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MORPHOLOGICAL IDENTIFICATION AND CHEMICAL CONTROL OF WEED POPULATION GROWTH IN AEROBIC RICE (*Oryza sativa* L.) SYSTEM

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By

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Chairman : Professor Abdul Shukor bin Juraimi, PhD
Faculty : Agriculture

Aerobic rice production is a revolutionary way of rice cultivation in well-drained, non-puddled, and non-saturated soils condition with very minimal water requirements. However, weed is one of the most troublesome issues in aerobic rice field due to no standing water to suppress weed germination upon early stage of rice development. To overcome this constraint and plan for future weed management, fundamental studies of weed population growth under aerobic rice is important. Two aerobic rice varieties, AERON 1 and MRIA 1 cultivated in three different types of soils collected from three different fields around Malaysia were evaluated to identify most dominance weed invasion in the glasshouse trial. Survey of weed population in the actual field of aerobic rice was also carried out in order to check the similarities and difference of weed infestation in control and uncontrolled environment. The most dominant weed species found in glasshouse study and field survey regardless of soil textures and aerobic rice varieties were *Leptochloa chinensis* and *Cyperus iria.* Controlling weeds during the critical period of crop growth is one of the early steps in designing integrated weed management (IWM) and crucial for better yield and quality. Hence, determinations of the critical period for weed control (CPWC) study were conducted in main and off season by using a four parameter log-logistic model. Based on 5% Accepted Yield Loss (AYL), aerobic rice field should be weed free during 8 DAS to 45 DAS in the off season while, 14 DAS to 41 DAS in the main season. The acceptable of 10% AYL in the off season ranged from 12 DAS until 40 DAS in the off season while, 23 DAS until 37 DAS in the main season. Experiment of weed-crop competition by using additive design was also carried out. Identification of two most predominant weed species from experiment 1, *Leptochloa chinensis* and *Cyperus iria* were used. Different level of weed infestation against constant aerobic rice density was assessed. Infestation of *Cyperus iria* in aerobic rice MRIA 1 at 7 different levels of weed density recorded higher impact on rice growth and production compared to *Leptochloa chinensis* intervention based on the findings recorded. A total of 13

herbicides treatments consist of sequential application in single and combination herbicide were tested to evaluate the response of weed flora towards different approaches. A single application of herbicides such as Penoxsulam and Imazapyr-isopropylammonium did not provided maximum control compared to the sequential application of Bispyribac-sodium fb Bentazon/MCPA and Pretilachlor fb Propanil/Thiobencarb. Study of weed population in aerobic rice, critical period of weed control, weed-crop competition and suitable herbicides application could help farmers in facing difficulties with weed management along the cultivation seasons. Besides that, these approaches will enable weed scientists to make an important contribution towards the development of weed control options with minimal herbicides doses. Thus, awareness on the importance of improved cultural practices, their impact on weed suppression, and benefits to the ecosystem would be helpful in the implementation of crop interference strategies.

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PENGENALPASTIAN SECARA MORPHOLOGI DAN KAWALAN KIMIA KE ATAS POPULASI RUMPAI YANG TUMBUH DI DALAM PADI AEROB (*Oryza sativa* L.)

Oleh

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Pengeluaran padi aerob merupakan satu revolusi proses penanaman padi di dalam keadaan tanah yang baik salirannya, tiada air bertakung dan tidak tepu serta memerlukan kadar air yang minima. Walaubagaimanapun, rumpai merupakan salah satu perosak di dalam tanaman padi aerob akibat daripada ketiadaan air bertakung di permukaan tanah untuk menghalang pertumbuhan rumpai terutamanya di awal penanaman. Bagi mengatasi masalah dan merancang kawalan rumpai di masa hadapan, kajian asas mengenai populasi rumpai yang tumbuh di bawah penanaman padi aerob adalah sangat penting. Dua variati padi aerob, AERON 1 dan MRIA 1 telah ditanam di dalam tiga jenis tanah yang berbeza yang diambil dari tiga sawah padi aerob yang berbeza di seluruh Malaysia untuk dinilai dan menentukan populasi rumpai paling dominan di dalam kajian rumah kaca. Tinjauan populasi rumpai di dalam kawasan padi aerob yang sebenar di sawah petani juga dijalankan untuk memeriksa persamaan dan perbezaan populasi rumpai yang wujud di dalam kedua-dua persekitaran terkawal dan tidak terkawal. *Leptochloa chinensis* dan *Cyperus iria* merupakan dua spesis rumpai yang mendominasi kajian rumah kaca dan tinjauan di sawah padi. Pengawalan rumpai semasa tempoh pertumbuhan kritikal ialah salah satu langkah awal dalam merancang pengurusan integrasi rumpai (IWM), adalah penting untuk mendapatkan hasil dan kualiti yang lebih baik. Oleh itu, penentuan tempoh kritikal bagi kajian kawalan rumpai (CPWC) dijalankan pada musim utama dan di luar musim dengan menggunakan kaedah ‘Empat Parameter log logistik model’. Berdasarkan 5% kerugian hasil yang dibenarkan (AYL), padi aerob haruslah bebas dari gangguan rumpai seawal 8 hari selepas cambah (DAS) sehingga 45 hari selepas cambah pada luar musim manakala 14 hari selepas cambah sehingga 41 hari selepas cambah pada musim utama. Bagi 10% kerugian hasil yang dibenarkan (AYL) pula, padi aerob hendaklah bebas dari serangan rumpai dari hari ke 12 hingga 40 hari selepas cambah pada luar musim dan hari ke 23 hingga 37 di dalam musim utama. Seterusnya, kajian persaingan rumpai dan padi aerob telah dijalankan dengan menggunakan

kaedah Tambahan (Additive design). Dua jenis rumpai paling dominan yang dikenal pasti di dalam ekperimen 1 telah digunakan iaitu, *Leptochloa chinensis* dan *Cyperus iria.* Tahap persaingan rumpai pada peringkat yang berbeza terhadap pertumbuhan padi aerob telah dinilai. Melalui dapatan kajian, persaingan *Cyperus iria* terhadap padi aerob variati MRIA 1 adalah lebih tinggi dan memudaratkan berbanding persaingan oleh *Leptochloa chinensis*. Sebanyak 13 jenis racun rumpai yang disembur secara sendirian dan campuran bersama racun rumpai yang lain telah diuji untuk menilai tindak balas rumpai terhadap racun rumpai yang berbeza. Didapati racun Penoxsulam dan Imazapyr-isopropylammonium yang diaplikasikan secara sendirian tidak dapat memberikan kawalan maksimum terhadap rumpai berbanding aplikasi rumpai secara campuran iaitu Bispyribac-sodium fb Bentazon/MCPA dan Pretilachlor fb Propanil/Thiobencarb. Kajian populasi rumpai dalam padi aerob, tempoh kritikal kawalan rumpai, persaingan rumpai dan padi aerob serta aplikasi racun rumpai yang sesuai dapat membantu petani menghadapi masalah serangan rumpai sepanjang musim penanaman. Selain itu, hasilan dapatan daripada kajian ini membolehkan para saintis rumpai memberikan sumbangan penting kepada penggunaan racun rumpai dengan dos yang minima. Oleh itu, kesedaran yang tinggi dalam pengawalan rumpai akan memberi manfaat kepada ekosistem.

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

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
AWC	Available water capacity
AWD	Alternate Wetting and Drying
AYL	Accepted Yield Loss
CPWC	Critical period of weed control
DAS	Day after sowing
Ha	Hectare
IPM	Integrated Pest Management
IRRI	The International Rice Research Institute
IWM	Integrated Weed Management
KADA	Kemubu Agricultural Development Authority
KETARA	North Terengganu Integrated Agriculture Development
kPa	kiloPascal
LSD	Least Significant Difference
MADA	Muda Agricultural Development Authority
MARDI	Malaysian Agricultural Research Institute
mm/season	Milimeter/season
MP	Muriate of potash
NPK	Natrium/Potassium/Kalium
RCBD	Randomized Complete Block Design
RCC	Relative chlorophyll content
RD	Relative density
RDW	Relative dry weight

RY	Relative yield
SDR	Summed dominance ratio
SPAD	Silicon Photon Activated Diode
SRI	System of Rice Intensification
SSC	Saturated Soil Culture
t/ha	Tan/hectare
TSP	Triple super phosphate
WD	Weed density
WDW	Weed dry weight
WCE	Weed control efficiency
YOC	Yield increase against control

CHAPTER 1

INTRODUCTION

Rice, scientifically known as *Oryza sativa* L. is one of the economically important cereal crops and consumed as staple food by over half of the world's population. As claimed by Maclean et al. (2002), rice demand is projected to increase by 25% from 2001 to 2025 to keep pace with population growth. Statistic by Ministry of Agriculture in 2015, stated rice was placed as third most important crop in Malaysia which cultivated in ten granary areas covering approximately 600 000 ha around Peninsular Malaysia. Irrigated rice cultivation in Malaysia requires more than 90% of three quarters of the total fresh water supply (Juraimi et al., 2013), which is equal to three times water quantity used in wheat and maize (Swamy and Kumar, 2012). However, rice production is threatened by reduced water quality and water scarcity nowadays. A few factors influencing this phenomenon including increasing temperature and sea level, changes in rainfall distributions, changing of global climate could lead to significant modifications in land and water resources for rice production (Nguyen, 2006). This phenomenon inevitably would influence the productivity and ecosystem of rice cropping activities in the majority parts of the world. Hence, one of the alternatives to overcome this problem was the introduction of aerobic rice. Aerobic rice is direct seeded rice planted in non-puddled and non-flooded condition where soil moisture condition is maintained at field capacity (Zhao, 2006). The production of aerobic rice is moderately high, estimated at 4 – 6 tonnes/ha while saving as much as 50% of water compared to lowland rice. Thus, promising water saving rice systems particularly aerobic rice need to be further developed in order to ensure sustainability of rice production. However, weed invasion has been deliberated as among the most significant biological constraints to rice production and is most crucial to be addressed particularly in aerobic rice cultivation (Awan et al., 2016). This is because due to less water consumption by the aerobic rice, rice field is maintained under dry condition. Since aerobic rice seeds broadcasting are done on the dry fields, aerobic rice germinates simultaneously with weeds. Many weed species, predominantly grasses and sedges which are normally suppressed in flooded rice fields, thrive in aerobic rice fields due to the non-existence of standing water.

Severe infestation of weeds could cause 30 - 90% yield loss in aerobic rice system (Sariam et al., 2014). To overcome weeds problem, farmers tend to apply chemical control instantly compared with other control methods due to effective result and time saving, without considering the excessive use of chemical control would cause environmental pollution and herbicide resistance. As an example, repetitive application of the same herbicide mode of action such as 2,4-D had triggered resistance in *Fimbristylis miliacea* and bensulfuron in *Cyperus difformis* (Valverde et al., 2000). Whilst, other control method such as manual weeding would be time consuming and labor intensive which is often not done properly due to high cost or unavailability of labor. Thus, integrated weed management should be implemented in order to reduce the extent of weeds and the weed seed stock in the soil. A single weed control approach may not be able to keep weeds below the threshold level and prevent

the invasion of weed in aerobic rice population. Fundamental study on the growth and distribution of weed population is necessary before any action taken against weed infestation. It can cater accurate information for farmers' necessity. For example, knowing the current weed infestation in their field and the ideal herbicides selection for weed controlling (Lawson, 1988). As stated by Sago et al. (1983), the identification of weed species and estimation density of the existing weed seed in the soil bank could assist the prediction of dominant weeds species for the next season. Nevertheless, aerobic rice cultivation is still relatively new in Malaysia. To date, information on weed composition and control is limited (Monshiur et al., 2012; Jaya Suria et al., 2013; Anwar et al., 2011), while research on appropriate weed control strategies of the new aerobic rice variety is still lacking. Therefore, study of identification and classification of weed population growth in aerobic rice is very crucial hence, these objectives need to be achieved:

i. To identify and characterize weed population growth in aerobic rice varieties in different soil textures.
ii. To analyze the occurrence and composition of weed population in selected aerobic rice field cultivation areas.
iii. To estimate the critical period of weed control in aerobic rice.
iv. To investigate the nature of competition between aerobic rice MRIA 1 and different densities of dominant weed species.
v. To determine the efficacy of selected herbicides for the efficient weed control in aerobic rice.

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Siti Nur Anisah Binti Aani was born in Kuala Lumpur, Malaysia on April 5, 1983. She is the first daughter of Aani Bin Dahalan and Habsah Binti Hashim. She received her primary education at Sek. Keb. Serendah, Selangor for 6 years. She continued her secondary school at Sek. Men. Aminuddin Baki, Kuala Lumpur for 5 years. She pursued her matriculation level at Pusat Asasi Sains, University of Malaya, then, she furthered her Bachelor Degree in Science (Major Biotechnology) at Faculty of Science, University of Malaya from 2002-2005. She obtained her Master Degree in Crop Protection from University of Queensland, Australia in 2009. In 2010, she started her career as Lecturer in the Department of Crop Protection, Faculty of Plantation and Agro technology, University Technology of MARA (UiTM), Malacca branch. She is now doing her degree in Doctor of Philosophy starting from October 2014 under the supervision of Prof. Dr. Abdul Shukor bin Juraimi.

LIST OF PUBLICATIONS

Proceedings papers

S. N. A, Aani, A. S. Juraimi, M. S. Ahmad Hamdani and M. R. A. Halim (2017) Survey of Weed Floral Composition under Aerobic Rice (*Oryza sativa* L.) Soil Condition in Malaysia. The 26th Asian-Pacific Weed Science Society Conference, 19 - 22 September 2017, Kyoto, Japan.

S. N. A, Aani, A. S. Juraimi, M. S. Ahmad Hamdani and M. Jusoh (2018) Determination of critical period of weed control in aerobic rice MRIA 1. 10th International Conference on Plant Protection in the Tropics, 6 – 8 August 2018, Malacca, Malaysia.

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