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A comparison of weed communities of coastal rice fields in Peninsular Malaysia

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Abstract

A survey was conducted at 100 different rice fields in coastal areas of West Malaysia to identify most common and prevalent weeds associated with rice. Fields surveyed were done according to the quantitative survey method by using 0.5m x 0.5m size quadrate with 20 samples from each field. A total of 53 different weed species belong to 18 families were identified of which 32 annual and 21 perennial; 12 grassy, 13 sedges and 28 broadleaved weeds. Based on relative abundance the most prevalent and abundant weed species were selected in the coastal rice field. Among the 10 most abundant weed species, there were four grasses viz. *Echinochloa crusgalli*, *Leptochloa chinensis*, *Echinochloa colona*, *Oryza sativa* L. (weedy rice).; four sedges viz. *Fimbristylis miliacea*, *Cyperus iria*, *Cyperus difformis*, *Scirpus grossus* and two broadleaved weeds viz. *Sphenoclea zeylanica*, *Jussiaea linifolia*. *Leptochloa chinensis*, *E. crusgalli*, *F. miliacea*, *E. colona* were more prevalent and abundant species out of the 10 most dominant weed species in the coastal rice field of Peninsular Malaysia.

Key words

Coastal region, Malaysia, Rice field, Weed survey

Introduction

Weeds are notorious pest of rice causing serious yield reduction in rice worldwide. Annual worldwide rice yield loss by weeds is 15–21% (Karim *et al*., 2004). Losses caused by weeds vary from one location to another, depending on the predominant weed flora and on the control methods practiced by farmers. It was estimated in Malaysia that the yield loss by grasses, broad-leaved and sedges was 41, 28 and 10%, respectively (Begum *et al*., 2005). A crop loss due to weed competition varies with the duration of weed infestation of the crop. The crop is likely to experience yield reduction, unless field is kept weed free during a part of its growing period (Azmi *et al*., 2007). The main factors for which crops and weeds compete are light, water and nutrients. Weeds commonly absorb added nutrients as much or more rapidly than crops (Moody, 1990). Salinity is another dramatic factor causing yield reduction in rice. Increased salinity due to global warming could not only decrease rice yields, but also could cause havoc to the future food supply in Malaysia (Vaghefi *et al*., 2011). Weeds also are adversely affected by a combination of increased salinity and high temperatures (Greenwood and MacFarlane, 2006). The composition of weed flora is also expected to differ depending on location (Uddin *et al*., 2010). Salinity could also cause changes in weed flora in the coastal areas. The distribution and nature of weeds in coastal areas would be different from non-saline areas. Current information on presence, composition, abundance, importance and ranking of weed species are essential to formulate appropriate weed management strategies to achieve optimum yields of rice (Begum *et al*., 2005). Surveys are the key to identifying major and prevalent weeds in the rice fields. In any weed management program, a thorough survey is necessary to address current weed problems and such information is absolutely important in developing target oriented research

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programs (Coble 1994; Boldt *et al*., 1998). However, detailed information on presence, composition, abundance, importance and ranking of weed species in coastal rice field areas of Malaysia are limited. Specific knowledge on the nature and extent of infestation of weed flora in the coastal rice fields is essential to formulate appropriate weed control recommendations under saline environments. The present study was therefore undertaken to investigate the distribution and severity of weed flora prevailing in major coastal rice growing areas of Peninsular Malaysia.

Materials and Methods

The surveys were conducted in some selected coastal rice field areas in Seberang Perak, Tanjung Karang (Barat Luat Selangor), and Muda, Kedah (Fig.1A-C) in West Peninsular Malaysia to identify and evaluate the major weed species in rice fields during May to November 2010. Rice field surveyed covering eight blocks in rice scheme of Seberang Perak, 10 farm blocks in rice scheme of Muda, Kedah and seven in Tanjung Karang. The age of rice plants was around 60 days at the time of survey, and fields were flooded with 2-4 cm of water. The soil salinity was measured using a conductivity meter (Model: ECTestr, Spectrum Technologies, Inc.). A GIS value of each surveyed specific area was recorded by Global Positioning Satellite (GPS) (model: Value Buy 2nd Hand 2GB Sony Ericsson XPERIA X1 FULL BOX). A total of 100 rice fields were surveyed including 32 in Seberang Perak, 40 in Muda, 28 in Tanjung Karang. The fields were randomly selected within each surveyed area. The detail information (soil salinity levels, GIS values, average temperature, average rainfall and average relative humidity) of the surveyed area have been presented in Table 1.

The quantitative field survey was performed according to the method described by Thomas (1985). An inverted "W" pattern was used to systematically walk through each sample field. One hundred rice fields were sampled with a total of 20 quadrats per field. Rice field size ranged from 1.1 to 2.8 acre. A quadrat of 0.5×0.5 m size was used. The distance between quadrats was fixed based on the size and shape of the field. All weeds in each quadrat were identified, counted, and recorded. Species that could not be identified in the field were tagged and transported for later identification (Chancellor and Froud-Williams, 1982; 1984). Probable anomalies in sampling areas, such as shoulder and foot slopes, potholes, ditches, bluffs, power lines, and paths were avoided.

The data were summarized using quantitative measures on frequency, distribution uniformity, field density, relative frequency, relative field density, relative field uniformity and relative abundance. These values were calculated for each weed species according to the method of Thomas (1985).

Results and Discussion

Of the 100 fields surveyed, a total of 53 weed species belonging to 18 families were recorded (Table 2). However, number of weed species and families among the three locations did not differ greatly. The hierarchical order of species composition ranking was as follows: Muda, Kedah (42) > Seberang Perak (40) > Tanjung Karang (39). Weed shifts usually occur due to differences in herbicides, soil conditions and agronomic practices. The variation in the hierarchical importance of weeds was earlier reported by Begum *et al*. (2008).

A total of 53 weed species were identified in the three coastal areas (Table 2). The weed community comprised 32 annuals and 21 perennial weeds; of which 12 were grasses, 13 were sedges, and 28 were broadleaved weeds. Among these weeds, grasses were 12 in Seberang Perak, 11 in Tanjung Karang and 10 in Muda. Numbers for sedges were 10 in Seberang Perak, 9 in Tanjung Karang and 11 in Muda. There were 18, 20 and 22 broadleaved weeds in Seberang Perak, Tanjung Karang and Muda, respectively. Some weed species were common in all three coastal rice field areas. The annual species were higher (around 150%) in number than perennial species and overall annual grasses were more prevalent than perennial grasses. The abundance of annual grasses in an annual cereal crop is a normal occurrence. Similar results were also noted by Wicks *et al.* (2003) and Singh *et al.* (2008), where 22 species belonging to 17 families, of which 17 species occurred in the dry land rice plots and 18 in irrigated rice plots during the rainy season. These studies and the present study indicate that annual weeds usually outnumber biennial and perennial weeds in grain crops.

The identified weed species represent 18 families (Table 2), among which Cyperaceae had the highest number (13), followed by Poaceae (12) and Euphorbiaceae, Pontederiaceae, Scorphulariaceae and Rubiaceae which consisted of 3 species each. Convolvulaceae, Capparidaceae, Asteraceae and Onagraceae had two species each. The remaining 8 families were represented by only one species each (Table 3). Poaceae and Cyperaceae together accounted for 47% of the species. Turki and Sheded (2002) also found that 71 weed species in rice belonging to 28 families in the coastal delta regions of Egypt. The families represented were Poaceae (28.2%), Compositae (8.5%), Cyperaceae (7%), Malvaceae (6%), Lythraceae (6%), Chenopodiaceae (6%), Leguminosae (5.6%) and Convolvulaceae (4.2%). These results also indicate that weeds of Poaceae family were more dominant and prevalent in grain crops. Generally, the weed vegetation of a particular area is determined by environmental, edaphic and biological factors that include soil structure, pH, nutrients, moisture

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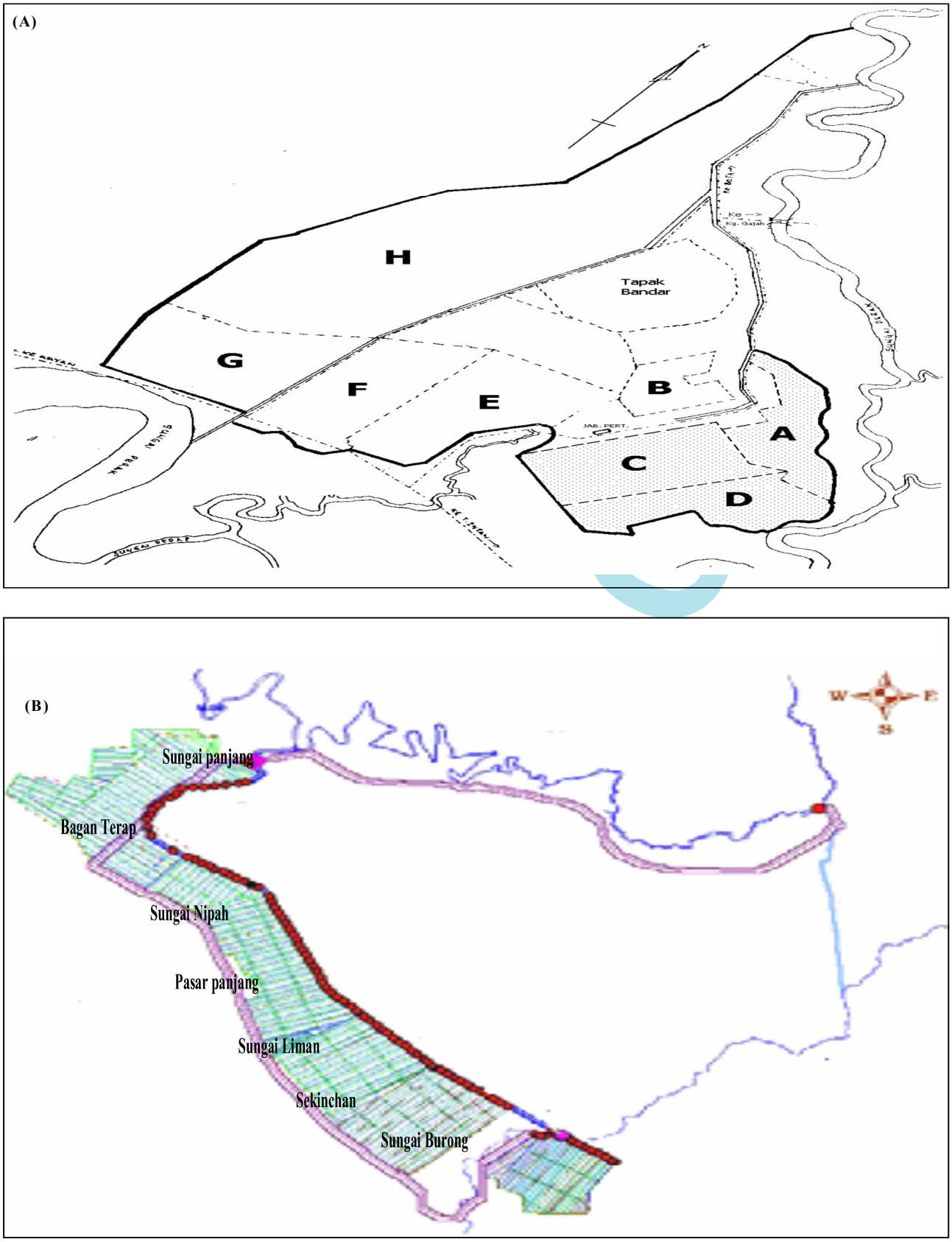

Fig. 1 (A-B) : Map of (A) Seberang Perak and (B) Tanjung Karang rice growing areas of Peninsular Malaysia indicating surveyed zone

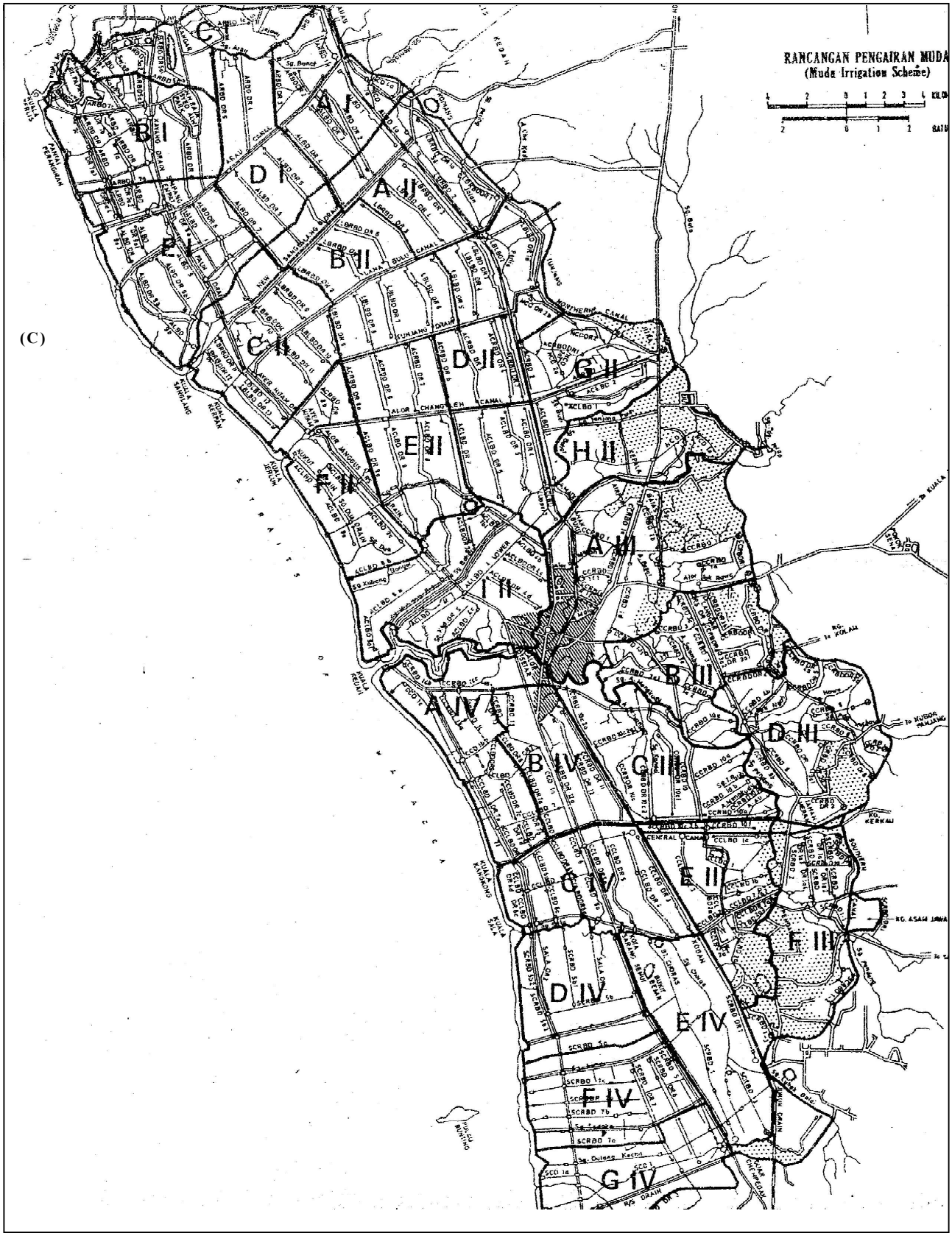

Fig. 1 (C) : Map of Muda, Kedah rice growing area of Peninsular Malaysia indicating surveyed zone

Table 1 : Detail information of surveyed area of coastal rice field in Peninsular Malaysia

Locations	Specific surveyed area	No. of fields surveyed	Salinity levels (dS m^{-1})	GIS values	Temperature (average)	Average monthly rainfall	Average relative humidity
	Block A	4	1.21	40° 07' N and 101° 04.2' E			
	Block B	4	0.45	40° 08.3' N and 101° 7.1' E			
	Block C	4	1.02	39° 06.3' N and 100° 09' E			
	Block D	4	0.85	40° 06.5' N and 101° 03.4' E	23–32 ^{0}C	150–260 mm	74–77%
Sebarang	Block E	4	2.23	41° 01' N and 101° 02.5' E			
Perak	Block F	4	2.15	40° 01.8' N and 99° 09.4' E			
	Block G	4	2.01	38° 87' N and 102° 14' E			
	Block H	4	2.25	39° 26' N and 101° 34' E			
	Sungai Burong	4	2.10	3^{0}25' N and 101^0 11' E			
	Sekanchan	4	0.94	3°35' N and 101°05' E			
Tanjung	Sungai Leman	4	2.58	4° 15.07' N and 100° 39' E			
Karang	Pasar panjang	4	1.89	3^{0}54' N and 99° 50.33'	23-33 ^{0}C	220-360 mm	80-88%
	Sungai Nipah	4	1.02	3^{0}61' N and 100° 19.23'			
	Bagan Terap	4	1.56	4^{0}11' N and 100° 33'			
	Sungai panjang	4	2.70	3^{0}78' N and 101° 03'			
	PPK BI	4	2.36	6^{0}21' N and 100^{0}09' E			
	PPK E 1	4	0.83	6^{0}20.9 'N and 100^{0}08.9' E			
	PPK CII	4	1.90	6^0 15.3'N and 100^{0}12.1' E			
Muda,	PPK F II	4	3.16	6^0 09.2N and 100^{0}16.6' E			
Kedah	PPK I II	4	1.57	6^0 09 N and 100^{0}16.3' E	23–33 ^{0}C	150 –240 mm	71–87%
	PPK A IV	4	2.56	6^0 09.2' N and 100^{0}16.7' E			
	PPK CIV	4	2.01	6^0 09.2' N and 100^{0}16.6' E			
	PPK D IV	4	1.86	6^0 13.5' N and 100^{0}15.6' E			
	PPK FIV	4	1.12	6^0 11.2' N and 100^{0}16.4' E			

Table 2 : Number of weed species and families recorded in the surveyed regions of Peninsular Malaysia

Locations	No. of fields	No. of species	No. of families
Seberang Perak	32	40	16
Tanjong Karang	28	39	14
Muda, Kedah	40	42	17
Total	100	53	18

status, associated crops, weed control measures, and field history (Kim *et al*., 1983).

Among the grasses, the most common and frequent weed species was *Echinochola crus-galli* in Seberang Perak and Tanjung Karang (86% frequency) followed by *Echinochloa colona* and *Leptochloa chinensis (*58% frequency*)*. However, *Leptochola chinensis* was the most common weed species in Muda (78% frequency) followed by *Echinochola crus-galli* and *Echinochloa colona* (Table 4). Among the sedges, the most widespread weed species was *Fimbristylis milicaea* (68-86% frequency) in all regions followed by *Cyperus iria* (60-66.67% frequency)*, C. difformis* (53.57-60% frequency)*,* and *Scirpus grossus* (52.50-72% frequency). Among the broadleaved weeds, the most frequent weed species was *Jussiaea linifolia* in Seberang Perak (61% frequency); *Limnocharis flava* in Tanjung Karang (76% frequency); and *Sphenoclea zeylanica* in Muda (60% frequency). Begum *et al.* (2008) reported that *O. sativa* complex and *E. crus-galli* appeared to be the most frequently weed species in all blocks in the Muda rice growing area in West Peninsular Malaysia. Variations in common weed species among the different surveyed areas are attributed to biotic and abiotic factors, in particular variation in cultural practices such as irrigation, fertilizer, cultivar, tillage, growth habit of weeds and crop, herbicide usage and crop rotation as reported by Kim *et al.* (1983).

The uniformity in weed species distribution in each rice field area was variable. Among the grasses *E. crus-galli* and *E. colona* were more uniformly distributed in Seberang Perak; *E. crus-galli*, *E. colonum* and *L. chinensis* in Tanjung Karang; and *L. chinensis* and *E. crus-galli* in Muda. Among the sedges, *F. miliacea* was uniformly distributed in Seberang Perak and Tanjung Karang, while the broad leaved weed *Jussiaea linifolia* was uniformly distributed in Tanjung Karang (Table 4). The highest uniformity value was recorded for *E. crus-galli* (74.46%), while the lowest was for *Ipomea triloba* 2.68%) in Seberang Perak. In Tanjong Karang, *F. miliacea* (76.43%) had maximum uniform distribution over the entire field, while *C. dactylon* and *B. setidens* showed least uniformity (5.24%). However,

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Table 3 : Distribution of weed species based on family, scientific name, common name and life cycle (P= perennial, A= annual) in the surveyed regions of Peninsular Malaysia

Family name	Scientific name	Common name	Life cycle
Grasses			
	Cynodon dactylon (L.) Pers.	Bermuda grass	P
	Digitaria ischaemum (Schr.) Muhl	Smooth crabgrass	A
	Digitaria sanguinalis (L.) Scop.	Hairy crabgrass	A
	Echinochloa crus-galli (L.) Beauv	Barnyard grass	A
Poaceae	*Echinochloa colona* (L.) Link	Jungle rice	A
	Eleusine indica (L.) Gaertn.	Goose grass	A
	*Ischaemum rugosum*Salisb.	Wrinkled grass	P
	Leptochloa chinensis (L.) Nees	Feather grass	A
	Oryza sativa complex (weedy rice)	weedy rice	A
	Paspalum conjugatum Berg.	Buffallo grass	P
	Paspalum vaginatum Sw.	Water couch grass	P
	Paspalum commersonii Lan*k*	Bull paspalum	P
Sedges			
	Cyperus aromaticus	Greater kyllingia	P
	Cyperus babakensis Steud	Babakensis clarke	P
	Cyperus difformis L.	Small-flowered umbrella plant	A
	Cyperus distans L.f.	Slender cyperus	P
Cyperaceae	*Cyperus iria* L.	Grasshopper's cyperus	A
	Cyperus pilosus Vahl	Fuzzy flat sedge	A
	Cyperus rotandus L.	Nut grass	P
	Eleocharis variegata (nec.) Boeck.	Spikerush	P
	Fimbristylis globulosa Kunth	Globular fimbristylis	P
	Fimbrystylis milliacea (L.) Vahl	Lesser fimbry	A
	Scirpus grossus L. f.	Creater club-rush	P
	Scirpus supinus	Rush hair sedge	A
	Scirpus mucronatus L	Bogbulrush	P
Broad leaved			
Alismataceae	*Sagitaria guyanensis* H.B.K. Bogin	Kelipokpadang	P
Amarantaceae	*Amaranthus viridis*	Slender amaranth	A
Asteraceae	*Eclipta alba*	False Daisy	A
	Eclipta prostata (L.) L.	White heads	A
Boraginaceae	*Heliotropium indicum L.*	Buntuttikus, Indian Heliotrope	A
Butomaceae	*Limnocharis flava* (L.) Buchenan	Yellow sawah lettuce	P
Capparidaceae	*Cleome rutidosperma* DC.	Yellow cleome	A
	Oldenlandia dichotoma var	Many flowered oldenlandia	A
Convolvulaceae	*Ipomea aquatica* L.	White-Flowering Kangkong	P
	Ipomea triloba L.	Little bell	P
Euphorbiaceae	*Euphorbia hirta* L.	Hairy spurge	A
	Phyllanthus niruri Linn.	Pick-a-back	A
	Phyllanthus amarus Sch. & Thonn..	Lagoon spurge	A
Lythraceae	*Rotala indica* (Willd) Kochne	Ameletia aquatidens	A
Marsileaceae	*Marsilea crenata* Presl.	Dwarf Four-leaf Clover	P
Onagraceae	*Jussiaea linifolia*	Narrow leaved willow herb	A
	Jussiaea repens L.	Ludwigia peploides ssp. glabrescens	A
Pontederiaceae	*Eichornia crassipes* (Mart.) Solms	Water Hyacinth	P
	Monochoria hastata (L.) Solms	Arrow leaf False Pickerelweed	A
	Monochoria vaginalis (Burm.f.) Presl	Oval-Leaved pond weed	A
Rubiaceae	*Borreria laevicaulis* Ridl	Purple-leaved Button Weed	P
	Borreria setidens (Miq.) Bold.	Toothed button weed	A
	Hedyotis corymbosa (L) Lamk.	Two flowered oldenlandia	A
Scrophulariaceae	*Bacopa rotundifolia* (Mic.) Wettst.	Disk Water hyssop	A
	Lindernia crustacea (L.) F. Muell.	Malaysian false pimpernel, Round-fruited Lindernia	P
	Lindernia rotundifolia	Baby Tears	A
Salviniaceae	*Salvinia molesta D.S.Mitchel*	Giant Salvinia, Water Fern	A
Sphenocleaceae	*Sphenoclea zeylanica* Gaertn.	Gunda padi	A

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Table 4 : Composition and distribution of weed species in the west coastal rice growing areas of Peninsular Malaysia

Scientific name	Rice field area								
	Seberang Perak			Tanjung Karang			Muda, Kedah		
	F (%)	FU (%)	MFD (No. m^{-2})	F (%)	FU (%)	MFD (No. m^{-2})	F (%)	FU (%)	MFD (No. m^{-2})
Grasses									
Echinochloa crus-galli	85.71	74.46	5.10	85.71	74.29	3.21	72.50	56.38	4.53
Echinochloa colona	67.86	53.93	4.02	71.43	71.43	3.04	62.50	40.75	3.46
Leptochloa chinensis	67.86	49.64	3.60	76.19	70.48	3.01	77.50	61.25	5.67
Oryza sativa L. (weedy rice)	57.14	20.89	1.85	57.14	25.71	1.92	50.00	26.88	2.85
Paspalum conjugatum	28.57	7.32	0.55	38.10	9.76	0.55	37.50	7.63	0.59
Paspalum vaginatum	53.57	19.11	1.16	33.33	12.38	0.56	15.0	2.88	0.23
Paspalum commersonii	32.14	9.11	0.71	42.86	10.00	0.51			
Ischaemum rugosum	57.14	20.00	1.53	61.90	24.05	1.21	32.50	13.50	1.34
Eleusine indica	42.86	17.32	1.12	23.81	8.81	0.47	15.00	1.75	0.10
Cynodon dactylon	25.00	5.71	0.53	33.33	5.24	0.39	12.50	4.38	0.37
Digitaria ischaemum	39.29	9.64	0.70	38.10	10.71	0.59			
Digitaria sangunalis	17.86	5.18	0.51						
Sedges									
Fimbrystylis miliacea	75.00	67.14	5.09	85.71	76.43	4.09	67.50	48.00	5.06
Fimbristylis globulosa	35.71	17.50	1.54	38.10	9.05	0.56	12.50	6.00	0.43
Cyperus iria	64.29	35.89	3.02	66.67	37.38	2.62	60.00	34.75	3.18
Cyperus difformis	53.57	25.89	1.85	57.14	26.67	2.21	60.00	31.88	3.09
Cyperus pilosus	39.29	19.72	1.18	33.33	17.86	0.81	27.50	4.13	0.48
Cyperus babakensis							22.50	8.63	1.01
Cyperus aromaticus	28.57	7.86	0.51	42.86	10.48	0.72			
Cyperus distans	50.00	15.36	1.18	19.05	8.10	0.39	15.00	5.38	0.45
Cyperus rotundus				47.62	9.29	0.74	10.00	4.75	0.34
Scirpus grossus	75.00	37.68	3.02	61.90	24.29	1.45	52.50	24.75	2.54
Scirpus supinus							20.00	4.38	0.45
Scirpus mucronatus	28.57	9.46	0.80				15.00	4.00	0.36
Eleocharis variegata	46.43	12.68	1.02						
Continued Broadleaved									
Amaranthus viridis	35.71	11.25	0.76						
Sphenoclea zeylanica	57.14	18.93	1.35	66.67	37.86	2.27	60.00	30.00	3.60
Jussiaea linifolia	60.71	36.96	2.69	71.43	50.48	2.28	52.50	23.38	2.31
Jussiaea repens L.	35.71	8.93	0.69	14.29	6.90	0.33			
Euphorbia hirta	17.86	3.75	0.37	47.62	15.48	1.11	35.00	4.25	0.32
Phylanthus urinaria							12.50	1.38	0.12
Phylanthus amarus							20.00	1.75	0.25
Sagitaria guyanensis	57.14	17.14	1.22	52.38	13.81	1.01	35.00	14.25	1.24
Limnocharis flava	35.71	9.64	0.80	76.19	33.81	1.49	32.50	4.25	0.52
Eclipta alba				42.86	10.71	0.77	20.00	2.25	0.35
Eclipta prostata	32.14	5.89	0.72	23.81	7.86	0.61	15.00	2.63	0.35
Rotala indica							25.00	3.38	0.27
Monochoria hastata	53.57	20.18	1.45	47.62	13.81	0.89	25.00	3.00	0.47
Monochoria vaginalis	25.00	8.57	0.67	52.38	15.48	1.32	37.50	8.25	0.74
Eichornia crassipes							20.00	3.63	0.48
Heliotropium indicum							22.50	3.63	0.43
Bacopa rotundifolia							20.00	4.75	0.35
Lindernia crustacea				38.10	6.67	0.54			
Lindernia rotundifolia	42.86	7.50	0.81	42.86	10.71	0.77			
Ipomea triloba	14.29	2.68	0.22	57.14	17.62	0.80	20.00	2.13	0.36
Ipomea aquatica	39.29	10.00	0.73	28.57	10.00	0.80	30.00	3.13	0.44
Borreria laevicaulis	25.00	5.36	0.62	33.33	7.14	0.51	17.50	2.75	0.28
Borreria setidens				47.62	5.24	0.53			
Hedyotis corymbosa	42.86	10.00	0.79	52.38	20.24	1.10	17.50	4.88	0.48
Cleome rutidosperma							17.50	2.25	0.27
Oldenlandia dichotoma	21.43	3.04	0.41						
Salvinia molesta	25.00	4.11	0.39	42.86	13.10	0.81	37.50	10.63	0.88
Marsilea crenata	39.29	17.32	1.34	47.62	15.48	0.96	27.50	9.75	1.16

F = Frequency, FU = Field uniformity, MFD = Mean field density

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the species *L. chinensis* (61.25%) exhibited high uniformity value, while *P. urinaria* had the lowest uniformity (1.38%) in Muda. Begum *et al.* (2005) observed that weeds from the different families were generally uniformly distributed among the four rice growing districts in Muda rice granary area. Weeds with high uniformity values would require special attention from the management point of view (McCully *et al*., 1991).

In Seberang Perak, *E. crus-galli* and *F. miliacea* were the most abundant weeds with a density of around 5 plants m^{-2} followed by *E. colona, L. chinensis, C. iria,* and *J. linifolia* with densities of over 2 plants m^{-2}. In Tanjung Karang, *F. miliacea* was the most abundant weed with a density of around 4 plants m^{-2} followed by *E. crus-galli, E. colona, L. chinensis, C. iria, J. linifolia, S. zeylanica and C. difformis* with densities of more than 2 plants m^{-2}. *Leptochloa chinensis* was the most abundant weed with a density of around 5.5 plants m^{-2} in Muda, followed by *F. miliacea, E. crus-galli, E. colona, S. zeylanica, C. iria, C. difformis, O. sativa* L. (weedy rice) and *J. linifolia* with densities of more than 2 plants m^{-2} (Table 4). Weeds with higher frequencies also had higher field uniformity and mean field density, also indicating that these weeds were more difficult to control. These species should be carefully monitored. On the other hand, weeds that have a field frequency of less than 40%, uniformity of less than 10 and mean field density of less than 2 plants m^{-2} are either less competitive with rice or effectively controlled by current weed management practices in the study area. Weed density is an important factor in the control of weed species due to high density of any specific weed is a consequence of high seed production in the previous cropping season and a poor stand of crops. Wicks *et al*. (2003) was found in wheat crop where the average density of weed species was <9 weeds m^{-2} and some fields showed greater density within the surveyed wheat field. Similar results were reported by Uddin *et al*. (2009) who observed that the density of most of the weed species increased compared to densities obtained from all of the fields. *Oryza sativa* complex appeared most abounded weed species with high density followed by *L. chinensis*, *E. crus-galli*, *L. hyssopifolia* and *F. miliacea* in the Block-1 of Muda rice growing area (Begum *et al*., 2005).

The most abundant grass species in Seberang Perak was *E. crus-galli* (27.5), followed by *L. chinensis* (21.22), *E. colona* (18.42) and *O. sativa* L. (10.99) (Table 5). A similar trend was observed in Tanjung Karang. In Muda however, *L. chinensis* was observed with the highest relative abundance (RA) (28.1) among grass weeds; followed by *E. crus-galli* (24.62), *E. colona* (18.53) and *O. sativa* L. (14.21). Among the sedges, the highest RA was observed for *F. miliacea* followed by *C. iria* and *S. grossus* in all sites.

Table 5 : Relative abundance (RA) of grasses, sedges and broadleaf weeds in west coastal rice growing area of Peninsular Malaysia

Scientific name	RA Value		
	Seberang Perak	Tanjung Karang	Muda, Kedah
Grasses			
Echinochloa crus-galli	36.24	20.95	24.62
Echinochloa colona	19.63	18.93	18.53
Leptochloa chinensis	17.26	19.02	28.10
Oryza sativa L. (weedy rice)	10.16	10.41	14.21
Paspalum conjugatum	3.04	5.21	5.36
Paspalum vaginatum	7.06	3.29	2.20
Paspalum commersonii	3.64	4.39	
Ischaemum rugosum	8.63	9.44	7.52
Eleusine indica	5.89	2.50	1.84
Cynodon dactylon	2.58	3.11	2.46
Digitaria ischaemum	4.18	3.39	
Digitaria sangunalis	2.07	2.12	
Sedges			
Fimbrystylis miliacea	25.60	22.58	23.71
Fimbristylis globulosa	5.78	3.16	2.88
Cyperus iria	13.55	14.11	17.07
Cyperus difformis	8.13	11.55	16.36
Cyperus pilosus	5.97	4.42	3.75
Cyperus babakensis			5.22
Cyperus aromaticus	3.07	3.89	
Cyperus distans	6.27	2.70	2.94
Cyperus rotundus		4.23	2.78
Scirpus grossus	13.70	10.02	13.41
Scirpus supinus			2.63
Scirpus mucronatus	3.54		3.17
Eleocharis variegata	5.44		
Broadleaved			
Amaranthus viridis	4.21		
Sphenoclea zeylanica	8.58	13.44	16.98
Jussiaea linifolia	12.49	15.15	12.72
Jussiaea repens L.	7.38	2.20	
Euphorbia hirta	1.77	7.50	4.02
Phylanthus urinaria			1.51
Phylanthus amarus			2.65
Sagitaria guyanensis	8.31	5.36	7.65
Limnocharis flava	4.03	11.87	4.21
Eclipta alba		3.82	3.55
Eclipta prostata	3.13	3.37	2.47
Rotala indica			2.12
Monochoria hastata	8.63	4.87	3.32
Monochoria vaginalis	3.08	8.19	5.76
Eichornia crassipes			3.09
Heliotropium indicum			3.17
Bacopa rotundifolia			1.89
Lindernia crustacea		2.96	
Lindernia rotundifolia	3.32	4.11	
Ipomea triloba	1.31	5.60	2.58
Ipomea aquatica	4.25	4.60	3.67
Borreria laevicaulis	2.61	3.58	2.45
Borreria setidens		4.13	
Hedyotis corymbosa	4.57	6.28	2.33
Cleome rutidosperma			2.55
Oldenlandia dichotoma	0.90	2.96	
Salvinia molesta	2.26	6.38	6.46
Marsilea crenata	7.50	4.21	6.09
Total RA value	300	300	300

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Table 6 : Relative abundance and ranking of the most prevalent weed species in west coastal rice growing areas of Peninsular Malaysia

Scientific name	Relative Abundance and Ranking					
	Seberang Perak		Tanjung Karang		Muda, Kedah	
	RA	R	RA	R	RA	R
Echinochloa crus-galli	36.24	1	20.95	2	24.62	2
Echinochloa colona	19.63	3	18.93	4	18.53	4
Leptochloa chinensis	17.26	4	19.02	3	28.10	1
Oryza sativa L. (weedy rice)	10.16	8	10.41	9	14.21	8
Ischaemum rugosum	8.63	10	9.44		7.52	
Fimbrystylis miliacea	25.60	2	22.58	1	23.71	3
Cyperus iria	13.55	6	14.11	6	17.07	5
Cyperus difformis	8.13		11.55	10	16.36	7
Scirpus grossus	13.70	5	9.95		13.41	9
Sphenoclea zeylanica	8.58		13.44	7	16.98	6
Jussia linifolia	12.49	7	15.15	5	12.72	10
Limnocharis flava	4.03		11.87	8	4.21	
Monochoria hastata	8.87	9	4.87		3.32	
Total RA value	**187.00**		**182.27**		**200.76**	

RA= Relative abundance, R=Ranking

However, among the broad leaved weeds in Seberang Perak; the highest RA value was obtained for *J. linifolia* (12.49) followed by *S. zeylanica* (8.63) and *M. hastata* (8.58). In Tanjung Karang, the highest RA value (15.15) was recorded for *J. linifolia* followed by *S. zeylanica* (13.44) and *L. flava* (11.87), while in Muda the highest RA value (16.98) was observed in *S. zeylanica* followed by *J. linifolia (*12.72) and *S. guyanensis* (7.65). In descending order of RA values, the top most 10 species were *E. crus-galli, F. miliacea, E. colona, L. chinensis, S. grossus, C. iria, J. linifolia , O. sativa* L.*, C. difformis* and *M. hastata* in Seberang Perak. The top 10 species in Tanjung Karang were *F. miliacea, E. crus-galli, L. chinensis, E. colona, J. linifolia, C. iria, S. zeylanica, L. flava, O. sativa L.* and *C. difformis.* In Muda the top 10 species were *L. chinensis, E. crus-galli, F. miliacea, E. colona, C. iria, S. zeylanica, C. difformis, O. sativa* L*, S. grossus* and *J. linifolia* (Table 5). Most of the abundant weeds were annual in nature.

The ranking of weed species based on frequency (F), field uniformity (FU) and mean field density (MFD) showed differences. However, within the weed types, a higher RA value is reflected by higher values of F, FU and MFD (Tables 4). In the areas surveyed, *E. crussgalli, F. miliacea, E. colona, C. iria* and *L. chinensis* were consistently the top abundant species with F of ≥ 60%, FU of ≥ 40%, and MFD of ≥ 3 plant/m^2. The result indicates that *L. chinensis*, *E. cruss-galli, E. colona* and *F. miliacea* were the most notorious weeds in the surveyed rice growing areas (Tables 5 and 6). However, *Oryza sativa* L. (weedy rice), *Ischaemum rugosum, C. iria, C. difformis, S. grossus, S. zeylanica, J. linifolia* and *M. hastata* were relatively abundant in Seberang Perak with F ≥ 50% and RA values ≥ 8. In Tanjung Karang, *Oryza sativa* L., *C. iria, C. difformis, S. grossus, S. zeylanica, L. flava* and *J. linifolia* were relatively abundant species with F ≥ 50% and RA values ≥ 10; while in Muda, *Oryza sativa L., C. iria, C. difformis, S. grossus, S. zeylanica* and *J. linifolia* were abundant species with F ≥ 50% and RA values ≥ 12. Similar pattern of weed dominance ranking in the Muda area was reported by Azmi and Baki (2002) and the ranking of weeds in descending order of importance were *E. crus-galli* complex, *L. chinensis*, *O. sativa* (weedy rice), *L. hyssopifolia, F. miliacea, S. zeylanica* and *S. grossus*. In 2008 however, *O. sativa* complex ranked top in the Muda rice granary in peninsular Malaysia, followed by *E. crus-galli*, *L. chinensis*, *L. hyssopifolia* and *F. miliacea* (Begum *et al*., 2008). Similarly, Uddin *et al.* (2009) observed that two sedges *C. aromaticus* and *F. dichotoma*, two grasses *E. indica* and *C. aciculatus*, and two broadleaved weeds *D. triflorum* and *B. repens,* were most abundant species out of 28 species with a frequency ≥ 50% and RA value ≥ 12 in the turf field in Malaysia.

Among the 10 most abundant weed species, there were four grasses *viz., E. crus-galli, L. chinensis, E. colona, O. sativa* L (weedy rice).; four sedges *viz., F. miliacea, C. iria, C. difformis, S. grossus* and two broadleaved weeds viz. *S. zeylanica, J. linifolia.*

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