UNIVERSITI PUTRA MALAYSIA

RICE STRAW COMPOSTING BY LIGNOCELLULYTIC MICROORGANISMS FOR IMPROVED STABILITY AND BIOEFFICACY IN SCLEROTIAL DISEASE SUPPRESSION

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By

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

July 2011

Dedicated

to

Departed Parents

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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 Sariah Meon, PhD

Institute: Institute of Tropical Agriculture

Rice (*Oryza sativa* L.) is an important cereal crop in the world. Annually, a huge amount of rice straw (RST) is produced as by-product of rice cultivation. Proper disposal of RST is a concern across the world. Composting is an alternative for recycling of RST into a useful product. Composting of RST however is time consuming as it comprises of lignocellulosic material. Therefore, in the present study, the ability of a lignocellulolytic microbial consortium (*Aspergillus niger* and *Trichoderma viride*) at different pH conditions as activator and enhancer of maturity and stability of RST compost was evaluated, and its bioefficacy against sclerotial foot rot of chilli was determined. A total of 125 microbes were isolated from different *in-situ* and *in-vitro* RST compost sources. Twenty lignocellulolytic microbial isolates (5-bacteria, 5-actinobacteria and 10-fungi) were selected based on enzymatic degradation of starch,

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cellulose and lignin, followed by screening for adaptability on rice straw powder (RSP)-amended media. Six isolates (B37, A7, F26, F28, F29 and F44) were selected as lignocellulolytic agents for *in-vitro* RST biodegradation based on their optimum growth rate, biomass production and lignocellulolytic activities on RSP-amended media. Fungal isolates were found to be more efficient than bacteria and actinobacteria in terms of decomposing cellulose, hemicellulose, and lignin, and total carbon during RST biodegradation. Four fungal isolates (F26, F28, F29 and F44) were evaluated for their *in-vitro* compatibility. Six different interactions were found between the four interacting fungal isolates in the form of mutual intermingling, partial mutual intermingling and inhibition at the contact point. Finally, a consortium of *A. niger* (F44) and *T. viride* (F26) was selected as the best potential lignocellulolytic microbial consortium for rapid composting of RST. Compost stability and maturity were determined by monitoring the physical, biochemical and biological changes during composting. The RST compost produced was termed as *microbial infused* RST compost was also tested for its bioefficacy in terms of seed germination and seedling establishment, plant growth and disease suppression in chilli under plant house condition. Composting of RST amended with lignocellulolytic microbial consortium (*A. niger* and *T. viride*) under natural (pH 6.75) pH condition showed significant changes in terms of physical, biochemical and biological parameters compared to acidic (pH 5.75) and alkaline (pH 7.75) pH conditions. After day 21, microbial consortium under natural pH condition was found to reduce C/N ratio to 17.5 from an initial value of 29.2 and increased germination index to 75.5. The remaining lignin and cellulose contents in *microbial infused* RST compost were 9.8 and 12.4%, respectively. Enzymatic activities namely, β-1,4-endo-glucanase,

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β-1,4-exo-glucanase and total dehydrogenase activity were significantly lower than non-inoculated treatments. The contents of N, P, K, Ca and Mg were 2.3, 1.1, 2.6, 2.5 and 1.4%, respectively. These results suggest that, after day 21, *microbial infused* RST compost produced under natural pH could be used as a substitute for inorganic fertilizers. Under plant house condition, it was found that application of *microbial infused* RST compost significantly increased seed germination, plant growth and suppressed the development of foot rot caused by *S. rolfsii* in chilli compared to commercial compost (BFC, CMT Agro Resources Sdn Bhd) or the use of fungicide Benomyl. Application at a rate of 15 t/ha was optimum for seed germination and seedling establishment, plant growth and disease suppression suggesting that *microbial infused* RST compost could be used as an alternative to chemical fungicide Benomyl for the control of sclerotial disease in chilli.

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

PENGKOMPOSAN JERAMI PADI MMENGGUNAKAN MIKROB UNTUK PENAMBAHBAIKAN KESTABILAN DAN EFIKASI BIOLOGI

Oleh

MD. KAUSAR HOSSAIN

Julai 2011

Pengerusi: Profesor Sariah Meon, PhD

Institut: Institut Pertanian Tropika

Padi (*Sativa Oryza* L.) merupakan tanaman bijirin penting di dunia. Setiap tahun, sejumlah besar jerami padi (RST) dihasilkan sebagai hasil sampingan penanaman padi. Cara pelupusan yang betul bagi RST telah menjadi satu kebimbangan merentasi dunia. Pengkomposan merupakan satu alternatif untuk kitar semula RST menjadi produk yang bermanfaat. Pengkomposan RST bagaimanapun memakan masa yamg lama kerana ianya mengandungi bahan lignosellulosa. Oleh itu, kajian ini telah menilai kemampuan konsortium mikrob lignoselulolitik (*Aspergillus niger* dan *Trichoderma viride*) pada pH yang berbeza sebagai pemangkin dan penambah kematangan dan kestabilan kompos RST, dan efikasi biologinya terhadap jangkitan *Sclerotium* pangkal cili telah ditentukan. Sebanyak 125 mikrob telah diasingkan dari berbagai sumber kompos RST *in-situ* and *in-vitro.* Dua puluh isolat mikrob lignoselulolitik berpotensi (5 bakteria, 5-aktinobakteria dan 10 kulat) dipilih berdasarkan pendegradan enzim kanji, selulosa dan

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lignin, diikuti oleh penyaringan pada media ubahsuai serbuk jerami padi (RSP). Enam isolat (B37, A7, F26, F28, F29 dan F44) dipilih sebagai agen lignoselulolitik dalam biodegradasi RST in *vitro* berdasarkan kadar pertumbuhan optimum, pengeluaran biojisim dan aktiviti lignoselulolitik pada media ubahsuai serbuk jerami padi. Isolat kulat didapati lebih cekap daripada bakteria dan aktinobakteria dari aspek penguraian selulosa, hemiselulosa, dan lignin, dan jumlah karbon semasa biodegradasi jerami padi. Empat isolat kulat (F26, F28, F29 and F44) telah dinilai untuk keserasian *in-vitro.* Enam interaksi berbeza telah ditemui antara empat interaksi isolat kulat dalam bentuk penggabungjalinan saling, penggabungjalinan saling separa dan perencatan pada titik sentuhan. Akhirnya, konsortium terdiri dari pada *A. niger* (F44) dan *T. viride* (F26) telah dipilih sebagai konsortium kulat lignoselulolitik berpotensi untuk pengkomposan RST. Kematangan dan kestabilan kompos ditentukan dengan memantau perubahan fizikal, biokimia dan biologi yang berlaku semasa proses pengkomposan. Kompos RST terhasil dikenali sebagai *microbial infused* juga diuji untuk keberkesanannya dalam percambahan biji benih dan kematangan anak benih, pertumbuhan pokok dan penindasan jangkitan penyakit pada cili di dalam rumah tanaman. Pengkomposan RST dengan konsortium kulat lignoselulolitik (F44 and F26) pada pH normal (pH 6.75) menunjukkan perubahan signifikan dalam ciri fizikal, biokimia dan biologi berbanding dengan pH asid (pH 5.75) dan pH alkali (pH 7.75). Selepas hari ke 21, konsortium kulat dan pH normal mengurangkan nisbah C/N kepada 17.5 daripada nilai awal 29.2, dan meningkatkan indeks percambahan (GI) kepada 75.5. Lignin dan selulosa yang tidak terurai dalam kompos *microbial infused* adalah 9.8 dan 12.4 %. β-1,4-endo-glucanase, β-1,4-exo-glucanase dan jumlah aktiviti dehidrogenase adalah lebih rendah secara

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signifikannya dibanding dengan kompos tanpa rawatna mikrob. Kandungan N, P, K, Ca dan Mg dalam kompos *microbial infused* adalah 2,3, 1,1, 2,6, 2.5 dan 1.4 %. Keputusan ini menunjukkan bahawa kompos RST *microbial infused* yang terhasil pada pH normal selepas hari ke21 boleh digunakan sebagai pengganti baja bukan organik. Di bawah rumah tanaman, aplikasi kompos *microbial infused* meningkatkan secara signifikan percambahan biji benih, pertumbuhan tanaman dan mengurangkan jangkitan *S. rolfsii* pada tanaman cili berbanding kompos komersial (BFC, CMT Agro Resources Sdn Bhd) atau racun kulat Benomyl. Aplikasi pada tahap 15 t/ha juga adalah optimum untuk percambahan biji benih dan kematangan anak benih, pertumbuhan pokok serta pengurangan jangkitan penyakit, mencadangkan kompos RST *microbial infused* boleh digunakan sebagai alternatif kepada racun kulat Benomyl untuk mengawal jangkitan *Sclerotium* pada tanaman cili.

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I certify that a Thesis Examination Committee has met on -/-/- to conduct the final examination of Md. Kausar Hossain on his thesis entitled **"Microbial composting of rice straw for improved stability and bioefficacy"** in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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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 any other institution.

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