J. Trop. Agric. and Fd. Sc. 35(2)(2007): 319–331

Weed flora landscapes of the Muda rice granary in the new millennium: A descriptive analysis

(Landskap flora rumpai di jelapang padi Muda dalam milenium baru: Analisis deskriptif)

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Key words: direct-seeded rice, weedy rice, *Echinochloa crus-galli*, Canonical correspondence analysis (CCA)

Abstract

Weed surveys were conducted from 2001–2005 to ascertain the dominant weed species in the Muda area. A total of 58 weed species belonging to 26 families, comprising 27 broad-leaved weeds, 14 grasses, 12 sedges and 5 aquatic plants, were recorded. The Sorenson's Index of Similarity indicated that at least 74.4% of the listed species prevailed in all five seasons. An almost similar trend in weed species abundance and dominance in each season was also observed. Quantitative estimates based on percentage of area infested showed the dominance and almost ubiquitous status of the *Oryza sativa* complex (weedy rice), *Echinochloa crus-galli* complex, *Leptochloa chinensis* and *Ludwigia hyssopifolia* in the Muda rice area. The hierarchical dominance of weed type according to percentage of field infested ratio in the Muda area was in the order of grasses > broad-leaved weeds > sedges > aquatics. Canonical correspondence analysis (CCA) showed commonality in dominant species occurrence in four out of five seasons. *Fimbristylis acuminata, Cyperus polystachyos,* and *Echinochloa stagnina* were highly prevalent in the off-season of 2001, while *Oryza rufipogon* was highly associated in the off-season of 2002. There was no indication of preferential season prevalence among the weed species in the off-season of 2003, despite a relatively higher rainfall *vis-à-vis* the off-seasons of 2001 and 2002. The off-season of 2004 registered measurable association between species dominance in *Azolla pinnata* and *Salvinia molesta* and total average annual rainfall. The relatively low total average annual rainfall in the off-season 2005 registered higher species diversity as indicated by the vector lengths in the CCA, with particular dominance of *Hydrilla verticillata, Paspalum longifolium, Ipomoea aquatica* and *Commelina nudiflora*.

Introduction

In Malaysia, the agricultural areas cover 4.64 million ha and about 14% of these areas are dedicated to rice cultivation. The new millennium saw rice areas dropping from 686,200 ha in 1990 to 674,400 ha in 2000. In 2005, rice areas dropped further to 611,000 ha. Muda is a principal rice granary in Peninsular Malaysia, covering an area of 96,000 ha (Anon. 2004). The late 1980s witnessed the gradual change in rice culture from the predominantly transplanting

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method to the direct-seeded (DS) method, with the eventual coverage of 70–80% of the Muda granary in the 1990s (Morooka and Jegatheesan 1996).

Direct-seeded rice crops are either wet sown or dry sown. Wet seeding is normally preferred, but this system needs proper water management for good crop establishment. Direct-seeding is normally done by hand broadcasting or using motorised blowers. In certain areas of Muda, due to the shortage of water in the off-season, dry seeding is practised. Volunteer seeding with minimum tillage to incorporate the shattered seed of the previous crop is also practised. Thus, the DS culture adopted in the Muda area can be classified into three types: wet seeding, dry seeding and volunteer seeding, representing 67%, 24% and 9% of the main crop, respectively (Morooka and Jegatheesan 1996). In the second (main season) crop where irrigation water is adequately available, wet seeding is employed in almost all fields. At present, about 90% of the rice fields in the Muda area are direct-seeded.

Some of the factors influencing weed prevalence in rice fields include the rice culture system, soil moisture regime, crop rotation, cropping pattern, land preparation and tillage regimes, light, soil temperature, fertilizer application, rice cultivar and seeding rate, as well as weed control technology (Baki and Azmi 1994). As such, time-mediated and space-mediated species dominance and their patterns of distribution vary considerably. This has been clearly elucidated by several detailed surveys of rice field weeds in the granary areas. Azmi et al. (1993) showed that the most dominant weeds in the Muda area in decreasing order in the 1989/1990 season were *Echinochloa crus-galli, Leptochloa chinensis, Fimbristylis miliacea, Scirpus grossus* and *Monochoria vaginalis*.

Ecological studies conducted in 1994 showed that the whole Muda rice area was infested by 12 dominant weeds (Pane 1996). The most dominant species was *L. chinensis*, heavily covering 75% of the sampling sites. In 1988, most of the southern parts of the Muda area were colonized by this weed. In 1990, the populations of *L. chinensis* reached the northern part of the Muda area. The whole Muda area was finally infested with *L. chinensis* by 1992. From 1981 until 1994, the increase of area infested per unit time was estimated at about 4% of the area based on the previous years' records. Perhaps the widespread use of herbicides by local farmers specifically to suppress the massive population of *E. crus-galli* has led to the consequential increase of *L. chinensis*. In addition, Ho (1991) reported that continuous adoption of DS enhanced the occurrence of perennial weeds, such as *E. stagnina, Paspalum distichum* and *Cyperus babakan*, in the Muda area.

A common problem in weed community ecology is to discover how a multitude of weed species respond to external and agronomic factors such as tillage, seasonal availability of water and rainfall, fertilizer regimes, and management regime. In weed surveys, data are collected on weed species composition and the external and agronomic variables at a number of points in time and space. The statistical methods available so far in the analysis of such data bear the assumption that linear relationships were restricted to regression of the response of individual species separately. In order to analyse the generally non-linear, non-monotone response of a community of weed species, one had to resort to the data-analytic methods of ordination and cluster analysis.

The employment of canonical ordination techniques greatly improves the power to detect the specific effects a researcher is interested in. The canonical correspondence analysis (CCA) through the computer program CANOCO developed by ter Braak (1996) escapes the assumption of linearity and is able to detect unimodal relationships between species and external variables. The program includes weighted averaging, reciprocal averaging or multiple correspondence analysis, detrended correspondence analysis and canonical correspondence analysis.

In recent years, there has been an increasing need for more information on the occurrence of individual weed species so that research can be concentrated on the most important ones. Monitoring these changes is important to formulate appropriate weed management strategies in the rice crop. This paper reports the results of a study carried out with the main objective of listing the principal weed species in the Muda rice area. Further, an analysis of species occurrence over seasons, time-mediated differences in species dominance and their spatio-temporal dynamics can also be ascertained.

Materials and methods

Field surveys

These were conducted in DS rice fields in the off-seasons for five consecutive years from 2001 to 2005 between the booting and heading stages of rice in farmers' fields in the Muda area *(Figure 1)*. Farmers had weeded and applied herbicides to their rice fields when the surveys were conducted, thereby generating data and information on weed species which had survived the instituted control measures, and thus likely to pose consequential problems in DS rice. Before starting the survey, a route was planned to provide adequate coverage of the whole area. Two field assistants surveyed each field. Normally the rice fields were 0.4 ha and above in size. Comparisons were made among the occurrence and density of individual species while walking through the field, and again when returning along the other side of the field. A score of occurrence for each weed was then registered. This method was adopted both to reduce the time taken to survey a field and to prevent possible damage to the crop.

Weed species and their percentage cover were recorded. The percentage cover of weeds prevailing above the rice canopy was based on the whole field, whereas the percentage cover of weeds below the crop canopy was taken from four 1 m^2 quadrats placed randomly in each rice field. All weed species present were recorded and scored for distribution and frequency. A rating scale of 0 to 10 to denote weed cover was used (Chancellor and Froud-Williams 1984; Pablico and Moody 1985; Elazegul et al. 1990), namely: 0 = no weed present; Tr = a few scattered plants, 1 = 1–10% ; 2 = 11–20%; 3 = 21–30%; 4 = 31–40%; 5 = 41–50%, and 6 = 51–60%.

The rainfall distribution patterns for the period from 2001–2005 is shown in *Figure 2,* and these were taken from 27 meteorological stations in the Muda area.

Data analysis

Collated data on the incidence of weed species and their cover in five seasons from 2001–2005 were analysed to assess weed flora in different farmers' fields in the Muda rice area. The analyses based on percentage of weed infestation are presented in this paper. Comparisons of species affiliation among weed communities for different seasons were made using the Sorenson's Index of Similarity (S) (Goldsmith et al. 1986). Canonical correspondence analyses (CCA) through the computer program CANOCO (ter Braak 1996) were conducted to assess association, if any, between species prevalence and average total annual rainfall in the off-seasons of 2001 through 2005, and between species prevalence and the average rice yields in the Muda area. Biplot scaling of dominant weed species vectors indicate the associations of season (= rainfall distribution and quantity) with weed species abundance, and of weed abundance with rice yield. Associations of species abundance with season, average annual total rainfall and yield can be ascertained by the direction of the vectors. Vector lengths indicate the relative strength of the association between the respective weed species and the season of planting (year), total average annual rainfall and yield.

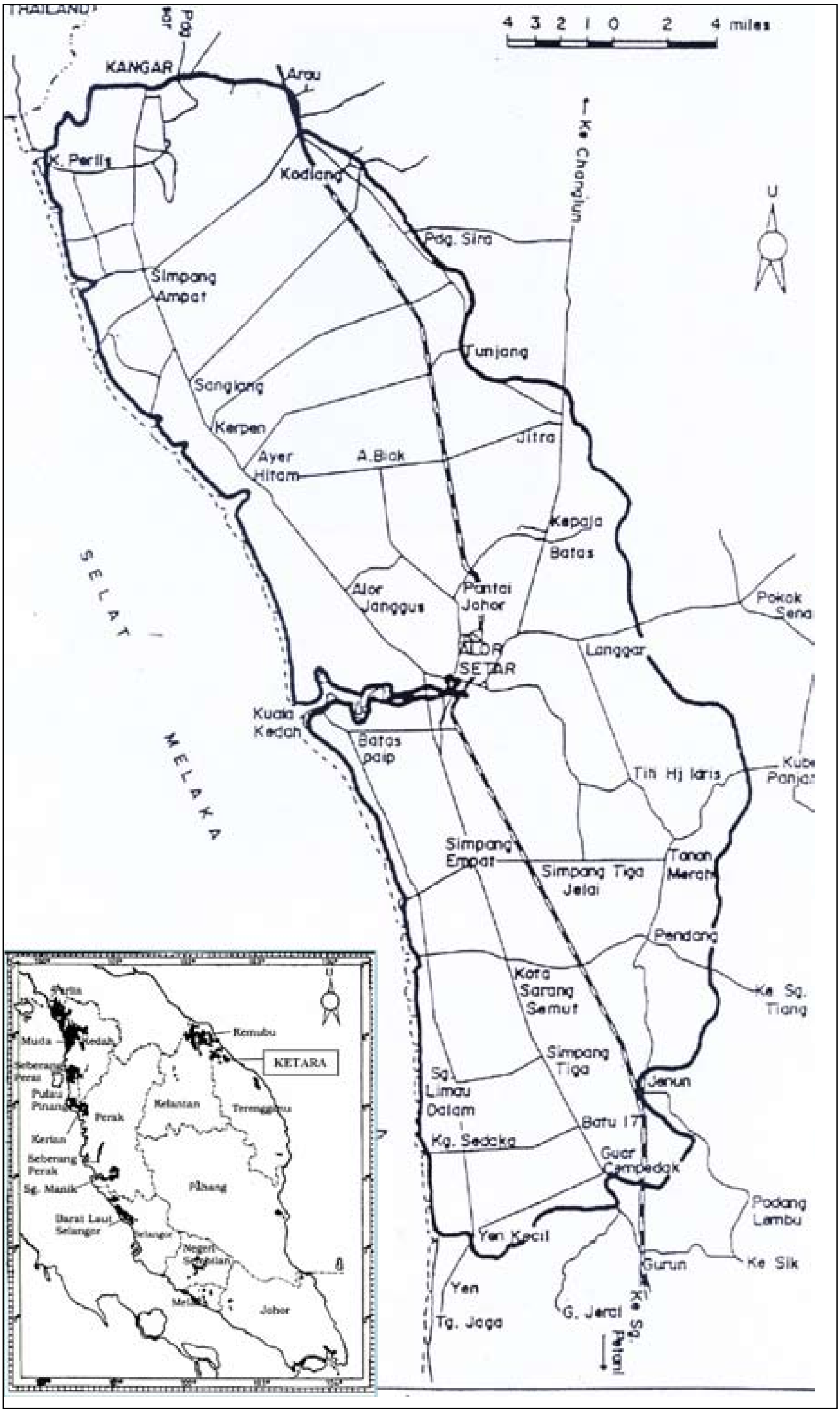

Figure 1. Rice-growing area of Muda (marked by a bold border) where the weed surveys were conducted

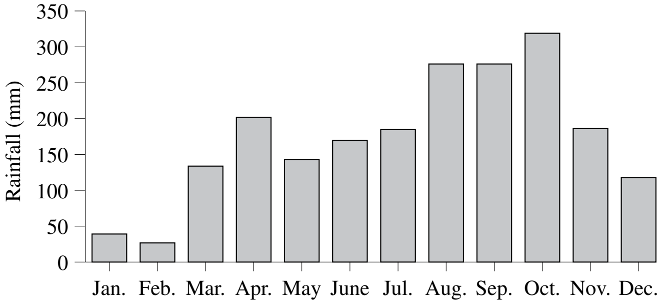

Figure 2. Average rainfall distribution of the Muda area, 2001–2005 (data taken from 27 meteorological stations)

Results and discussion

Farm surveys assessing the magnitude and extent of weed infestations in rice-growing areas are an important step in formulating an appropriate control package. A total of 382, 428, 582, 788 and 1,145 rice fields were surveyed covering the whole Muda Irrigation Scheme in the off-seasons of 2001, 2002, 2003, 2004 and 2005, respectively. The areas surveyed practise DS rice culture.

High incidences of weed infestation might be due to the scarcity of rainfall during the fallow period normally in January and February each year. This apparent scarcity of rainfall may not be sufficient to trigger weed germination during the pre-planting stage in the early part of the off-seasons, pointing out the possible strong correlations between them *(Figure 2)*.

Further, the lack of rainfall from March to May during the off-season period is normally not efficient in arresting weed infestations by submergence especially at the early crop growing stages, leading to sequential luxurious weed growth under DS. Similarly, total rainfall in the off-season 2005 was the lowest compared to other seasons studied, arguably, resulting in increased weed diversity in this season *(Figure 3)*.

A total of 58 weed species belonging to 26 families comprising 27 broad-leaved weeds, 14 grasses, 12 sedges and 5 aquatic plants was recorded across the seasons (2001–05) in the Muda irrigation scheme *(Table 1)*. The Poaceae family had the highest number of species (14), followed by Cyperaceae (12), and 21 other families of broadleaved weeds and aquatics.

Thirty-eight weed species were found in the off-season of 2001 and a similar number of weed species (39) were observed in 2002, 2003 and 2004, while 49 species were registered in 2005. The higher number of weed species found in 2005 might be due to increased adoption of water seeding by farmers as reflected by increased numbers in broad-leaved weeds recorded. However, new species recorded were of minor importance.

The most widespread weed species in terms of frequency and abundance (according to percentage fields infested value) of more than 60% in the off-season of 2001 were the *E. crus-galli* complex > *L. chinensis* > *Oryza sativa* (weedy rice accessions) > *Ludwigia hyssopifolia* having values of percentage fields infested of 94.6, 86.9, 82.4 and 63.8%, respectively. In the following year (off-season of 2002), the hierarchy of dominance was weedy rice (92.51%) > *E. crus-galli* complex (91.36%) > *L. chinensis* (84.11%) > *L. hyssopifolia* (67.52%). Similar patterns of weed dominance to those observed in the off-season 2002 were observed in the off-seasons of 2003, 2004, and 2005.

Persistent dominance of grass weeds, especially weedy rice accessions, *E. crus-galli*, and *L. chinensis* followed by *L. hyssopifolia*, a broadleaved weed, was observed in the off-season of 2003

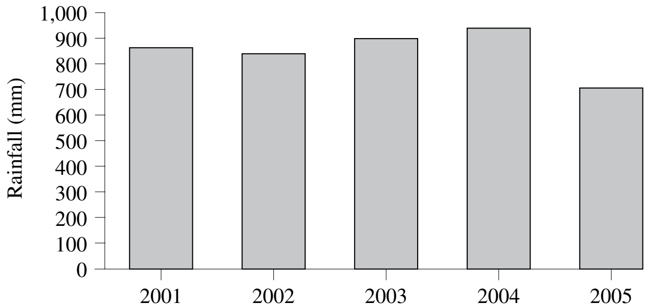

Figure 3. Total rainfall for the off-seasons (February–July) of 2001–2005 in the Muda area (data taken from 27 meteorological stations)

Table 1. Distribution of weed species based on family affiliation (% of fields infested) in the Muda area from the off-season of 2001 to the off-season of 2005

Family	Weed species	2001	2002	2003	2004	2005
Grass						
Poaceae	*Oryza sativa* complex L. (weedy rice)	82.4	92.5	97.4	93.9	96.9
Poaceae	*Echinochloa crus-galli* (L.) *Beauv.* complex*;* i) *E. crus-galli var. crus-galli* ii) *E. crus-galli var. formosensis* iii) *E. oryzicola*	94.2	91.4	88.1	88.3	90.8
Poaceae	*Leptochloa chinensis* (L.) Nees	86.9	84.1	86.6	80.7	82.9
Poaceae	*Ischaemum rugosum* Salisb.	28.9	40.4	45.0	41.0	45.5
Poaceae	*Echinochloa colona* (L.) Link	17.8	22.7	10.2	22.8	17.6
Poaceae	*Echinochloa stagnina* (Rets) Beauv.	5.0	–	–	–	0.5
Poaceae	*Panicum repens* L.	0.3	0.2	–	–	0.4
Poaceae	*Sacciolepis indica* (L.) Chase	0.3	0.2	–	0.4	–
Poaceae	*Leersia hexandra* Sw.	0.5	0.5	–	1.4	1.8
Poaceae	*Paspalum vaginatum* Sw.	–	2.8	1.7	3.0	2.4
Poaceae	*Oryza rufipogon* Griff.	–	0.7	–	–	0.1
Poaceae	*Panicum amplexicaule* Rudge	–	0.2	0.2	0.1	0.3
Poaceae	*Echinochloa stagnina* (Rets) Beauv.	–	–	–	–	0.5
Poaceae	*Paspalum longifolium* Roxb.	–	–	–	–	0.3
Sedges						
Cyperaceae	*Fimbristylis miliacea* (L.) Vahl	57.5	55.1	49.0	61.8	71.5
Cyperaceae	*Scirpus grossus* L.	41.2	33.9	35.6	34.8	25.4
Cyperaceae	*Cyperus iria* L.	35.7	30.4	26.6	28.4	30.5
Cyperaceae	*Cyperus babakan* Steud.	11.5	11.9	9.1	10.2	7.0
Cyperaceae	*Cyperus difformis* L.	9.2	8.9	7.7	7.6	11.9
Cyperaceae	*Scirpus juncoides* Roxb.	3.4	1.6	1.0	0.8	0.5
Cyperaceae	*Scirpus lateriflorus* Gmel	2.9	0.2	1.4	1.6	2.7
Cyperaceae	*Fimbristylis acuminata* Vahl.	0.3	–	–	–	–
Cyperaceae	*Fuirena umbellata* Rottb.	0.3	0.2	0.9	0.3	0.9
Cyperaceae	*Cyperus polystachyos* Rottb.	0.3	–	–	–	–
Cyperaceae	*Cyperus haspans* L.	0.8	1.2	1.2	1.6	1.8

(cont.)

Table 1. *(cont.)*

Family	Weed species	2001	2002	2003	2004	2005
Cyperaceae	*Eleocharis variegata* (non Presl, nec Kunth) Boeck	–	–	0.3	0.3	0.3
Broad-leaved weeds						
Sphenocleaceae	*Sphenoclea zeylanica* Gaertn	43.0	18.7	19.9	24.5	22.5
Onagraceae	*Ludwigia hyssopifolia* (G. Don) Exell	63.8	67.5	67.5	71.3	72.9
Onagraceae	*Ludwigia octovalvis* (Jacq.) Raven	2.1	4.7	–	–	–
Onagraceae	*Ludwigia adscendens* (L.) Hara	0.3	1.2	2.1	–	0.1
Alismataceae	*Sagittaria guyanensis* H.B.K.	12.9	8.9	7.0	10.8	10.4
Marsileaceae	*Marsilea crenata* Presl	11.3	5.4	5.5	7.0	6.7
Pontederiaceae	*Monochoria vaginalis* (Burm.f.) Presl	10.2	8.9	6.9	6.3	8.8
Pontederiaceae	*Monochoria hastata* (L.) Solms	–	2.4	0.7	2.5	2.6
Butomaceae	*Limnocharis flava* (L.) Buchenau	9.7	12.4	8.1	9.1	8.1
Lemnaceae	*Lemna perpusilla* Torr.	6.3	3.0	2.9	2.9	7.4
Scrophulariaceae	*Bacopa rotundifolia* (Michx.) Wettst.	5.0	7.0	9.6	16.9	18.3
Scrophulariaceae	*Lindernia pusila* Boldingh	4.5	1.2	0.3	1.1	2.0
Scrophulariaceae	*Limnophila erecta* Benth	–	4.9	3.3	2.5	3.8
Parkeriaceae	*Ceratopteris pteridoides* (Hook) Hieron	2.6	1.9	2.2	1.4	1.4
Rubiaceae	*Hedyotis corymbosa* (L.) Lamk	1.6	6.1	2.2	3.3	6.5
Gentiaceae	*Nymphaea nouchali* Burm. f.	1.6	–	1.7	0.1	1.4
Gentiaceae	*Nymphoides indica* (L.) O. K.	1.0	0.5	1.4	–	0.4
Salviniaceae	*Salvinia cucullata* Roxb. Ex Bory	–	–	0.2	–	–
Salviniaceae	*Salivinia molesta* D. S. Mitchel				0.1	–
Asteraceae	*Eclipta alba* (L.) Hassk.	–	–	–	0.3	–
Azollaceae	*Azolla pinnata* R. Br.	–	–	–	0.1	–
Convolvulaceae	*Ipomea aquatica* Forsk.	–	–	–	–	0.4
Leguminosae	*Aeschnomene aspera* Linn	–	–	–	–	0.2
Lythraceae	*Rotala indica* (Willd.) Koehne	–	–	–	–	0.2
Commelinaceae	*Commelina nudiflora* L.	–	–	–	–	0.1
Pontederiaceae	*Eihhornia crassipes* (Mart.) Solms	–	–	–	–	0.1
Araceae	*Pistia stratiotes* L.	–	–	–	–	0.1
Aquatic weeds						
Hydrocharitaceae	*Blyxa malayana* Ridl.	0.3	0.2	0.7	0.4	0.4
Hydrocharitaceae	*Ottelia alismoides* (L.) Hassk	–	–	0.2	–	–
Hydrocharitaceae	*Hydrilla verticillata* (L.f.) Royle	–	–	–	–	0.4
Najadaceae	*Najas graminea* Del.	6.6	5.6	5.2	–	3.3
Lentibulariaceae	*Utricularia aurea* Lour	11.5	8.2	7.2	11.8	16.8

registering percentage dominance of 97.4, 88.1, 86.6 and 67.5%, respectively. The respective parallel figures of dominance in the off-season of 2004 were 93.9, 88.3, 80.7, and 71.3% and in the off-season 2005, these were in the order of 96.9, 90.8, 82.9 and 72.9% *(Table 1)*.

The similarity in hierarchical importance of weed species throughout the seasons, arguably, reflects similarity in agronomic practices prevailing in the Muda area where DS has become the most widespread technique of rice crop establishment. An analysis of weed species diversity based on Sorenson's Index of Similarity showed consistently large values ranging from 74.4% to 86.0%, indicating that similar weed species were present in each season. Perhaps, this phenomenon was due to the total adoption of DS culture throughout the Muda area where farmers follow similar cultural practices each season, although the niches of occurrence of these weeds based on soil types were inherently different.

The weed surveys registered the commonality of *padi angin* or weedy rice in the off-seasons of 2001–2005 as the emerging weed problem in the area *(Figure 4)*. This recalcitrant weed is difficult to control because of its morpho-ecological and physiological similarities to the cultivated rice plant especially at the early crop growing stage. Weedy rice was the third dominant weed in the Muda rice area in the of 2001, and became the most dominant weed from the off-season of 2002 up to that of 2005 *(Table 1)*. Intriguingly, the percentages of rice fields registering *trace* occurrence of weedy rice showed an increase from 28.3% in the of 2001 to 50.6% in off-season of 2005 *(Figure 4)*. Such increments in areas with trace occurrence or infestation of weedy rice is a strong manifestation resulting from the improvement in land preparation techniques and changes in crop establishment method to water seeding in off-season 2005 by farmers in the Muda area.

In the same vein, a similar trend of reduced weed infestation was also observed for the other three most important weeds. The *E. crus-galli* complex also showed a significant increase in infested fields with *trace* occurrence – from 23.6% in the off-season of 2001 to 75.3% in the off-season of 2005 (*Figure 5a*), probably due to better weed control practices adopted by farmers. Similar arguments can be forwarded for the high number of fields registering *trace* occurrence of *L. chinensis,* from 39.1% in the off-season of 2001 to 55.1% in the off-

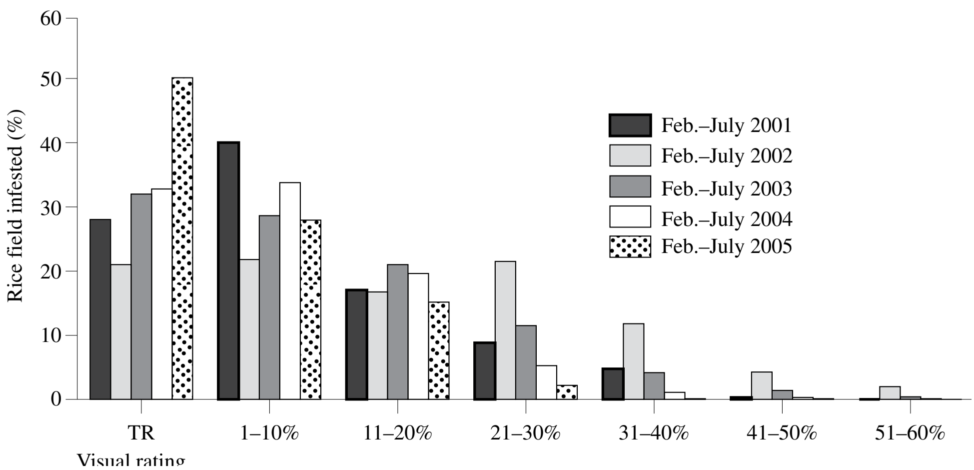

Figure 4. Severity of weedy rice ***(Oryza sativa*** *complex) infestation in the Muda area (off-seasons, 2001–2005)*

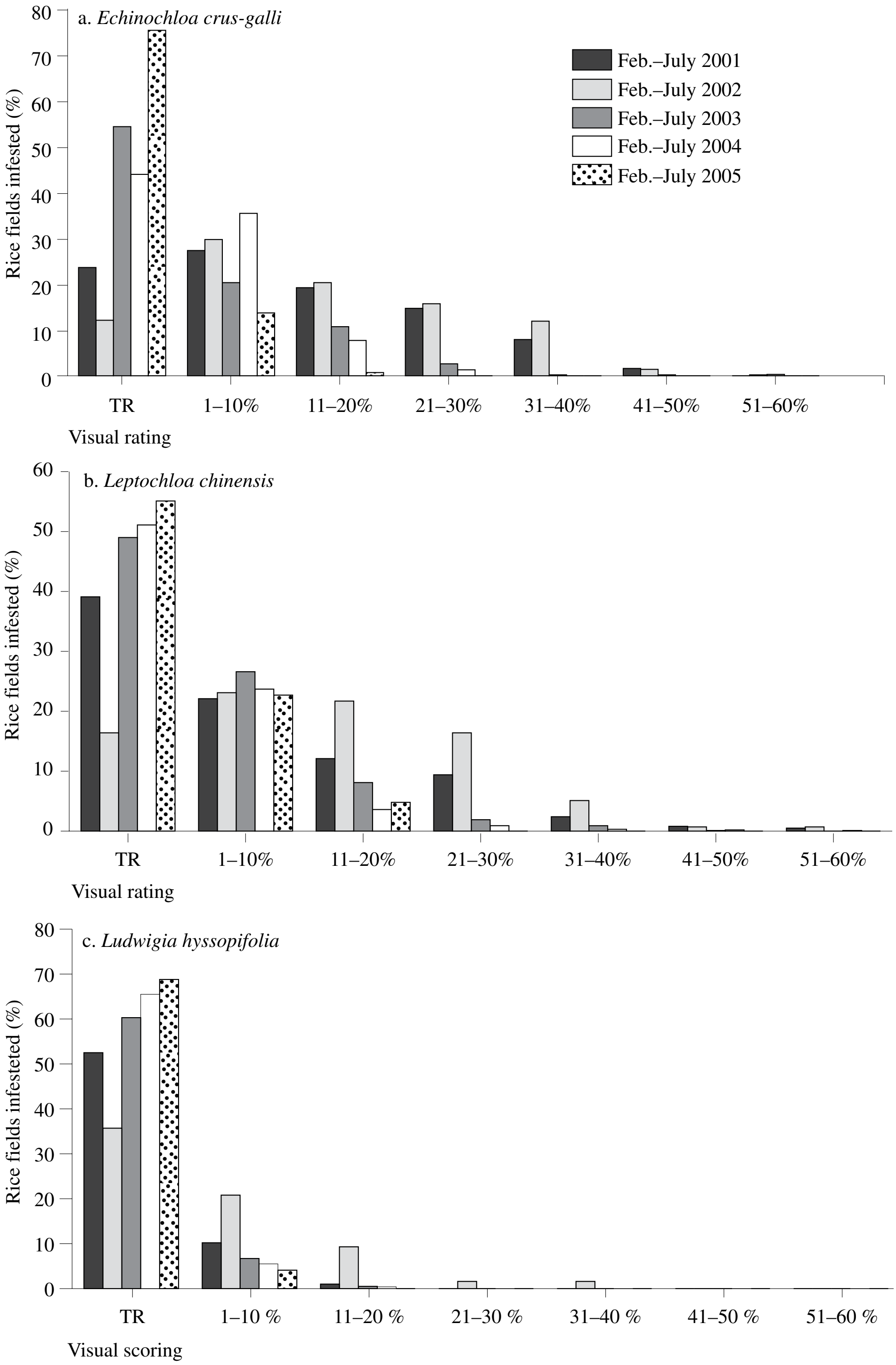

Figure 5. Severity of ***Echinochloa crus-galli, Leptochloa chinensis*** *and* ***Ludwigia hyssopifolia*** *infestation in the Muda area (off-seasons, 2001–2005)*

season of 2005 *(Figure 5b)*, and in the case of *L. hyssopifolia*, from 52.5% to 68.8% *(Figure 5c)*.

This study revealed that there was a gradual increase in grassy weeds, especially weedy rice, in all years compared to previous studies by Azmi et al. (1993) and Pane (1996) in Muda area. The predominance of grasses such as *E. crus-galli* and *L. chinensis* as key species in the Muda area prevailed. Ho and Md. Zuki (1988), Supaad et al. (1991) and Azmi (1994) argued that the shift from transplanting to DS in the Muda rice fields has resulted in the measurable increases in grassy weeds notably *E. crus-galli, L. chinensis, E. colona,* and *I. rugosum*. It is interesting to note that in this study, the grassy weed components were dominated by weedy rice, *E. crus-galli* complex and *L. chinensis*. Weedy rice was a completely new dominant grassy weed species, occurring in all seasons surveyed making it a serious threat to DS rice in the Muda granary.

It is reasonable to argue that this might be due to no selective herbicide being available to control this weed, perhaps the farmer's inability and reluctance to manually control this weed at the early stage of crop growth possibly due to crop mimicry. On the other hand, grassy weeds like *E. crus-galli* and *L. chinensis* can be controlled by selective herbicides such as cyhalopfop-butyl, quinlorac, molinate, propanil, fenoxaprop-ethyl and bispyribac-sodium if applied correctly (Karim et al. 2004).

Therefore, for effective weed control, it is recommended that control measures should first be targeted towards grassy weeds, especially the most noxious and the newly emerging, competitive and rapid-spreading weed, i.e. weedy rice. Detailed studies on the biology and ecology of weeds – especially weedy rice, *E. crus-galli, L. chinensis* and *L. hyssopifolia* and other recalcitrant and hard-to-control weeds, namely, *F. miliacea, Limnocharis flava*, herbicide-resistant species – need to be continued in order to formulate successful weed control measures for rice cultivation in this country.

The CCA ordination diagram denotes the variable relationships between weed species and environmental factors, viz. rainfall and season, and between weed species and yields of the Muda area (*Figure 6*). Generally, weed species across seasons were dominated by grasses especially weedy rice, the *E. crus-galli* complex and *L. chinensis*. However, the off-season of 2005 registered higher species diversity compared to the other seasons surveyed. This phenomenon might be due to low rainfall in this season.

The bi-plot scaling of dominant weed species vectors indicated the associations between seasons (= rainfall distribution and quantity) and weed species abundance, and between weed abundance and rice yield. The association of species abundance with seasons, average annual total rainfall and yield can be ascertained by the direction of the vectors, while vector lengths indicate the relative strength of association between the respective weed species and the seasons of planting, total average annual rainfall and yield.

The CCA showed commonality in dominance species occurrence in four out of five seasons. *Fimbristylis acuminata, Cyperus polystachyos,* and *E. stagnina* were highly prevalent in off-season of 2001, while *O. rufipogon* was highly associated with off-season 2002. There was no indication of preferential season prevalence in weed species in off-season of 2003, despite relatively higher rainfall compared to off-seasons 2001 and 2002. The off-season of 2004 registered a measurable association in species dominance between *Azolla pinnata* and *Salvinia molesta* and total average annual rainfall. The relatively lower total average annual rainfall in the off-season of 2005 resulted in higher species diversity as indicated by the vector lengths in the CCA with particular dominance by *H. verticillata, P. longifolium, I. aquatica* and *C. nudiflora*.

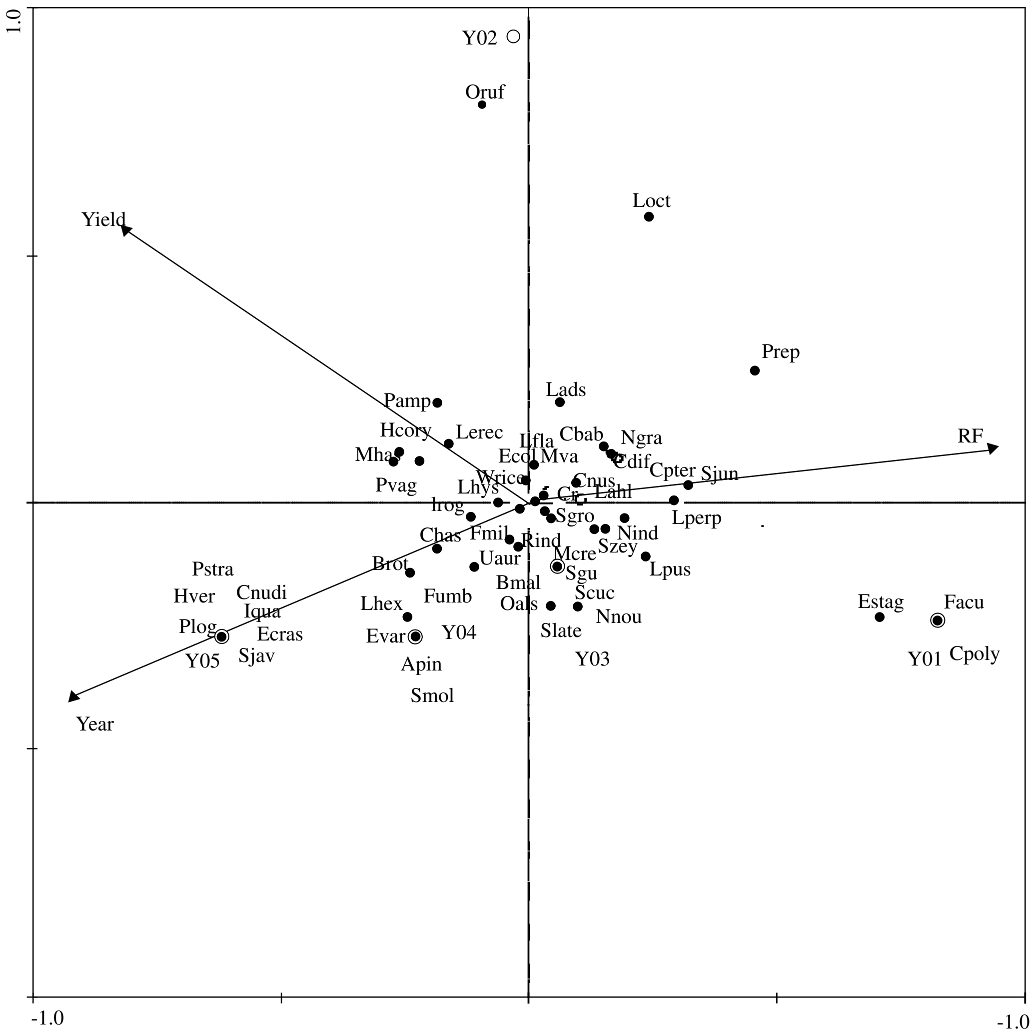

*Figure 6. Canonical correspondence analysis ordination diagram denoting the relationships between weed species and environments [Rainfall (RF), Yield and Year (or season)] of the Muda area (off-seasons, 2001-2005) (□; Y01 = off-season 2001, Y02 = off-season 2002, Y03 = off-season 2003, Y04 = off-season 2004 and Y05 = off-season 2005). x-axis = canonical function 1, y-axis canonical function 2. The weeds shown are, Apin = **A. pinnata**, Bmal = **B. malayana**, Brot = **B. rotundifolia**, Cbab = **C. babakan**, Cdif = **C. difformis**, Chas = **C. haspan**, Cir = **C. iria**, Cpter = **C. pteridoides**, Ealba = **E. alba**, Ecrus = **E. crus-galli**, Ecol = **E. colona**, Estag = **E. stagnina**, Evar = **E. variegata**, Eras = **E. crassipes**, Fmil = **F. miliacea**, Fumb = **F. umbellata**, Hcory = **H. corymbosa**, Hver = **H. verticillata**, Irog = **I. rugosum**, Lchi = **L. chinensis**, Lerec = **L. erecta**, Lfla = **L. flava**, Lhex = **L. hexandra**, Lhys = **L. hyssopifolia**, Loct = **L. octovalvis**, Lperp = **L. perpusila**, Mcre = **M. crenata**, Mhas = **M. hastata**, Oalis = **O. alismoides**, Oruf = **O. rufipogon**, Ngra = **N. graminea**, Nind = **N. indica**, Nnou = **N. nouchali**, Pamp = **P. amplexicaule**, Plong = **P. longifolium**, Prep = **P. repens**, Pstra = **P. stratiotes,** Pvag = **P. vaginalis**, Rind = **R. indica**, Sgro = **S. grossus**, Sgu = **S. guyanensis**, Sjav = **S. javanica**, Sjun = **S. juncoides**, Smol = **S. molesta**, Szey = **S. zeylanica**, Wrice = weedy rice and Uaur = **U. aurea***

Conclusion

Weed populations and species diversity are dynamic in nature, and they change in abundance and dominance according to changes in the rice agro-ecosystem. Measurable and parallel increases in infestation and population density especially of grassy weed species, namely, weedy rice, *L. chinensis*, the *E. crus-galli* complex and *I. rugosum* (the four most widespread and abundant species), were consistently observed following the significant change in Malaysian rice culture from transplanting to DS. Weedy rice was not reported as the most noxious weed until recently. In the same vein, other dominant, perhaps, equally important weed species with a measurable parallel increase in population counts observed in the surveys were *F. miliacea* and *L. hyssopifolia*.

We believe that the increasing dominance of weedy rice and widespread nature of this scourge in DS fields in the Muda granary may be due to the continuous and persistent practice of DS, frequent use of machineries (four-wheel tractors, combine harvesters, etc.) contaminated with weedy rice seeds, aligned with the use of uncertified rice seeds by farmers (Azmi et al. 2005).Water seeding of pre-germinated rice seed ensure proper crop establishment compared to weedy rice, giving the rice crop the growth advantage. This is in line with the assumption that proper tillage regimes and judicious water management are in place before and during the crop establishment. Such practices are only possible with good water availability during the main season (August–January), while in the off-season (February–July) water availability is restricted. The off-season generally displays heavier infestation of weeds including weedy rice following inadequate land preparation primarily, and low water availability generally, with consequential and persistent weed seedbanks (Azmi et al. 2005).

Acknowledgement

The authors are grateful to Ms Chew See Eng, Mr Saharuddin Shari, Mr Abdul Hamid, and Mr Mohd Najib Yusof for their help in conducting the weed surveys and Mr Priyatno Safari for CANOCO analysis . The project was funded by MARDI under IRPA (Research Grant no. IR-IE032-0903) and International Rice Research Institute (IRRI, Code 80202).

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Abstrak

Survei rumpai telah dijalankan pada musim 2001–2005 yang menyenaraikan dan menentukan spesies rumpai yang dominan di kawasan Muda, Kedah. Sejumlah 58 spesies rumpai tergolong dalam 26 famili yang terdiri daripada 27 rumpai daun lebar, 14 rumpai daun tirus, 12 rusiga dan 5 tumbuhan akuatik telah dikenal pasti. *Indeks Kesamaan Sorenson* menunjukkan 74.4% daripada spesies yang disenarai terdapat pada semua lima musim. Terdapat juga trend yang hampir sama bagi kelimpahan spesies dan kedominanan spesies pada setiap musim. Anggaran kuantitatif berdasarkan peratus kawasan yang diserang menunjukkan status kedominanan dan kelimpahan kompleks *Oryza sativa* kompleks (padi angin), *Echinochloa crus-galli* kompleks, *Leptochloa chinensis* dan *Ludwigia hyssopifolia* di kawasan Muda. Hierarki kumpulan rumpai yang terdapat di kawasan Muda mengikut peratusan serangan ialah rumpai daun tirus > rumpai daun lebar > rusiga > rumpai air. Analisis *Canonical Correspondence* (ACC) menunjukkan persamaan kedominan spesies pada empat daripada lima musim. *Fimbristylis acuminata, Cyperus polystachyos,* dan *Echinochloa stagnina* wujud secara ketara pada luar musim 2001, manakala *Oryza rufipogon* amat berhubung kait dengan luar musim 2002. Ternyata tiada pemilihan ketara dalam kewujudan spesies tertentu pada luar musim 2003, meskipun terdapat purata hujan berlebihan pada musim tersebut berbanding dengan luar musim 2001 dan 2002. Luar musim 2004 mempamerkan hubungan antara kedominanan spesies *Azolla pinnata* dan *Salvinia molesta* dan purata jumlah hujan tahunan. Kekurangan purata jumlah hujan tahunan pada luar musim 2005 menampakkan peningkatan kepelbagaian seperti yang ditunjukkan oleh *vector length* pada ACC, khususnya kedominanan dalam *Hydrilla verticillata, Paspalum longifolium, Ipomoea aquatica* dan *Commelina nudiflora*.

Accepted for publication on 13 December 2006