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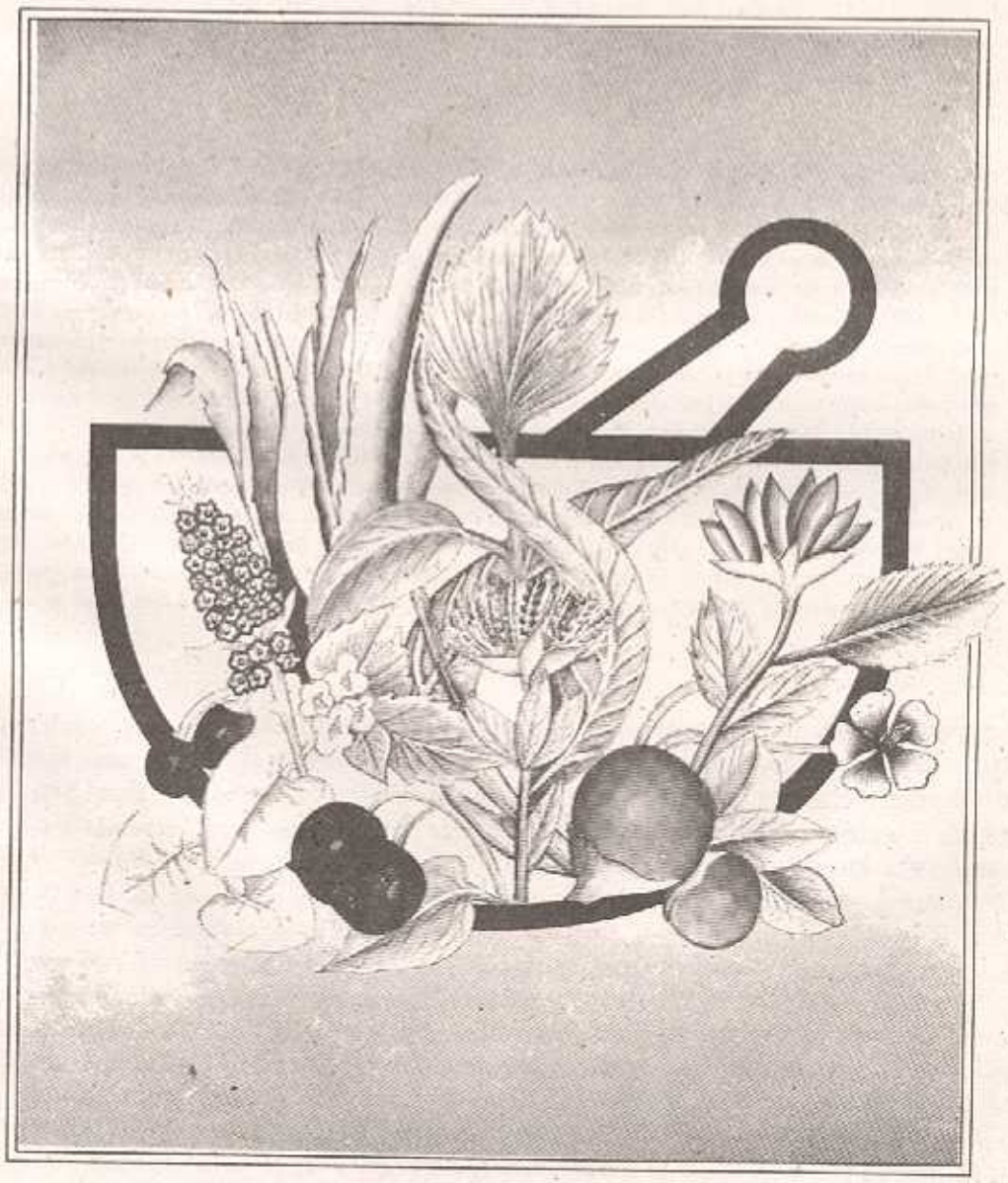

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Biodiversity of Arbuscular Mycorrhizal Fungi in Turmeric (*Curcuma domestica* Vahl.)

An Important Spice and Medicinal Plant in Bangladesh

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The status of colonization of Arbuscular Mycorrhizal Fungi (AMF) in the roots and AMF spore population in the rhizosphere soils of Turmeric (*Curcuma domestica* Vahl.) were assessed with the samples collected from Dashmail, Kantaji and Ramsagar of Dinajpur district, Thengamara of Bogra district and Boalmari of Faridpur district. Roots were assessed for AMF colonization after staining in aniline blue and rhizosphere soil samples were assessed for AM fungal spore population following wet sieving and decanting methods. Turmeric roots collected from different locations were found mycotrophic and the rhizosphere soil samples contained a large number of AMF spores. Significant variation of biodiversity of colonization and spore population were recorded in the present investigation. The range of AM colonization varied from 34% to 52% with the highest AM colonization was recorded from Kantaji (52%) and the lowest from Thengamara (34%). The range of mycelial, vesicular and arbuscular colonization was recorded as 34-52%, 24-48% and 26-40% respectively. Poor, moderate and abundant intensity was recorded as 51-71%, 21-40% and 5-22% for mycelial colonization; 34-67%, 21-54% and 4-24% for vesicular colonization and 54-81%, 17-39% and 2-22% for arbuscular colonization respectively. Total range of spore population was recorded as 54-154 with the highest from Boalmari (154) and the lowest from Dashmail (54). No correlation was found between percent colonization and the spore population. *Glomus* was dominant among the available AM fungal genera. Biodiversity of structural colonization in the roots and AM fungal genera in the rhizosphere soil samples of turmeric growing areas indicate the applicability of AM fungal technology in turmeric growing areas.

Introduction

Turmeric (*Curcuma domestica* Vahl., N.O. family Zingiberaceae) is popular in South Asian countries including Bangladesh for its medicinal value and usage as spice. This plant is easy to grow in the homestead garden, agroforestry systems, marginal lands, arid lands etc. It is grown allover Bangladesh particularly in the northern part of the country. Its leaves, inflorescence and rhizome (fresh and/or dried) are used as spice for everyday cooking in the households of Bangladesh. Because of its antiseptic properties, turmeric is widely used against poisonous affections, wounds, ulcers, skin diseases etc. It purifies blood by destroying pathogenic organisms. It is also used against cold, cough, bronchitis, conjunctivitis, liver affections etc. (Joshi, 2003).

In low fertile soils, mycorrhizal symbiosis has great potential to reduce production cost improving plant growth by taking up Phosphorus and micronutrients, controlling soil borne plant diseases, improving water balance and reducing drought stress (Dhar and Mridha, 2003). Reports on the occurrence of arbuscular mycorrhizae in turmeric from Pakistan are available (Nasim and Zahoor, 1995; Iqbal and Nasim, 1986). There is no detailed works on the biodiversity of arbuscular mycorrhizal associations with turmeric roots and soils in Bangladesh. In the present study, survey was conducted to observe the biodiversity of arbuscular mycorrhizal fungal colonization in the roots and the population of AM fungi in the rhizosphere soils of turmeric growing areas of Bangladesh to understand the present status for the management of mycorrhizal fungi to reduce the use of chemical fertilizers and to encourage the use of mycorrhizal biofertilizer.

Materials and Methods

Roots and rhizosphere soils of *Curcuma domestica* were collected from different parts of Bangladesh (Dashmail, Kantaji and Ramsagar of Dinajpur district, Boalmari of Faridpur district and Thengamara of Bogra district). Replicated samples of roots and rhizosphere soils were collected from each location. Fine roots and rhizosphere soils were collected by digging the soils of 0-15 cm depth. Roots were separated immediately from the soils and chopped into pieces of 1 cm length to assess the root colonization. The roots were cleaned and stained with aniline-blue following the method of Phillips and Hayman (1970) and Dhar *et al.*, (2005). At least fifty stained root segments were assessed and the percent of colonization was calculated by the following formula:

$$\% \text{ Colonization} = \frac{\text{Total number of positive segments}}{\text{Total number of segments studied}} \times 100$$

TABLE 1
Biodiversity of arbuscular mycorrhizal structural colonization in *Curcuma domestica*

Locations	Total colonization (%)			Intensity of structural colonization (%)								
				Mycelium			Vesicles			Arbuscules		
	Mycelium	Vesicles	Arbuscules	P[1]	M[2]	A[3]	P	M	A	P	M	A
Dashmail	36b*	48a	37a	54c	40a	5b	42b	54a	4c	61b	39a	–
Kantaji	52a	45a	38a	51c	27b	22a	38bc	52a	10b	57b	37a	6b
Ramsagar	48a	44a	40a	58b	21c	21a	67a	26b	7c	68b	21b	11b
Thengamara	34b	34b	37a	66b	34b	–	34c	51a	15b	54c	24b	22a
Boalmari	42ab	41a	26b	71c	24c	5b	55b	21b	24s	81a	17b	2c

Note: *Means followed by the same letter (s) are not significantly different at P<0.05.
[1]P = Poor, [2]M = Moderate, [3]A = Abundant.

TABLE 2
Biodiversity of arbuscular mycorrhizal spores in the rhizosphere soils of *C. domestica*

Locations	Total population	*Glm* (%)	*Scl* (%)	*Acl* (%)	*Ent* (%)	*Gig* (%)	*Scut* (%)
Dashmail	54c*	83a	4	7	–	6	
Kantaji	111b	90a	6	–	–	–	4
Ramsagar	84b	86a	–	–	5	9	–
Thengamara	106b	73b	–	13	7		7
Boalmari	154c	81a	5	9	–	5	–

Note: *Means followed by the same letter (s) are not significantly different at P<0.05.
Glm = *Glomus*, Scl = *Sclerocystis*, Acl = *Acaulospora*, Ent = *Entrophospora*, Gig = *Gigaspora*, Scut = *Scutellospora*.

Presence of mycelium was considered as AM positive and percent colonization of mycelium, vesicles and arbuscules were recorded to calculate the percent of structural colonization. Intensity of mycelial, vesicular and arbuscular colonization was recorded as poor, moderate and abundant (Dhar and Mridha, 2003) on the basis of individual structural colonization. Soils were studied earlier to avoid the damage and desiccation of the spores. From each sample, 100 g of soil was used for spore extraction. Spores were extracted by wet sieving and decanting method (Gerdemann and Nicolson, 1963; Dhar *et al.*, 2005). They were separated and identified (Schenck and Perez, 1990) mounting on PVLG and Melzer's reagent. Statistical analyses (correlation and DMRT) were performed using the SPSS-11.5 software.

Results

All the root samples of *C. domestica* collected from different locations showed colonization with AMF and the rhizosphere soils produced wide range of spore population. Statistical analysis revealed the significant variation in percent colonization and spore population. The range of total AM colonization was recorded as 34-52% with the highest from Kantaji (52%) followed by Ramsagar (48%), Boalmari (42%) and Dashmail (36%). The lowest AM colonization was recorded from Thengamara (34%). The range of mycelial, vesicular and arbuscular colonization was recorded as 34-52%, 24-48% and 26-40% respectively (Table 1). The highest mycelial, vesicular and arbuscular colonization was recorded from Kantaji (52%), Dashmail (48%) and Ramsagar (40%) while the lowest was from Thengamara (34%), Thengamara (34%) and Boalmari (26%) respectively. Poor, moderate and abundant intensity was recorded as 51-71%, 21-40% and 5-22% for mycelial colonization; 34-67%, 21-54% and 4-24% for vesicular colonization and 54-81%, 17-39% and 2-22% for arbuscular colonization respectively.

Total arbuscular mycorrhizal spore population was recorded as 54-154/100 g dry soil (Table 2). The highest spore population was recorded from Boalmari (154) which was followed by Kantaji (111), Thengamara (106) and Ramsagar (84) and the lowest was recorded from Dashmail (54). Out of six recorded genera, *Glomus* was recorded from all the selected locations whereas *Sclerocystis, Acaulospora* and *Gigaspora* were found in three locations and *Entrophospora* as well as *Scutellospora* were found in two locations (Table 2). The range of percent population of *Glomus, Sclerocystis, Acaulospora, Entrophospora, Gigaspora* and *Scutellospora* was recorded as 73-90, 4-6%, 7-13%, 5-7%, 5-9% and 4-7% respectively. The highest percent population of *Glomus, Sclerocystis, Acaulospora, Entrophospora, Gigaspora* and *Scutellospora* was recorded from Kantaji (90%), Kantaji (6%), Thengamara (13%), (13%), Thengamara (7%), Ramsagar (9%) and Thengamara (7%) while the lowest was from Thengamara (73%), Dashmail (4%), Dashmail (7%), Ramsagar (5%) and Boalmari (5%) respectively (Table 2). To determine the correlation between AM colonization and spore population statistical analysis was performed which indicated no correlation between total AM colonization and total spore population.

Discussion

Turmeric plants collected from different areas of Bangladesh are found to be mycotrophic. Association of mycorrhizal fungi in turmeric is also reported from Pakistan (Nasim and Zahoor, 1995; Iqbal and Nasim, 1986). A wide range of variation in percent colonization, structural colonization and spore population was recorded in the present study. This variation may be due to physical and chemical properties of the soils (soil type, soil pH, soil depth, soil moisture content, etc.) and environmental factors (rainfall, temperature, etc.) as reported by several authors with many different crops (Abbott and Robson, 1991; Sharma *et al.*, 1996; Muthukumar *et al.*, 1994). Different cultural practices (e.g. removal of grasses, weeds etc.) might be contributory to the variation in percent colonization, AM fungal spore population and the distribution of different AM fungal genera (Siguenza *et al.*, 1996; Verma and Jamaluddin, 1995) as reported in the present study. Presence of diverse type of AM fungal genera in soil-samples from different locations might contribute to the variation in the AM colonization and the distribution of AM fungi recorded in the present study.

No correlation was observed between the AM colonization and spore populations. It supports the reports of Dhar *et al.*, (2005) and Chaurasia *et al.*, (2005). They reported no correlation between AM colonization and spore population for other crops. However, it contradicts with the report of Saif and Khan, (1975) and Verma and Jamaluddin, (1995),

who have reported the positive correlation between the colonization and the spore population working with different plants. It was probably caused by the presence of different AM fungal species (Mehrotra, 1998). Among six AM fungal genera, *Glomus* was dominating. This study corroborates with the findings of others who reported the findings for other plant species (Chaurasia *et al.*, 2005; Dhar *et al.*, 2005). Dominancy of *Glomus* might be due to the aggressiveness, wide adaptation to acid soils (Sieverding, 1991), high competitiveness and/or reproductive capability (Sieverding, 1991) of the genus.

Although turmeric is an important medicinal and spicy crop growing in marginal lands, farmers are not giving proper attention for balanced fertilizers. However, it is urgently needed to pay proper attention for soil management with organic and biofertilizers as the plant parts are used directly for different purposes like medicine and spice. In our study, it reveals that the turmeric plant is mycotrophic however, due to a contained sort of root system, the plant is dependent on mycorrhizal association. It is widely accepted that the plants, which have sparse root systems, are highly dependent on mycorrhiza (Baylis, 1975). So mycorrhizal technology may be introduced in turmeric production systems to reduce the use of chemical fertilizers and to encourage mycorrhizal biofertilizers for improving better growth and yield.

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