GROWTH AND YIELD COMPARISON OF RICE TREATED WITH *Trichoderma asperellum* (UPM 40) IN FLOODED AND SATURATED SOIL CONDITION

By

IFFATUL ARIFAH BINTI YUSUP

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

March 2021

FP 2021 77

DEDICATION

I dedicate this thesis to my beloved husband, Mohd Azwan bin Juperi, my parents Yusup bin Omar and Sa'audah binti Hamdin and my siblings for their support, love and encouragement.

Thank you very much for everything

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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Chairman : Martini Mohammad Yusoff, PhD
Faculty : Agriculture

Malaysian consumed 2.7 million MT rice per year. Only 67% of the amount is produced locally and the rest of the number is imported from Thailand, Vietnam, Pakistan and other countries. Most of the crops are planted in conventional flooded rice cultivation which requires proper water irrigation in order to make sure enough water supplied to the field. Limitation of water will suppress plant growth which reduce plant height, flowering and retarded maturity and at the end causes less yield production. Trichoderma can beneficially interact with plant roots and can induce disease resistance, plant growth promotion and tolerance to abiotic stresses including drought. Thus, this study is aimed to determine the optimum rate of encapsulated *T. asperellum* (UPM 40) in improving rice growth and yield, to study growth and yield performance of rice plants through the application of encapsulated *T. asperellum* (UPM 40) in saturated and flooded soil conditions and to evaluate the effects of encapsulated *T. asperellum* (UPM 40) on rice plants in response to drought stress. The study was consists of two separated experiment. The first study was carried out by planting rice plants in different soil conditions while treated with different rates of *T. asperellum* (UPM40). Rates of encapsulated *T. asperellum* (UPM 40) were 0, 1, 3 and 5 g. The soil conditions were consist of saturated and flooded water level. From the results 5 g encapsulated *T. asperelllum* (UPM 40) was the best rate as 1000 grains weights, harvest index, total yield, spikelet weight per panicle, percentage of filled grains per panicle, number of filled grains per panilce, relative chlorophyll content, maximum root area, root volume and root length of the rice plants were significantly better than the other treatments. The best rate of the experiment (5 g) was carried to the second experiment which was aimed to evaluate effect of encapsulated *T. asperellum* (UPM 40) on rice plants during drought stress at early anthesis. The outcome was the encapsulated *T. asperellum* (UPM 40) had significantly improve growth and yield of the rice plants under drought stress. Relative water content of rice plants treated with *T. asperellum* (UPM 40) was 78.51%, higher than control with 72.09% has shown the ability of the fungus to help rice plants alleviate detrimental effects of drought stress. The application helped to delay the onset of adverse effects of drought stress to the crop simultaneously improving rice yield as compared to untreated

plants. Thus, encapsulated *T. asperellum* (UPM 40) may help farmers to reduce yield loss during drought season.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PERBANDINGAN PERTUMBUHAN DAN HASIL POKOK PADI YANG DIRAWAT DENGAN KAPSUL *Trichoderma asperellum* (UPM 40) DALAM KEAADAN PARAS AIR PADA TANAH BERTAKUNG DAN TEPU.

Oleh

IFFATUL ARIFAH YUSUP

Mac 2021

Penyelia :**Martini Mohammad Yusoff, PhD**
Fakulti :**Pertanian**

Rakyat Malaysia makan 2.7 milion MT nasi dalam setahun. Daripada jumlah tersebut hanya 67% merupakan hasil tempatan dan selebihnya diimport daripada Thailand, Vietnam, Pakistan dan negara-negara lain. Kebanyakan tanaman tersebut ditanam secara konvensional di mana ia memerlukan pengairan yang baik bagi memastikan air sentiasa dibekalkan ke sawah. Kekangan terhadap air akan membantutkan pertumbuhan pokok di mana ketinggian pokok, pembungaan dan kematangan terbantut dan akhirnya menyebabkan kerugian hasil. Trichoderma boleh berinteraksi secara berfaedah dengan akar tumbuhan dan mendorong rintang terhadap penyakit, menggalakkan pertumbuhan pokok dan ketahanan terhadap tekanan abiotik seperti kemarau. Dengan itu kajian ini bertujuan untuk menentukan kadar optima kapsul *T. asperellum* (UPM 40) dalam meningkatkan pertumbuhan dan hasil padi. Seterusnya untuk mengkaji kesan kapsul *T. asperellum* (UPM 40) terhadap pertumbuhan pokok padi yang ditanam dalam keadaan paras air tanah tepu dan paras air tanah bertakung dan mengkaji kesan kapsul *T. asperellum* (UPM 40) terhadap pokok padi dalam situasi kemarau. Kajian tersebut mengandungi dua eksperimen berasingan. Eksperimen pertama dijalankan dengan menanam pokok padi yang telah dirawat dengan kadar kapsul *T. asperellum* (UPM 40) yang berbeza dan dalam paras air tanah yang berlainan. Kadar kapsul *T. asperellum* (UPM 40) yang digunakan di dalam eksperimen ini adalah 0, 1, 3 dan 5 g. Manakala keadaan tanah yang digunakan untuk menanam pokok padi ialah paras air tanah tepu dan paras air dalam tanah tinggi. Berdasarkan dapatan kajian ini penggunaan kapsul *T. asperellum* (UPM 40) pada kadar 5 g telah menunjukkan hasil terbaik terhadap berat 1000 biji padi, hasil keseluruhan, berat biji padi untuk satu pokok, peratusan biji padi berisi, kandungan relatif klorofil, keluasan akar, isipadu akar dan panjang akar berbanding kadar yang lain. Kadar yang terbaik (5 g) telah dipilih untuk digunakan dalam eksperimen kedua. Eksperimen tersebut bertujuan untuk mengetahui kesan kapsul *T. asperellum* (UPM 40) ke atas tanaman padi sewaktu kemarau pada peringkat awal antesis. Dapatan kajian menunjukkan kapsul *T. asperellum* (UPM 40) berjaya memperbaiki pertumbuhan dan hasil pokok padi yang ditanam dalam keadaan kemarau. Kandungan relatif air dalam pokok padi yang telah dirawat dengan kapsul *T. asperellum*

(UPM 40) adalah 78.1%, lebih baik daripada pokok yang tidak dirawat dengan bacaan 72.09%. Situasi demikian telah menunjukkan kulat tersebut mempunyai kelebihan dalam membantu pokok padi melawan kesan buruk terhadap tekanan oleh kemarau. Dengan itu penggunaan kapsul *T. asperellum* (UPM 40) boleh membantu petani mengurangkan kehilangan hasil padi pada musim kemarau.

ACKNOWLEDGEMENTS

Praise be to Allah the most Gracious and Merciful, upon His Permission giving me patience and blessings, I could complete the thesis well.

I wish to give my sincere and special thanks to my supervisor, Dr. Martini Mohammad Yusoff for her invaluable support, encouragement and helpful suggestions throughout the project of my study. I wish to express my heartfelt thankfulness to my co-supervisors Prof. Dr. Mohd Razi Ismail for their encouragement and guidance which led to the success of my research.

My sincere thanks to all the staff in Agriculture faculty, especially Dr. Fariz Adzmi, Dr. Zulkarami Berahim, Mr. Muhammad Adzan Mastor and Mr. Mazlan Bangi for their friendship and help.

A special gratitude goes to the staff in Institute of Tropical Agriculture and Food Security and Crop Science Department for their assistance on the laboratory techniques throughout my project. My special thanks to all my friends for their kind assistance during the study. I wish to convey my deepest gratitude to my husband Mohd Azwan bin Juperi and beloved parents Yusup bin Omar and Sa'audah binti Hamdin and all my family members for the love and encouragement.

I certify that a Thesis Examination Committee has met on 15 March 2021 to conduct the final examination of Iffatul Arifah binti Yusup on her thesis entitled "Growth and Yield Comparison of Rice Treated with *Trichoderma asperellum* (UPM 40) in Flooded and Saturated Soil Condition" 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 Master of Science.

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This is to confirm that:

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LIST OF ABBREVIATIONS

PAR	Photosynthetically active radiation
RUE	Radiation use efficiency
PDA	Potato dextrose agar
MMT	Montmorillonite clay
$CaCl_2$	Calcium chloride
RCBD	Randomized complete block design
RGR	Relative growth rate
ANOVA	Analysis of variance
T	Rate of encapsulated *T. asperellum* (UPM 40)
W	Water condition
HI	Harvest index
FELCRA	Federal Land Consolidation and Rehabilitation Authority
GY	Grain yield
BY	Biomass yield
RWC	Relative water content
FW	Fresh weight
DW	Dry weight
LSD	Least significant difference
ns	Not significant

CHAPTER 1

INTRODUCTION

Rice is one of the major food crops in the world. Almost 90% of the rice production are in Asia where nearly 2.4 billion people are living in the region.Thus, rice is a staple food for most of the countries in Asia, including Malaysia. In Malaysia, 83.3 kg per capita are consumed every year (Papademetriou, 2000). Currently, Malaysia's self sufficiency level (SSL) for rice is at sixty to seventy percent where the remaining thirty to fourty percent are imported from other countries such as Thailand,Vietnam and Pakistan. For Malaysia to achieve SSL for rice, the government needs to increase the present level of local rice production (Azman et al., 2014). Rice yield harvested from 619 132 ha of total Malaysia rice planted area was 2 689 821 MT (DOA, 2016). Azman et al. (2014) suggested three possible options to increase rice production in Malaysia which are expanding the rice cultivation area, increasing yield per unit area and/ or combination of both options.

Most of the rice plants are planted in conventional flooded rice cultivation area which requires proper water irrigation to ensure sufficient water is supplied to the field (Amin, Rowshon and Aimrun, 2011). However, drought is one of global environmental issues which could cause impossible situation to supply enough water to flood the rice field during the particular season (Sok et al., 2021). Limited water supply will suppress plant growth which could reduce plant height and flowering and retard maturity and at the end cause less yield (Lisar et al., 2012).

Rice is most affected by limited water condition as compared to the other crops because firstly, it has small root system which limits its ability to extract water from the soil during water stress. Secondly, the rice plant stomata will close rapidly when the leaf water potential starts to decrease. The final cause for rice intolerance to water stress is a small reduction in soil moisture may affect leaf senescence of the rice plant (Ito et al., 1999). A few solutions have been suggested to counter this problem such as reducing soil permeability by tillage, using aerobic rice as planting material and practise water-saving irrigation, for example, reducing ponded water depths to soil saturation or by alternate wetting drying technique (Materu et al., 2018).

Aside from the above suggestions to counter detrimental effects of water stress toward rice plants is the use of *Trichoderma spp*. Studies have shown *Trichoderma spp*. has the abilty to counter adverse effects of biotic and abiotic stresses (Brotman et al., 2013; de Franca et al., 2016). Trichoderma strain has the ability to induce defensive mechanisms of the colonized plants. Root colonization by *Trichoderma spp*. is often associated with root growth development and enhancement, increased crop productivity, induction of resistance towards abiotic stresses and enhanced nutrient uptake and use by plants.

Trichoderma also known as bio-control agent which has been used to control different plant pathogenic fungi is also recognized as plant growth promoting fungi (PGPF) (Kumar et al., 2017). Saba et al. (2012) summarized that Trichoderma strain can act to benefit plants in four ways by colonizing the soil and/or parts of the plant, occupying physical space, avoiding the multiplication of the pathogens and producing cell wall to degrade enzymes against pathogens. Moreover, Trichoderma strain can produce antibiotic that can kill plant pathogens (Hermosa et al., 2014).

Trichoderma spp. was shown to possess the ability to control plant disease such as phythium damping-off on *Brassica rapa* (Khor, 2002) and to enhance water stress resistance in rice plants (Gusain et al., 2014). *Trichoderma spp*. can beneficially interact with plant roots and can induce disease resistance, plant growth promotion and tolerance to abiotic stresses including drought (Harman et al., 2004a). In order to develop water stress tolerant rice crop and enhance biomass production, encouraging a ramified root system has been implicated due to its ability to absorb more water from the soil and transport it to above ground parts for photosynthesis (Jaleel et al., 2009).

Treating plants with Trichoderma during drought stress will help to restore cellular homeostasis, toxins detoxification and recovery of growth due to the ability of the fungus to physiologically and biochemically control drought effects on plants (Singh, Gill and Tuteja, 2011). By colonizing plant roots, *Trichoderma spp* helps to promote root growth resulting in better water acquisition from the soil. The event will cause drought response on the plant to be delayed through delaying the increase of stress induced metabolites such as proline, malondialdehyde (MDA), hydrogen peroxide (H_2O_2) content and increasing total phenol under drought stress (Shukla et al., 2012).

Normally before applying to a targetted crop, a particular beneficial microorganism will be stored by incorporating it with liquid, organic matter or as seed piece treatment (O'Callaghan, 2016; Singh, 2012). However, these forms of storing technique may require a lot of space and less convenient to transport. Encapsulation technology has been introduced to ease the microbial application on plants. In addition, suitable micro-environment can also be provided to the microorganisms which protects it from the adverse biotic and abiotic factors (Berniger et al., 2018). Prolonged effect of the beneficial microorganisms with one time application is also the aim of the encapsulation through the continous release of cells into the surrounding environment. Furthermore, spreading of the microorganisms to the untargetted area can be minimized (Vassileva et al.,1999).

Shaban and El-Komy (2001) showed that when conidial suspension of *Trichoderma* spp. was added directly to the soil, their numbers declined dramatically and never increased. However, alginate encapsulated *Trichoderma* spp. was able to maintain the same colony count up to two months of incubation period in both sterile and nonsterile soils. Maintaining presence of the fungus in the soil will result in rapid fungal increase and proliferation in the soil which will also prolong its positive effect in helping rice plants to survive water limited environment.

Thus, the experiment was carried out with the following objectives:

1. To determine the optimum rate of encapsulated *T. asperellum* (UPM 40) in improving rice growth and yield.
2. To study growth and yield performance of rice plants through the application of encapsulated *T. asperellum* (UPM 40) in saturated and flooded soil conditions..
3. To evaluate the effects of encapsulated *T. asperellum* (UPM 40) on rice plants in response to drought stress

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