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Research Article

PROMINENCE OF MYCORRHIZAL COLONIZATION AND DIVERSITY IN WEED SPECIES GROWING IN AGRONOMIC FIELD OF NALDURG, INDIA

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ABSTRACT

In present study, 12 species belonging to 8 families and 11 genera in rabi and 14 weed species belonging to 9 families and 13 genera in kharif season were collected from agricultural field and examined arbuscular mycorrhizal fungi (AMF) status. AMF root colonization ranged from 41.56to 84.0%. The highest colonization was recorded in Dichanthium caricosum (84.0%) while least in Abelomoscus manihot (41.56%) in rabi season. In case of kharif, AMF root colonization ranged from 50- 85.12%. The more colonization was noted in Cassia tora (85.12%) and Celosia argentea (81.25%) while least in Cyprus rotundus (50%). Eight weed species were found common in both the seasons and assessed for AMF. Of the eight species, five species i.e. Parthenium hysterophorus, Corchorus capsularis, Cyprus rotundus, Cyanodon dactylon and Dichanthium caricosum recorded higher AM colonization in rabi season as compared to kharif. AMF spores densityvaried in weed species and ranged from 287-1070 spores/100g soil in rabi while 245-770/100g soil in kharif season. Mycorrhizal spore density was found more in rabi than kharif season. During the kharif season, highest root colonization was recorded in three plant species viz.,Commelina benghalensis,C. albescens and Celosia argentea compared to rabi season. Vesicular, arbuscular, hyphal and dark septate endophytes types of root colonization was recorded in both seasons. Celosia argentea, Abutilon indicum and Alternenthera sessilis found DSE types of colonization only. Six species of AM fungi i.e. Acaulospora rehmii, Glomus macrocarpum, Glomus microaggregatum, Glomus delicata, Glomus geosporum and Sclerocystis sp. (unidentified) were identified.

INTRODUCTION

Mycorrhizae are probably the most common and widespread form of plant/fungus symbioses including angiosperms, gymnosperms, pteridophytes and even bryophytes and in terms of their occurrence in most major terrestrial ecosystems (Smith *et al.,* 2001). Arbuscular mycorrhizal fungi (AMF) are plant root symbionts that provide many benefits to crop production and agroecosystem; therefore, management of AMF is increasingly seen as important to environmental farming. Agricultural weeds form a symbiotic relationship with AMF and raised diversity and richness of agronomical beneficial AMF species. It was observed that many agricultural weeds have a fouler lifestyle and belong to families that comprise many non-hosts viz., Chenopodiaceae and Cruciferae (Harley and Harley 1987; Brundrett, 2002; Wang and Qiu 2006;Valeria *et al.,* 2010). Oringa *et al*.(1997) described some families such as chenopodiaceae, fumariaceae, polygonaceae, proteaceae, cyperaceae, utriculaceae, amaranthaceae and commelinaceae are generally thought to be non- mycorrhizal.

Current evidence suggests that weed species can provide certain agroecological assistances and therefore it will be a useful biodiversity component, if beneficial weed species can be identified and managed at supportable levels of richness (Jordan and Vatovec, 2004). Weeds represent one of the most serious problems in crop production, with a potential crop loss of up to 34% each year (Van der Heijden , 2002).Weed species may help to maintain diversity and agronomically beneficial taxa of AM fungi (Vatovec *et al*., 2005). Chen *et al.* (2004) observed that the number of AM fungal spores increased significantly with increasing weed species number and also reported that with well-developed root systems, Agricultural sustainability, environmental quality and ultimately, plant, animal and human health are determined by soil quality like physical, chemical and biological properties (Doran and Safley, 1997; Gugino, et al., 2009). However, conventional agricultural practices have reduced soil productivity at such an alarming step (Salviano, 2012) and many agricultural soils are unfeasible of nutrients and unable to naturally sustain crops (Habig*et al.,* 2015). In

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agroecosystems, the effects of AMF on crops have been thoroughly studied (Plenchette,1996; Gosling *et al*.,2006) .The studies show that AMF mainly promote crop yield under nutrient deficient conditions, although negative or no effects have also been reported (Koide,1985;Verbruggen *et al.,*2011**)** andfewer is known about the interactions between AMF and agricultural weeds.Therefore the present investigation was made to study the prominence of AM fungal colonization and diversity in weed species growing in agronomic field.

MATERIALS AND METHODS

Study Location

Naldurg is situated at National Highway NH-9 (65) Vijayawada to Pune. Agricultural land investigation was conducted during 2015-16. Total land area of Naldurg is 2787 ha and 2367ha is using for agriculture. It has an average elevation of 566 meters (1856 feet) andlocated at 17.49°N Latitude, 76.16°E Longitude. Temperature ranges from 10.1 °C to 43.1^{0}C. Average rainfall per year is 760 mm (Fig 1).

AMF Root colonization

Agricultural weed species of roots were collected in rabi&kharif season during 2015-2016. Plant species were selected for assessment of AMF root colonization in three replications. The plant roots i.e. primary and secondary fine roots were washed in water to remove soil debris and then preserved in Formalin-Acetic-Alcohol (FAA) (50:5:10:35) in specimen bottles. During assessment of root colonization, preserved roots were washed in water and remove the traces of FAA, Anabout 20-30 root segments were added in 50 mL beaker half filled with 10 % KOH to facilitate stain penetration in cortical tissue. Beaker was placed in oven for two hours at 70^0 C. Roots were heated till depigmentation. In some cases microwave oven (30 seconds) was used for 10% KOH treatment. The root segments were sluiced till no brown precipitate in water to dilute KOH residue and then immersed in 15 mL of Hydrochloric acid (5 %) for 3 minutes at room temperature.The acidified root segments were washed in water for 4 to 5 times and deeper in trypan blue (0.05 %) for overnight period. To remove excess stain from root tissues using water for destaining (Phillips and Hayman,1970). Stained root segments were observed under the binocular compound microscope (LOBAMED Vision 2000) and photographed with a Sony digital camera (DSC-W310/BC E37).In root having hyphae, vesicles, arbuscules were present was considered as mycorrhizal infection. The percentage of root colonization was calculated according to the Giovannetti and Mosse (1980) by using the following formula.

$$\text{Root colonizati on (\%)} = \frac{\text{Number of colonized segments}}{\text{Total number of segments examined}} \times 100$$

Assessment of AMF Spores

The rhizospheresoils of weed species were collected from agricultural fields. The 500g of rhizosphere soil was taken at a depth up to 10-15 cm of the plants of each species in separate polythene ziplock bags. Soil was dried at room temperature for 48 hours and samples were store at 4^{0}C until processing. In soil sample AM fungal spores were isolated by using wet sieving and decanting method of Gerdemann and Nicolson (1963) and identification of AM fungal spores was carried out based on morphotaxonomic criteria using INVAM International Collection of Vesicular Arbuscular Mycorrhizal (http://invam. wvu.edu/the-fungi) and available manuals (Schenck and Perez, 1990; Rodrigues and Muthukumar, 2009). The voucher specimens of AM fungi were deposited at Department of Botany, Arts, Science and Commerce College Naldurg, Maharashtra, India.

Statistical Analysis

Each experimental data was subjected to analysis statistically by variance (ANOVA) Means were separated using at 5% level of significance.

RESULTS AND DISCUSSION

AMF Root Colonization

A total of 13 weedy species belonging to 8 families and 13 genera were collected and examined from agricultural field during *rabi*season for percent AM root colonization, spore density and AM richness. Percent root colonization was ranged from 41.56-84%. The highest colonization was recorded in *Dichanthium caricosum* (84.0±3.22%) while minimum was observed in *Abelomoscus manihot* (41.56±2.11%). Poaceae members were found to show higher colonization levels followed by Asteraceae, Tilliaceae, Amaranthaceae and Euphorbiaceae in rabi season (Fig.1). A total of 14 weedy species belonging to 9 families and 14 genera were collected and examined from agricultural field during kharif season.Percent colonization ranged from 50 - 85.12%. The highest colonization was recorded in *Cassia tora* (85.12±3.11%) and *Celosia argentea* (81.25±3.22%) while minimum was observed in C*yprus rotundus* (50.00±4.33%). Vesicular, arbuscular hyphal and DSE colonization was recorded in both seasons. But only *Celosia argentea, Abutilon indicum and Alternenthera sessilis* found DSE types of colonization.

AMF Spore Density

The AM fungal spore density was ranged from 287-1070 spores/100g soil. Highest spore density was recorded in *Commelinaalbescens* (1070/100g soil) while least was recorded in *Abutilon indicum* (287/100g soil). AM fungal spore density was also found more in *Cynodondactylon, Dichanthium caricosum* and *Commelina benghalensis* in rabi season.The AM fungal spore density varied in different weed species. It was ranged from 245-770spores/100g soil. Highest spore density was recorded in *Phyllanthus niruri* (770/100g soil) followed by *Cassia tora* (725/100g soil) while least was recorded in *Commelina benghalensis* (245 /100g soil) in kharif season.

AMF genera

Five different genera *viz.,Acaulospora,Glomus, Gigaspora, Scutellospora* and *Sclerocystis*were recorded in weedy plants growing in agricultural fields during the rabi season. Among these, the genera *Acaulospora* and *Glomus* were dominant. *Gigaspora* was found associated with the roots of *Euphorbia*

hirta and *Abelomoscusmanihot*. Four different genera *viz., Acaulospora, Glomus, Scutellospora* and *Sclerocystis* were associated with the rhizosphere of *Cyprus rotundus.* Five different genera *viz., Acaulospora,Glomus, Gigaspora, Scutellospora* and *Sclerocystis* were recorded in weedy plants growing in agricultural fields during the kharif season. Among these, the genera *Acaulospora* and *Glomus* were dominant. *Gigaspora* was found associated with the roots of *Acalyphaciliata* and *Cassia tora*. Four different genera *viz., Acaulospora, Glomus, Scutellospora* and *Sclerocystis* were associated with the rhizosphere of *Corchorus capsularis*.

Seasonal variation among common weed species

A total of 8weed species belonging to 6 families and 8 genera found commonly during the rabiand kharif season were collected from agricultural field and examined for percent AM root colonization, spore density and AM richness **(**table 3; Fig 1 & 2**).** Eight weed species were found common in both the seasons and were assessed for AM root colonization. Of the eight species, five species i.e. *Parthenium hysterophorus, Corchorusc apsularis,Cyprusr otundus, Cyanodon dactylon* and *Dichanthium caricosum* recorded higher percent AM colonization in rabi season as compared to kharif. During the kharif season, highest root colonization was recorded in three plant species *viz.,Commelina benghalensis,C. albescens* and *Celosia argentea* compared to colonization in the rabiseason.Vesicular, arbuscular and hyphal colonization was recorded. In almost all weedy plants, AM spore density was greater in the *rabi* season than in the kharifwith the exception of *Parthinium hysterophorus.* Two AM fungal genera *viz., Acaulospora* and *Glomus* were dominant in both the seasons. *Gigaspora* was found in the rhizosphere of *Dihanthiumcaricosum* only in the kharifseason. A total of four AM genera *viz., Acaulospora, Glomus, Scutellospora* and *Sclerocystis* were *recorded in Corchoruscapsularis* during kharif season and in *Cyprus rotundus* during the rabi season.

Taxonomic Identification of AM Fungal Species

In all, six species of AM fungi were identified from both seasons. These include *Acaulospor arehmii, Glomus macrocarpum, Glomus microaggregatum, Glomus delicata*, *Glomus geosporum* and *Sclerocystis* sp. (unidentified).**(**table 4 fig.4).

Our findings are discussed the rabi and kharif weed plant species were collected from agronomic field and extensive observation was made for diversity and richness of arbuscular mycorrhizal fungi (AMF) status. Three dominant AM fungi genera were recovered in association of weed species from agricultural field. Mycorrhizal infection when found more, it was positively prejudiced for soil fertility. In present study, it isolated indigenous AMF species i.e. *Acaulosporarehmii, Glomus macrocarpum, Glomus microaggregatum, Glomus delicata*, *Glomus geosporum* and *Sclerocystis* sp from both the seasons. It was mass multiplied of dominant species with restoring plant species and developed good source of inoculums for other experiments. Some weeds like *Commelinaalbescens, Celosia argentea* and *Cynodondactylon* were found helpful for regenerating crop plants and its productivity. Thus, weeds plant will benefit directly from the AM symbiosis through increased nutrient uptake and certainly increased growth. Weeds are an important variable in crop productivity, economically, ecologically and also may serve to maintain diversity and agronomic beneficial species of AM fungi. When weeds assists mycorrhizae or any types of plant in being able to absorb more nutrients and moisture, and maintained better stress resistance and be more vigorous even present in agricultural field.

Previous studies have indicated that there is evidence to suggest the presence of mycorrhizal weed hosts maintains a diverse AMF population and promotes highly effective symbiosis with the crop plant. Sawant *et al.* (2011) reported *Cassia tora* L. AMF percentage of root length colonization was highest in Osmanabad (82.17 %) and lowest in Parbhani (61.79 %) and Beed rhizospheric soil showed (1038) spores which was maximum, while it was minimum in Parbhani (610) and relation (r = 0.89) between soil moisture and root colonization was positive. Smith *et al.*(2008) reported increased number of arbuscular mycorrhizal fungal spores when studied in association to large number of weeds species and enhanced positive effects of AM fungi on the growth and existence of *Vincetoxicumrossicum* species. Weed species differed in the response to AM root colonization and the highest AM root colonization was found for *Lactucaserriola, Picrisechioides, Plantagolanceolata* and *Gallium aparine* and in addition, *Avenasterilis, Fumaria officinalis* and *Stellaria media* had the lowest AM root colonization (Bilalis *et al.,* 2011). Veiga *et al.* (2011) reportedarbuscular mycorrhizal fungi (AMF) are known for their beneficial effects on plants; however, there is growing signals that some plants and agricultural weeds were respond negative impact to AMF colonization. Tahira *et al.* (2012) reportedfourteen weed species and belonging to eight angiospermic families were studied for arbuscular mycorrhizal association, the infection was maximum on*Sonchusaspera L.* (81.2%), followed by *Cynodondactylon* (70.1%), *Oxalis corniculata* (69.3%), *Malvastrum, Coromandelianum* (68.2%), and *Phalaris minor* (66.5%). However, *Ageratum conyzoides L.* (6.5%)and*Trifoliumresupinatum*(7.3%) were poorly colonized. Recently, It was find out the presence of weed plants such as *Dichanthiumcaricosum, Partheniumhysterophorus, Cynodondatylon, Dineberaretroflexa* and *Chrohrouscapsularis* in crop fields, it would be support for higher AM colonization and directly increased the biomass and yield of crop plants (Bhale, 2018). Feldman and Boyle (1998) reported various proofs that AMF enhance effective symbiosis with the crop plant and upholding a diverse AMF population and also found that the advantages of AMF to maize yield from keeping up a different weed cover species which overshadowed any yield penalty because of competition.

Table 1 AM root colonization and diversity in weed species growing in agricultural field (Rabiseason)

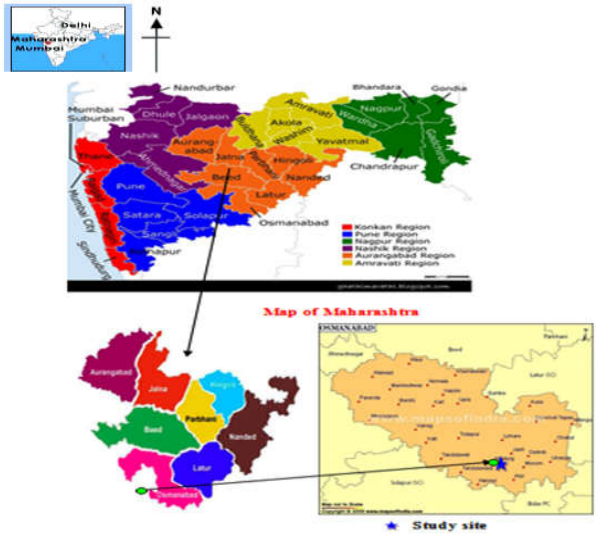
Sr. No.	Name of Weeds	Family	RC (%)	Types of RC	Spore density/100g	AM Richness
1	*Partheniumhysterophoru s*(L)	Asteraceae	71.87±2.22	HAV	402±2.33	*Acaulospora,Glomus*
2	*Celosia argentea*(L)	Amaranthaceae	65.62±3.77	HAV,DSE	668±6.22	*Acaulospora,Glomus*
3	*Euphorbia hirta*(L)	Euphorbiaceae	66.66±5.11	AH	338±12.11	*Acaulospora,Glomus,Gigaspora*
4	*Cyprus rotundus*(L)	Cyperaceae	62.05±0.98	HAV	581±4.99	*Acaulospora,Glomus,Scutellospora, Sclerocystis*
5	*Cynodondactylon* (L) Pers.	Poaceae	71.87±4.22	HAV	860±2.99	*Acaulospora,Glomus,*
6	*Dichanthiumcaricosum*(L) A.Camus	Poaceae	84.0±3.22	HAV	814±10.11	*Acaulospora,Glomus,*
7	*Dineberaretroflexa*(Vahl)Panz.	Poaceae	75.44±5.99	HAV	567±3.23	*Glomus*
8	*Commelinabenghalensis*(L)	Commeliniaceae	50.00±4.11	VH	742±11.11	*Acaulospora,Glomus*
9	*Commelinaalbescens*(L)	Commeliniaceae	53.33±5.23	HAV	1070±7.66	*Acaulospora*
10	*Abutilon indicum*(L)	Malvaceae	62.5±6.22	VH,DSE	287±7.11	*Acaulospora,Glomus, Sclerocystis*
11	*Corchoruscapsularis*(L)	Tiliaceae	70.83±2.11	H	391±12.71	*Acaulospora,Glomus*
12	*Corchorusolitorius*(L)	Tiliaceae	47.61±1.11	VH	427±4.11	*Acaulospora,Glomus,*
13	*Abelomoschusmanihot* (L.) Medik	Malvaceae	41.56±2.11	AV	317±3.99	*Acaulospora,Gigaspora*

Legends: Values are means of three replicates; standard error (±), RC-root colonization; A-arbuscular; V-vesicular; H-hyphal, DSE-dark septate endophyte.

Table 2 AM root colonization and diversity in weed species growing in agricultural field (Kharif season).

Sr. No.	Name of Weedy	Family	RC (%)	Types of RC	Spore Density/100g	AM Genera recovered
1	*Partheniumhysterophorus*(L)	Asteraceae	68.75±4.11	HAV	460±11.23	*Acaulospora*
2	*Alternenthera sessilis* (L.) R.Br. ex DC	Amaranthaceae	78.12±2.11	AV,DSE	322±5.99	*Acaulospora,Glomus*
3	*Acalyphaciliata*Forssk.	Euphorbiaceae	65.62±4.23	HAV	694±12.11	*Acaulospora,Glomus,Gigaspora*
4	*Corchoruscapsularis*(L)	Tiliaceae	62.00±3,11	HAV	293±9.11	*Acaulospora,Glomus, Scutellospora,Sclerocystis*
5	*Commelinabenghalensis*(L)	Commeliniaceae	56.25±9.11	HAV	245±3.67	*Acaulospora,Glomus*
6	*Commelinaalbescens*(L)	Commeliniaceae	71.87±12.99	HAV	791±4.87	*Acaulospora,Glomus*
7	*Cyprus rotundus*(L)	Cyperaceae	50.00±4.33	AV	486±4.22	*Acaulospora,Glomus*
8	*Phyllanthusniruri*(L)	Euphorbiaceae	59.37±2.99	HAV	770±6.33	*Glomus*
9	*Digeramuricata*(L) Mart.	Amaranthaceae	68.75±1.99	HAV	581±3.11	*Acaulospora,Glomus*
10	*Physalis angulate* (L)	Solanaceae	75.00±2.77	HAV	446±4.22	*Acaulospora,Glomus, Sclerocystis*
11	*Celosia argentea*(L)	Amaranthaceae	81.25±3.22	HAV,DSE	445±255	*Acaulospora,Glomus*
12	*Cynodondactylon*(L) Pers.	Poaceae	62.00±4.55	HAV	624±12.33	*Acaulospora*
13	*Dichanthiumcaricosum*(L) A. Camus	Poaceae	64.27±2.66	HAV	428±14.11	*Acaulospora,Gigaspora*
14	*Cassia tora*(L)	Caesalpinaceae	85.12±3.11	HAV	726±9.00	*Acaulospora, Glomus*

Legends: Values are means of three replicates; standard error (±) RC-root colonization; A-arbuscular; V-vesicular; H-hyphal, DSE-dark septate endophytes



Osmanabad District

Fig 1 Map showing the study location.

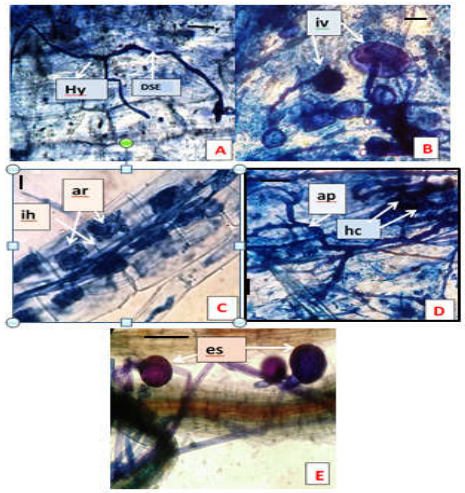
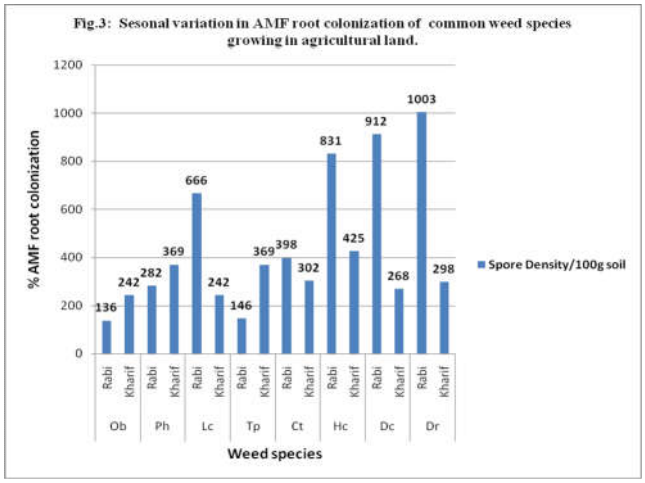


Fig 2 AM colonization in the roots of weed species growing in agricultural land (400X),A-Hyphal colonization (hy), **B**-Intra-radical vesicles (iv) , **C**-Intercellularhyphal and Arbuscular colonization (ih,ar), **D**-Appressorium and hyphal coils (ap,hc), **E**- Extra-radical spore (es) (Sale Bars =100µm)

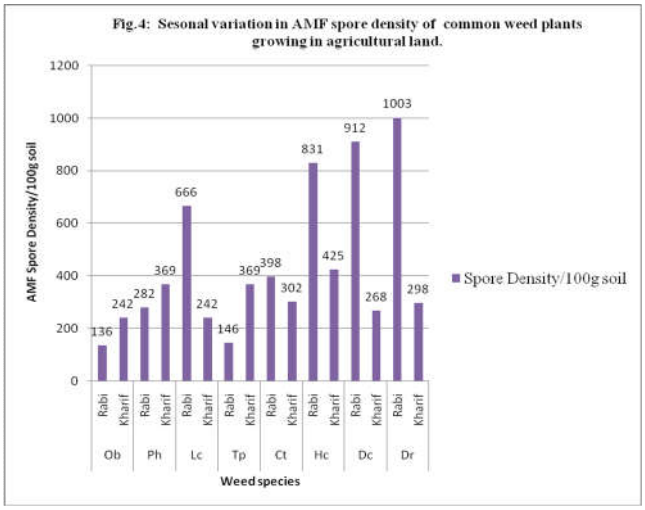
Table 3 Seasonal variation of common weed species in agricultural fields

Sr. No.	Name of Weeds	Family	Season	RC (%)	Types of RC	Spore Density/100g soil	AM Genera
1	*Partheniumhysterophorus*(L)	Asteraceae	Rabi	68.75±4.11	HAV	460±11.23	*Acaulospora,Glomus*
			Kharif	68.75±4.11	HAV	460±11.23	*Acaulospora*
2	*Corchoruscapsularis*(L)	Tiliaceae	Rabi	47.61±1.11	VH	427±4.11	*Acaulospora,Glomus*
			Kharif	62.00±3,11	HAV	293±9.11	*Acaulospora,Glomus, Scutellospora,Sclerocystis*
3	*Commelinabenghalensis*(L)	Commeliniaceae	Rabi	50.00±4.11	VH	742±11.11	*Acaulospora,Glomus*
			Kharif	56.25±9.11	HAV	245±3.67	*Acaulospora,Glomus*
4	*Commelinaalbescens*(L)	Commiliniaceae	Rabi	53.33±5.23	HAV	1070±7.66	*Acaulospora*
			Kharif	71.87±12.99	HAV	791±4.87	*Acaulospora,Glomus*
5	*Cyprus rotundus*(L)	Cyperaceae	Rabi	62.05±0.98	HAV	581±4.99	*Acaulospora,Glomus, Scutellospora,Scleroystis*
			Kharif	50.00±4.33	AV	486±4.22	*Acaulospora,Glomus*
6	*Celosia argentea*(L)	Amaranthaceae	Rabi	65.62±3.77	HAV,DSE	668±6.22	*Acaulospora,Glomus*
			Kharif	81.25±3.22	HAV,DSE	445±255	*Acaulospora,Glomus*
7	*Cynodondactylon*(L) Pers	Poaceae	Rabi	71.87±4.22	HAV	860±2.99	*Acaulospora,Glomus*
			Kharif	62.00±4.55	HAV	624±12.33	*Acaulospora*
8	*Dichanthiumcaricosum*(L) A. Camus	Poaceae	Rabi	84.0±3.22	HAV	814±10.11	*Acaulospora,Glomus*
			Kharif	64.27±2.66	HAV	428±14.11	*Acaulospora,Gigaspora*

Legends: Values are means of three replicates; standard error (±) RC-root colonization; A-arbuscular; V-vesicular; H-hyphal, DSE-dark septate endophytes



Legends: Ph-*Parthenium hysterophorus*, **Cc-***Corchoruscapsularis*,**Cb-***Commelinabenghalensis*,**Cr-***Cyprus rotundus*, **Ca-** *Commelinaalbesens*, **Car-***Celosia argentea*, **Cd-***Cyanodondactylon*, **Dc-***Dicanthiumcaricosum.*



Legends: Ph-*Parthenium hysterophorus*, **Cs-***Corchoruscapsularis*,**Cb-***Commelinabenghalensis*,**Cr-***Cyprus rotundus*, **Ca-** *Commelinaalbesens*, **Car-***Celosia argentea*, **Cd-***Cyanodondactylon*, **Dc-***Dicanthiumcaricosum.*

Table 4 AM fungal species from weed species found in agricultural fields.

Sr. No.	AMF Species	Family
1.	*Acaulosporarehmii*Sieverding& Toro	Acaulosporaceae
2.	*Glomus macrocarpum* Tulasne & Tulasne	Glomeraceae
3.	*Glomus microaggregatum*	Glomeraceae
4.	*Glomus delicata* walker, Pfeiffer & Bloss	Glomeraceae
5.	*Glomus geosporum*Walker	Glomeraceae
6.	*Sclerocystis* sp. (unidentified)	Glomeraceae

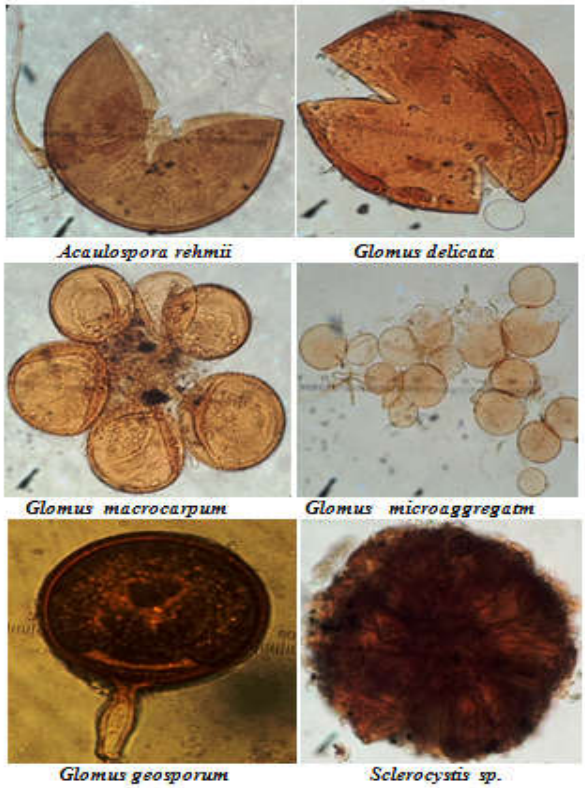


Fig 5 Showing different species of AM fungi identified during the study (Sale Bars=50µm)

CONCLUSION

Study concluded that, five species i.e. *Partheniumhysterophorus, Corchoruscapsularis, Cyprus rotundus, Cyanodondactylon* and *Dichanthiumcaricosum* recorded higher percent AM colonization in *rabi* season as compared to *kharif*. Weed species differed in the response to AM root colonization. While mycorrhizal symbiosis had no effects on the growth of non-competitive weeds, competitive weed growth was positively influenced by the present of the fungal symbiont. . In almost all weedy plants, AM spore density was greater in the rabi season than in the kharifwith the exception of *Parthiniumhysterophorus*. Our finding is considerable variation among common agronomic weed species in AMF colonization and communities on AMF diversity and abundance.

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