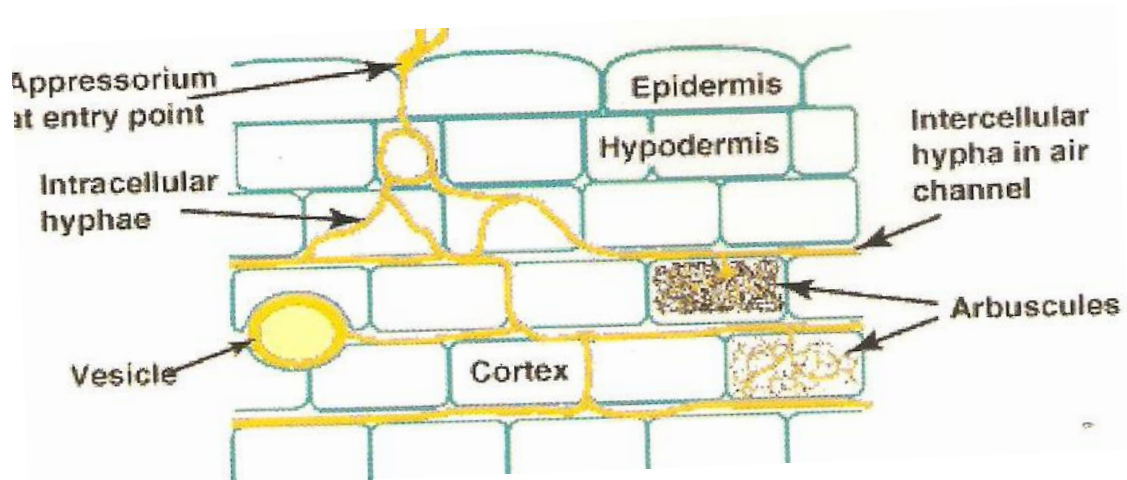
AM fungal species in soil-1	AM fungal species soil-2
1. <i>Acaulospora appendicula</i>	1. <i>Acaulospora appendicula</i> .
2. <i>A. bireticulata</i> .	2. <i>A. denticulate</i> .
3. <i>A. foveata</i> .	3. <i>A. foveata</i> .
4. <i>A. lacunose</i> .	4. <i>A. laevis</i> .
5. <i>A. laevis</i> .	5. <i>A. scrobiculata</i> .
6. <i>Gigaspora gigantean</i> .	6. <i>Glomus arborence</i> .
7. <i>Glomus arborence</i> .	7. <i>G. deserticola</i> .
8. <i>G. deserticola</i> .	
9. <i>G. geosporum</i>	

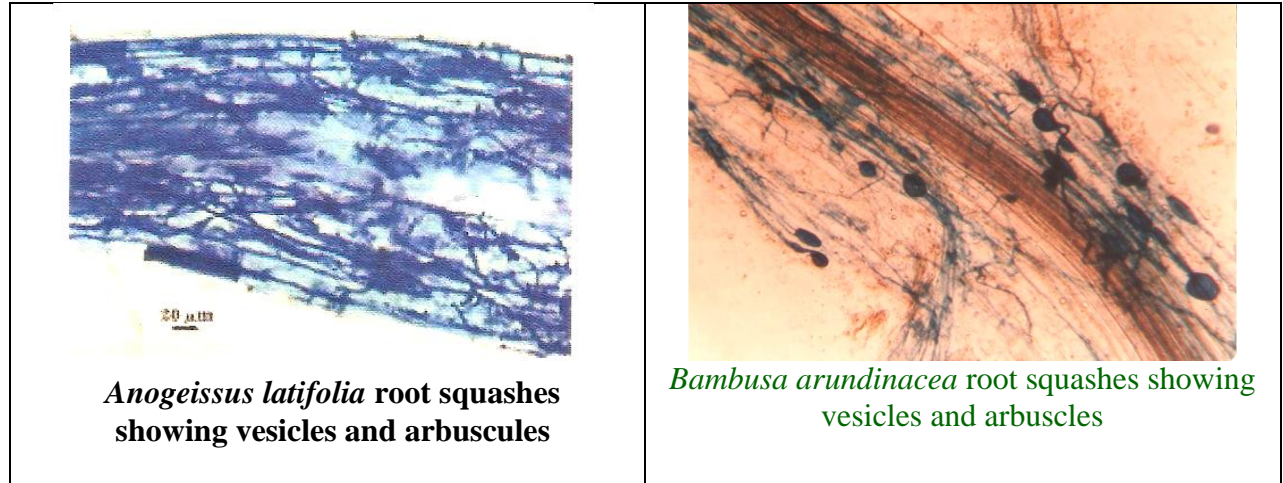
Diagram showing different structures related to AM fungi.



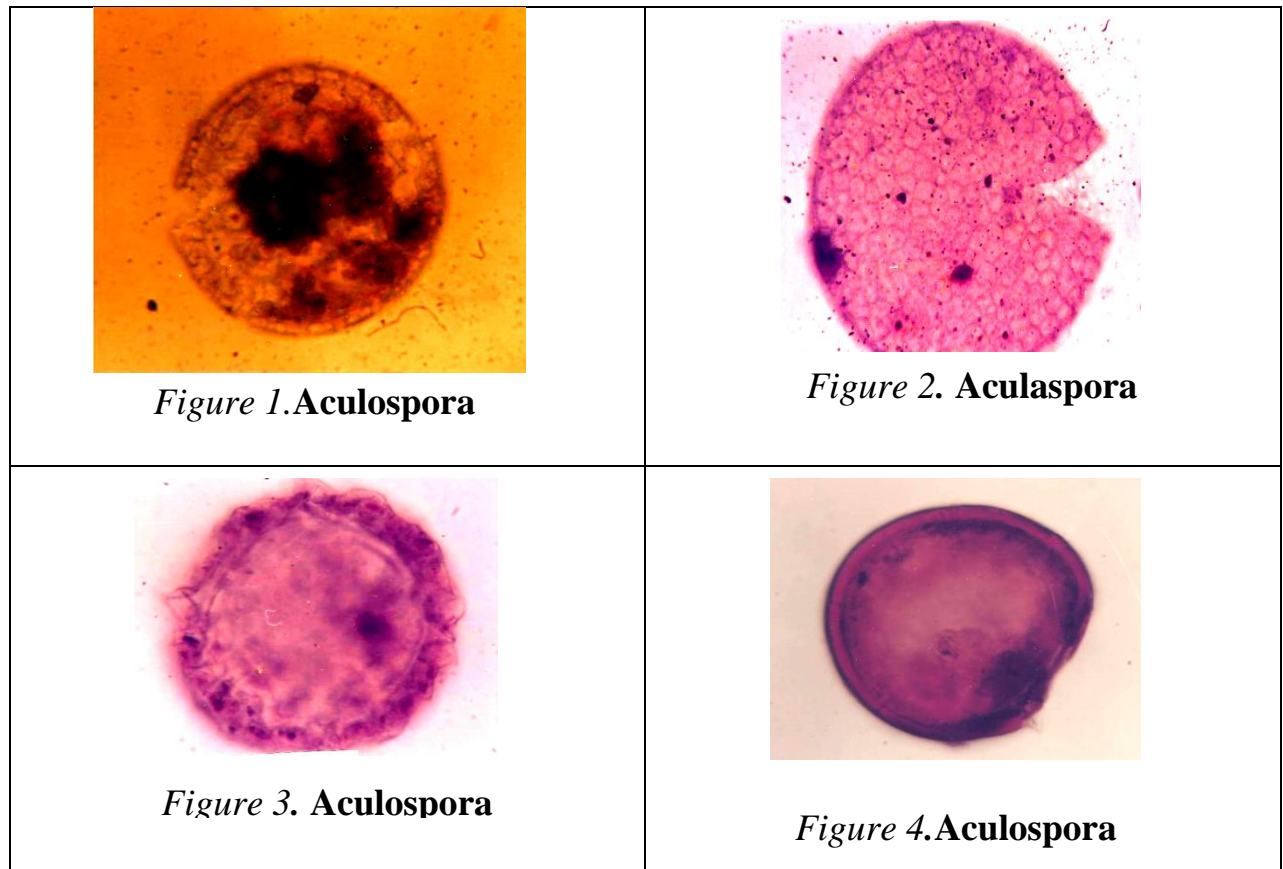
Outside the root

in the soil





Figures showing the root squashes with vesicles and arbuscules.



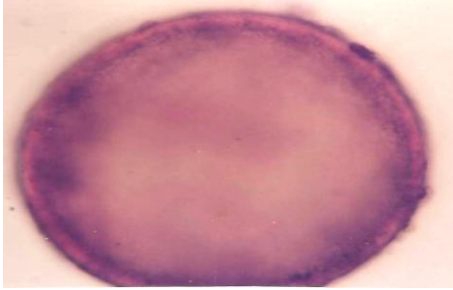


Figure 5. Aculospora

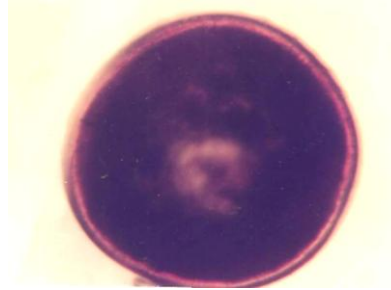


Figure 6. Aculospora

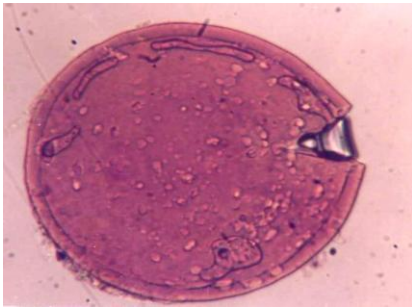


Figure 7. Aculospora



Figure 8. Gigaspora

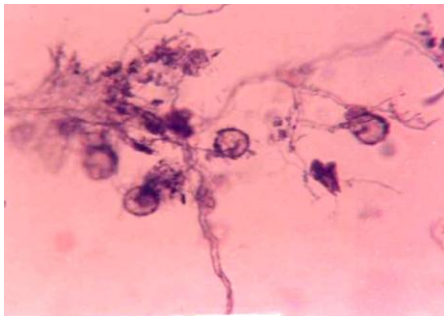


Figure 9. Glomus

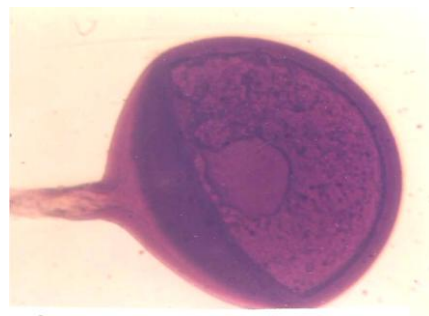


Figure 10. Glomus

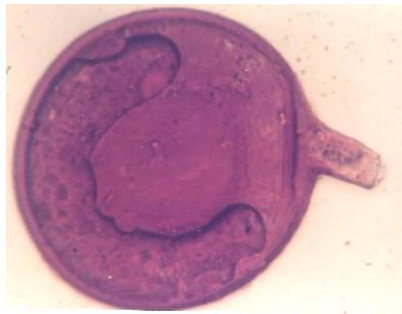


Figure 11. Glomus

Spores with one straight to recurved, simple to slightly funnel shaped subtending hypha (rarely with two adjacent attachments), 11 - 22 μm in diameter, with yellow to dark yellow - brown wallthickening. Occasionally spores lacking a subtending hypha due to breakage close to the spore base.

Spore contents of uniform oil droplets when young, becoming increasingly granular in appearance with age, cut off by a septum that protrudes slightly into hypha (Figure 11).

The soil is a complex medium. It is very difficult to interpret the part played by different factors, as some of them tend to exert a positive influence, while others have reverse effect or no effect. Unless a factor behaves in such a way as to be called a limiting factor, it is not safe to ascribe the observations to a single factor. There are many factors playing important role at micro-environmental level which are very difficult to analyze, assign or to define. In spite of having a constellation of physio-chemical and biological factors, still the soil maintains a dynamic equilibrium of microorganisms. However, threesome information available to study the quantitative and qualitative distribution of AM fungi.

In the present study the soils were collected during the dry days i.e. April 2018. Hence, a study of quantitative and qualitative occurrence of propagules and % colonization of AM fungi is made to different physio-chemical properties of soil. However, the availability of other micro and macro elements in the soil, also play a vital role in the distribution of these AM fungi they were not considered here. The detailed discussion as topic wise mentioned below:

Seasonal distribution

Redhead (1975) recorded high propagule count in October in semideciduous forest soil

and low count in January in sahel savannas. In the present investigation also, the same thing has been noticed that the number of sporepropagules are less in summer with a high % of colonization.

Moisture content/water holding capacity

Eventhough the water holding capacity of the soil may be more, such situation occurs when soils were satisfied with full water capacity in the rainy season.

There are contradictory reports regarding the effect of soil moisture on the number of AM fungal propagules. Sieverding (1980) revealed that the mycorrhizal plants are less sensitive than non-mycorrhizal plants to water stress. Parameswaran and Augustine (1988) observed that mycorrhizal activity in soil was influenced by the moisture level (5 - 8%) and their numbers decreased with the further increase in moisture level above 9%. Increase in moisture content has a negative effect on spore count and percentage infection.

In the present investigation, the AM fungal propagules are less in number and more in %colonization. These results are in agreement with the conclusions of Hafeel and Gunatilleke (1988), Jha *et al.*, (1988), Laxman Rao Goje (1991), Mohan Kumar and Mahadevan (1988).

pH and AM fungal numbers and % of colonization

Hagberg (1986) revealed that the availability of phosphorous is dependent on the soil reaction (p^{H}) and is particularly low in humid areas where deeply weathered and leached acid soils bind P in Fe and Al phosphates of low solubility. Nemeč *et al.*, (1981) came to the same conclusion and stated that there is a direct correlation between soil pH and spore numbers (Kruckelman, 1975; Read *et al.*, (1976). Most of the AM spores are known to

germinate between 4 - 7 pH at high temperature (Green *et al.*, (1976). In the present work, where the pH is near 7 (neutral) and as to high temperature of summer, the AM fungal propagules are less but the % colonization is high.

Soil temperature and AM fungal spores

Nyabyenda (1977) found that plants infected with mycorrhizal were extraordinarily dependent on soil temperature for growth. The best vesicle and spore formation in *Glycinemax* took place at 35⁰ C, the optimum temperature for arbuscule formation was 30⁰ C and the mycelium development best between 28 and 30⁰ C (Schenck and Schroder, 1974; Schenck and Smith, (1982). In the present work, the number of AM propagules is less when the temperature is at 31 or 32⁰ C, whereas the % of infection is more i.e. 73 and 75 %.

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