WEED POPULATION DYNAMICS AND CONTROL IN CULTIVATED RICE UNDER DIFFERENT WATER REGIMES IN THE KADA REGION IN KELANTAN, MALAYSIA

MOHD RAZIF BIN ABDULLAH

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By

MOHD RAZIF BIN ABDULLAH

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Chairman : Muhammad Saiful bin Ahmad Hamdani, PhD
Faculty : Agriculture

This study comprised of three sets of experiment. The weed composition surveys were conducted at rice fields in Kota Bharu, Bachok, and Pasir Puteh in Kemubu Agriculture and Development Authority (KADA) region. The field experiments on weed and rice competition under different biological and ecological conditions and the effects on rice yield were conducted at a farmer's field in Kampung Tunjong, Kota Bharu, Kelantan. The third experiment on herbicides efficacy was carried out in containers in an open area at the Pertubuhan Peladang Kawasan (PPK) Nilam Puri, Kota Bharu, Kelantan. The objectives of the research were: a) to identify weeds composition and distribution under reduced water conditions in the KADA rice fields; b) to quantify weed growth response and population dynamics, as well as rice growth and yield to different water conditions and planting methods in KADA rice field; and c) to evaluate herbicides performance and efficacy under different water conditions.

In the weed survey, we identified a total of 30 weed species from 14 different families, comprising of 22 annuals and 8 perennials (6 grasses, 6 sedges, and 18 broadleaved weeds). Based on the relative abundance and ranking of the weeds in the surveyed rice fields, *Fimbristylis miliacea* (84.20%), *Leptochloa chinensis* (41.60%), *Scirpus grossus* (30.13%), *Ischaemum rugosum* (23.64%), and *Echinochloa colona* (20.41%) were the most prevalent and abundant species in the Off Season 2014 while *Echinochloa crus-galli* (62.84%), *Leptochloa chinensis* (37.25%), *Limnocharis flava* (25.12%), *Fimbristylis miliacea* (22.26%), and *Ludwigia hyssopifolia* (22.23%) highly dominated the rice fields in the Main Season 2014/2015. The survey also found that 'padi angin' or weedy rice occurred in the surveyed areas with 40% frequency in both planting seasons.

Results from the field experiments indicated that under the two planting methods, continuous flooded at 5 cm depth (W1), continuous flooded at 2 cm depth (W2), and flooded at 5 cm depth until 45 DAS, followed by saturated (W3) exhibited an effective suppression of weeds. Plots treated W1 significantly suppressed weed population to approximately 33 – 47% and reduced weed biomass to 51 – 59% as compared to the highest in W5 in both planting season. More weed problems generally occurred in continuous saturated (W4) and field capacity (W5) conditions. However, planting method evidently exhibited stronger effect on weed suppression since transplanted plots showed significantly higher degree of weed suppression under all water regime treatments over the direct seeded plots (34 – 43%). Under both direct seeding and transplanting plots, aquatic weeds, mostly *Monochoria vaginalis* and *Limnocharis flava* were the most dominant weeds in most of the water regime treatments. Those two weed species were highly dominant during W1, W2, and W3 in Off Season 2015, outnumbering other weeds under all water regime treatments in Main Season 2015/2016, thus making the control of these weeds very important. The sedges, namely *Scirpus grossus* and *Fimbristylis miliacea*, and grasses, comprised of *Leptochloa chinensis* and *Echinochloa crus-galli* were also highly dominant in W4 and W5; therefore, the program of monitoring and control of the distribution of these weed species should be given due attention in KADA rice fields. High rice yield was achieved through the implementation of continuous flooding conditions (W1 and W2). However, high rice production was also observed in W3 (flooded at 5 cm depth until 45 DAS, followed by saturated), indicating that this water-saving regime could play an important role for rice cultivation under limited water condition. The rice production in transplanted plot was in 65.8% higher than in direct seeded plot. The percentages of reduction from the highest rice yield in W1 to lowest in W5 were 63.4%.

During the herbicide pot-trial evaluation, twelve weed species were found growing across all water regime treatments. In both seasons, *Monochoria vaginalis* and *Echinochloa crus-galli* were the most dominant weed species, followed by *Leptochloa chinensis*, *Fimbristylis milliacea*, *Ludwigia hyssopifolia*, *Limnocharis flava*, *Cyperus iria*, and *Scirpus grossus*. Five of the eight treatments over the two cropping seasons showed better weed control efficiency (57 – 100%), increased grain yields (30 – 108%), and higher net benefits from the economic analysis (77 – 133%) as compared to the manual weeding treatment. Due the variation of the dominant weed infestation between water regimes, the potential treatments were pretilachor followed by bentazon/MCPA (T3) and pyrazosulfuron followed by bentazon/MCPA (T6) in flooded treatments (W1 and W2). Meanwhile, pretilachor+pyribenzoxim followed by bentazon/MCPA (T4) and bispyribac-sodium followed by bentazon/MCPA (T5) were the best weed control treatments under saturated condition (W3). For field capacity (W4), bispyribac-sodium followed bentazon/MCPA (T5) and thiobencarb+propanil followed by bentazon/MCPA (T8) showed promising results, encouraging the implementation as the possible alternative for effective and economic weed control in rice fields under dry condition.

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

DINAMIK POPULASI RUMPAI DAN KAWALANNYA DALAM TANAMAN PADI DI BAWAH REGIM AIR BERBEZA DI KAWASAN KADA DI KELANTAN, MALAYSIA

Oleh

MOHD RAZIF BIN ABDULLAH

September 2018

Pengerusi : Muhammad Saiful bin Ahmad Hamdani, PhD
Fakulti : Pertanian

Terdapat tiga eksperimen yang terlibat dalam kajian ini. Kajian pertama terdiri daripada tinjauan/survei mengenai komposisi spesies rumpai di sawah padi di bawah kawasan pengurusan Lembaga Pengurusan Pertanian Kemubu (KADA) di Kota Bharu, Bachok, dan Pasir Puteh. Eksperimen kedua adalah kajian lapangan di sawah padi petani yang dijalankan di Kampung Tunjong, Kota Bharu, Kelantan mengenai persaingan rumpai dan padi di bawah keadaan biologi dan ekologi yang berbeza, serta kesannya ke atas hasil padi. Manakala, kajian ketiga adalah untuk menilai keberkesanan racun rumpai berbeza, yang dijalankan di dalam bekas di kawasan terbuka di Pertubuhan Peladang Kawasan (PPK) Nilam Puri, Kota Bharu, Kelantan. Objektif penyelidikan adalah: a) untuk mengenal pasti komposisi dan penyebaran spesies rumpai di sawah padi yang mengalami keadaan kekurangan air di kawasan KADA; b) untuk mengukur tindak balas pertumbuhan dinamik populasi rumpai, serta pertumbuhan dan hasil padi di bawah keadaan air dan kaedah penanaman yang berbeza di sawah KADA; c) menilai prestasi racun herba dan keberkesanan di bawah keadaan air yang berbeza.

Keputusan tinjauan rumpai menunjukkan bahawa 30 spesis rumpai dan 14 jenis telah dikenalpasti iaitu komuniti rumpai terdiri daripada 22 tahunan dan 8 saka (6 daun tirus, 6 rusiga dan 18 daun lebar). Berdasarkan kepada kelimpahan relatif dan taburan rumpai di sawah padi yang dikaji, *Fimbristylis miliacea* (84.20%), *Leptochloa chinensis* (41.60%), *Scirpus grossus* (30.13%), *Ischaemum rugosum* (23.64%), dan *Echinochloa colona* (20.41%) adalah spesis yang paling utama dan berlimpah pada Musim Luar 2014, manakala *Echinochloa crus-galli* (62.84%), *Leptochloa chinensis* (37.25%), *Limnocharis flava* (25.12%), *Fimbristylis miliacea* (22.26%), dan *Ludwigia hyssopifolia* (22.23%) menguasai di kawasan sawah padi pada Musim Utama 2014/2015. Kajian ini juga mendapati bahawa ‘padi angin’

berlaku di kawasan yang dikaji, mempunyai tahap frekuensi sebanyak 40% bagi kedua-dua musim penanaman.

Keputusan ujian ladang menunjukkan bahawa di bawah kedua-dua kaedah penanaman, bahawa banjir berterusan pada kedalaman 5 cm (W1), banjir berterusan pada kedalaman 2cm (W2) dan banjir pada kedalaman 5 cm sehingga 45 HLT, diikuti dengan keadaan tanah tepu air (W3) menunjukkan penindasan rumpai yang berkesan. Plot-plot yang dirawat dengan W1 didapati mengurangkan populasi rumpai kepada kira-kira 33 – 47% dan mengurangkan biomass rumpai sebanyak 51 – 59% berbanding nilai tertinggi dalam W5 pada kedua-dua musim penanaman. Masalah rumpai yang lebih tinggi adalah berkaitan pada keadaan tanah tepu air yang berterusan (W4) dan keadaan tanah pada takat kapasiti ladang berterusan (W5). Walau bagaimanapun, kaedah penanaman dengan jelas menunjukkan bahawa kesan yang lebih tinggi dalam penindasan rumpai, kerana plot bertanam menunjukkan kesan yang lebih ketara tahap penindasan rumpai yang lebih tinggi di bawah semua rawatan rejim air berbanding plot secara tabur terus (34 – 43%). Di bawah kedua-dua tanaman secara tabur terus dan bertanam, rumpai akuatik, majoriti terdiri daripada *Monochoria vaginalis* dan *Limnocharis flava* yang merupakan rumpai paling dominan di kebanyakan rawatan rejim air yang digunakan. Kedua-dua spesis rumpai ini sangat mendominasi di W1, W2 dan W3 pada Musim Luar 2015 dan ianya melebihi bilangan spesis rumpai lain di bawah semua rawatan rejim air di Musim Utama 2015/2016, justeru kawalan kepada spesis rumpai ini sangat penting. Rusiga, iaitu *Scirpus grossus* dan *Fimbristylis miliacea* dan rumpai daun tirus daripada *Leptochloa chinensis dan Echinochloa crus-galli* turut mendominasi bilangan rumpai yang sangat tinggi di W4 dan W5. Oleh itu, program pemantauan dan pengawalan pengedaran spesis rumpai ini perlu diberi perhatian yang sewajarnya di sawah padi yang mengalami keadaan air yang berkurangan di kawasan KADA. Hasil padi yang tinggi dapat diperolehi melalui perlaksanaan keadaan banjir yang berterusan (W1 dan W2). Walaubagaimanapun, pengeluaran padi yang tinggi juga dapat diperhatikan di W3 (keadaan banjir pada kedalaman 5 cm sehingga 45 HLT, diikuti dengan keadaan tanah tepu air) menunjukkan bahawa rejim penjimatan air ini boleh memainkan peranan yang penting untuk penanaman padi di bawah keadaan air yang terhad. Pengeluaran padi dalam plot bertanam secara puratanya 65.8% lebih tinggi berbanding plot secara tabur terus. Peratus kehilangan hasil padi daripada hasil tertinggi dalam W1 berbanding hasil terendah dalam W5 ialah 63.4%.

Hasil daripada kajian percubaan racun herba, terdapat 12 spesis rumpai dalam rawatan rejim air yang berbeza. Pada kedua-dua musim penanaman, *Monochoria vaginalis* dan *Echinochloa crus-galli* adalah spesies rumpai yang dominan diikuti oleh *Leptochloa chinensis, Fimbristylis milliacea, Ludwigia hyssopifolia, Limnocharis flava, Cyperus iria dan Scirpus grossus*. Lima daripada lapan perlakuan yang diuji selama dua musim menunjukkan kecekapan kawalan rumpai yang meluas (57 – 100%), peningkatan hasil padi (30 – 108%) dan manfaat bersih dari analisis ekonomi (77 – 133%) berbanding rawatan merumput secara manual. Disebabkan kepelbagaian serangan yang dominan di antara rejim air, rawatan yang berpotensi digunakan adalah adalah pretilachor, diikuti bentazon /MCPA (T3) dan pyrazosulfuron, diikuti bentazon/MCPA (T6) pada rawatan banjir (W1 dan W2).

Manakala pada plot tanah tepu air adalah pretilachor+pyribenzoxim, diikuti bentazon/MCPA (T4) dan bispyribac-natrium, diikuti bentazon/MCPA (T5) adalah rawatan kawalan rumpai terbaik di bawah tanah tepu air (W3). Bagi takat kapasiti ladang (W4), bispyribac-natrium, diikuti bentazon/MCPA (T5) dan thiobencarb+propanil, diikuti bentazon/MCPA (T8) menunjukkan keputusan yang dijanjikan, yang dapat dilaksanakan sebagai berkemungkinan pilihan alternatif untuk kawalan rumpai yang berkesan dan ekonomik di sawah padi dalam keadaan kering.

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CHAPTER 1

INTRODUCTION

1.1 Problem Statements

Rice (*Oryza sativa* L.) serves as the main staple food and diet for more than 520 million of Asian population (Muthayya *et al.*, 2014), meeting the demand especially in the developing countries. However, the global rice demand is expected to increase by 60% in 2050 to accommodate the population growth (Fischer et al., 2014). Since the early 1980s, it was observed that in some rice-growing areas of Asia there was continuous occurrence of rice yield reduction (Flinn and De Datta, 1984). Among the main factors is the scarcity of fresh water for irrigation. Supply of irrigation water to agriculture sector had been dropping significantly from 98% in 1900 to less than 80% in 2000 because of the increased demand from domestic, urban, and industrial sectors (Matloob *et al.*, 2015; Tabbal *et al.*, 2002). Unfortunately, the acute water shortage coupled with increasing water crisis and time has threatened the sustainability of irrigated rice culture. Report from Tuong and Bouman (2003) stated that in 2025 about 20% of the 75 million hectares of irrigated rice cropping areas in Asia will be affected by water scarcity.

Many studies and observations have revealed that weeds are among the major threats and serious biological constraint to rice production in both lowland and upland ecosystems (Ni *et al.*, 2000), possibly further reducing productivity of rice fields. In the absence of proper weed control measures, weed infestation causes a loss of an average 10% of the total rice production (Wilhelm, 2004), an equivalent to US$30 billion annually (Beltran *et al.*, 2012). According to Azmi *et al.*, (2005), one of the parameters that cause rice yield to decrease drastically is the increase in weed infestations caused by limited water supply.

The occurrence of major shifts in weed populations involving annual and perennial, broadleaves, sedges, grasses, and other weed species is usually observed in rice fields when there are rapid changes in rice establishment techniques and water availability. The increased incidences of weed community in rice fields are much higher after the introduction of direct seeding rice cultures. According to Juraimi *et al.* (2013), the factors in determining the degree of infestation and weed types encountered in rice often depended on rice ecosystems and establishment methods. Bhagat *et al.*, (1996) and Matloob *et al.* (2015) also explained that factors such as cultural practices (fertilizer and type of rice cultivar), rice cultivation practice (irrigated, rainfed lowland, upland, deepwater, or tidal wetlands), moisture regime (irrigated or rainfed), crop establishment (transplanted or direct seeded), and land preparation (lowland, upland, tillage, or no-till) influence the weed types and degree of infestation in rice fields. Moreover, different water conditions in rice fields may also determine the level of weed infestation and yield loss in rice, especially under reduced water conditions. As an example, the dominant rice weeds such as

Echinochloa crus-galli, *Leptochloa chinensis*, *Fimbristylis miliacea*, *Cyperus iria*, *Cyperus difformis* and *Oryza sativa* L. (complex) (weedy rice) become widespread and dominant in direct seeded rice fields of Malaysia, especially in rice fields experiencing water scarcity (Hakim *et al.*, 2013a).

1.2 Significant of Study

Water is the best herbicide in lowland rice cultivation (Juraimi *et al.*, 2013). Each weed species has optimum soil moisture levels, providing different reactions between weeds and the rice crop. Therefore, a good water management in terms of depth, time, and duration of flooding is an important factor influencing effective weed control in rice. Under saturated condition, grasses showed greater emergence while sedges grow rapidly when soil moisture was below saturation (Bhagat *et al.*, 1999a). Juraimi *et al.* (2009) explained that the yield was reduced more significantly under saturated conditions at 54% compared with 35% in flooded conditions, and thus creating great variation in the floristic composition of weeds.

Weed management has always been a big challenge for farmers especially in the face of rapid changes in critical water situations. Unfortunately, specific information on the effect of reduced water conditions on weed flora composition dynamics, and herbicides efficiency for weed control in KADA region is limited. Thus, the present study was carried out to determine the weed species composition, proper amount and period of water to be maintained in the field, and appropriate selection of herbicides under reduced water conditions. All these information could provide valuable indications about current and future weed problems, and further devise proper weed control strategies to enhance the rice yield in KADA rice fields.

1.3 Objectives of Study

The objectives of the research were:

1. To identify weed composition and distribution in rice fields experiencing reduced water conditions in the KADA region.
2. To quantify weed growth response and population dynamics, as well as rice growth and yield under different water regimes and planting methods in KADA rice field.
3. To evaluate herbicides performance and efficiency under the different water conditions for efficient weed control in KADA rice fields.

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