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VEGETATIVE AND REPRODUCTIVE GROWTH OF WEEDY RICE IN SELANGOR, MALAYSIA: A COMPARATIVE STUDY WITH COMMERCIAL RICE VARIETIES

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ABSTRACT

Malaysia has been facing weedy rice problem in the rice granaries. A random sampling was done in 2010 to collect the weedy rice populations from eight sites of Selangor rice granaries in Malaysia. The study was done to understand the chronology of vegetative and reproductive growth of weedy rice found in Selangor rice granaries. A total of 360 plant accessions were collected and scored in twelve weedy rice morphotypic group on the basis of plant height, panicle type, lemma and palea colour, presence of awn and apiculus colour. Data from different growth stages of these along with four commercial rice varieties (MR84, MR185, MR211 and MR219) were recorded and analyzed. Most of weedy morphotypes were observed having vigorous growth at early growth stage. Most of weedy morphotypes were found 10 to 84% taller with 29 to 61% higher leaf area indexes at all the growth stages. Tillering ability initially was comparatively 69% higher in weedy morphotypes at 14 days after planting and was decreased at later growth stages. Wide range of flowering and maturity periods were observed in weedy morphotypes, where some flowered earlier and some flowered at the same time or later than the commercial varieties. All these characteristics of weedy rice might help to identify them for better control in the rice granaries.

Key words: Weedy rice, vegetative growth, reproductive growth, Selangor rice granaries, Malaysia

INTRODUCTION

Weedy rice (*Oryza* spp.) is now a problematic weed in the Malaysian rice granaries. Currently in Malaysia, agricultural areas covered 4.64 million hectares and approximately 14% (622,500 ha) of these areas are dedicated to rice cultivation (Hamid, 2007). Malaysia is currently producing about 2.51 million tons of rice at an average of 3.73 t ha^{-1} in 672.3 thousand ha of land (FAOSTAT, 2011). The extensive adoption of direct seeding cultivation practice is a major cause of weedy rice spreading in Peninsular Malaysia (Azmi *et al.,* 2000; Bakar *et al.,* 2000; Karim *et al.,* 2004). There are eight granary areas (MADA, Kerian-Sg. Manik, Seberang Perak, Project Barat Laut Selangor, IADP-PP, KADA, Kemasin-Semarak and Besut) which are permanent rice producing areas in Peninsular Malaysia (Karim *et al.,* 2004). These granaries supply almost 70% of national rice output (Begum *et al.,* 2008). Selangor rice granaries are highly affected by weedy rice morphotypes which have increased owning to the frequent use of direct-seeded culture technique and predominant use by farmers of self-supplied seeds (Azmi *et al.,* 2000).

Weedy rice is taxonomically the same rice cultivated *Oryza sativa* L. (Langevin *et al.,* 1990), its morphological and physiological characteristics are almost the same as those of cultivated rice varieties (Kwon *et al.,* 1992; Tewari, 2008). However, weedy rice possesses considerable morphological diversity, which can often mimic rice varieties in response to selection pressures resulting from commercial rice farming. Weedy rice is usually taller than the commercial varieties, have less tillers and higher leaf area index per hill. Taller plant in combination with higher leaf area index competes with the cultivated rice for space, lights and nutrients and ultimately reduces yield (Azmi *et al.,* 2004).

It is much important to know the vegetative growth trend of weedy rice as they are difficult to recognize during periodic weeding of the crop from seedling to reproductive stage. This study was performed to (1) collect weedy rice population from Selangor rice granaries, and (2) evaluate the vegetative and reproductive development of weedy rice morphotypes in comparison to commercial rice varieties.

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MATERIALS AND METHODS

Weedy rice morphotype samples were collected by random sampling from different locations of Barat Laut and Sungai Besar in Selangor, Malaysia in February, 2010. The geographical locations of the weedy rice collection sites were recorded with a global position system Garmin, GPS12XLTM: 1. 03°41'15"N, 100°59'33"E in Kampung Panchang Bedena; 2. 03°42'21"N, 101°58'52"E in Kampung Che Lias; 3. 03°41'47"N, 101°01'53"E in Parit 7 Timur; 4. 03°39'39"N, 101°2'34"E in Kampung Parit Empat; 5. 03°31'54"N, 101°06'35"E in Kampung Sungai Leman; and 6. 03°30'56"N, 101°09'21"E; 7. 03°29'38"N, 101°09'24"E; 8. 03°28'47"N, 101°10'44"E in Kampung Parit Empat and Kampung Sungai Burung (Fig. 1). Three hundred and sixty weedy rice accessions were collected from the sampling sites and scored by plant morphological characteristics such as plant height, lemma and palea colour, awn and apiculus colour (Table 1) according to IRRI (2002). Each morphotype was termed as SWR (Selangor weedy rice) to build an approach to identify them later on. Seeds of each accession were collected, dried and stored at 4°C. Seeds of each homogenous group were designated as a population. Seeds of commercial rice varieties MR84, MR185, MR211 and MR219 were obtained from the Department of Agriculture Malaysia and the Malaysian Agricultural Research and Development Institute and were also included in the study.

Weedy rice morphotypes and the commercial varieties were transplanted following Completely Randomized Design with three replications in the plant house of Universiti Sains Malaysia. Seeds were sprouted in following a standard germination procedure and planted in the portable trays and allowed to grow for 25 days. Plastic pots (0.30 m deep) were prepared by pouring well-puddled clay soil. Seedlings of each accession were transplanted with 30 cm x 15 cm spacing on 4 April 2010 in these pots. Crop management was done following the standard cultivation guidelines.

Three vegetative descriptors (plant height, tillering ability and leaf area index) were evaluated every two weeks during the vegetative cycle. Leaf area index was estimated by measuring the length and average width of leaf and multiplying by a factor of 0.75 (Yoshida, 1981). In addition, five reproductive descriptors for all weedy rice morphotypes and commercial rice varieties were evaluated according to the Standard Evaluation System for Rice (IRRI 2002). Mean comparison between each morphotypic group at 70 days after planting was conducted by Tukey's test at $P \leq 0.05$ using computer program SPSS version 13.0 (SPSS, 2004).

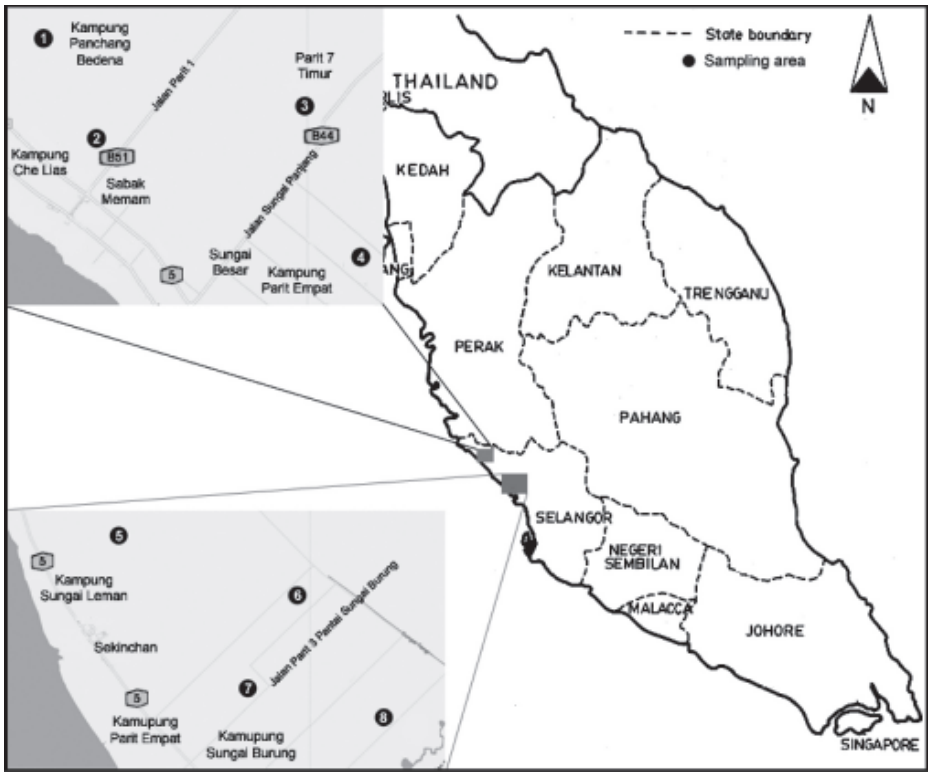

Fig. 1. Map showing the collecting sites of weedy morphotypes in the rice granary areas of Selangor (Source: Google maps)

Table 1. Description of weedy rice morphotypes found in Selangor rice granaries and studied commercial rice varieties according to IRRI (2002)

Morphotype/ variety	Plant height	Panicle type	Awn	Apiculus colour	Lemma and palea colour
SWR01	Tall (9)	Compact (1)	Awnless (0)	Brown (3)	Brown tawny (4)
SWR02	Intermediate (5)	Open (9)	Awnless (0)	Straw (2)	Straw (0)
SWR03	Intermediate (5)	Compact (1)	Awnless (0)	Straw (2)	Straw (0)
SWR04	Tall (9)	Open (9)	Awnless (0)	Straw (2)	Straw (0)
SWR05	Tall (9)	Open (9)	Awnless (0)	Brown (3)	Brown tawny (4)
SWR06	Tall (9)	Compact (1)	Awnless (0)	Straw (2)	Straw (0)
SWR07	Intermediate (5)	Intermediate (5)	Straw (1)	Straw (2)	Straw (0)
SWR08	Tall (9)	Compact (1)	Awnless (0)	Brown (3)	Brown tawny (4)
SWR09	Intermediate (5)	Open (9)	Straw (1)	Straw (2)	Straw (0)
SWR10	Tall (9)	Compact (1)	Awnless (0)	Brown (3)	Brown tawny (4)
SWR11	Semidwarf (1)	Open (9)	Awnless (0)	Brown (3)	Brown tawny (4)
SWR12	Semidwarf (1)	Compact (1)	Straw (1)	Straw (2)	Straw (0)
MR84	Semidwarf (1)	Intermediate (5)	Awnless (0)	Straw (2)	Straw (0)
MR185	Semidwarf (1)	Intermediate (5)	Awnless (0)	Straw (2)	Straw (0)
MR211	Semidwarf (1)	Intermediate (5)	Awnless (0)	Straw (2)	Straw (0)
MR219	Semidwarf (1)	Intermediate (5)	Awnless (0)	Straw (2)	Straw (0)

RESULTS

Vegetative Phase

Weedy morphotypes showed comparatively higher vegetative growth than the commercial varieties after planting. Weedy rice morphotypes showed a higher plant height increase ranging from 9 to 36 cm in every two weeks, whereas noticeably low plant height increase ranging from 9 to 21 cm was observed in commercial rice varieties during the same period. Higher plant heights of weedy rice except weedy morphotypes SWR11 and SWR12 compared to that of commercial varieties were observed at 70 days after planting (DAP). Weedy rice also showed a wide range of plant heights among the same and different morphotype groups. At 14 DAP, weedy morphotypes except SWR11 and SWR12 were 10-36% taller than the commercial varieties. Subsequently, the rate increased rapidly resulting in 15-47% taller weedy morphotypes than the commercial rice varieties at 28 DAP. All weedy rice morphotypes except SWR11 and SWR12 were 17-54%, 22-70% and 22-84% taller than the commercial varieties at 42, 56 and 70 DAP respectively. A wide range of variation was also observed within weedy morphotypes at 70 DAP (Fig. 2). Tukey's multiple comparison test for plant height at 70 DAP showed that weedy morphotype SWR11 formed a separate group which had very short plants (70.55±3.1 cm). Weedy morphotype SWR12 overlapped with three of the commercial varieties. Rest of the weedy morphotypes overlapped in four groups and morphotype SWR05 formed a separate group having the tallest plants (140.56±8.4

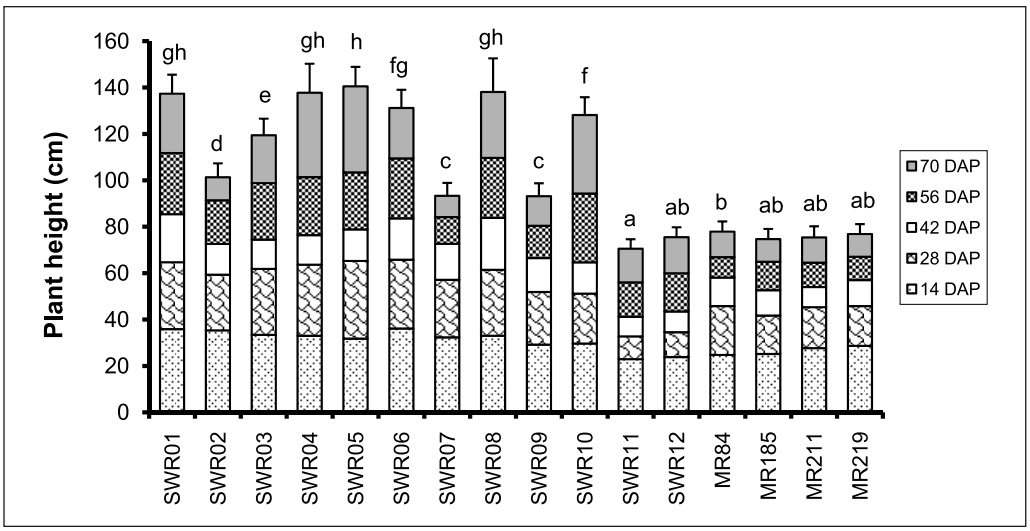

Fig. 2. Cumulative plant height of weedy rice morphotypes and commercial rice varieties at different growth stages. Bars shows standard deviation at 70 DAP

cm). The standard deviation values also indicated a high variation within weedy morphotypes (4.1 to 14.5 at 70 DAP), whereas commercial varieties were more uniform (4.3 to 4.8 at 70 DAP).

In case of tiller number, most of the weedy morphotypes except SWR11 and SWR12 showed greater tillering ability in comparison with that of commercial varieties at 14 DAP. However, all commercial varieties and weedy morphotypes SWR11 and SWR12 showed greater tillering ability during later stages up to 70 DAP (Fig. 3). The number of ineffective tillers was less in weedy morphotypes. Standard deviation values were higher in all weedy morphotypes in comparison with the commercial varieties. Tukey's multiple comparison test for tiller number at 70 DAP showed that weedy morphotype SWR08 produced a separate group which produced minimum tiller number (9.7±3.2) among all populations. Morphotypes SWR11 and SWR12 produced the highest tillers (25.1±2.6 and 26.1±2.4, respectively) and were separated in group which overlapped with commercial variety MR211. All commercial varieties were separated with the same group. Rest of the weedy morphotypes overlapped in five groups.

Correlation analysis between plant height and tiller number produced a negative correlation (r = 0.5), where taller plants produced fewer tillers than shorter plants (Fig. 4). Weedy morphotype SWR08 produced the lowest number of tillers having more than 120 cm plant height, whereas weedy morphotypes SWR01, SWR04, SWR05, SWR06 and SWR10 produced moderate number of tillers having the same plant height. Weedy morphotypes SWR02, SWR03, SWR07 and SWR09 produced moderate number of tillers having less than 120 cm plant height.

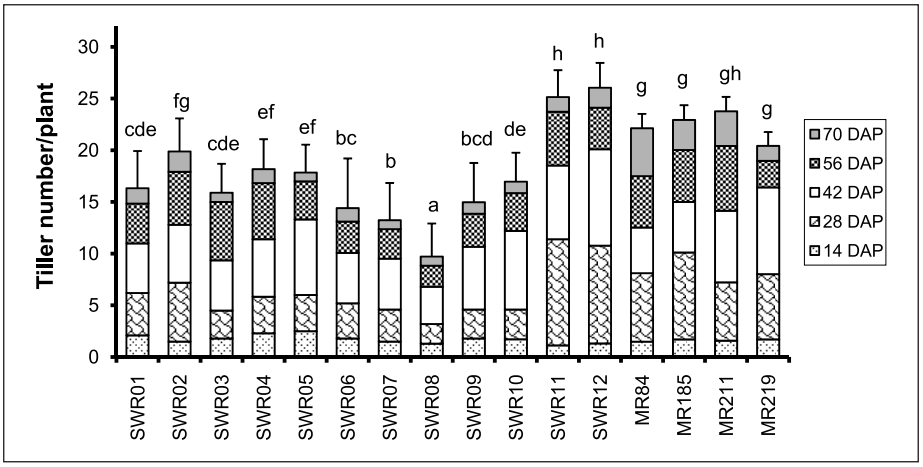

Fig. 3. Cumulative tiller number per plant of weedy rice morphotypes and commercial rice varieties at different growth stages. Bars shows standard deviation at 70 DAP

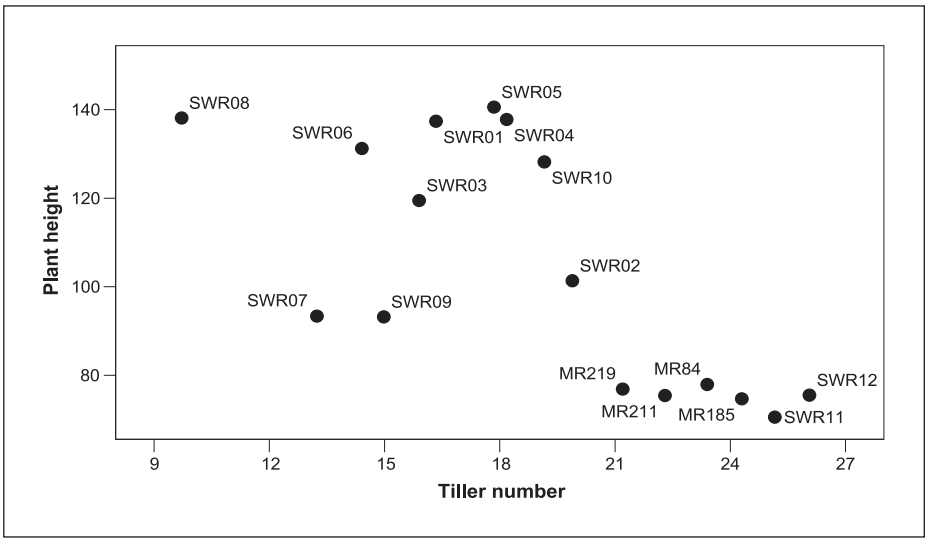

Fig. 4. Correlation between tiller number and plant height for the weedy rice morphotypes and the commercial rice varieties at 70 DAP

Regarding LAI, significant variation ($P \leq 0.05$) was observed among the weedy morphotypes and commercial varieties (Fig. 5). All weedy morphotypes produced higher LAI during all the vegetative stages compared with commercial varieties. Though morphotypes SWR11 and SWR12 had lower plant height in comparison with commercial varieties, it had greater LAI due to the greater number of tillers. Tukey's multiple comparison test for LAI at 70 DAP showed that all commercial varieties were separated in same group and weedy morphotypes overlapped in 7 groups.

Reproductive Phase

Booting, anthesis and maturity period were analyzed to understand the reproductive phases of weedy morphotypes and commercial rice varieties (Table 2). Weedy rice morphotypes reached flowering at different times. Booting time of different morphotypic group ranged between 75.4±3.0 and 84.0±3.4 DAP. However, commercial varieties reached this stage between 73.2±2.4 and 82.8±2.5.

Anthesis started within 3-4 days in the commercial varieties. However anthesis continued

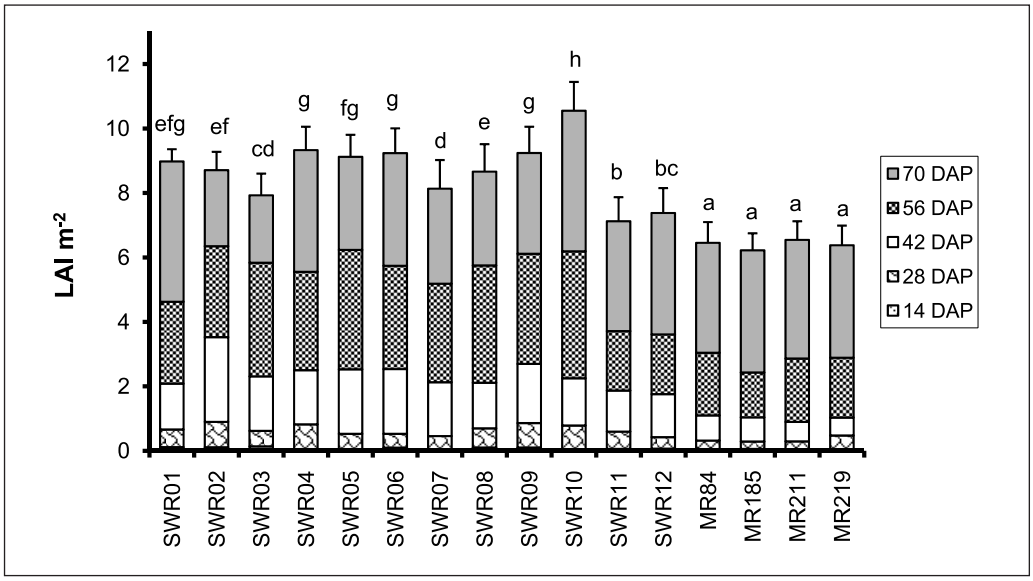

Fig. 5. Cumulative LAI m^{-2} of weedy rice morphotypes and commercial rice varieties at different growth stages. Bars showed standard deviation at 70 DAS

Table 2. Days after transplanting for different growth stages in weedy rice morphotypes and commercial rice varieties (Means ± standard deviations are shown)

Morphotypes/Varieties	Booting stage	Beginning of anthesis	50% anthesis	Maturity stage	Anthesis duration
SWR01	77.8±3.8	82.4±3.1	87.9±3.7	106.2±4.3	24.2
SWR02	81.3±4.2	88.2±4.1	92.6±3.8	115.7±4.7	27.4
SWR03	80.8±4.4	85.3±3.4	89.6±2.8	111.2±5.2	26.3
SWR04	75.4±3.0	81.8±4.3	85.4±3.4	107.4±4.3	24.8
SWR05	83.7±5.2	89.3±6.2	91.1±5.4	117.6±6.2	28.1
SWR06	81.1±3.0	85.6±3.2	90.8±2.8	110.2±3.2	25.3
SWR07	84.0±2.4	89.2±3.2	94.4±2.4	113.9±2.9	24.2
SWR08	84.2±3.8	88.7±3.8	94.7±3.1	112.1±3.2	24.6
SWR09	80.4±3.2	83.3±2.9	87.4±3.2	107.1±4.3	24.4
SWR10	78.5±2.4	82.4±3.4	88.6±3.1	104.6±4.1	22.2
SWR11	75.5±2.7	79.2±2.5	84.4±3.1	100.5±3.4	21.5
SWR12	79.5±2.8	83.2±3.2	87.3±2.4	109.2±2.5	26.4
MR84	82.8±2.5	86.2±2.4	92.4±2.3	114.5±2.5	28.7
MR185	79.1±2.2	82.4±2.3	86.6±2.6	112.4±2.3	30.2
MR211	73.2±2.4	77.5±2.4	82.3±2.1	106.2±2.4	29.4
MR219	77.2±2.4	81.2±2.5	86.2±2.4	110.4±2.6	29.3

up to 7 days in some morphotypic group of weedy rice. Higher standard values of weedy morphotypes indicated that different accessions started anthesis at different time even in same morphotypic group. Commercial varieties reached maturity between 106.2±2.4 and 114.5±2.5 DAP, whereas weedy morphotypes matured between 100.5±3.4 and 117.6±6.2 DAP. Higher standard deviation values also indicated the wide range of maturity period even in same morphotypic group. However, all the weedy morphotypes required less time to complete their anthesis period (21.5 to 28.1 days) in comparison to the commercial varieties (28.7 to 30.2 days).

DISCUSSION

Weedy rice morphotypes in this region were found mostly tall, whereas commercial varieties were semi-dwarf in stature. Choudhary (2011) also reported similar result in an investigation. Plant height is one of the characteristics conferring competitive advantage to cultivated rice (Kwon *et al.,* 1992). The height differences between weedy rice morphotypes and commercial rice varieties correlated with flag leaf and might be due to competition for nutrient and sunrise, or heterosis pressure present in some morphotypes. Even wide variation of plant height was observed among the similar weedy rice morphotype population (Shivrain *et al.,* 2010). Vigorous and competitive growth was observed in weedy rice morphotypes which let them established over the commercial varieties. This vigorous growth of weedy rice can be an identifying characteristic of weedy morphotypes at early vegetative stage. Even at mid and late vegetative stages, weedy morphotypes continued to show their vigorous growth. Leaf area index (LAI) had increased in weedy morphotypes due to the greater number in addition with long and wide leaves. Taller weedy rice plants with higher LAI compete more efficiently for space and resources in the rice field than commercial varieties causes increased shading and is associated with reduced tillering rate in rice crops (Graf *et al.,* 1990).

The standard deviation values of plant height at 70 DAP indicated this variation (4.4 to 15.6) among weedy morphotypes, whereas commercial varieties were more or less uniform resulting 6.9 to 7.3 standard deviation values. This heterogenic characteristic could be a problem to identify all weedy morphotypes from the field, as some of these plants possessed similar plant height of commercial varieties. Some of weedy rice morphotypic group had at least one accession which was similar to the plant height of commercial varieties.

Weedy morphotypes except SWR11 and SWR12 produced less tillers at initial stages and greater tiller during later stages in comparison with commercial varieties. This confirms that weedy morphotypes grow vigorously initially however in later stage it fails to produce more effective tillers in comparison with commercial varieties. Standard deviation values at 70 DAP indicates greater variation of tiller production ability of same weedy morphotype group than commercial varieties. This in together with same plant height will facilitate some morphotypes to be appeared similar as the cultivated varieties in the field. Correlation between plant height and tillering suggests that both characters are not exhibited simultaneously in weedy rice morphotypes. Taller plants usually produced fewer tillers than shorter plants.

Weedy rice showed a wide range of flowering period. Some morphotypic group completed flowering earlier than the commercial varieties while some were late. Weedy strains are reported to flower earlier, synchronously with or after the crop (Gealy, 2005). Similar trend was observed in case of maturity period. Weedy morphotypes which matures earlier than commercial varieties shatter on the soil surface before harvesting. Even standard deviation values showed that accessions of same morphotypic group were more heterogeneous during flowering and maturity period than the commercial varieties. All weedy morphotype took less time to complete anthesis in comparison with commercial varieties. Weedy morphotypes which started flowering with the same date of commercial rice plants matured earlier. Similar findings were also observed by Arrieta-Espinoza *et al.* (2005).

CONCLUSION

The studies indicated that weedy rice morphotypes are well adapted to the Malaysian environment. They can be identified by their early vigorous growth and morphological traits like plant height, tiller number, culm angle, awn, lemma and palea colour and better controlled during post-emergence period. Early flowering and maturity could be also identical at later growth stages. Manual roguing at early vegetative stage could reduce weedy rice infestation. At later growth stages, weedy rice could be controlled mechanically or chemically, such as cutting bars, sponge or rope bars wetted with herbicide. These widely diverse weedy rice morphotypes could be used as a valuable germplasm and designing a gene flow study for the confirmation of the studied relationship.

ACKNOWLEDGEMENTS

The support of this work from TWAS-USM fellowship by TWAS and Universiti Sains Malaysia is gratefully acknowledged. The research has been also supported by RU grants from Universiti Sains Malaysia.

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