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Association of arbuscular mycorrhizal fungi in some plants of amaranthaceae*

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Abstract: Arbuscular mycorrhizal (AM) fungal associations in majority of terrestrial plants are universal. AM fungal association on amaranthaceae considered to be disputed. The present studies enlist the prevalence of AM fungal colonization in amaranthaceae. Field studies were undertaken to screen AM fungal association and isolate interesting AM fungal spores. Twenty three plants have screened for AMF which were grown in agricultural fields. Altogether thirty five indigenous AM fungal spores are recovered from this study. There was variation in the mycorrhizal colonization and spore number. Therefore, the present study revealed that the genus *Glomus* was more predominant than others and *Scutellospora* was least amongst the recovered AMF spores. The presence fungal components in the roots and the spore number in the soil has brought possible mycorrhizal association with varied per cent of colonization in members of Amaranthaceae

Key words: mycorrhiza, root colonization, spore number, terrestrial plants

Introduction

Arbuscular mycorrhizae (AM) are regarded as a mutualistic association in which plant provides the fungus with assimilates in exchange for mineral nutrients and water. (Smith and Read, 1997). In natural communities, approximately 80% of higher plants are obligatorily dependent on fungal associates and 18% typically non mycorrhizal (Trappe, 1987). This is in contrast to the antagonistic interactions of plants and pathogenic fungi, with defense mechanism of Arbuscular mycorrhizal fungal relationship with plants which can increase the growth of plants by enhancing phosphate uptake mainly and perhaps the other minerals such as K, Fe, Cu, Ca and Zn (Lakshman, 2009).

Families such as chenopodiaceae, fumariaceae, polygonaceae, proteaceae, cyperaceae, utriculaceae, amaranthaceae and commelinaceae are widely thought to be non mycorrhizal (Oringa *et al.,* 1997). A large number of species belonging to different families are not colonized by mycorrhizal fungi (Meada, 1954; Harley and Harley, 1987). However, mycorrhizae are absent or rarely present in some species of distinct families and it has been pointed out that members of these particular families need not always have non mycorrhizal status (Hirrel *et al.,* 1978; Lakshman *et al.,* 2001). The present study enlists the prevalence of AM colonization in some disputed plants of amaranthaceae where these plants are grown in agricultural soils.

Material and methods

Rhizospheric soil and roots of plants belonging to Amaranthaceae were collected from agricultural lands in September-December, 2009 from selected places of Dharwad district in Karnataka which is geographically situated in between 140 15' and 150 50' North longitude and 740 48' and 760 20' East latitude. For each species, eight plants were sampled, roots were dug out, washed to remove soil and stored in FAA (Formalin Aceto Alcohol) prior to staining. Rhizosphere soil samples of individual plants within the species were mixed; one part was used for the analysis and enumeration of AM fungal spores and other for the analysis of soil characteristics. Twelve soil variables were measured and nutrients estimated following the Jackson method (1973). Temperature of the rhizospheric soil was measured in the sampling spots using mercury thermometer at a depth of 10-20 cm. Percentage of organic matter was determined according to Piper, (1950). Electrical conductivity was measured by using a bridge meter and pH by mixing with soil and water at (1:1) ratio. Root bits (size 1cm) were boiled in 10% of KOH for 15-20 min. washed in tap water and stained in 0.05% Tryphan blue in lacto phenol following the method of Phillips and Hayman (1970) and percentage of AM colonization was estimated by the magnified intersection. AM fungal spores were recovered by the wet sieving and decanting technique (Gerdemann and Nicolson, 1963). Spores were mounted in polyvinyl alcohol lacto phenol and identified using a manual (Schenck and Perez, 1990).

Results and discussion

Soil and root samples were collected from ten agricultural fields in Dharwad district which possess lower phosphorus content. They were analyzed for presence of AM fungi. Twenty three plants belonging to amaranthaceae exhibited varied range of per cent root colonization. Fungal components consist of vesicles, arbuscules with coiled hyphae. Vesicles were more and they ranged from 11.50% to 18.48% in *Amaranthus blitum, Alternanthera echinata, Celosia cristata, Gomphrena globosa, Pupalia lappaceae* and *Alternanthera sessilis*. Higher numbers of arbuscules were observed in *Amaranthus polygamus, Amaranthus caudatus, Altenanthera triandra, Celosia argentea, Celosia albida* and *Amaranthus paniculatus* (Table.1). Highly coiled hyphae were seen in the macerated root samples of *Amaranthus caudatus, Amaranthus gangeticus, Aerva lanata, Celosia albida* and *Gomphrena decumbens*. The lowest spore number of 11 was recorded in *Celosia polygonoides* and the highest number of.36 was in *Celosia albida.* Table.2 gives the presence or absence of specific AM fungal spore species in ten selected agricultural areas. The results revealed that the genus *Glomus* was more predominant than others and *Acaulospora, Gigaspora* and *Sclerocystis* occupied second and third position respectively. Scuttelospora was in the least number amongst recovered AMF spores. There

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Table 1. Incidence and extent of AM fungal colonization in plants of amaranthaceae grown in Dharwad district in Karnataka

Plant species	% of Root colonization		Coiled hyphae	Spore number/10 g air dried soil
	Vesicle	Arbuscules		
Achyranthes aspera L.	2.50 ± 1.53	12.41 ± 1.97	11.70 ± 4.13	21.95 ± 6.90
Aerva javanica Juss.	0.74 ± 0.03	3.30 ± 0.00	5.93 ± 4.63	16.52 ± 9.50
Aerva lanata Juss.	0.812 ± 0.03	3.10 ± 0.35	18.05 ± 0.40	19.30 ± 7.40
Aerva monosoniae Mart.	2.10 ± 0.00	3.75 ± 0.33	4.05 ± 1.53	17.30 ± 6.27
Allamania nodiflora R.Br.	2.50 ± 0.00	2.82 ± 0.00	1.15 ± 0.00	20.27 ± 5.23
Alternanthera echinata Sm.	12.17 ± 2.72	5.10 ± 0.00	36.5 ± 10.10	41.30 ± 11.79
Alternanthera sessilis R. Br.	11.48 ± 3.21	5.21 ± 0.003	22.10 ± 1.10	21.11 ± 9.31
Alternanthera triandra Forsk.	7.01 ± 0.02	13.00 ± 1.00	19.02 ± 0.34	27.80 ± 4.53
Amaranthus blitum L.	11.50 ± 0.00	06.03 ± 4.00	14.51 ± 3.01	33.10 ± 7.40
Amaranthus caudatus L.	5.97 ± 1.14	15.62 ± 4.23	19.20 ± 5.75	34.15 ± 1.32
Amaranthus gangeticus L.	1.48 ± 2.00	2.58 ± 0.00	02.54 ± 4.12	23.50 ± 9.52
Amaranthus paniculatus L.	7.50 ± 1.50	17.97±10.34	14.18±11.43	21.95 ± 8.12
Amaranthus polygamus L.	6.08 ± 2.04	11.85 ± 2.65	14.53 ± 4.35	19.63 ± 9.20
Amaranthus spinosus L.	4.60 ± 4.12	3.80 ± 0.00	11.59 ± 4.10	21.92 ± 9.40
Amaranthus viridis L.	9.10 ± 4.12	1.01 ± 0.00	08.00 ± 3.40	18.53 ± 5.32
Celosia argentea L.	7.05 ± 3.05	11.01 ± 5.31	16.30 ± 5.50	19.54 ± 8.06
Celosia cristata L.	14.00 ± 3.31	9.00 ±1.36	21.00 ± 7.12	27.34 ± 4.32
Celosia polygonoides Retz.	5.12 ± 3.12	3.50 ±1.00	7.00 ± 4.32	11.42 ± 4.32
Celosia albida L.	4.09 ± 2.8	14.65 ± 4.14	24.12 ± 5.62	36.21 ± 1.25
Digera arvensis Forsk.	7.10 ± 2.00	4.13 ± 1.37	10.02 ± 3.22	23.52 ± 11.56
Gomphrena decumbens Jacq.	4.23 ± 1.77	0.00 ± 0.00	31.52 ± 4.70	32.90 ± 12.50
Gomphrena globosa Linn.	14.12 ± 6.32	3.13 ± 1.12	9.02 ± 2.43	24.26 ± 10.25
Pupalia lappaceae Moq.	13.00 ± 8.41	0.59 ± 1.54	8.00 ±2.48	22.32 ± 9.32

were finger shaped (irregular) arbuscules with very small, medium and large vesicles as shown in plate1. Many coiled running hyphae with appressorium were observed in *Amaranthus viridis* roots. Higher numbers of *Glomus* species were recorded in the present study. These observations are in consistence with early workers (Mosse, 1990; Rani and Bhaduria, 2001). Some of the selected AMF spores were micro photographed and presented in plate 2. AM Fungi are a great component of soil microbial biomass. This symbiosis benefits plant growth, particularly by enhancing phosphorus, water and mineral nutrient uptake (Li *et al.,* 1991). This association may be important, as most of the amaranthaceae members are growing in agricultural soils.

The hyphae of AM fungi play an important role in the formation and stability of soil aggregates and contribute to the composition of plant community structures (Smith and Read, 1997). In the present work, there were large numbers of hyphae in plant roots. The role of root exudates is once mycorrhizal colonization has occurred, subsequent exudation released by the root may be modified both through the mycorrhizal fungus acting as a considerable carbon sink for photo assimilates and through the hyphal exudation. This may be expected to lead to changes in both the qualitative and quantitative release of exudates into the mycorrhizosphere *(*Hale *et al., 1971)*. Germination of AM fungal spores and the initial growth of hyphal germ tubes can occur in the absence of the plant. Experimental evidence indicates that the quality and source of exudates play an important role in triggering germination and AM fungi respond to host exudates with extensive hyphal growth and branching (Giovannetti *et al.,* 1993). Nagahashi and Douds (2000) showed that in response to a soluble host factor derived from the roots, the branching pattern of *Gigaspora gigantia* changed from dense to scattered. The topographical or biochemical signals on the root surface may be necessary for appressorium formation (Gadkar *et al.,* 2001). Although components of root exudates are capable of stimulating hyphal growth and branching, they are unable to elicit the formation of appressoria, which were observed only on intact plant root. The experiment confirms that the branching signal is either loosely bound to the wall or exuded from the roots. In *Gomphrena globosa* L. possess the branching type of hyphae and appressorium were observed in the present study (Plate 1).

The present work clearly showed that amaranthaceae members possess AM fungal colonization with low per cent colonization in roots. However, this study needs detailed biochemical analysis of roots and examination AMF association of Amaranthaceae in cultivated soils.

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Table 2. Distribution of species of AM fungal spores in 10 different agricultural soils of Dharwad district in Karnataka

Species of AM fungi	Places of agriculture area									
	a	b	c	d	e	f	g	h	i	j
Acaulospora										
Acaulospora scrobiculatum Trappe.	+	-	+	+	+	-	-	+	-	-
A.denticulata Sieverding and Toro.	+	-	+	-	-	+	+	-	-	-
A. delicate Walker, Pfeiffer and Bloss.	-	+	-	-	-	-	-	+	-	-
A. Laevis Gerdemann and Trappe.	+	+	-	+	+	-	+	-	+	+
A. spinosa Walker and Trappe.	-	-	+	-	-	+	-	-	-	+
A. dilatata Morton.	-	+	-	-	-	+	+	-	-	-
Gigaspora										
Gigaspora rosea Nicolson and Schenck.	-	-	-	+	+	-	-	+	-	-
G. margarita Becker and Hall.	+	-	-	+	+	+	-	+	-	-
G.gigantea (Nicolson and Gerdemann) Gerdemann and Trappe.	+	+	-	+	-	-	-	+	-	-
G. ramisporophora Spain, Sieverding and Schenck.	+	-	-	-	-	-	-	-	-	-
G. decipiens Hall and Abbott.	-	+	-	-	-	-	-	-	+	-
Glomus										
Glomus mosseae (Nicolson and Gerdemann) Gerdrmann and Trappe.	+	+	+	+	-	+	+	-	+	+
G. fasciculatum Gerdemann and Trappe emend Walker and Koske.	+	-	+	-	-	+	-	+	+	+
G. aggregatum Schenck and Smith emend Koske.	-	+	+	-	-	-	-	+	+	+
G. microcarpum Tulasne and Tulasne.	-	+	-	-	+	+	-	-	-	-
G. intraradix Schenck and Smith.	-	-	+	-	-	+	-	-	-	-
G. deserticola Trappe, Bloss and Menge.	-	+	-	-	+	-	-	-	-	-
G. tenebrosum Berch.	+	+	-	-	-	+	-	-	-	-
G. etunicatum Becker and Gerdemann.	+	-	-	-	-	-	-	+	-	-
G. boreale Trappe and Gerdemann.	-	+	-	-	-	-	-	-	-	-
G. botryoides Rothwell and Victor.	+	-	+	-	-	+	-	-	-	-
G.geosporum (Nicolson and Gerdemann) Walker.	+	+	-	-	-	-	+	-	-	-
G. clarum Nicolson and Schenck.	-	-	-	-	+	-	-	-	-	-
G. fulvus (Berkeley and Broome) Trappe and Gerdemann.	-	-	-	+	-	+	-	-	-	-
G. macrocarpum Tulasne and Tulasne.	+	-	+	-	-	-	+	-	-	-
G. claroides Schenck and Smith.	-	-	-	-	-	+	-	-	-	-
G. occultum Walker.	+	-	+	-	-	-	-	-	+	-
G. flavisporum (M. Lange and Lund) Trappe and Gerdemann.	-	-	-	+	-	+	-	-	-	-
Sclerocystis										
Sclerocystis pachycaulis Wu and Chen.	+	-	+	-	-	-	-	+	-	-
S. dussii Von (Patouillard) Hohnel.	+	+	+	-	-	+	+	-	-	+
S. microcarpa Iqbal and Bushra.	-	-	+	-	-	-	+	-	+	-
S. sinuosa Gerdemann and Bakshi.	-	-	-	+	-	-	-	-	-	-
S. clavispora Trappe.	-	+	-	-	-	-	+	-	-	-
Scutellospora										
Scutellospora calospora (Nicolson and Gerdemann) Walker and Sanders.	+	-	-	-	-	-	+	-	-	-
Enterophosphora.										
Enterophosphora schenckii Sieverding and Toro.	-	+	-	-	-	-	+	-	-	-

+: present; -: absent.

a. Manasuru, b. Mondihala, c. Nuggikeri, d. Varuru, e. Kudagola, f. Kyarakoppa, g. Garaga, h. Yattinagudda, i. Byahatti, j. Bhadrapura.

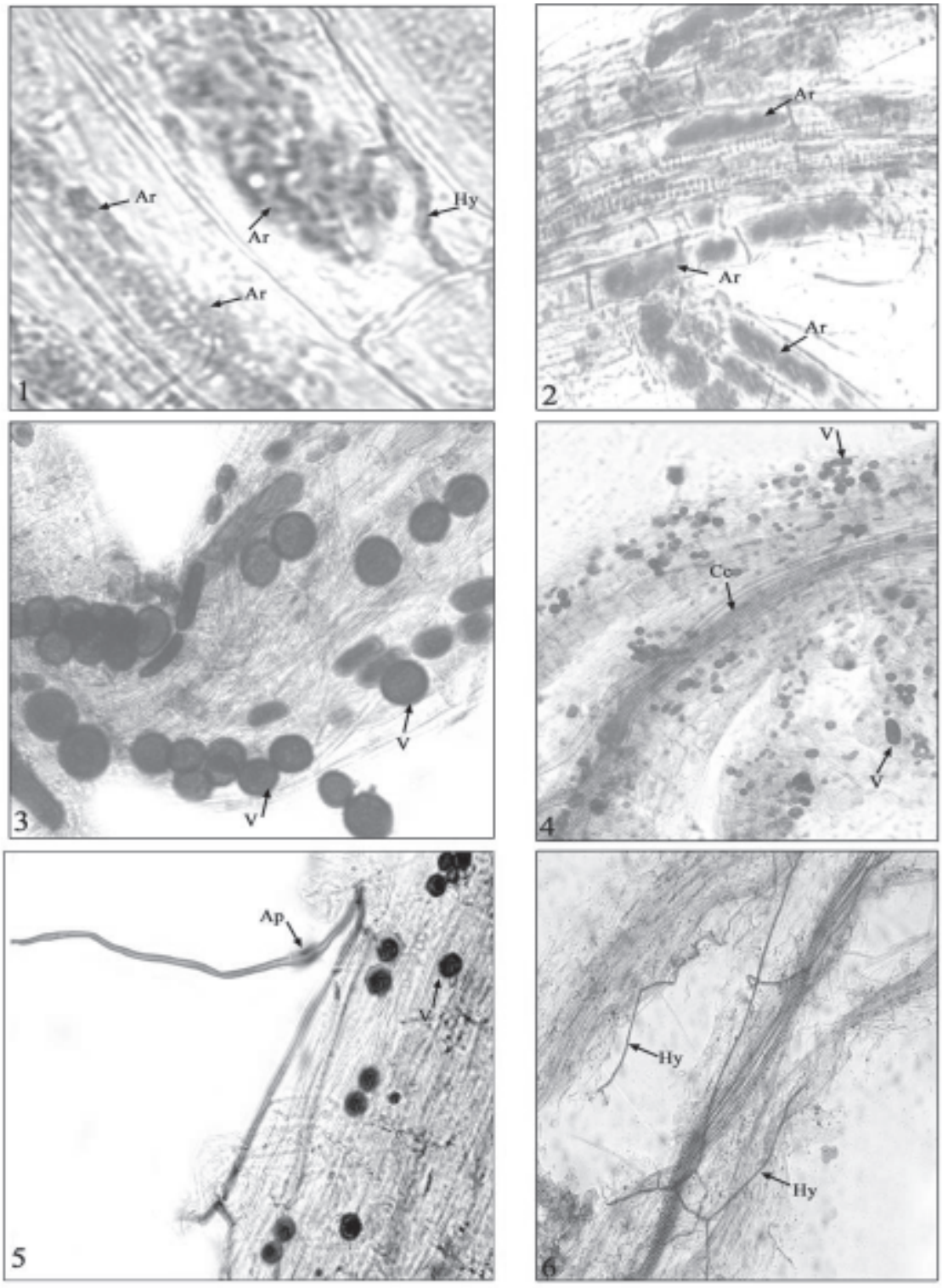

Plate 1. Showing arbuscular mycorrhizal fungal components in macerated root sections of different plants species of amaranthaceae.

Ar-Arbuscules, Hy-Hyphae, V-Vesicle, Ap- Appressorium, Cc - Central cylinder

Fig. 1 : Arbuscules and hyphae in cacerated root sample of *Alternathera echinata S.*

Fig. 2 : Irregularly distributed arbuscules in root sample of *Amaranthes paniculatus* L.

Fig. 3-5 : Large, small and medium sized vesicles in the root samples of *Achyranthus aspera* L.,

Fig. 5-6 : Hypha entering to epidermis through cuticle from interside in *Amarnathus viridis* l. and running coiled hyphae in *Gomphrena globosa* L. root sample.

Figures are not in scale

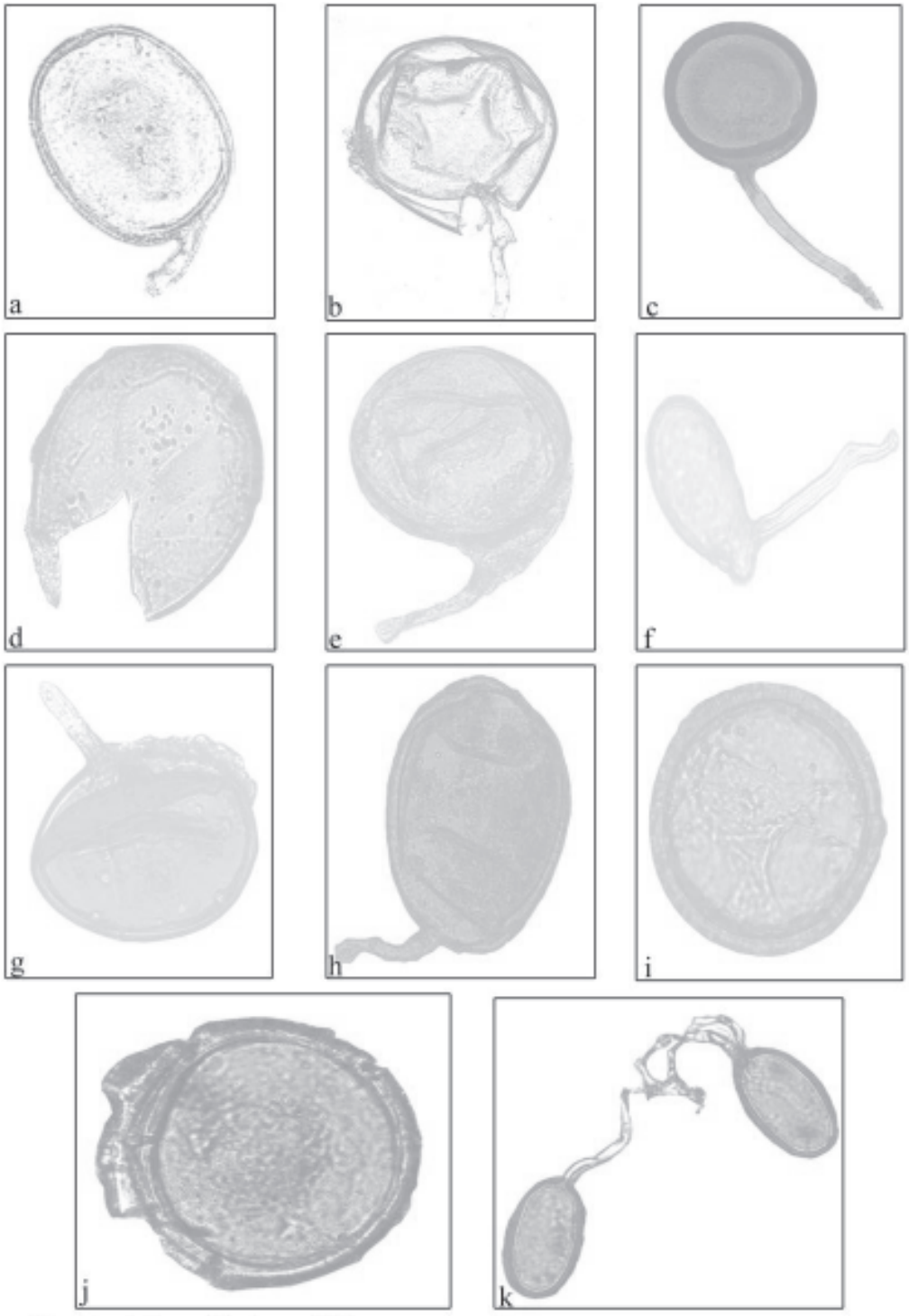

Plate 2. Showing some important arbuscular mycorrhizal fungal spores recovered from rhizosphere of amarnthaceae species.

a - *Glomus boreale* Trappe & Gerdemann.(100x)
b - *Acaulospora* scrobiculata Trappe. (100x)
c - *Glomus tenebrosum* Berch. (100x)
d - *Acaulospora dialtata* Morton. (100x)
e - *Glomus mosseae* (Nicolson & Gerdemann) Gerdemann & Trappe. (100x)
f - *Scterocystis clavispora.* (100x)
g - *Glomus geosporum* (Nicolson & Gerdemann) Walker. (100x)
h - *Glomus fasciculatum* (Gerdemann & Trappe emend) Walker and Koske. (100x)
i - *Glomus intraradix* Scheck & Smith. (100x)
j - *Glomus ckaroides* Schenck & Smith. (100x)
k - *Glomus flavisporum* Trappe & Gerdemann. (40x)

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