Arbuscular mycrorrhizal association in popular banana (*Musa* sp.) variety from the state of Goa

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Introduction

Banana (*Musa* sp.), a large herbaceous perennial plant, is so popular that backyards of practically every house in the rural areas of Goa contain banana plants. Family Musaceae, to which banana belongs, contains two genera—*Musa* and *Ensete*. *Ensete* is used for extracting fibre and as a vegetable. *Musa* is best divided into four sections. Of these, *Emusa* contains majority of edible banana derived from *Musa accuminata* (AAA) and *Musa balbisiana* (BBB). At present, in Goa, banana plantation occupies an area of 1875 hectares, with corresponding production of 10 650 tonnes, which is sufficient to meet 40% of the banana requirement of the state. The balance 60% is met by import from neighbouring states.

Symbiotic mycorrhizal association between fungi and roots of higher plants is a common feature and is gaining importance due to the fact that it enhances plant productivity. The ecological and economical value of arbuscular mycorrhizae can be directly inferred from the fact that about four-fifths of all land plants, including the agronomically important crops, form this type of mycorrhiza (Azcón-Aguilar and Barea 1997). AM (arbuscular mycorrhizal) symbiosis influences several aspects of plant physiology, such as mineral nutrition, plant development, and plant protection (Gianinazzi, Trouvelot, and Gianinazzi-Pearson 1990). The primary aim of AM symbiosis is to increase the supply of mineral nutrients, particularly those, the ionic forms of which have poor mobility rate or those that are present in low concentration in soil solution. This mainly includes phosphate, ammonium, zinc, and copper (Barea 1991).

AM colonization in several banana varieties has been studied in India by Girija and Nair (1988). The AM populations associated with banana have been studied by Arias, Balanco, Vargas, *et* al. (1998) in the Caribbean region of Costa Rica, and the ones associated with seasonality have been studied by Khade and Rodrigues (2004) in the state of Goa. In the present study, the AM associations and distribution of AMF (arbuscular mycorrhizal fungi) in popular banana cultivar, for example, Saldatti (AAB) from North Goa, have been investigated.

Materials and methods

Sample collection

Commonly occurring Saldatti variety from agricultural farms of Mapusa, Old Goa, and Valpoi was surveyed for AM association. Selection of the sites was carried out on the basis of the type of soil. All the plants selected for the study at these sites were medium to tall fruit-bearing plants. Five plants per variety were selected for study from each site. At each site, roots and rhizospheric soil samples of Saldatti variety were collected from the field at a depth of 10–20 cm, placed in plastic bags, labelled, and transported to the laboratory. All the samples were collected in May 1998 when the air temperature varied between 34.6 °C and 27.9 °C and humidity ranged from 66% to 77%.

Root samples were freshly processed, whereas, the soil samples were stored at 4 °C until further analysis. The roots were cleared and stained in 0.05% trypan in lactoglycerol (Phillips and Hayman 1970), and the degree of colonization was estimated by slide method (Giovannetti and Mosse 1980). Spores of AMF were isolated by wet sieving and decanting method (Gerdemann and Nicolson 1963), and quantification of spore density was carried out (Gaur and Adholeya 1994). AMF were identified to species level using bibliographies provided by Schenck and Perez (1990), Almeida and Schenck (1990), and Walker and Vestberg (1998). Standard deviation was calculated for mean root colonization and mean spore density of AMF.

Rhizosphere soil samples per plant species were used for analysis. Soil pH was measured in 1:2 soil water suspension by using a pH meter. Electrical conductivity was measured at room temperature in 1:5 soil suspension by using a conductivity meter. Standard soil analysis techniques, for example, Walkley and Black's (1934) rapid titration method, micro-Kjeldahl method (Jackson 1971), and a method by Oleson, Cole, Watanabe, *et al.* (1954) were employed for

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determination of organic carbon, total nitrogen, and available phosphorous, respectively. Available potassium was estimated by ammonium acetate method (Hanway and Heidel 1952) by using flame photometer. Metals like aluminium, arsenic, cadmium, chromium, copper, iron, manganese, nickel, lead, and zinc were quantified by using atomic absorption spectrophotometer.

Diversity indices

Species richness per site is the mean number of AM fungal species associated with each site (Beena, Raviraja, Arun, *et al.* 2000).

Results

Data on rhizospheric soil analysis of three study sites is presented in Table 1. The soil was acidic to near neutral and electrical conductivity was found to be satisfactory. The total nitrogen and available phosphorous levels were limiting, while the available potassium levels were low to medium. Data on micronutrient analysis of soils samples at the study sites is presented in Table 2. All the four micronutrients, that is, Zn, Cu, Fe, and Mn, were found in high levels in the rhizosphere soil of Saldatti variety. Data on mycorrhizal association in Saldatti variety is presented in Table 3. Root colonization was characterized by the presence of hyphae, arbuscules, and vesicles.

Root colonization ranged from 37% (Mapusa) to 58% (Old Goa), while spore density ranged from 91.04 (Mapusa) to 403.65 (Old Goa) spores 100 g/rhizosphere soil.

Data on the distribution of AMF associated with Saldatti variety from three study sites is presented in Table 4. A total of 11 species of AMF belonging to two genera, that is, *Acaulospora* and *Glomus*, were recorded. *Glomus claroideum* Schenck and Smith emend. Walker and Vestberg was the predominant species followed by *Glomus* sp. in

Table 1 Comparative account of edaphic factors and macronutrients in the rhizosphere soil of Saldatti (*Musa* sp.) variety

Variety	*Locality*	*Type of soil*	*pH**	*EC**(mhos/cm)
Saldatti	Mapusa	Lateritic soil	6.3 ± 0.21	0.04 ± 0.00
Saldatti	Valpoi	Clayey loam	6.6 ± 0.25	0.98 ± 0.01
Saldatti	Old Goa	Alluvial soil	5.7 ± 0.07	0.86 ± 0.03

*Values indicate n = 5 ± 1 SD

Table 2 Comparative account of micronutrients in the rhizosphere soil of banana (*Musa* sp. of Saldatti) variety

		*Micronutrients** (µg/gm)			
Variety	*Locality*	*Zn*	*Cu*	*Fe*	*Mn*
Saldatti	Mapusa	1.72 ± 0.68	2.84 ± 0.18	13.84 ± 1.28	22.65 ± 3.36
Saldatti	Valpoi	1.67 ± 0.12	3.75 ± 0.18	18.55 ± 1.66	23.84 ± 0.83
Saldatti	Old Goa	2.95 ± 0.32	3.84 ± 0.28	12.63 ± 1.62	19.51 ± 2.62

Zn – zinc; Cu – copper; Fe – iron; Mn – mangenese
*Values indicate n = 5 ± 1 SD

Table 3 Comparative account of spore density and root colonization in Saldatti *(Musa* sp.) variety

Variety	*Locality*	*Spore density** (100g/rhizosphere soil)	*Root colonization** (%)
Saldatti	Mapusa	91.04 ± 11.71	37 ± 2.89
Saldatti	Valpoi	381.96 ± 30.45	55 ± 4.56
Saldatti	Old Goa	403.65 ± 21.55	58 ± 5.77

*Values indicate n = 5 ± 1 SD

Table 4 Distribution of AMF in Saldatti variety from the study sites

AMF	*Mapusa*	*Valpoi*	*Old Goa*
Acaulospora nicolsonii Walker, Reed and Sanders	–	+	–
Glomus claroideum Schenck and Smith emend. Walker and Vestberg	+	+	+
Glomus geosporum (Nicol. and Gerd.) Walker	–	–	+
Glomus globiferum Koske and Walker	–	–	+
Glomus heterosporum Smith and Schenck	–	–	+
Glomus monosporum Gerdemann and Trappe	–	–	+
Glomus clavisporum (Trappe) Almeida and Schenck	–	+	–
Species richness	**1**	**3**	**5**

AMF – arbuscular mycorrhizal fungi

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rhizospheric soils of Saldatti variety. The species richness of AMF in the present study ranged from one species (Mapusa) to nine species (Old Goa).

Discussion

In the present study, all the samples of Saldatti variety selected at the study sites recorded AM colonization. Similarly, Girija and Nair (1988) reported the natural incidence of AM colonization in commonly cultivated *Musa sapientum* L. from Kerala. The root colonization levels reported by them varied from 22.7% to 60.9%. The spore density in the present study ranged from moderate (Mapusa) to high levels (Valpoi and Old Goa). Similarly, high levels of AM populations were reported by Khade and Rodrigues (2004) in Savarbondi variety from Valpoi during summer. Our study recorded the presence of single species of *Acualospora* and 10 species of *Glomus* associated with Saldatti variety. Similarly, Khade and Rodrigues (2004) recorded three species of *Acualospora* and four species of *Glomus* associated with Savarbondi variety from Valpoi during summer. Our study supports the findings of Arias, Balanco, Vargas, *et al.* (1998), who reported that *Glomus* was dominant (nine species) followed by *Acaulospora* (four species) in three banana plantations in Caribbean region of Costa Rica.

In the present study, the soil types varied at the study sites. Lateritic soils of Mapusa recorded low levels of root colonization, spore density, and distribution of AMF, while clayey loam and alluvial soils of Valpoi and Old Goa recorded high levels of root colonization, spore density, and distribution of AMF. In general, the AM association and distribution in identical host cultivar under identical environmental conditions may be influenced by soil types.

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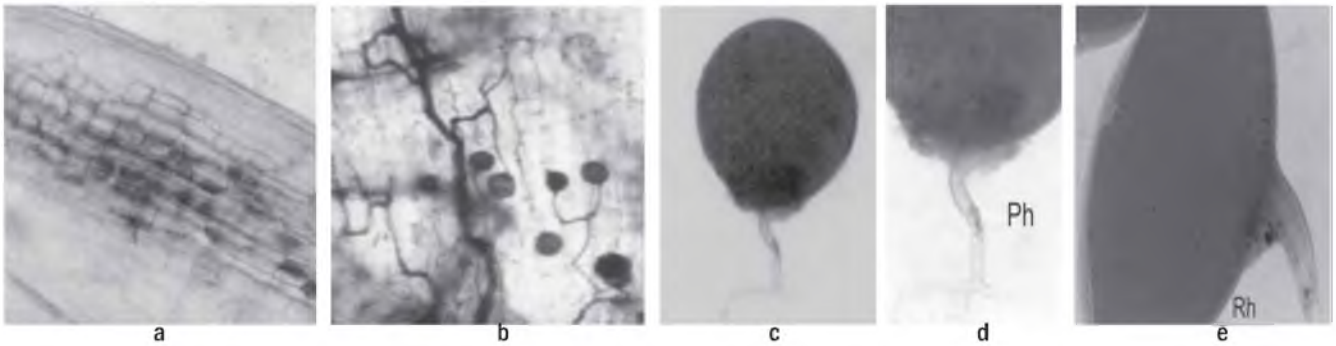

Figure 1(a) Arbuscular colonization of arbuscular mycorrhizal fungi (× 100).
Figure 1(b) Vesicular colonization of arbuscular mycorrhizal fungi (× 100).
Figure 1(c) A spore of *Glomus globiferum* Koske and Walker (× 100).
Figure 1(d) A portion of spore of *Glomus globiferum* attached to parent hyphae (Ph) Koske and Walker (× 400).
Figure 1(e) Crushed spore of *Glomus monosporum* with recurved hyphae (Rh) Gerdemann and Trappe (× 400).

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Influence of Arbuscular mycorrhizal fungi on plant biomass of *Euphorbia prostrata*

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Introduction

Symbiotic associations between AMF (arbuscular mycorrhizal fungi) and plant roots are widespread in the natural environment and can provide a range of benefits to the host plant. These include improved yield, nutrition, enhanced resistance to soil-borne pests and disease, improved resistance to drought, tolerance of heavy metals, and better soil structure (Gosling, Hodge, Goodlass, *et al.* 2006). Many agricultural crops are mycorrhizal and there is widespread, although equivocal, evidence that crop plants benefit from the AM (arbuscular mycorrhizal) association in the same way.

Organic farming has developed from a wide number of disparate movements across the world, into a more uniform group of farming systems. Though the

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