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INFLUENCE OF RICE VARIETY AND PLANT SPACING ON WEED SUPPRESSION UNDER AEROBIC SOIL CONDITION

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By

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INFLUENCE OF RICE VARIETY AND PLANT SPACING ON WEED SUPPRESSION UNDER AEROBIC SOIL CONDITION

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This study comprised of two sets of experiments. The plant house and field trials were conducted at MARDI Bertam Rice Research Station in Seberang Perai, Penang. First experiment was conducted in plant house and it was repeated in the field. The second experiment which also repeated was conducted both at experimental field. These studies began in December 2008 and ended in March 2011. Weeds are the greatest constraint in aerobic rice cultivation due to lack of water standing to suppress weed. Therefore, by adoption of competitive rice varieties and the optimum plant spacing could reduce yield losses due to weed competition.

The objectives of the first experiment were to evaluate the competitive ability of five rice varieties (AERON 1, AERON 4, M9, MR211 and MR 220CL2) against weeds under aerobic rice systems, and thus determining the suitable variety for aerobic rice cultivation. The above five rice varieties were evaluated to determine their performance under two weeding regimes (weedy and weed free condition). The experimental units were kept unweeded (weedy treatment) and weed free (weed free treatment) throughout the growing season. Manual weeding and the application of recommended herbicides (Sofit and Satunil) were conducted to control weeds in weed free treatments. AERON 1 had resulted in the lowest weed dry weight and weed density while the highest was observed in MR211, in both plant house and field experiments. Sixteen weed species had infested the experimental unit in the plant house and field experiments. In weed composition, the sum dominance ratio (SDR) value showed that grasses infested at the highest percentage as compared to those of sedges and broadleaves (resulted in minor infestation). *Leptochloa chinensis* was the most dominant weed in plant house while in field was *Echinochloa colona*. Weed competition gave negative effect on selected parameters of growth and development [plant height, tiller number and SPAD value], grain yield and yield components (filled grain panicle^{-1}, sterility percentage and thousand grain weight). AERON 1 produced the highest grain yield which 2.02 t ha^{-1} and 1.79 t ha^{-1} in plant house and field experiment, respectively while MR211 produced the lowest yield. The yield production of M9, MR220 MCL2 and especially MR211 were adversely affected by weeds and possibly by aerobic condition. Relative yield loss was higher in plant house (57.1 % to 74.8%) as compared to those in the field (53.1% to 70.9%). The lowest percentage relative yield loss was obtained at AERON 1 and this showed that AERON 1 was the most competitive variety against weeds as it yielded the lowest weed dry weight (better weed suppressive ability) and relative yield loss (weed tolerance) and it had high grain yield.

The objective of second experiment was to determine the best plant spacing to achieve maximum yield and better weed suppression under aerobic condition. From previous study, AERON 1 had been chosen as planting material as it produced the highest grain yield and the lowest relative yield loss. The second experiment consist of five plant spacing namely 10 x 10 cm, 15 x 15 cm, 20 x 20 cm, 25 x 25 cm and 30 x 30 and was repeated in the second trial with the slightly modification of treatment with spacing of 15 x 15 cm, 15 x 20 cm, 20 x 20 cm, 20 x 25 cm and 25 x 25 cm. Both trials were tested under two weeding regimes (weedy and weed free condition). The lowest weed dry weight was produced by the closest plant spacing (10 x 10 cm in first trial and 15 x 15 cm in second trial). Similar pattern was observed in weed density (no. m^{-2}). Grasses was the most dominant weeds in both trials, followed by sedges and with smaller amount of broadleaves. In the first trial, rice field was infested with 12 weed species with the most dominant weed was *Echinochloa colona*. The second trial was dominanted by *Leptochloa chinensis* with 22 weed species observed. Mean of grain yield was highest at closest spacing of 10 x 10 cm (2.55 t ha^{-1}) in first trial, and in the second trial was 1.85 t ha^{-1} of yield in 15 x 15 cm spacing. Relative yield loss due to weed competition was ranging from 36.1 % to 54.9 % in the first trial, and with the range of 50.7% to 57.2% in the second trial. The best plant spacing suggested from this study was 10 x 10 cm spacing or 15 x 15 cm for higher yield and better weed suppression.

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

PENGARUH VARIETI PADI DAN JARAK TANAMAN TERHADAP PENYEKATAN RUMPAI DALAM KEADAAN TANAH AEROBIK

Oleh

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Kajian ini terdiri daripada dua set ekperimen. Percubaan rumah tanaman dan ladang dijalankan di Stesen Penyelidikan MARDI, di Seberang Perai, Pulau Pinang. Ekperimen pertama dijalankan di rumah tanaman dan diulangi di ladang. Manakala eksperimen kedua yang mana kedua-duanya dijalankan di ladang. Kajian ini bermula pada Disember 2008 dan berakhir pada Mac 2011. Rumpai merupakan halangan terbesar dalam penanaman padi aerob disebabkan oleh ketiadaan air bertakung untuk menghalang pertumbuhan rumpai.

Objektif eksperimen pertama adalah untuk menilai kebolehansaingan lima jenis varieti padi terpilih (AERON 1, AERON 4, M9, MR211 dan MR 220CL2) terhadap rumpai dalam sistem aerobik dan seterusnya mengenalpasti varieti yang sesuai untuk penanaman secara aerobik. Lima jenis varieti padi telah dinilai keupayaannya dalam dua keadaan

rawatan iaitu berumpai dan tidak berumpai. Unit-unit eksperimen ini dibiarkan tidak dirumpai (rawatan berumpai) dan tiada rumpai (rawatan bebas rumpai) sepanjang musim penanaman. Merumpai secara manual dan penggunaan racun herba yang disarankan (Sofit dan Satunil) dilakukan bagi mengawal rumpai dalam rawatan tiada rumpai. Eksperimen pertama menunjukkan AERON 1 memberikan berat rumpai kering dan kepadatan rumpai yang paling sedikit dan MR211 memberikan berat rumput kering yang tertinggi, dalam kedua-dua keadaan rumah tanaman dan ladang. Terdapat enam belas spesies rumpai di kedua-dua rumah tanaman dan ladang. Untuk komposisi rumpai, nilai jumlah nisbah dominan menunjukkan rumpai jenis rumput menyerang pada peratusan yang tinggi berbanding rusiga dan rumpai berdaun lebar (infestasi rendah). *Leptochloa chinensis* adalah rumpai dominan di dalam rumah tanaman, manakala di ladang adalah *Echinochloa colona*. Persaingan dengan rumpai memberikan kesan negatif terhadap pertumbuhan dan pengembangan pokok padi [tinggi pokok, bilangan anak bilah dan nilai (SPAD)] beserta hasil padi dan komponen hasil (biji berisi per tangkai, peratusan hampa dan berat seribu biji). AERON 1 mengeluarkan hasil purata yang paling tinggi iaitu 2.02 tan per ht dan 1.79 tan per ht masing masing dalam rumah tanaman dan ladang manakala MR211 memberikan hasil terendah. Kehilangan hasil secara relatif dalam rumah tanaman adalah lebih tinggi (57.1% hingga 74.8%, berbanding di ladang (53.1% hingga 70.9%). AERON 1 memberikan peratusan kehilangan hasil secara relatif terendah dan ini menunjukkan AERON 1 adalah varieti yang paling kompetitif terhadap persaingan rumpai sebagaimana ia menunjukkan berat kering rumpai yang terendah (penekanan rumpai yang lebih baik) dan kehilangan hasil secara relatif (toleransi terhadap rumput) serta mengeluarkan hasil yang lebih tinggi.

Objektif kajian kedua adalah untuk mengenalpasti jarak tanaman yang terbaik untuk mencapai hasil yang optimum dan pengurangan rumpai yang lebih baik dalam keadaan aerobik. Berdasarkan keputusan kajian sebelumnya, AERON 1 telah dipilih untuk dikaji dalam kajian ini kerana mengeluarkan hasil padi yang tinggi dan menunjukkan kehilangan hasil secara relatif yang rendah. Rawatan untuk percubaan kedua terdiri daripada lima jarak tanaman iaitu 10 x 10 cm, 15 x 15 cm, 20 x 20 cm, 25 x 25 cm dan 30 x 30 cm, dan telah diulang pada percubaan kedua dengan sedikit perubahan pada jarak tanaman iaitu 15 x 15 cm, 15 x 20 cm, 20 x 20 cm, 20 x 25 cm dan 25 x 25 cm. Kedua-dua percubaan yang diuji dalam keadaan keadaan berumpai dan keadaan tidak berumpai. Berat kering rumpai yang paling rendah dihasilkan oleh jarak tanaman yang paling dekat iaitu 10 x 10 cm dalam percubaan pertama dan 15 x 15 cm untuk percubaan kedua. Corak yang sama dapat diperhatikan pada kepadatan rumpai (bil. m^{-2}). Percubaan pertama diinfestasi dengan dua belas jenis rumpai yang didominasi oleh *Echinochloa colona* dan percubaan kedua diinfestasi dengan dua puluh dua jenis rumpai yang didominasi oleh *Leptochloa chinensis*. Rumpai jenis rumput adalah yang paling dominan di kedua-dua percubaan, diikuti rusiga dan sejumlah kecil rumpai berdaun lebar. Purata hasil menunjukkan jarak tanaman 10 x 10 cm dan 15 x 15 cm mengeluarkan hasil paling tinggi iaitu masing-masing 2.55 tan per ht dan 1.85 tan per ht pada percubaan pertama dan kedua. Kehilangan hasil secara relatif disebabkan oleh persaingan rumpai berjulat daripada 36.1% hingga 54.9% dalam percubaan pertama dan 50.7% sehingga 57.2% pada percubaan kedua. Daripada kajian ini, jarak tanaman yang disyorkan adalah 10 x 10 cm atau 15 x 15 cm untuk hasil yang lebih tinggi dan pengawalan rumpai dengan lebih baik.

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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.

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NORHIDAYATI BT SUNYOB

Date: 23rd August 2013

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LIST OF ABBREVIATIONS

DAS	Days after sowing
DF	Days to flowering
DTM	Days to maturity
IRRI	International Rice Research Institute
LSD	Least significant difference
MARDI	Malaysian Agricultural Research and Development Institute
PH	Plant height
RYL	Relative yield loss
SAS	Statistical analysis system
SDR	Summed dominance ratio
SPAD	Silicon photon activated diode
TGW	Thousand-grain weight
WC	Weed competitiveness
WD	Weed density
WDW	Weed dry weight
WSA	Weed suppressive ability
WT	Weed tolerance
cm	Centimeter
kg	Kilogram
g	Gram
ha^{-1}	Per hectare

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa* L.) is considered as the most important staple food in the world as it supplies the major food requirement for more than one half of the world's population (Adigun *et al*., 2005). It provides 27% of dietary energy and 20% of dietary protein in the developing countries, and it is the primary source of income and employment for more than 100 million households in Asia and Africa (FAO, 2004). The cultivation of paddy consumes a huge amount of water as compared to other crops. More than 75% of the world's rice production comes from 79 million ha of irrigated lowland (Maclean *et al*., 2002) where about 50% out of 90% of total diverted fresh water in the world is used for production of rice alone (Barker *et al*., 1998).

Water for agricultural usage is becoming increasingly scarce (Rijsberman, 2006). The main reasons of declining fresh water in agriculture sector are diverse and location specific, include shifting to urban and industrial demand and decreasing the availability because of pollution (chemicals, salts, silts) and resource depletion (Lampayan *et al*., 2003). It is estimated that by 2025, 15-20 million ha of irrigated rice will be suffering to some degree from water scarcity (Tuong and Bouman, 2003).

In mitigating to this situation, a fundamentally different approach must be found, in example, by shifting the traditional rice production system to a new promising cultivation system called ‘aerobic rice’. Aerobic rice is a new concept of growing rice in non-puddled and non flooded aerobic soil (Martin *et al.*, 2007), i.e., similar to those of wheat or maize which grown in upland condition. Aerobic rice could solve the water problem requirement as it can reduce water usage by eliminating continuous seepage and percolation that greatly reducing evaporation (Castaneda *et al*., 2004).

However, the main constraint of aerobic rice systems is the occurrence of severe weed infestation than those of transplanted irrigated and rainfed lowland rice since the direct seeded aerobic rice grows simultaneously with weed growth and thus having no ‘head start’ over weeds and lacks a standing water layer to suppress weeds (Moody, 1983). Weeds are the greatest yield-limiting factor to direct seeded aerobic rice, in which it contributes to about 50% of yield losses, followed by constraints of nitrogen deficiency, pest and disease (WARDA, 1996). Crops and weeds compete for belowground resources like water and nutrient while aboveground resources for light. Under drought and high temperature, plants with C_4 carbon fixation pathway (most of weeds) have a competitive advantage over plants possessing the more common C_3 pathways (rice) (Rodernburg and Meinke, 2010).

There are different methods of weed control in rice such as the preventive weed control, biological and chemical weed control. Nowadays, the usage of herbicides is the most effective method to control weed. However, intensive herbicide usage can increase costs, pose a threat to the environment and farmers health and, it may promote the development of herbicide resistance weed (Valverde *et al*., 2000). Reducing farmers' dependence on herbicides is desirable to reduce herbicide costs and selection pressure and to delay the development of herbicide resistance in weeds. Attention had been shifted to increase the integration of non-chemical methods of weed control into the current farming systems to reduce exposure of weeds to herbicide (Mcdonald, 2003), such as cultural weed control. Cultural practices, that is by using competitive cultivar (Zhao *et al*., 2006), tillage, crop rotation, variety selection, rice seeding rate and row spacing and orientation are generally based on agronomic considerations and could be manipulated that yielding in the crop-weed interaction in the favor of crops (Roa, 2000). It was reported that rice cultivars with increased competitiveness could reduce yield losses due to weed interaction, and also it could lessen hand-weeding requirements, and lower herbicides application (Haefele *et al*., 2004). Rice varieties respond differently to competition such that tall, droopy and late maturing varieties are more productive under weed infestations that short stature and semi-dwarf early maturing types (Johnson and Jones, 1993). Plant traits such as tiller number and leaf area index have shown to confer competitiveness (Fischer et al., 2001).

Hypothetically, manipulating agronomic factors such as row and plant spacing may provide a nonchemical means for reducing the impact of weed interference on crop yield (Ghadiri and Bhayat, 2004). Since the information in Malaysia is still limited, the study about competitive ability under aerobic condition is needed in order to investigate the ability of rice varieties competing with weeds under several plant spacing. Thus, it is envisaged that the adoption of competitive rice cultivars against weeds and the suitable plant spacing could control weed infestation and achieve optimum yield under aerobic rice cultivation.

Objectives:

The general objective of the study was to reduce weed pressure in aerobic rice through adoption of competitive variety and optimum plant density. The specific objectives were:

1. To compare the competitive ability of selected rice varieties against weed, and to identify suitable rice varieties for cultivation under aerobic soil condition.
2. To evaluate the influence of different plant spacing on weed suppression and rice yield and, to determine the optimum plant spacing for aerobic rice growing.

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