

ECTOMYCORRHIZA REQUIREMENTS OF DIPTEROCARP TREES FOR AGROFOREST: SHIFTING PARADIGM

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INTRODUCTION

- Natural forest in Sumatra is dominated by Dipterocarpaceae, which produce valuable timber and NTFP.
- Dipterocarps has close association with ectomycorrhiza (EM) fungi → nutrient and water absorption
- Deforestation → forest area decrease
- Farmer managed rubber agroforst (RAF) has become a major reservoir of forest biodiversity and forest services
- Enrichment planting with Dipterocarps → an option for landscape restoration
- Efforts to re-introduce forest trees may be limited by survival of these fungal partners in the soil
- Survival of forest EM fungi in different land use types probably depends on the type of vegetation and on the possibilities for these fungi to find suitable hosts.

Existing Paradigm of EM

A. Mechanism

- Dominant EM Fungi : Basidiomycetes, such as *Russula*, *Amanita*, *Scleroderma*, *Boletus*, *Laccaria* (Smits, 1995)
- Sensitivity to land cover change: very sensitive to open soil

B. Consequence

- * Forest regeneration: dipterocarp species are not easily establish in open vegetation
- * Silviculture: EM inoculation is essential

Hypothesis

Inoculum of ectomycorrhizal fungi will survive in the soils for limited time after a change to a different land use type; the need for artificial mycorrhization in the nursery of dipterocarps can thus be predicted from the plot history

“One of the tree families that is relatively scarce in the rubber agroforests is the *Dipterocarpaceae*, the main timber producers of the lowland forests. With increasing scarcity, it becomes interesting for farmers to enrich their agroforests with such trees. Is that difficult?”

“My PhD research is supported by a number of institutions. The starting point is the requirement of Dipterocarpaceae for an ectomycorrhiza (EM) partner. If that is no longer present in the soil, after disturbance, it will have to be introduced in the nursery stage, with costs & effort to find a good match.”

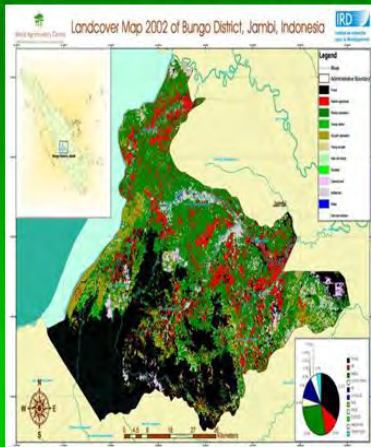
“The current ‘paradigm’ (researched in Kalimantan) is that it is indeed difficult to get *Dipterocarpaceae* started in reforestation or enrichment planting efforts, because the main EM fungi are themselves sensitive to forest disturbance (exposure of the soil to sunshine). Inoculation is thus essential.”

LAND USE CHANGE IN JAMBI

How's survival of mycorrhiza for reforestation with Dipterocarp trees?

“The past decades of land use change in Jambi province have provided an ‘experiment’ that allows us to test the decline of inoculum potential of soils for Dipterocarps, along a habitat gradient from forest to crop fields and *Imperata* grasslands. The Belowground Biodiversity project set up a series of sites.”

Site Descriptions



Slope (0- 6 %)- Muara Kuamang
6-15% - Kuamang Kuning
15->45%-Rantau Pandan

Altitude : 100 m – 500 m

Rainfall 3000 mm/yr
Temperature:27-30 °C

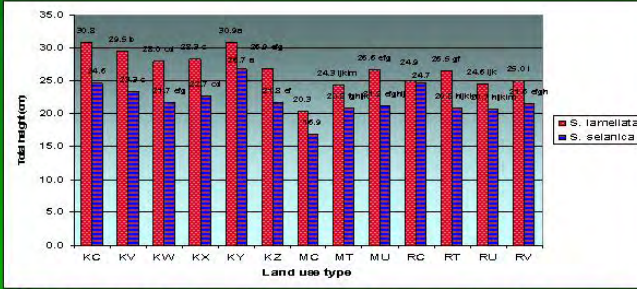
Soil Type:

- ▲ Rantau Pandan (R): kandiudults, good drainage, depth solum,
- ▲ Muara Kuamang (M): dystrodepts, poor drainage, severely flooded
- ▲ Kuamang Kuning (K): hapludults, depth solum

“Survey data were collected from the lowland peneplain in Muara Kuamang and Kuamang Kuning, and the lower piedmont zone in Rantau Pandan – both in Jambi. Soils on the sites (Ultisols and Inceptisols) are typical for the respective zones.”

Study mycorrhizal inoculum potential of various LUT in nursery using *Shorea* as bait

“Soil from a range of land use histories was brought to Bogor for an inoculum test with two *Dipterocarp* tree species. The growth of tree seedlings was recorded and their roots were analyzed for mycorrhiza (nearly all roots), followed by identification of fungal species using molecular taxonomy.”



Mean of total height of *S. lamellata* and *S. selanica* seedlings at the age of 10 months. (V= rubber monoculture, W=oilpalm, X=cassava, Y=agriculture, Z=Imperata grassland, K=Kuamang Kuning, M=Muara Kuamang, R=Rantau Pandan, C=Control)



S. lamellata, 10 months

Table 1. Soil chemical properties at different LUT in Jambi

LUT	pH		Bahan organik			HCl 25%		Bray 1	Nilai Tukar Kation (NH ₄ Acetat 1N, pH7)					KCl 1N		Total	Koreksi Kadar Air
	H ₂ O	KCl	Walkley/Kjeldahl	C	N	C/N	P ₂ O ₅		K ₂ O	Ca	Mg	K	Na	Jumlah	KB ⁺		
			----- % -----			-- mg/100 g --		----- ppm -----					cmol/kg		%		
MU	4.35	3.87	1.55	0.11	14.34	13.47	3.58	17.51	0.50	0.17	0.06	0.03	0.75	1.50	0.35	1.37	1.07
MT	3.76	3.74	3.25	0.26	12.58	42.84	11.91	25.46	0.73	0.45	0.12	0.01	1.30	4.95	0.68	4.30	1.27
RU	3.88	3.71	2.53	0.17	15.05	15.47	6.43	7.51	0.61	0.21	0.10	0.01	0.93	4.50	0.65	2.21	1.25
RT	3.70	3.69	3.21	0.22	14.96	19.61	7.78	11.49	0.76	0.24	0.11	0.00	1.11	4.52	0.67	2.43	1.21
RV	4.15	4.01	1.90	0.13	14.54	13.44	4.77	8.87	1.29	0.35	0.06	0.00	1.69	1.87	0.32	1.76	1.11
KW	4.35	4.02	1.84	0.13	14.30	22.42	6.36	26.89	1.27	0.34	0.10	0.02	1.73	1.70	0.25	2.53	1.10
KV	4.45	4.00	2.21	0.15	15.06	17.90	4.46	14.63	1.46	0.47	0.06	0.02	2.02	1.69	0.35	2.72	1.18
KX	4.36	4.06	1.59	0.11	14.77	17.96	5.57	17.22	1.37	0.43	0.08	0.00	1.87	1.36	0.29	2.26	1.11
KZ	4.40	3.99	1.87	0.13	14.38	19.04	6.59	15.83	1.57	0.48	0.10	0.03	2.18	1.58	0.35	2.10	1.11
KY	4.13	4.03	3.39	0.22	15.17	17.21	4.97	29.15	1.91	0.59	0.07	0.07	2.64	1.51	0.30	0.52	1.07

(Note: T=forest, U=RAF, V=rubber monoculture, W= oilpalm, X=cassava, Y=agriculture, Z=imperata, M=Ma. Kuamang, R=R. Pandan, K=K. Kuning)

“To our surprise, the tree seedlings planted in soil from *Imperata* grasslands in the Kuamang Kuning area were growing very well. In fact land use history proved to be unimportant for this site; overall growth was slightly less on the Rantau Pandan soils, again without clear advantage for the forest soils.”

“Soil chemical analysis provides some clues to a possible explanation. Soils from Kuamang Kuning had rather high available phosphorus levels, while those for Rantau Pandan are poorer. All soils are very acid, with pH (KCl) around 4.0 and exchangeable aluminium at 10-40% of ECEC.”

EM Fungi Identification

Sporocarp surveys :

Suspected EM fungus:

- *Scleroderma*, *Boletus*, *Russula*, *Clavaria*, *Handkea*, *Thelephora*

Molecular Analysis:

- REF and mycorrhizosphere fungus colonize *Shorea* seedlings planted in the soil from 7 LUT.

- REF and mycorrhizosphere present at all LUT

- Identification based on 28S DNA: *Thelephoraceae*, *Cortinarius callisteus* and *Laccaria* sp., several *Ascomycetes* group of *Fusarium*, *Pestalotiopsis*, *Nectria*, *Aspergillus*, *Trichoderma*, *Phoma*, *Phomopsis*



“Identification of the mushrooms (‘sporocarps’) collected in the plots brought some surprises. In fact the higher fungi (*Basidiomycetes*) were infrequent, but DNA analysis showed an abundance of *Ascomycetes*. This analysis is still ongoing, so results are preliminary.”

Evidence of EM in Jambi Site

A. Mechanism

- Dominant EM Fungi : Basidiomycetes (*Russula*, *Scleroderma*, *Boletus*) and Ascomycetes (*Cratellus*, and *Tuberaceae*)
- Sensitivity to land cover change: Longterm Imperata grassland site still has high MIP

B. Consequence

* Silviculture: Initial growth of non-inoculated EM Dipterocarps seedlings in RAF seems to be OK

“Compared with the initial paradigm and expectations, however, we notice a number of contrasts. It appears that groups of fungi that survive under land use change are effective EM partners for the *Dipterocarps* so the need for inoculation is probably less than usually assumed.”

“New” Paradigm

A. Mechanism

- Dominant EMF: Other groups of Basidiomycetes (*Thelephoraceae*) and Ascomycetes (*Tuberaceae*)
- Sensitivity to land cover change: Either inoculum survival or effect of dispersal agent maintain high MIP

B. Consequence

Inoculation of EM in nursery stage is not necessary

Formulate Hypothesis:

Is “new” paradigm suit for Jambi site?

Is existing paradigm suit for all Borneo site?

“In fact we have to review the existing *paradigm* of sensitive ectomycorrhizal fungi as limitation on Dipterocarp growth. If inoculation is not necessary, enrichment planting may be easier than assumed. It is possible that Sumatran soils and fungi differ from those in Kalimantan/Borneo.”

Future Research

A. Mechanism

- * Dominant EMF : Exploration and taxonomy of EMF
- * Sensitivity to land use change: Experiment of soil sterilization (drought and heat) and its impact to MIP

B. Consequence

- Good news for farmer → no need EM inoculation (cost & management)
- Bad news for conservationist → may need revise argument

“Next steps in this research will aim to provide more detailed evidence. A field trial with inoculated/non-inoculated Dipterocarps in rubber agroforests of different age is under way. A new experiment will test stepwise soil sterilization. So maybe our forests can be restored after all...”