International Journal of Scientific & Engineering Research Volume 11, Issue 7, July-2020
ISSN 2229-5518

Weed identification And Aerobic Rice Performance (*Oryza sativa* L.) Of Different Soil Textures in Peninsular Malaysia

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Abstract— Two types of aerobic rice varieties namely AERON 1 and MRIA 1 were cultivated in three different types of soil textures consist of silty clay, clay and sandy soil collected from three different rice fields in Peninsular Malaysia. A Randomized Complete Block Design with four replications was arranged in the glashouse. This study was performed with the objectives to identify weed population growth in aerobic rice condition and to determine aerobic rice performance under different types of soil textures. The most dominant weed species growing in the glass house regardless of rice cultivar and soil texture were *Leptochloa chinensis, Cyperus iria, Fimbristylis miliaceae* and *Digitaria ciliaris*. Weed population was mostly dominated by grasses and sedges with very little contribution of broadleaved. Weeds were also infested vigorously in silty clay and clay soil compared to sandy soil. Besides that, both aerobic rice varieties of AERON 1 and MRIA 1 performed at par in accordance to plant height and production of tiller while, showed significantly distinguished effect towards certain physiological traits. These findings will be the key tool for sustainable weed management since weed invasion is the most fundamental problem in aerobic rice cultivation.

Index Terms— Aerobic rice, *Cyperus iria*, *Fimbrystilis miliaceae*, *Leptochloa chinensis*, sandy soil, silty clay and soil textures.

1 Introduction

Rice (*Oryza sativa* L.) provides 20% of the daily calories intake to approximately 3.5 billion people, particularly in Asia. Rice supplied 19% of human per capita energy and 13% of per capita protein in 2009 (Rice Field Guide 2013). Rice requires approximately 1700 – 3000 liter of water to produce 1 kg of grain depending on the water availability (rain and irrigation), types of soil (soil texture, organic matter content, hydraulic conductivity, percolation rate and others) and climate (temperature, sunshine hours, humidity and wind velocity) (Prasad, 2011). However, Tuong and Bouman (2003) predicted that by year 2025, 2 million/ha of Asia's irrigated dry season rice and 13 million/ha of its irrigated wetland rice may experience 'physical water scarcity' and the rest of the approximately 22 million/ha of irrigated dry season rice in South and Southeast Asia may suffer from 'economic water scarcity'. Besides that, rice production is more vulnerable to drought stress. Hence, for the last few decades, researchers have been struggling and highly focusing on development of water rice production technologies to cope and overcome these limitations. Aerobic rice system is one of the waters saving technology introduced with the aims to produce rice with less water requirements. Aerobic rice is a direct seeding system in which rice seeds are sown in dry or moist soil and irrigation is subsequently applied to keep the soil moist but not saturated (Chauhan and Johnson, 2011). In other words, aerobic rice is planted in dry tillage and aerobic soil condition. This is an emerging agronomic production system intended to save irrigation water compared to flooded rice (Tuong et al., 2005). Unfortunately, weeds are a major constraint to direct - seeded rice systems and may cause yield losses up to 35% worldwide due to no standing supress weed germination at early stage of rice cultivation (Oerke and Dehne, 2004). Some cases caused 100% yield loss due to invasion of noxious weed species (Jayadeva et al., 2011). This study aimed to identify and characterize weed flora composition grown under aerobic rice varieties (AERON 1 and MRIA 1) in different soil textures (clay, silty clay and sandy soil). As suggested by Jabran and Chauhan (2015), monitoring of weed flora in response to changing agronomic management as well as environmental factor is crucial for determination of suitable weed management program. The outcome of this study could be used as fundamental knowledge and support the decision making for controlling purposes in future by other researchers or farmers.

2 Materials and Methods

2.1 Experimental site and soil characteristics

The trough experiments were conducted in a glasshouse at Field 10, Universiti Putra Malaysia, (UPM) (3° 02′ N, 101° 42′ E, 31 m elevation). The local climate is hot humid with high humidity and abundant rainfall. Monthly weather data of maximum and minimum temperature, relative humidity, rainfall and sunshine hours throughout the experimental duration were recorded from the weather station situated in study area. Three types of soils were used in this study originated from rice fields in Tanjung Karang (Tg. Karang), Selangor, Seberang Perak (Seb. Perak), Perak and Bachok, Kelantan in Malaysia. These areas have been planted with direct seeded aerobic rice for at least the last two seasons. Collection of soil samples was done using 7 cm diameter Tokai Soil Auger to 20 cm deep. Soil was sampled randomly in each rice field, with a total of 10 sampling points in each rice field. To ensure maximum weed seedbank in the soil samples, soil collection was made after

ISSN 2229-5518

the dry rotovation was done. Soils samples were brought to glasshouse and allowed to dry before used. Soil samples in each location were mixed thoroughly during soil preparation to ensure proportional distribution of weed seeds in the soils. The soils were dry - ploughed and harrowed but not puddled during preparation. Soils were filled to 2/3 full into 60 cm x 50 cm x 30 cm fiber glass troughs and leveled.

2.2 Crop husbandry, plant material and experimental layout

Aerobic rice line AERON 1 obtained from IRRI (International Rice Research Institute, Los Banos, Philippines) and MRIA 1 from MARDI (Malaysian Agricultural Research and Development Institute, Selangor, Malaysia) were used as plant materials. The pre - germinated rice seeds were then sown at 2.5 cm depth in rows with 25 cm inter row and 15 cm intra row spacing at the recommended seeding rate of 40 - 60 kg/ha (Singh and Chinnusamy, 2006). The troughs were incorporated with triple super phosphate (TSP) and muriate of potash (MP) at 100 kg P/ha and 100kg K/ha, respectively as basal application. Urea was dressed on top at 50 kg N/ha at 2, 4 and 6 weeks after seeding. Soil was maintained under aerobic condition at -33 kPa as determined by Tensiometer (Decagon) throughout the growing season. Pest and disease management was done according to 'Manual Padi Aerob' (MARDI, 2015).

The treatments were arranged in a Randomized Complete Block Design (RCBD) with two factorials namely rice varieties (AERON 1 and MRIA 1) and soil mediums; Tg. Karang Seb. Perak and Bachok with four replications. Weeds were allowed to grow up to 6 weeks after sowing (panicle initiation stage) before removal for weed data collection.

2.3 Data collection and statistical analysis

The whole weed population for each trough was used for data recording. Weeds were clipped aboveground, identified, counted and placed in paper bags according to weed species. All collected weeds were transported to the Weed Science Laboratory, Universiti Putra Malaysia and oven dried at 70°C for 72 hours. Weed density and weed dry weight for each species were recorded as no./m^2 and g/m^2, respectively. The rank of dominance in weed species was determined by using the calculations of summed dominance ratio (SDR) as documented by Janiya and Mood (1989). Plant height was determined by measuring the distance from ground level to the tip of the longest leaf or panicle (where present at that time) in cm (cm/plant) from eight randomly selected plants at 15, 30, 45, and 60 days after sowing (DAS) and at harvesting. While, number of tillers were obtained by counting the tillers (appeared at least one visible leaf) from eight randomly selected hills at 15, 30, 45, and 60 days after sowing (DAS) and at harvesting which expressed as no./plant. Data on yield attributes were recorded at harvest. Five panicles collected upon maturity were hand-trashed to separate the filled an unfilled grain. The total number of grains/panicle (filled + unfilled), filled grains/panicle, percentage of grain filling [filled grains/ (filled grains + unfilled grains) x 100], panicle weight and thousand grains weight were recorded. Panicle weight, thousand grains weight and grain yield were adjusted to 14% moisture content. Aboveground biomass was determined from the total dry matter of straw, rachis, filled grains and unfilled grains and was expressed as no. and g/plant.

All data were analyzed using SAS statistical software package version 9.4 for Analysis of variance (ANOVA) and significant differences among the treatments were tested using Fischer's protected Least Significant Difference (LSD) test at $P \leq 0.05$. Pearson's correlation coefficients ($P \leq 0.05$) were used to draw interferences on relationship among various traits.

3 Results and Discussion

3.1 Summary of weed composition

Twenty types of weed species from 9 different families were identified across two aerobic rice varieties cultivated in three different soil textures (Table 1). Weed families consisted of five grasses (Poaceae), seven sedges (Cyperaceae) and eight broadleaves (Portulaceae, Euphorbiaceae, Onagraceae, Amaranthaceae, Capparidaceae, two Asteraceae and Rubiaceae). The summed dominance ratio (SDR) values show that the most dominant weed species was *Leptochloa chinensis* at 32% followed by *Cyperus iria* at 26%, *Fimbristylis miliaceae* at 11%, *Digitaria ciliaris* at 8% and *Eleusine indica* at 6%. The least prevalent weed species was *Ageratum conyzoides* at only 0.13%. Grasses contributed about 48% of relative weed dry weight and 38% of relative weed density in all troughs as compared to sedges (45% and 37%) and broadleaves (7% and 5%) respectively (Figure 1). Total amount of weed density (no.) and weed dry weight (g) of grasses in all troughs were 530 and 1795 g whilst, sedges contributed 787 and 1053 g, as well as broadleaves were about 75 and 286 g, respectively.

Table 1: Dominant weed species with family name, weed type and percentage of summed dominance ratio (SDR) in all troughs.

SCIENTIFIC NAMES	FAMILY NAME	WEED TYPE	SDR (%)
Leptochloa chinensis	Poaceae	Grass	31.1
Cyperus iria	Cyperaceae	Sedge	25.8
Fimbristylis miliaceae	Cyperaceae	Sedge	11.1
Digitaria ciliaris	Poaceae	Grass	7.95
Eleusine indica	Poaceae	Grass	5.97
Cyperus difformis	Cyperaceae	Sedge	5.61
Portulaca oleracea	Portulacaceae	Broadleaf	4.39
Echinochloa colona	Poaceae	Grass	2.20
Phyllanthus niruri.	Euphorbiaceae	Broadleaf	1.18
Cyperus rotundus.	Cyperaceae	Sedge	1.01
Cyperus sphacelatus	Cyperaceae	Sedge	0.85
Cyperus compressus	Cyperaceae	Sedge	0.41

Oryza sativa	Poaceae	Grass	0.38
Ludwigia octovalvis	Onagraceae	Broadleaf	0.38
Amaranthus spinosus	Amaranthaceae	Broadleaf	0.36
Cleome rutidosperma	Capparidaceae	Broadleaf	0.35
Eleutheranthera ru-deralis	Asteraceae	Broadleaf	0.25
Hedyotis corymbosa	Rubiaceae	Broadleaf	0.19
Fimbristylis globulosa	Cyperaceae	Sedge	0.15
Ageratum conyzoides	Asteraceae	Broadleaf	0.13

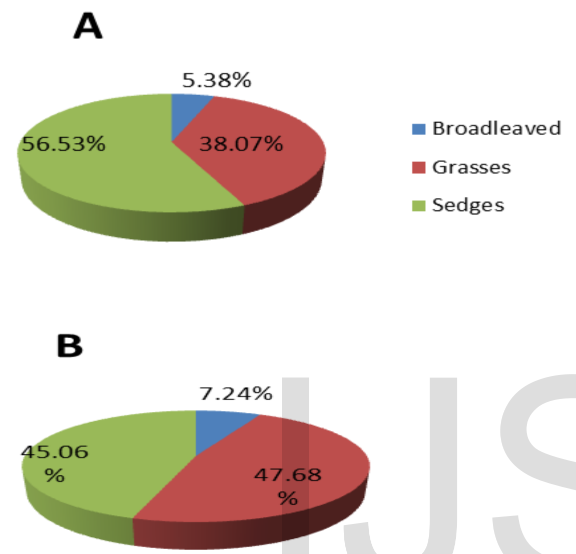

Figure 1: Relative weed density (A) and relative weed dry weight (B) of different weed groups.

Dominance of weed species in different soil textures planted with 2 aerobic rice varieties was quantified (Table 2). *Leptochloa chinensis* was found as the most prominent weed species in Tg. Karang soil planted with AERON 1 variety, producing 44.86% SDR value. However, the result was different in Seb. Perak treatment where *Cyperus iria* dominated the flora composition contributing approximately 44%, while and *Digitaria ciliaris* appeared the most abundant weed species in soil sampled from Bachok. Similar trend was observed in MRIA 1 variety where *Leptochloa chinensis* was also observed as the most prevalent weed species in Tg. Karang with 44.45% SDR value while, *Cyperus iria* contributed about 38.27% in Seb. Perak soil and *Digitaria ciliaris* was respectively contributed 39.17% in Bachok soil texture. Referring to Table 2, the most dominant weed species growing under aerobic rice condition in the glasshouse trial regardless of variety (AERON 1 and MRIA 1) and soil texture (Tg. Karang, Seb. Perak and Bachok) were *Leptochloa chinensis, Cyperus iria* and *Digitaria ciliaris*. Different weed varities produced similar predominant weed species in the same soil texture. Evidently, this outcome suggests that establishment and dominance of weed species were influenced by different soil textures instead of aerobic rice variety.

Table 2 : Five most dominant weed species with summed dominance ratio (SDR) across two types of aerobic rice; Aeron 1 (V1) and MRIA 1 (V2), and three types of soil medium; Tanjung Karang (S1), Seberang Perak (S2) and Bachok (S3).

V/S	Weed species	SDR (%)	V/S	Weed species	SDR (%)
V1S1	*Leptochloa chinensis*	44.86	V2S1	*Leptochloa chinensis*	44.45
	Cyperus difformis	22.38		*Fimbristylis miliaceae*	14.41
	Eleusine indica	13.34		*Cyperus difformis*	13.87
	Cyperus rotundus	5.71		*Cyperus iria*	7.66
	Phyl-lanthus niruri	5.13		*Eleusine indica*	5.57
V1S2	*Cyperus iria*	43.65	V2S2	*Cyperus iria*	38.27
	Leptochloa chinensis	35.27		*Leptochloa chinensis*	33.65
	Fim-bristylis miliaceae	13.70		*Fimbristylis miliaceae*	17.56
	Echi-nochloa colona	2.90		*Eleusine indica*	7.14
	Eleusine indica	1.77		*Echinochloa colona*	2.28
V1S3	*Digitaria ciliaris*	38.13	V2S3	*Digitaria ciliaris*	39.17
	Leptochloa chinensis	29.37		*Portulacea oleracea*	25.20
	Portulaca oleracea	17.79		*Eleusine indica*	19.14
	Cyperus compressus	6.09		*Cyperus sphacelatus*	9.06
	Echi-nochloa colona	2.88		*Cyperus iria*	3.87

Figure 2 represents the dominance ranking of weed groups in soil textures originated from three different aerobic rice fields. Regardless of rice variety, grasses profoundly dominated the weed composition ranking in soils taken from Tg. Karang and Bachok, producing SDR values of 60% and 74% for AERON 1 and 54% and 59% for MRIA 1 respectively. On the other hand, soil in Seb. Perak was highly infested with sedges, while broadleaf weeds recorded the least dominance in all aerobic rice soil textures.

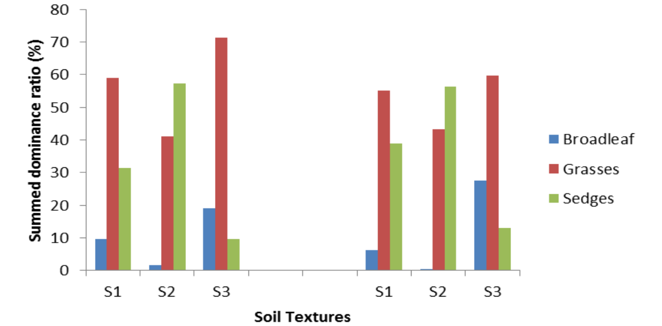

Figure 2 : SDR% of weed classification as influenced by variety, AERON 1 and MRIA 1 and soil texture, Tanjung Karang (S1), Seberang Perak (S2) and Bachok (S3).

3.2 Weed density and weed dry weight

Referring to Table 3, weed dry weight had highly significant interaction between variety and soil texture whereas, no significant interactions in weed density between those factors. It is interesting to note that higher number of weed species did not necessarily represent higher amount of weed dry weight due to morphological structures of the weeds. Weed density parameter was significantly affected by soil but unaffected by those two rice varieties. This happened might due to MRIA 1 and AERON 1 have been genetically developed as an aerobic rice variety that can survive dry condition which performed at par for both plant height and no. of tiller (data not shown). These two varieties possessed an equal ability to suppress weed germination and rendered more shading (Moynul et al., 2000) hence, would not affect the density of weed composition in this study. The highest weed density in descending order in different soil textures was Seb. Perak > Tg. Karang> Bachok. Similar pattern was also observed in weed dry weight parameter. Moreover, almost 20% of weed dry weight was accumulated higher in MRIA 1 compared to AERON 1.

Combination of AERON 1 and Seb. Perak produced the highest weed dry weight at 224 g followed by Tg. Karang (72 g) and Bachok (60 g) (Figure 3). Similar trend was also observed in MRIA 1 which produced maximum weed density when planted in Seb. Perak (180 g), followed by Tg. Karang (140 g) and lastly Bachok (105 g). This scenario proves that different textures of soil influenced weed germination. Evidently, clay soil (Seb. Perak) was found as the most conducive texture for weed germination compared to silty clay (Tg. Karang) and sandy soil (Bachok).

Table 3: Main and interaction effects for varieties over soils and for soils over varieties for weed density (no.) and weed dry weight (g).

Treatment	WD	WDW
Variety#		
Aeron 1	56.75 ± 11.22a	118.98 ± 23.83a
MRIA 1	59.25 ± 8.29a	142.06 ± 13.07a
LSD	16.71	29.01
Soil##		
Tg. Karang	57.75 ± 6.09b	106.34 ± 17.62b
Seb. Perak	91.88 ± 9.13a	202.30 ± 13.89a
Bachok	24.38 ± 3.63c	82.91 ± 12.31b
LSD	20.466	35.53
Interaction		
Variety	ns	**
Soil	***	***
Variety x Soil	ns	***

WD and WDW indicate weed density and weed dry weight.
#Data pooled across 3 soil medium, ##Data polled across 2 varieties.
Within a column for each parameter, means followed by different letters are significantly different at P=0.05 probability level according to least significant difference (LSD) test.

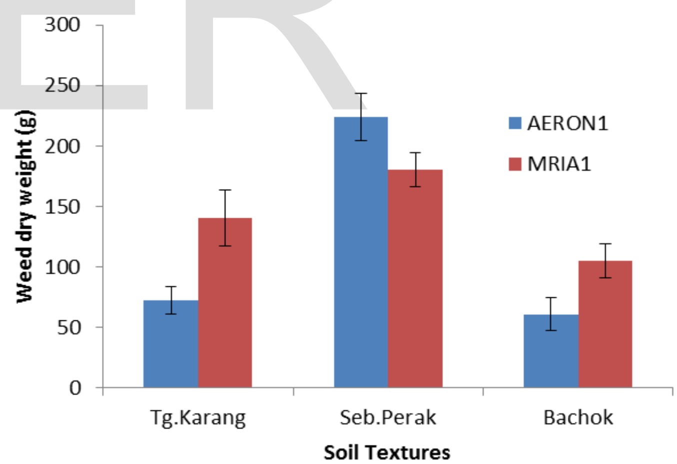

Figure 3: Relationship between weed dry weight over different varieties and type of soil textures.

3.3 Plant height

The variety and soil interaction effects were not significant, thus only main effect was explained (Table 4). AERON 1 and MRIA 1 exhibited significant difference in plant height at 15 days after sowing, but no significant difference was observed upon 30, 45, and 60 days after sowing and at harvesting stage. MRIA 1 was about 3 cm higher then AERON 1 during 15 days after sowing and only 0.5 cm higher upon harvesting. Soil textures from Tg. Karang, Seb. Perak and Bachok portrayed sig-

ISSN 2229-5518

nificant differences in plant height at all sampling dates. Initially, Seb. Perak rice plants appeared the tallest at 29 cm followed by Bachok (26 cm) and Tg. Karang (25 cm). However, during 30 days after sowing, the rice growth in Seb. Perak and Tg. Karang were at par. Towards the end of rice development, Tg. Karang was leading followed by Seb. Perak and Bachok. Data recorded for plant height by those soil textures were 102, 97 and 95 cm, respectively upon harvesting.

Table 4: Main and interaction effects for varieties over soils and for soils over varieties for plant height (cm).

Treatment	PH15	PH30	PH45	PH60	PHH
Variety (V)					
AERON 1	25.25±1.04b	57.1±1.46a	73.43±1.58a	86.67±2.52a	97.15±1.94a
MRIA 1	27.82±0.57a	60.25±1.08a	74.42±1.26a	87.50±1.78a	97.71±1.44a
LSD	1.99	3.22	3.90	5.89	4.41
Soil (S)					
Tg. Karang	24.90±0.97b	60.63±1.56a	76.65±1.65a	92.65±2.34a	101.38±1.31a
Seb. Perak	28.89±1.26a	60.62±1.39a	74.83±1.19ab	85.37±1.50b	96.21±1.47ab
Bachok	25.81±0.51b	54.79±1.09b	70.31±1.60b	83.25±2.79b	94.69±2.54b
LSD	2.44	3.95	4.79	7.22	5.40
V	*	ns	ns	ns	ns
S	***	**	*	*	*
V X S	ns	ns	ns	ns	ns

PH15, PH30, PH45, PH60 and PHH indicate plant height at 15 days after sowing (DAS), 30 DAS, 45 DAS, 60 DAS and at harvest, respectively.
#Data pooled across 3 soil medium, ##Data polled across 2 varieties.
Within a column for each parameter, means followed by different letters are significantly different at P=0.05 probability level according to least significant difference (LSD) test.

3.4 Number of tillers

The interaction between aerobic rice variety and soil texture upon number of tillers in all sampling dates was not significantly different (Table 5). A similar pattern was also observed in both main factors (variety and soil texture) across tillering ability. MRIA 1 produced lower number of tillers compared to AERON 1 in a range 0.5 – 3% at different sampling dates. The highest productive tillers produced by aerobic rice were approximately six tillers per rice hill. Number of tillers recorded was not significantly affected by different types of soil textures. Number of tillers produced at each sampling dates was relatively consistent in between soil textures where approximately three tillers per hill were produced at 30 days after sowing and six tillers per hill at harvesting. Sandy soil from Bachok Kelantan was estimated 4% higher in number of tillers compared to silty clay (Tg. Karang) and clay (Seb. Perak) soils.

Table 5: Main and interaction effects for varieties over soils and for soils over varieties for plant height (cm).

Treatment	NT30	NT45	NT60	NTH
Variety (V)				
Aeron 1	2.716±0.067a	4.7±0.15a	5.883±0.127a	6.033±0.077a
MRIA 1	2.651±0.078a	4.555±0.123a	5.853±0.111a	5.993±0.932a
LSD	0.2163	0.3234	0.3177	0.2194
Soil (S)				
Tg. Karang	2.65±0.823a	4.625±0.133a	5.825±0.116a	5.9±0.093a
Seb. Perak	2.625±0.088a	4.575±0.122a	5.85±0.082a	5.9±0.093a
Bachok	2.775±0.096a	4.675±0.241a	5.925±0.214a	6.15±0.119a
LSD	0.2649	0.3961	0.3891	0.2687
V	ns	ns	ns	ns
S	ns	ns	ns	ns
V X S	ns	ns	ns	ns

NT30, NT45, NT60 and NTH indicate no. of tiller at 30 days after sowing (DAS), 45 DAS, 60 DAS and at harvest, respectively
#Data pooled across 3 soil medium, ##Data polled across 2 varieties.
Within a column for each parameter, means followed by different letters are significantly different at P=0.05 probability level according to least significant difference (LSD) test.

3.5 Yield attributes

Interaction between AERON 1 and Tg. Karang developed maximum weight of grains at 2.19 g per panicle followed by Seb. Perak (1.76 g) and Bachok (1.73 g) (Figure 4). On the other hand, MRIA 1 produced the highest weight of grains per panicle when cultivated on Seb. Perak soil texture (1.85 g). Tg. Karang placed second with 15% higher grain weight compared to Bachok soil texture. Visually seeds produced by MRIA 1 and AERON 1 cultivated in three different types of soil texture were hardly distinguished, but these outcome suggested that the variation in grains weight did occur. Hence, clay soil type from Tg. Karang and Seb. Perak could be the best medium for cultivation of aerobic rice varieties as compared to sandy soil collected from Bachok, Kelantan.

Referring to Figure 5, growing AERON 1 in Tg. Karang soil significantly produced increased panicle weight as much as 2.57 g. It was then followed by cultivation of AERON 1 in Bachok (2.21 g) and Seb. Perak (2.13 g). These result were opposite in MRIA 1 variety which produced maximum weight of panicle when cultivated in Seb. Perak soil texture (2.22 g) followed by Tg. Karang (2.08 g) and Bachok (1.84 g). The outcomes from weight of grains/panicle and number of grains/panicle exhibited similar pattern where higher number of grains will produce the heavier weight of panicle, that could be happened due to longer panicle structure, which was evident in this study (data not shown).

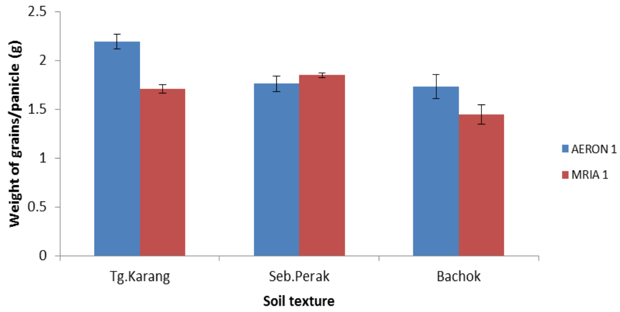

Figure 4: Relationship between weight of grain per panicle over different varieties and types of soil texture.

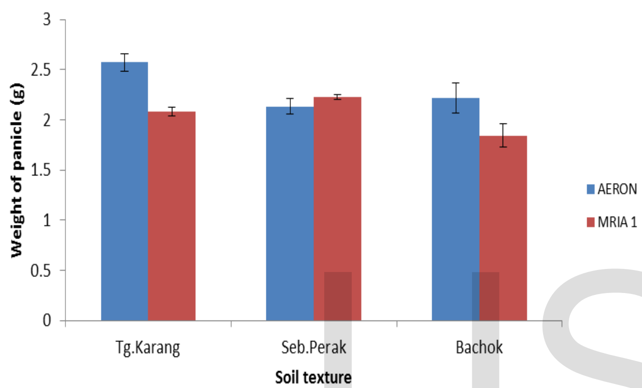

Figure 5: Relationship between weight of panicle over different varieties and type of soil texture.

4 Discussions

The top five most abundant and frequent weeds under glasshouse condition were from the families of Poaceae (*Leptochloa chinensis, Digitaria ciliaris* and *Eleusine indica*) and Cyperaceae (*Cyperus iria* and *Fimbristylis miliaceae*). Higher values of Summed Dominance Ratio (SDR) for glasshouse study had further proved that Poaceae and Cyperaceae grew abundantly and rapidly in growth-conducive aerobic rice systems, outcompeting other weed species succesfully. It was synchronized with Singh et al. (2008), which reported 78-96% of total weed biomass was contributed by grassy weeds grown under aerobic rice condition. Rao et al. (2007), also highlighted that most major weeds found in direct seeded rice were from both families. Families of Poaceae and Cyperaceae comprised roughly 79% of the total number of C_4 plant which perform better in dry condition and drought (Maria and Carlos 2011).

The quickly changing of soil texture, weather as well as agronomic management has favor germination of various weeds species in aerobic rice system. Interestingly, some of the weeds recorded in this study may be similar or vary with other weed species in different rice ecosystems. *Leptochloa chinensis, Cyperus iria, Fimbristylis miliaceae, Digitaria ciliaris, Eleusine indica* and *Echinocloa colona* were among the most abundant weed species found in the soil textures taken from Tg. Karang, Seb.Perak and Bachok. These results were parallel with Hakim et al. (2013), who observed the high dominance of *Echinochloa colona, Leptochloa chinensis, Fimbritylis miliaceae, Cyperus iria* and *Cyperus difformis* in conventionally flooded rice fields of Tg. Karang and Seb. Perak areas.

The highest weed dry weight and weed density accumulated in the glasshouse study were recorded in Seb. Perak soil texture compared to Tg. Karang and Bachok soil textures. Establishment of weed species in this study was influenced by different soil textures comprised of silty clay (Tg. Karang), clay (Seb. Perak), and sandy soil (Bachok and Seb. Perai). Apparently, these results indicated severe weed infestation in silty clay compared to sandy soil. Soil texture plays an important role in crop cultivation as it influences soil available water capacity (AWC) (Fugen Dou et al., 2016). Usually clay soil contains greater organic matter compared to sandy soil due to extra physical protection attributed (Six et al., 2000). Higher content of organic matter would lead to higher AWC. These characteristics possessed by clay would cause higher weed infestation compared to sandy soil. Sand provides easier passage through its aggregation, retaining less water including nutrients, hence may not meet the demands of the weed development. Weeds in aerobic rice systems quickly occupy space, grasping more soil, water, nutrients, and carbon dioxide (CO_2) than the rice crop (Jabran and Chauhan, 2015).

The agronomic traits like plant height of the crop in the glasshouse study were significantly affected by different types of soil textures instead of different varieties of aerobic rice. Plant height of aerobic rice was found 6% and 5% higher in silty clay and clay soil texture (Tg. Karang and Seb. Perak) compared to sandy soil (Bachok). Since majority weed dry weight was recorded in silty clay and loam soils compared to sandy soil, the differences of plant height in response to soil texture may be affected by competition between aerobic rice and weed species to produce higher plant. As documented by Saito et al. (2010), plant height is the key characteristic for weed suppressive ability for source of sunlight needed in photosynthesis process particularly at early stage of crop development. Besides that, clay and loam soil textures contained higher organic matter and nutrient compared to other mineral soils (Tahir and Marschner, 2017).

Similar to agronomic traits, physiological traits such as number of grains, weight of grains and grain yield of AERON 1 and MRIA 1 were significantly influenced by soil textures comprised of silty clay (Tg. Karang), clay (Seb. Perak) and sandy (Bachok) soil. Generally, those parameters developed maximum reading when aerobic rice was cultivated in silty clay soil, followed by clay and sandy soil. Higher number of grains and weight of grains has responded to maximum value of grain yield in clay soil compared to sandy soil. In a study by Ye et al. (2007) and Bouman et al. (2006), similar observation was recorded in China where aerobic rice cultivars produced less yield in sandy soils compared to clay soil due to varying nitrogen levels. Thus, this would influence nutrient uptake by crop which affected rice development. Besides that, in a rainfed lowland trial in Thailand, Tsubo et al. (2007), also found the same response, in which rice grown in higher clay-content soils had greater grain yield and above ground biomass accumulation than those grown in lower clay content soils (Junel et al., 2016).

4 Conclusion

Introduction of aerobic rice system in rice production is an attractive option to ‘‘produce more rice with less water’’ in water scarcity environment due to many factors such as climate change and contamination of water resources. However, the establishment of aerobic rice variety in the field which reduces 30 – 50% water supply is restricted due to weed infestation that led to lower yield production. *Leptochloa chinensis, Cyperus iria, Digitaria ciliaris, Fimbristylis miliaceae* and *Echinocloa colona* were predominant weed species found in different soils medium with Summed Dominance Ratio value more than 20%. Family of Poaceae and Cyperaceae were dominating aerobic rice with higher weed density and weed dry weight which recorded in silty clay, followed by clay loam and sandy soil. Fundamental knowledge of weed species invaded aerobic rice system is crucial for effective weed management. Hence, information provided in this research will benefit farmers for future weed controls.

Acknowledgment

The authors wish to thank Putra Grant from Universiti Putra Malaysia and Government Schlorship from Universiti Teknologi Mara Malaysia.

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