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SHORT COMMUNICATION

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Morphological types of arbuscular mycorrhizas in pioneer woody plants growing in an oil palm farm in Sumatra, Indonesia

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Abstract Morphological types of arbuscular mycorrhizas (AM) in pioneer woody plants were examined in an oil palm farm 1 year after reclamation. In total, 18 plant species belonging to 15 genera in 9 families were examined, and the *Arum* type was found in 12 species belonging to 9 genera in 5 families. In contrast, the *Paris* type was found in 5 species belonging to 5 genera in 4 families. The number of plant species with *Arum*-type AM was always higher than that with *Paris*-type AM in all four sampling plots. All the examined species in Euphorbiaceae, most of which are fast-growing pioneer trees and were dominant in forming the canopy in secondary forests, were found to have *Arum*-type AM. These results suggest that *Arum*-type colonization is beneficial for fast-growing woody plant species.

Key words Arbuscular mycorrhiza · *Arum* type · Euphorbiaceae · Morphological type · *Paris* type

Soil-inhabiting fungi belonging to Glomeromycota (Schüßler et al. 2001) form a symbiotic relationship, called arbuscular mycorrhizas (AM), with the majority of terrestrial plant species (Smith and Read 1997). AM are morphologically divided into two types, *Arum* type and *Paris* type, which were first described by Gallaud (1905). In *Arum*-type colonization, AM fungi form extensive intercellular hyphae in air spaces between cortical cells and invaginate the plasma membrane of the cells as short side branches to form arbuscules. On the other hand, in the *Paris* type, the colonization spreads from cell to cell in the cortex. This type is characterized by the development of intracellular hyphal coils that frequently have intercalary arbuscules.

Although functional differences between the two types have not been clarified, Brundrett and Kendrick (1990a) found a slower rate of colonization spread in *Paris*-type AM in an investigation in a woodland. They suggested that the slower colonization of AM fungi in the *Paris* type might be advantageous to maintain the energy supply to the fungi at a manageable level for plants growing slowly in a relatively dark environment (Brundrett and Kendrick 1990b). The slower rate of colonization spread in *Paris*-type AM was also demonstrated by Cavagnaro et al. (2001b) between *Asphodelus fistulosus* and *Glomus coronatum*.

Yamato and Iwasaki (2002) found dominance of *Paris*-type AM among herbaceous plants as understory vegetation in some deciduous broad-leaved forests. On the other hand, Yamato (2004) found dominance of *Arum*-type AM among weeds on vacant land. These studies also suggest that *Paris*-type AM is more appropriate for slowly growing plants than the *Arum* type.

In Southeast Asia, large areas have been converted into oil palm plantations. Usually, the plantation is reclaimed from degraded secondary forests by slash-and-burn treatment. Seedlings of diverse pioneer woody plants are usually found after the reclamation. Because most of such pioneer woody plant species are fast growers, it is presumed that *Arum*-type AM is dominant among them. In this study, thus, morphological types of AM were examined for the pioneer woody plants growing in an oil palm farm 1 year after reclamation.

The examined site is an oil palm plantation located in Muara Tebo, Jambi, Sumatra, Indonesia (102°23′ E, 1°34′ S), where secondary forest and an *Acacia mangium* plantation are adjacent. In the plantation, four sampling plots of 100 m^2 (10 × 10 m), which were about 100 m apart, were established. Root samples of pioneer woody plants were collected from three individuals per plant species in each plot in November 2002. The roots were fixed and preserved in 50% ethanol and then stained with 0.1% Chlorazol black E according to Yamato and Iwasaki (2002). The stained root samples were squashed and observed by a Nomarski interference-contrast microscope (Leitz DMR; Leica Microsystems, Heerbrugg, Switzerland) to determine the morphological type of AM. At least a 10-cm length of root in each plant individual was examined in each plot. The

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Table 1. Arbuscular mycorrhiza (AM) morphological types in examined plants

Family	Species	Life form	Distribution in plot				AM morphological type
			1	2	3	4	
Moraceae	*Ficus grossulariodes*	Shrub	+	−	−	−	*Paris*
	Sloetia elongata	Tree	−	+	−	−	*Paris*
Ulmaceae	*Trema tomentosa*	Tree	+	+	+	+	*Paris*
Fabaceae	*Fordia johorensis*	Tree	−	+	−	+	*Arum*
	Derris montana	Climber	−	−	+	−	*Arum*
	Acacia mangium	Tree	+	+	+	+	ND
Connaraceae	*Agelaea trinervis*	Climber	−	+	−	−	*Arum*[a]
Euphorbiaceae	*Macaranga gigantea*	Tree	+	+	−	+	*Arum*
	Macaranga triloba	Tree	+	+	−	−	*Arum*
	Macaranga conifera	Tree	−	+	+	+	*Arum*
	Macaranga indica	Tree	−	−	+	−	*Arum*
	Glochidion sericeum	Shrub	+	+	−	−	*Arum*
	Mallotus paniculatus	Tree	+	+	−	+	*Arum*
	Endospermum malaccense	Tree	−	−	+	−	*Arum*
Melastomataceae	*Melastoma malabathricum*	Shrub	+	+	+	+	*Arum*[a]
Rubiaceae	*Uncaria glabrata*	Climber	+	+	+	+	*Paris*
Myrsinaceae	*Embelia ribes*	Climber	+	+	+	+	*Paris*
Dilleniaceae	*Tetracera macrophylla*	Climber	+	+	−	−	*Arum*[a]

+, present; −, absent; ND, not detected
[a]New records of the morphological types of AM in each plant family

Table 2. The number of plant species that showed *Arum*- or *Paris*-type AM in each plot and plant life form

Plot number	Plant life form							
	Tree		Shrub		Climber		Total	
	Arum	*Paris*	*Arum*	*Paris*	*Arum*	*Paris*	*Arum*	*Paris*
1	3	1	2	1	1	2	6	4
2	5	2	2	0	2	2	9	4
3	3	1	1	0	1	2	5	3
4	4	1	1	0	0	2	5	3
Total	7	2	2	1	3	2	12	5

number of plant species in both AM morphological types was compared in each sampling plot.

Angiosperm Phylogeny Group (2003) was used for the plant classification system.

The planted oil palms were still very small at the sampling time, 1 year after reclamation, and the pioneer woody plants were growing under strong sunshine with very little shading.

In total, 18 species belonging to 15 genera in 9 families were examined, and AM colonization was found in all species except *A. mangium* (Table 1). Because fine roots of *A. mangium* were mostly colonized by ectomycorrhizal fungi with fungal sheath, this species was not used for AM observation. The morphological type of AM was always the same among individuals in each plant species, even in a different sampling plot. In total, *Arum*-type AM was found in 12 species belonging to 9 genera in 5 families, whereas *Paris*-type AM was found in 5 species belonging to 5 genera in 4 families (Table 1). In each sampling plot, the number of plant species with *Arum*-type AM was always larger than that with *Paris*-type AM (Table 2). When the examined species were divided into three life form, i.e., trees, shrubs, and climbers, according to Whitmore (1972), *Arum*-type AM was dominant in tree (Table 2). All examined species in Euphorbiaceae showed *Arum*-type AM. Muthukumar et al. (2003) reported *Arum*-type AM for all examined species in Euphorbiaceae in tropical ecosystems in southwest China. These results suggest that plants in this family preferably form *Arum*-type AM. Most of the Euphorbiaceae species examined in the present study are fast-growing pioneer trees (Whitmore 1972) and were dominant in forming canopy in secondary forests around the examined site (data not shown). *Arum*-type colonization is probably beneficial for fast-growing plants, as already suggested elsewhere (Yamato 2004; Yamato and Iwasaki 2002).

In contrast, *Paris*-type AM was observed in two tree species, *Trema tomentosa* and *Sloetia elongata*. The former is a well-known fast-growing pioneer tree species (Whitmore 1972). Further study would be required for this species as to the effect of AM symbiosis.

It has been shown that AM morphological types are primarily determined by host plant species (Gerdemann

1965; Jacquelinet-Jeanmougin and Gianinazzi-Pearson 1983). In this study, a single morphological type of AM was observed in each plant family level, which suggests the relationship between higher plant taxa and AM morphological type. However, Cavagnaro et al. (2001a) demonstrated that both morphological types of AM were formed in *Lycopersicon esculentum* (wild-type tomato) depending on AM fungal species. Therefore, the other morphological type of AM may be formed in the plant species examined in a different site with different AM fungi.

To our knowledge, presence of *Arum*-type AM in Connaraceae, Melastomataceae, and Dilleniaceae are new records.

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