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Comparative Study on Vegetative and Reproductive Development between Weedy Rice Morphotypes and Commercial Rice Varieties in Perak, Malaysia

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Abstrak: Kajian ini dijalankan untuk memeriksa kepelbagaian dalam kronologi vegetatif dan perkembangan pembiakan padi angin (*Oryza* spp.) apabila dibandingkan dengan variasi komersial. Data yang diperolehi daripada beberapa peringkat pertumbuhan untuk 14 morfotip padi angin dan 4 variasi padi komersial telah direkod and dianalisa. Ketinggian semua morfotip padi angin telah ditinjau dan didapati wujudnya perbezaan ketara dalam data untuk setiap peringkat pertumbuhan; peningkatan dalam ketinggian tumbuhan adalah di antara 10–37 cm untuk morfotip padi angin untuk setiap 2 minggu. Keupayaan untuk mempunyai berbilang batang semu pada hari ke 14 selepas penanaman (DAP) adalah lebih tinggi untuk morfotip padi angin. Namun begitu, kesemua variasi padi komersial menunjukan peningkatan keupayaan DAP yang lebih ketara sepanjang fasa vegetatifnya. Korelasi antara ketinggian tumbuhan dan bilangan batang semu telah dikesan dan didapati tumbuhan yang lebih tinggi menghasilkan bilangan batang semu yang lebih kurang berbanding tumbuhan yang lebih rendah. Indeks luas daun (LAI) untuk kesemua morfotip padi angin kecuali PWR01 pada peringkat awal pertumbuhan menunjukan pertumbuhan pesat. Morfotip padi angin juga menunjukan kepelbagaian semasa antesis dan durasi matang. Aksesi daripada morfotip padi angin yang sama menunjukan tumbuhan ini lebih heterogen semasa fasa berbunga, antesis dan durasi matang berbanding dengan variasi-variasi komersial. Trait-trait sebegini amat membantu untuk mengenal pasti morfotip padi angin semasa peringkat pertumbuhan yang berbeza di sawah.

Kata kunci: Pertumbuhan Vegetatif, Perkembangan Pembiakan, Padi Angin, Jelapang Padi Perak

Abstract: This study was conducted to examine the variabilities in the chronology of vegetative and reproductive development of weedy rice (*Oryza* spp.) in comparison with commercial varieties. Data at different growth stages of 14 weedy rice morphotypes and 4 commercial rice varieties were recorded and analysed. Plant height of all weedy rice morphotypes were observed to be significantly higher compared to the commercial varieties at every growth stages; increase in height was between 10–37 cm for weedy rice morphotype, for every 2 weeks. Initial tillering ability at 14 days after planting (DAP) was higher in weedy morphotypes, however all the commercial rice varieties produced significantly higher number of tillers throughout the rest of the vegetative phases. Correlation between plant height and tiller number detected that taller plants produce fewer tillers than shorter plants. Higher leaf area index (LAI) of all weedy morphotypes except PWR01 at early growth stages indicated the vigorous growth of the morphotypes. Weedy rice morphotypes showed a wide range of anthesis and maturity duration. Accessions from the same weedy rice morphotypes were more heterogeneous in the

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flowering, anthesis and maturity period than the commercial varieties. These traits enables identification of weedy rice morphotypes at their different growth stages in the field.

Keywords: Vegetative Growth, Reproductive Growth, Weedy Rice, Perak Granaries

INTRODUCTION

Weedy rice (*Oryza* spp.) is a major problem in rice fields of Malaysia. The widespread adoption of direct seeding has caused a dramatic change in weeds' flora. Continuous usage of farmers' seed made weeds to be consistently present and be more competitive in the fields (Karim *et al.* 2004; Begum *et al.* 2005; Azmi *et al.* 2007). Perak rice granaries are highly affected by weedy rice morphotypes which have increased owning to the frequent use of direct-seeded culture technique.

Weedy rice is a highly polymorphic group of plants of the rice agro-ecosystem which competes with cultivated rice varieties for space and resources (Sánchez-Olguín *et al.* 2007). Controlling of weedy rice morphotypes is very much difficult because of their characteristics such as easy seed-shattering and ability to remain dormant in soil for long periods. Manual elimination of panicles, good cultural practices and appropriate herbicide application are required to control weedy rice at different growth stages of rice (Ferrero 2003). Most weedy rice morphotypes are morphologically so similar to cultivated rice varieties from seedling to reproductive stage that they are difficult to be recognised during periodic weeding of the crop. However, these problems would be easily resolved if the weedy rice population could be identified at early vegetative stages. Detailed study of vegetative and reproductive development of weedy rice morphotypes can help in identifying weedy rice morphotypes at their different growth stages. This will also lead to discovering the biological aspects of weedy rice such as life table, growth pattern and life cycle.

MATERIAL AND METHODS

Random sampling was done to collect weedy rice morphotypes on September 2009 in six rice granaries of Perak, Malaysia: 1. 04°04′41′′N, 100°52′42′′E; 2. 04°03′07′′N 100°51′08′′E; 3. 04°03′05′′N, 100°52′09′′E and 4. 04°02′56′′N 100°52′49′′E in Kampung Sijagob; 5. 04°03′32′′N, 100°54′05′′E in Kampung Sungai Ranggam and 6. 04°05′06′′N, 100°56′35′′E in Kampung Sungai Mengkuang. Each morphotype was scored for plant morphological characteristics such as plant height, lemma and palea colour, awn and apiculus colour (Table 1) according to International Rice Research Institute (IRRI 1996). Fourteen weedy rice morphotypes were classified accordingly and labeled PWR01 to PWR14 to offer a nomenclatural standard that will allow the morphological comparison of weedy rice accessions among researchers and facilitate future analysis. The seeds of these morphotypes were dried overnight and stored at 4°C until they

were used. Seeds of commercial rice varieties MR84, MR185, MR211 and MR219 were also included in the study.

Table 1: Description of weedy rice morphotypes and rice varieties from Perak and average values [mean ± standard deviation (SD)] of height, tiller number and LAI of each morphotype at maturity stage.

Morphotype/ variety	Awn	Apiculus colour	Lemma and palea colour	Average height	Average tiller number
PWR01	Awnless (0)	Straw (2)	Straw (0)	147.9±4.8	7.6±1.7
PWR02	Awnless (0)	Straw (2)	Straw (0)	128.7±5.1	14.3±4.3
PWR03	Awnless (0)	Brown (3)	Brown (2)	103.3±2.8	12.9±5.7
PWR04	Awnless (0)	Brown (3)	Brown tawny (4)	138.6±8.7	12.0±4.8
PWR05	Straw (1)	Straw (2)	Straw (0)	127.2±5.6	11.4±3.8
PWR06	Straw (1)	Straw (2)	Straw (0)	132.9±20.7	14.5±6.5
PWR07	Awnless (0)	Red (4)	Reddish (5)	136.7±4.2	15.2±3.3
PWR08	Awnless (0)	Brown (3)	Brown tawny (4)	141.3±6.1	11.1±3.1
PWR09	Awnless (0)	Straw (2)	Straw (0)	114.7±15.5	11.5±5.9
PWR10	Awnless (0)	Brown (3)	Straw (0)	102.9±4.5	13.0±3.6
PWR11	Awnless (0)	Straw (2)	Straw (0)	129.6±8.4	13.1±6.6
PWR12	Awnless (0)	Straw (2)	Straw (0)	83.5±2.3	19.5±4.7
PWR13	Awnless (0)	Brown (3)	Straw (0)	138.6±17.8	12.5±3.3
PWR14	Awnless (0)	Brown (3)	Brown tawny (4)	130.4±9.2	14.4±2.8
MR84	Awnless (0)	Straw (2)	Straw (0)	82.6±1.7	20.0±1.5
MR185	Awnless (0)	Straw (2)	Straw (0)	84.6±3.0	20.9±1.9
MR211	Awnless (0)	Straw (2)	Straw (0)	81.7±2.6	21.7±2.4
MR219	Awnless (0)	Straw (2)	Straw (0)	80.4±2.9	19.6±1.7

Note: Codes given in parenthesis are according to IRRI (1996).

Weedy rice morphotypes and the commercial varieties were transplanted by following Completely Randomised Design with three replications (Cochran & Cox 1957) in the plant house of Universiti Sains Malaysia. Seeds were sprouted following a standard germination procedure (IRRI 2011) and planted in portable trays to grow the seedlings for 25 days. Seedlings of each accession were transplanted with 30 × 15 cm plant to plant spacing on 25 October 2009 in plastic pots (one foot deep) containing well-puddled clay soil. Crop management was done following the standard cultivation guideline (IRRI 2009).

Three vegetative descriptors (tillering ability, leaf area index and plant height) 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 1996). All data were analysed following the discriminate analysis and Tukey's multiple comparison test using SPSS version 13.0 (SPSS 2004).

RESULTS AND DISCUSSION

Vegetative Phase

The experimental results revealed significantly higher plant height of all weedy rice morphotypes in comparison with commercial varieties at every growth stage (Fig. 1). Specifically, all weedy rice morphotypes were 2%–58% and 15%–97% taller than the commercial varieties at 28 and 70 days after planting (DAP) respectively. Weedy rice morphotypes displayed a vigorous growth during early stages and can be identified in the field through visual observation. Weedy rice morphotypes had an increase of height by 10–37 cm every 2 weeks, whereas the commercial varieties showed considerably lower increase of plant height with 10–20 cm during the same period. Only morphotypes PWR03, PWR10 and PWR12 showed a low increase in plant height with 10–20 cm at 56 and 70 DAP. Sánchez-Olguín *et al.* (2007) also reported increase of plant height in weedy morphotypes with 10–30 cm every 2 weeks, however the increase in height for commercial rice varieties was considerably lower (8–14 cm) during the same period. Weedy rice morphotypes could be effectively identified at these stages which will lead to efficient control of these weedy rice morphotypes. Weedy rice that has grown taller than rice can be treated with foliar systemic herbicides by using wick/wiper applicators (Ferrero 2003).

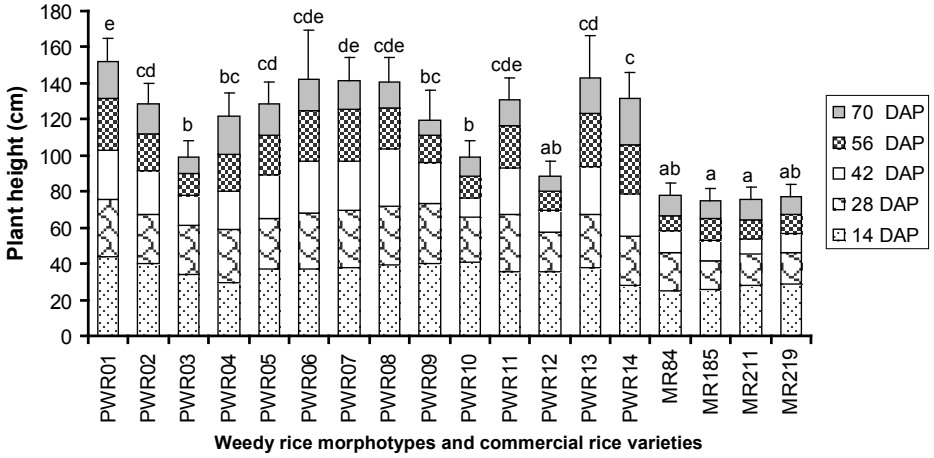

Figure 1: Cumulative plant height of weedy rice morphotypes and commercial rice varieties at different growth stages, bars show SD at 70 DAS.

Besides that, the standard deviation (SD) values indicated that there exists high variation within weedy morphotypes (7.9–27.3 at 70 DAP) as compared with commercial varieties which are more uniform (6.7–7.1 at 70 DAP). Weedy morphotypes PWR06, PWR13 and PWR09 had the highest variation among accessions of the same morphotypes (142±17.3, 143±22.9 and 119.3±17.1 cm respectively at 70 DAP). Each of these morphotypes, together with PWR11 and PWR14 had at least one accession which was similar to the

plant height of commercial varieties. Full identification of these plants is very much difficult in the field. However, some morphotypes such as PWR01, PWR06, PWR07, PWR08 and PWR13 were almost double the height of the commercial varieties. Tukey's multiple comparison test for plant height showed that morphotype PWR12 overlapped with two of the commercial varieties (Fig. 1). Morphotype PWR12 also showed statistically similar plant height ($p \leq 0.05$) to the plant height of morphotypes PWR03 and PWR10. Morphotype PWR01 was the tallest plant (152±13.4 cm), which overlapped with PWR06, PWR07, PWR08 and PWR11.

All commercial rice varieties produced a significantly higher number of tillers throughout the vegetative phase except at 14 DAP (Fig. 2). Though all weedy morphotypes and commercial varieties began tillering at the same rate, the tillering ability of some weedy morphotypes was greater at 14 DAP. Significant variations were observed between the weedy morphotypes and commercial varieties at all the growth stages. Weedy rice showed various amounts of tillering ability ranging from 9.5±2.1 to 19.4±3.99 per plant. It was interesting that all weedy morphotypes produced the most tillers within 56 DAP. Early tillering enables weedy morphotypes to set more competition against the commercial varieties in the field since a profusely tillering plant colonises space very efficiently, and has greater panicle density (Estorninos *et al.* 2002). However, the number of total tillers was higher in commercial varieties at all growth stages after 42 DAP in comparison with weedy morphotypes. The number of ineffective tillers was less in weedy morphotypes.

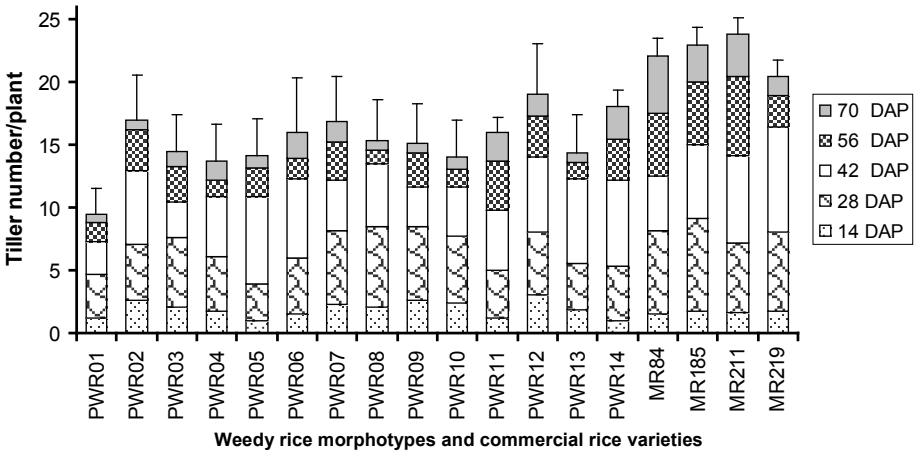

Figure 2: Cumulative tiller number per plant of weedy rice morphotypes and commercial rice varieties at different growth stages, bars show SD at 70 DAS.

Significant variation was observed in leaf area index (LAI) among weedy morphotypes and commercial varieties (Fig. 3). All weedy morphotypes except PWR01 produced higher LAI at 28, 42 and 56 DAP compared with commercial varieties. Morphotypes PWR01, PWR11 and PWR13 produced less LAI than commercial varieties at 70 DAP. Though the number of tillers was less in all

weedy morphotypes, these results were observed due to the greater number of leaves in addition with long and wide leaves. Increasing LAI causes increased shading and is associated with reduced tillering rate in rice crops (Graf *et al.* 1990).

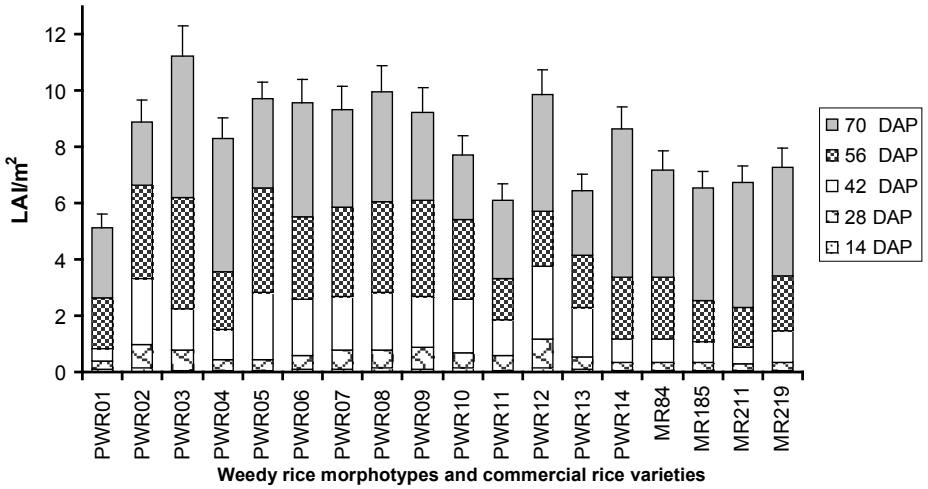

Figure 3: Cumulative LAI per m^2 of weedy rice morphotypes and commercial rice varieties at different growth stages, bars show SD at 70 DAS.

A negative correlation (r = –0.677) between plant height and tiller, observed between weedy morphotypes and commercial rice varieties suggest that taller plants produce fewer tillers than shorter plants. Similar findings were also reported by Sánchez-Olguín *et al.* (2007). Morphotype PWR12 showed a similar trend as commercial varieties. However, PWR10 and PWR03 did not follow this behaviour, although they were below 100 cm in height. This suggests a wide variation within weedy morphotypes (Fig. 4).

To summarise, plant height, faster tillering ability and higher LAI are important advantageous characteristics of weedy rice morphotypes. These traits enable identification of weedy rice morphotypes at their different growth stages in the field. Morphologically similar weedy morphotypes may be identified and removed from the field at different growth stages. Successful removal of weedy rice at early growth stages gives space to commercial varieties and reduces competition for light and nutrition. Weedy morphotypes with higher tillering ability and plant height shows a more competitive attitude. However morphotypes present on different rice farms could differ widely in their characteristics (Arrieta-Espinoza *et al.* 2005).

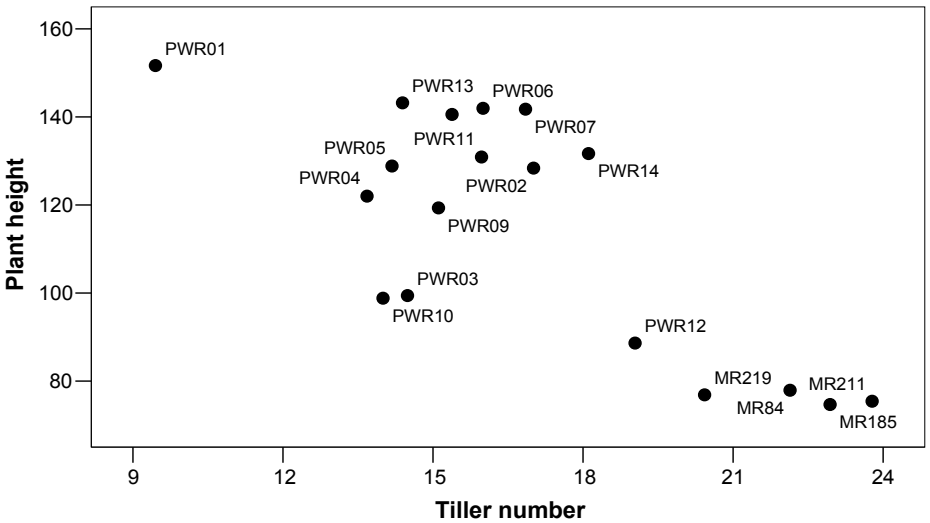

Figure 4: Relation between tiller number and plant height for weedy rice morphotypes and the commercial rice varieties at 70 DAS.

Reproductive Phase

The reproductive phases of weedy rice and cultivated rice were divided into booting, anthesis and maturity stage. Weedy rice morphotypes showed a wide range of flowering duration, reaching booting between 72.5±1.8 and 93.0±5.4 DAP. Significant variation was observed between all weedy morphotypes. Whereas, commercial varieties reached this stage between 74.5±1.8 and 86.4±2.6 DAP (Table 2). Uneven flowering was observed in all weedy rice morphotypes. Accessions from the same weedy rice morphotypes were more heterogeneous in the flowering period than the commercial varieties. Arrieta-Espinoza *et al.* (2005) also observed uneven flowering in the weedy rice morphotypes.

High SD recorded for beginning of anthesis and 50% anthesis reflected more heterogeneous flowering within weedy morphotypes compared to the commercial varieties. However, morphotype PWR12 showed a standard deviation value similar to those of the commercial varieties. Morphotype PWR04 showed the highest heterogeneity among the accessions, producing the highest standard deviation value. A similar trend was observed for anthesis period. Morphotypes PWR04 and PWR12 presented the highest anthesis duration with 28.5–29.0 days, similar to the anthesis period of the commercial varieties ranging from 29.8–30.0 days. Morphotypes PWR01, PWR02, PWR07 and PWR10 showed shortest anthesis span of 21.7–23.6 days.

Table 2: Mean and SD values for days after transplanting to reach each growth stage in weedy rice morphotypes and commercial rice varieties.

Morphotypes/ varieties	Booting stage	Beginning of anthesis	50% anthesis	Maturity stage	Anthesis duration
PWR01	72.8±2.6	76.9±2.8	80.9±2.9	100.4±3.6	23.6
PWR02	73.5±3.6	77.7±3.8	83.7±4.1	101.3±4.7	23.5
PWR03	79.2±4.2	83.1±3.3	89.1±2.5	108.8±3.9	25.7
PWR04	93.0±5.4	97.3±5.6	103.8±4.8	126.2±4.6	28.5
PWR05	78.7±4.8	86.0±3.1	91.1±3.3	111.3±4.3	25.3
PWR06	80.8±3.6	85.4±2.7	90.8±2.9	109.8±3.6	24.3
PWR07	75.0±2.2	79.2±2.3	83.4±2.4	100.9±2.9	21.7
PWR08	72.2±2.7	79.4±2.9	84.7±3.1	104.4±3.8	24.9
PWR09	79.7±3.9	83.0±3.1	86.2±3.8	107.1±5.7	24.1
PWR10	76.1±2.8	81.1±3.0	87.2±3.2	103.7±3.8	22.6
PWR11	83.8±3.2	87.9±3.2	92.0±3.3	113.6±4.1	25.7
PWR12	72.5±1.8	76.8±1.9	82.9±2.1	105.7±2.5	29.0
PWR13	77.3±2.8	84.1±3.1	89.3±3.2	107.7±3.9	23.6
PWR14	73.0±3.7	77.1±3.8	81.3±4.4	101.5±4.6	24.4
MR84	86.4±2.6	89.6±2.7	95.8±2.7	119.4±3.0	29.8
MR185	83.3±2.1	87.4±2.1	94.6±2.2	118.4±2.6	31.0
MR211	74.5±1.8	78.5±1.9	84.8±1.9	107.6±2.3	29.0
MR219	80.3±1.9	84.6±2.4	90.8±2.0	114.4±2.5	29.8

Weedy rice morphotypes reached maturity within a wide range of variation. Higher SD values presented greater heterogeneity among the accessions of weedy morphotypes than among commercial varieties. All weedy morphotypes except PWR04 matured earlier than most of the commercial varieties ranging from 100.4±3.6 to 111.3±4.3 days. Morphotypes PWR04 required 126.2±4.6 days to mature. However within the commercial varieties, MR211 reached maturity at 107.6±2.3 and the rest of the varieties required 114.4±2.5 to 119.4±3.0 days to mature.

In conclusion, uneven flowering observed in this study might be a competitive strategy for weedy rice plants to overcome possible adverse weather conditions during the reproductive phase. The diversity in flowering period assures continuous production and maturation of seeds from different weedy morphotypes (Ferrero 2003). Shorter anthesis period helps weedy morphotypes to mature early, while a wide variation in maturity time assists some weedy morphotypes to mix with the commercial varieties during the harvesting time. Early maturity of the weedy morphotypes will help identification at harvesting stage.

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