



UNIVERSITI PUTRA MALAYSIA

**GALL RUST DISEASE OF 'Batai' [*Falcataria moluccana* (Miq.) Barneby & J.W. Grimes]
IN SABAH, MALAYSIA**

SRI RAHAYU

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By

SRI RAHAYU

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Doctor of Philosophy**

July 2007



Allah has power over all things

*Among His signs is the creation of the heavens and earth and all the creatures
He has spread about in them. And He has the power to gather them together
whenever He wills (Qur'an, 42:29)*

*If all the trees on earth were pens and all the sea, with seven more seas besides,
was ink Allah's word still would not run dry. Allah is Almighty, All-Wise
(Qur'an 31:27)*



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman : Professor. Nor Aini Ab. Shukor, PhD

Faculty : Forestry

Batai (*Falcataria moluccana* (Miq.) Barneby and J.W. Grimes) is one of the valuable multipurpose tree species for forest plantations in Malaysia and Indonesia. However, since 1993, gall rust disease has been identified as a dangerous malady of batai causing severe damage to all growth stages of the plant from seedlings in the nursery to mature trees in the field. Thus, the objectives of this study were to evaluate the environmental factors affecting disease development, to characterize and identify the gall rust fungus and gall rust symptoms, to screen *F. moluccana* seedlings from eleven seed sources for growth and gall rust disease resistance, and to assess the genetic variation of those seed sources and its relationship with gall rust disease severity.



Based on the result from the step-wise multiple regression analysis, it was found that open sites with flat topography, preferably without the occurrence of fog did not favour gall rust disease development. In addition, silvicultural treatments such as pruning, thinning and clear cutting were able to reduce gall rust disease incidence and severity. Relative humidity and wind speed were two meteorological factors which were significantly associated with the incidence and severity of gall rust disease. High relative humidity ($RH \geq 90\%$) and slow wind speed ($WS \leq 80$ km/hours), was found to promote gall rust disease development. In addition, it appeared that the spread of gall rust spores originated from the north, probably from the Philippines to Brumas Estate, Tawau, Sabah, Malaysia.

Gall rust disease on *F. moluccana* in Brumas Estate, is caused by the gall rust fungus *Uromycladium tepperianum* (Sacc.) McAlp., family: Pileolariaceae, order: Uredinales class: Urediniomycetes. The fungus produces teliospores which have ridged longitudinal striations, with three spores on each head. The size of the teliospores ranged from 13-18 μm wide and 17-26 μm long. The fungus completed entire life cycle on one host, i.e. *F. moluccana*. This study confirmed that the teliospores cannot themselves infect the host; they have to germinate to produce basidiospores, which are formed at least 10 hours after inoculation. Then a penetration peg was formed by a matured



basidiospore 16 hours after inoculation, penetrates the host cells directly through the epidermis. Seven days after inoculation (DAI), vegetative mycelia of this gall-forming rust give rise to pycnia, recognized as small brown pustule which breaks through the epidermis. The typical symptom of gall rust disease on the seedlings is bending of the stem or shoot, either with or without the formation of a dark red necrotic lesion. However the symptoms on older trees range from the development of large chocolate brown, irregularly shaped, cauliflower-like or whip-like galls on the stem, branch, petiole, shoot, pod, seed or flower stalk. The surfaces of mature galls were generally covered with cinnamon-coloured spores. The older galls become reddish brown which eventually turned black and they are commonly invaded by tunneling insects.

Based on the rate of infection, cumulative mortality due to gall rust disease and the effect of gall rust disease on relative growth rate, seedlings from Wamena seed source were moderately resistant that this was the best seed source of the eleven seed sources tested. Generally, the effect of gall rust disease in decreasing the relative growth rate of seedlings was only significantly different at 47 DAI, particularly for seedlings from RO5/95 and Walang Gintang seed sources. Resistance to gall rust disease was accounted by approximately 41-46% of genetic and 54-59% of environmental factors



respectively. The qualitative character of height was accounted for by approximately 50-84% and 16-50% of genetic and environmental factors respectively. The genetic correlation between gall rust disease severity and height of seedling was high (85%) and positive, particularly at 27 DAI.

The genetic diversity of eleven seed sources *F. moluccana* seedlings assessed using RAPDs technique was small, with 1.036-1.094 effective alleles, 34-55 polymorphic loci, 35.05% to 56.76% proportion of polymorphic loci, Shannon Diversity Index of 0.115-0.192 and Nei's Diversity Index of 0.18-0.29. In addition, the genetic distance between seed sources was narrow (0.036 to 0.152). All seedlings from Brumas seed sources (RO2, RO5, R2001 and 2S/75) were closely related to those from East Timor, East Flores, Moluccas and Java, but were distant from Wamena. There were negative and small relationship between polymorphic loci, Shannon's Diversity Index, Nei's Diversity Index and gall rust disease severity at 7, 17 and 27 DAI ($R^2 = 4\%$ to 27%). However, their relationship at 37 and 47 DAI were positive and relatively moderate ($R^2 = 39\%$ to 49%). Thus, the correlations between genetic variation and gall rust disease severity of *F. moluccana* seedlings were inconsistent by times and their relationship was not strong.



Since gall rust disease resistance was accounted by genetic and environmental factors almost at the same proportion, applying integrated gall rust management control becomes essential. Site selection, using genetically resistant material, regular monitoring, pruning, thinning in the field and chemical control in the nursery are principle methods for preventing gall rust disease of *F. moluccana* at Brumas Estate.



Abstrak tesis yang dikemukakan kepada Senat, Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENYAKIT KARAT PURU BAGI 'Batai'
[*Falcataria moluccana* (Miq.) Barneby & J.W. Grimes]
DI SABAH, MALAYSIA

Oleh

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Julai, 2007

Pengerusi : Profesor. Nor Aini Ab. Shukor, PhD

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Falcataria moluccana (Miq.) Barneby and J.W. Grimes (batai) merupakan salah satu spesis pokok pelbagai guna yang berharga untuk tanaman hutan ladang di Malaysia dan Indonesia. Walau bagaimana pun, sejak 1993, penyakit karat puru telah menjadi salah satu penyakit merbahaya yang boleh menyebabkan kerosakan yang bererti terhadap semua peringkat pertumbuhan bermula dari anak benih di tapak semaian sehingga pokok matang di lapangan. Oleh itu, objektif kajian ini adalah untuk menilai faktor persekitaran yang berkaitan terhadap perkembangan penyakit, untuk mengenalpasti simptom dan kulat karat puru, untuk menyaring pertumbuhan dan rintangan terhadap penyakit karat puru ke atas sebelas



sumber benih dan untuk mengkaji variasi genetic dan hubungannya terhadap tahap bahaya penyakit karat puru.

Berdasarkan keputusan daripada analisis regresi pelbagai berperingkat menunjukkan kawasan hutan terbuka dengan topografi yang mendatar, terutamanya tanpa kejadian kabus boleh menghalang penyakit karat puru. Sehubungan ini, rawatan silvikultur seperti aktiviti pemangkasan, penjarangan dan tebang habis dapat mengurangkan insiden dan tahap bahaya penyakit karat puru. Kelembapan bandingan dan kelajuan angin adalah dua faktor meterologi yang sangat berkait rapat terhadap insiden dan tahap bahaya penyakit karat puru. Keadaan di ladang Brumas yang mempunyai kelembapan bandingan yang tinggi ($RH \geq 90\%$) dan kelajuan angin yang perlahan ($WS \leq 80$ km sejam), didapati menggalakkan perkembangan penyakit karat puru. Penyebaran spora karat puru pula didapati berasal daripada arah utara, terutamanya daripada Filipina ke ladang Brumas, Tawau, Sabah, Malaysia.

Penyakit karat puru terhadap *F. moluccana* di Brumas Estet, Tawau, Sabah, Malaysia adalah disebabkan kulat *Uromycladium tepperianum* (Sacc.) McAlp., famili: Pileolariaceae, order: Uredinales dan kelas: Urediniomycetes. Kulat ini menghasilkan teliospora yang mana mempunyai jaluran yang bermula



dari atas ke bawah, dengan tiga spora bagi setiap kepala, dan saiz teliospora berjulat dari 13-18 μm lebar dan 17-26 μm panjang. Kulat ini melengkapkan kesemua kitaran hidupnya dalam satu hos yaitu *F. moluccana*. Teliospora ini disahkan tidak dapat menjangkiti hos nya sendiri, dan ia perlu bercambah untuk menghasilkan basidiospora selepas di inokulasi sekurang-kurangnya 10 jam. Kemudiannya, selepas 16 jam diinokulasi, basidiospora yang matang akan membentuk satu "penetration peg" yang mana akan menyebabkan penembusan secara langsung ke dalam hos melalui epidermis. Selepas tujuh hari diinokulasi, mycelia vegetatif bengkakan karat tumor ini berkembang menjadi pycnia sebagai postul perang yang kecil yang memecah keluar daripada epidermis. Simptom umum bagi penyakit karat tumor terhadap bijih benih menunjukkan pembengkokkan batang atau pucuk, samada yang boleh mempunyai atau tidak bintik merah tua. Sebaliknya, simptom pada pokok berjulat dari perkembangan bengkakan yang besar berwarna coklat keperangan, atau mempunyai bentuk yang pelbagai, berbentuk bunga kobis atau berbentuk cemeti pada batang, dahan, petiole, pucuk, putik, biji benih atau tangkai bunga. Permukaan bagi bengkakan yang matang selalunya ditutupi dengan spora yang berwarna coklat keperangan. Lazimnya, bengkakan matang akan menjadi perang kemerahan dan kemudiannya bertukar menjadi hitam dan kebiasaannya dijangkiti oleh serangga penebuk.



Berdasarkan pada kadar jangkitan dan kadar mortality kumulatif yang disebabkan oleh penyakit dan kesan tahap bahaya penyakit karat tumor kepada kadar pertumbuhan relatif, menunjukkan bahawa anak benih daripada sumber Wamena menunjukkan kesan sederhana, dan merupakan sumber biji benih yang terbaik untuk kerintangan penyakit karat tumor. Secara umumnya, kesan penyakit gall rust ini menurunkan kadar pertumbuhan relatif anak benih dengan perbezaan yang bererti pada 47 hari selepas inokulasi, terutamanya bagi anak benih daripada sumber RO5/95 dan Walang Gintang. Rintangan kepada penyakit karat tumor menyumbang 41- 46% daripada genetik dan 54 - 59% daripada faktor persekitaran masing-masing. Ciri kuantitatif ketinggian pula menyumbang 50-84% dan 16-50% daripada genetik dan faktor persekitaran masing-masing. Korelasi genetik di antara tahap bahaya penyakit karat tumor dan ketinggian anak benih adalah tinggi (85%) dan positif, terutamanya pada 27 hari selepas inokulasi.

Variasi genetik menggunakan teknik RAPD ke atas 11 sumber *F. moluccana* adalah kecil, dimana bilangan efektif alel (1.036-1.094), bilangan lokus polimorfik (34-55), peratusan lokus polimorfik (35.05% to 56.76%), Indeks Kepelbagaian Shannon (0.115-0.192) dan Indeks Kepelbagaian Nei's (0.18-0.29). Tambahan pula, jarak genetik diantara sumber adalah kecil (0.036 to



0.152). Kesemua anak benih daripada sumber Brumas (RO2, RO5, R2001 and 2S/75) adalah sangat berkait rapat terhadap anak benih daripada sumber Timor Timur, Flores Timur, Maluku dan Jawa, tetapi adalah sangat berbeza daripada sumber Wamena. Korelasi diantara bahagian lokus polimorfik, Indeks Kepelbagaian Shannon dan Indeks Kepelbagaian Nei's terhadap tahap bahaya penyakit karat puru pada 7, 17 dan 27 hari selepas inokulasi adalah negative dan kecil secara relatifnya ($R^2 = 4\%$ to 27%), tetapi selepas 37 dan 47 hari korelasinya menjadi positif dan sederhana secara relatifnya ($R^2 = 39\%$ ke 40%). Namun begitu, korelasi diantara variasi genetik terhadap tahap bahaya penyakit karat puru adalah tidak konsisten dengan waktu dan perhubungannya adalah tidak kuat. Oleh karena rintangan terhadap penyakit karat puru yang disebabkan faktor genetik dan persekitaran adalah lebih kurang sama, aplikasi pengurusan penyakit karat puru bersepadu adalah menjadi keperluan. Pemilihan lapangan, penggunaan bahan yang secara genetik tahan terhadap karat puru, pemantauan berskala, pemangkasan, penjarangan di lapangan dan pengawalan kimia di tapak semaian adalah kaedah prinsip untuk menghalang penyakit karat puru untuk *F. moluccana* di ladang Brumas.

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I certify that an Examination Committee has met on July, 6, 2007 to conduct the final examination of Sri Rahayu on her Doctor of Philosophy thesis entitled “Gall Rust Disease of *Falcataria moluccana* (Miq.) Barneby & J.W. Grimes in Sabah, Malaysia ” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that candidate be awarded Doctor of Philosophy.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

SRI RAHAYU

Date: 7 August 2007



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