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Weed Populations and their Buried Seeds in Rice Fields of the Muda Area, Kedah, Malaysia.

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ABSTRAK

Sejumlah 25 spesies rumpai dari 15 famili ditemui dalam sawah di Kampung Tandop, Skim Pengairan Muda, Kedah, Malaysia. Rumpai yang paling dominan di dalam sawah tabur-terus kering ialah Utricularia aurea *Lour.*, Fimbristylis miliacea, *(L.) Vahl* Echinochloa crus-galli *(L.) Beauv.*, Monochoria vaginalis *(Burm. f.) Presl. dan* Najas graminea *(Del.) Ridl.. Dalam sawah tabur-terus basah, spesies dominan ialah* N. graminea, Lemna minor *L.*, Sphenoclea zeylanica *Gaertn.*, Utricularia aurea *dan* Sagittaria guayanensis *H.B.K., sementara dalam sawah padi batat, spesies yang dominan ialah* Echinochloa colonum *(L.) Link* Fimbristylis alboviridis *C.B. Clarke*, F. miliacea, Cyperus babakan *Steud. dan* Fuirena umbellata *Rottb.. Di sawah tabur-terus kering terdapat bilangan biji rumpai yang tertinggi (930,910/m² pada kedalaman 15 cm); padi batat 793,162/m² dan tabur-terus basah 712,228/m². Pada amnya biji rumpai berkurangan apabila kedalaman bertambah. Biji* U. aurea *dan* S. zeylanica *sangat dominan dalam tanah di sawah tabur-terus basah dan kering. Sebaliknya, biji* Scirpus juncoides *Roxb. dan* F. miliacea *dominan di sawah padi batat.*

ABSTRACT

Twenty-five weed species belonging to 15 families were found in rice fields near Kampung Tandop, in the Muda Irrigation Scheme, Kedah, Malaysia. The dominant weeds in dry-seeded rice were Utricularia aurea *Lour.*, Fimbristylis miliacea *(L.) Vahl.*, Echinochloa crus-galli *(L.) Beauv.*, Monochoria vaginalis *(Burm. f.) Presl. and* Najas graminea *(Del.) Ridl.. In the wet-seeded rice, the dominant species were* N. graminea, Lemna minor *L.*, Sphenoclea zeylanica *Gaertn.*, U. aurea, *and* Sagittaria guayanensis *H.B.K. while in volunteer seedling rice fields, the dominant species were* Echinochloa colonum *(L.) Link.*, Fimbristylis alboviridis *C.B. Clarke*, F. miliacea, Cyperus babakan *Steud. and* Fuirena umbellata *Rottb.. Dry-seeded rice fields contained the highest number of weed seeds (930,910/m² in the top 15 cm of soil); volunteer seedling rice fields contained 793,162/m² and wet-seeded rice fields 712,228/m². In general, seed number declined with increasing soil depth. At 10-15 cm depth, seeds of* U. aurea *and* S. zeylanica *were the most abundant in dry- and wet-seeded rice fields, whilst seeds of* Scirpus juncoides *Roxb. and* F. miliacea *were most abundant in volunteer seedling fields.*

INTRODUCTION

The size and species composition of populations of seeds present in arable soils reflect the extent to which past management has permitted seed production by weeds. More importantly, they also determine (at least in part) the nature and extent of weed problems in future cropping. Surveys conducted in many different countries have shown that the number of seeds present in arable soils is usually high (Roberts and Neilson 1981).

Reports on weed seed populations in Malaysian soils are limited. There is one report on soil weed seed populations in pineapple-growing areas in Johore (Wee 1974). On the other hand, many studies report weed populations growing above ground (Azmi and Supaad 1987). In the Muda Irrigation Area, extensive work has been carried out on above-ground weed populations, covering nearly all parts of the area (Ho and Itoh 1991; Itoh 1991). No information is available on buried weed seeds in rice fields in the area.

At present, direct seeding culture is the predominant practice (about 75%) in the Muda area; 51% of farmers practise wet-seeding, 30% dry-seeding and 19% volunteer seedling (Ho and Md Zuki 1988). The change in weed flora from transplanted to direct-seeded rice culture is well-documented (Ho and Md Zuki 1988). Weed populations may also vary with the three types of direct-seeded rice fields, *viz.* wet-seeded, dry-seeded and volunteer seedling. No study has been conducted on the differences in weed composition and buried seed populations in rice fields seeded by these three methods.

The purpose of the present investigation was to examine emerging weed populations and their soil seed bank in the direct-seeded rice fields employing the three different seeding methods, *viz.* wet-seeding, dry-seeding and volunteer seedling.

MATERIALS AND METHODS

Study Sites

The study was carried out at the Muda Irrigation Project near Kampung Tandop, District BIV, Kedah. The farmers in this area practise direct seeding with one of three seeding methods, dry-seeding, wet-seeding and volunteer seedling. In wet-seeded and volunteer seedling rice fields, the soil was ploughed twice, two weeks and one week before seeding, while in dry-seeded fields, the soil was ploughed once, about one week before seeding. Adequate water was supplied through irrigation canals to the wet-seeded and dry-seeded rice fields. In volunteer seedling rice fields, however, rain served as the main source of water in addition to the supply from the canals. The survey was conducted during the first cropping season (Aug - Dec) in 1992.

Evaluation of Weed Composition

Thirty plots, ten of each of the three seeding methods, with an average plot size of 0.25 to 0.3 ha were randomly selected and assessed for weed composition. At the time of the survey, the paddy plants were 4 $^1/_2$ months old in wet-seeded and volunteer seedling rice fields and 2 $^1/_2$ months old in dry-seeded rice fields.

All weeds from each of ten 1-m^2 quadrats in each plot were sampled and counted by species. Weed species were identified using the keys of Anwar and Azmi (1986) and Itoh (1991). Summed dominance ratio (SDR) of each weed species was determined from the sum of relative density, relative frequency and relative dominance (Numata 1982).

Estimation of Soil Weed Seed Populations

Total weed seed populations were estimated in the three different seeding methods. Soil was sampled from the same locations where samples were taken for weed composition evaluation. Soil samples 7 cm in diameter were taken to a depth of 15 cm. Approximately 3 kg soil was collected from five quadrats in each plot. The soil cores were divided into three different depths, 0-5 cm, 5-10 cm and 10-15 cm. Soil samples of the same depth for each particular seeding method were pooled, mixed thoroughly and air-dried.

The method of seed separation was similar to the method described by Wilson *et al.* (1985). About 400 gm of soil was passed through a descending series of five sieves containing screens of the following sizes: 4 mm (5 mesh), 2 mm (10 mesh), 850 µm (20 mesh), 425 µm (40 mesh) and 250 µm (60 mesh). Water was run through the sieves to enhance sample movement through the screens. The contents collected in each screen were removed, oven-dried (30°C), and seeds were removed under a luminated magnifier. Seeds from entire samples were sorted using a dissecting microscope and counted according to species. The total number of buried seeds found in soil at different depths were expressed in numbers per m^2.

RESULTS

Weed Composition

Twenty-five weed species belonging to 15 families were found in the three areas with different seeding method (Table 1). Cyperaceae was the family with the highest number of species (9). In general, broadleaf weeds were the most dominant (13 species), compared with sedges (9) and grasses (3). The broadleaf weeds included two ferns, namely *Marsilea crenata* Presl. and *Ceratopteris thalictroides* (L.) Brongn.

In general, the weed composition of the three areas with different seeding methods was

TABLE 1
Summed dominance ratio values of weeds in wet-seeded, dry-seeded and volunteer seedling rice fields at Kampung Tandop, District IV, Kedah

Family/species	Wet-seeded	Dry-seeded	Volunteer seedling
Alismataceae			
Sagittaria guayanensis	6.82	-	0.12
Cyperaceae			
Cyperus babakan	1.28	0.18	5.62
Cyperus difformis	1.64	0.10	0.12
Cyperus digitatus	0.40	0.22	1.69
Cyperus iria	-	2.90	0.94
Fimbrisylis miliacea	5.08	11.12	9.34
Fimbristylis alboviridis	-	0.74	9.43
Fuirena umbellata	0.36	1.32	5.04
Scirpus grossus	0.66	-	-
Scirpus juncoides	2.40	1.24	0.36
Lemnaceae			
Lemna minor	9.68	1.22	-
Lentibulariaceae			
Utricularia aurea	7.01	14.69	4.18
Lythraceae			
Rotala indica	0.92	1.78	-
Marsiliaceae			
Marsilea crenata	1.71	0.84	-
Najadaceae			
Najas graminea	12.78	7.58	0.72
Onagraceae			
Ludwigia hyssopifolia	0.96	0.94	3.02
Parkeriaceae			
Ceratopteris thalictroides	0.37	1.35	1.68
Poaceae			
Echinochloa colonum	2.41	5.50	12.58
Echinochloa crus-galli	6.60	10.06	0.47
Leptochloa chinensis	1.64	0.49	0.14
Pontederiaceae			
Monochoria vaginalis	6.57	7.68	2.47
Rubiaceae			
Hedyotis diffusa	-	-	4.63
Scrophulariaceae			
Bacopa monnieri	-	-	4.69
Spenocleaceae			
Sphenoclea zeylanica	7.10	3.06	0.57
Sterculiaceae			
Melochia corchorifolia	-	-	4.14
Crop plant			
Oryza sativa	24.98	22.53	28.40

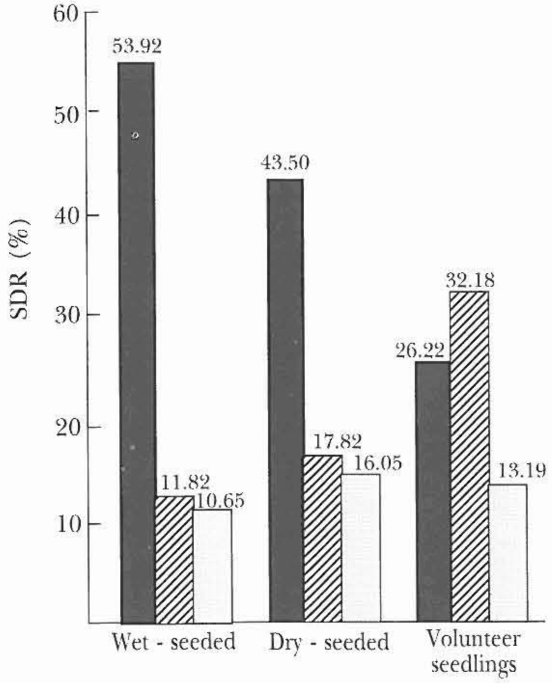

Fig. 1: SDR values of broadleaves (■), sedges (▨) and grasses (□) in wet-seeded, dry-seeded and volunteer seedling rice fields.

quite similar. Twenty-one weed species were found growing in wet- and dry-seding fields while there were 22 in volunteer seedling rice fields. Three species, *Hedyotis diffusa* (Willd.) Roxb., *Bacopa monnieri* (L.) Pennell and *Melochia corchorifolia* L. were not found in wet-seeded rice fields, while *H. diffusa, B. monnieri, M. corchorifolia* and *S. guayanensis* were not observed in the dry-seeded fields. *Lemna minor, Rotala indica* (Willd.) Koehne and *Marsilea crenata* Presl. were absent from volunteer seedling rice fields. In wet- and dry-seeded rice fields, broadleaf weeds were the most dominant (based on the SDR values), followed by sedges and grasses (*Fig. 1*). The SDR values for broadleaf weeds in wet- and dry-seeded fields were 54 and 44%, respectively. On the other hand, sedges were dominant in volunteer seedling rice fields. The SDR value for each species of broadleaf weeds in the volunteer seedling rice fields was found to be lower than 5%. *N. graminea, L. minor, S. zeylanica, U. aurea* and *S. guayanensis* were the most dominant weeds in wet-seeded rice fields (Table 1). The SDR value for *N. graminea, L. minor* and *S. zeylanica* in wet-seeded rice fields was 12.78, 9.68 and 7.1%, respectively. The hierarchical list of dominance (SDR value above 5%) was: *Najas graminea* > *L. minor* > *S. zeylanica* > *U. aurea* > *S. guayanensis* > *E. crus-galli* > *M. vaginalis* > *F. miliacea.* There were six species with SDR values of more than 5% in dry-seeded rice fields. The hierarchical order of those weeds was *U. aurea* > *F. miliacea* > *E. crus-galli* > *M. vaginalis* > *N. graminea* > *E. colonum.* However, in volunteer seedling rice fields, only five species had SDR more than 5%, with the hierarchical order *E. colonum* > *F. alboviridis* > *F. miliacea* > *C. babakan* > *F. umbellata.*

Weed Seed Populations in Soil

Total weed seed populations in the top 15 cm of soil were higher in dry-seeded fields (930,910/m^2) than wet-seeded (712,228/m^2) and volunteer seedling fields (793,162/m^2) (Table 2). In wet- and dry-seeded fields, seeds of *S. zeylanica* and *U. aurea* had the highest single percentages of total seeds found in the soil. In wet-seeded fields, *U. aurea* and *S. zeylanica* represented 39 and 24% of the total weed seed population, while in dry-seeded fields, the percentages of *U. aurea* and *S. zeylanica* seeds were 52 and 18%, respectively. However, in volunteer seedling fields, the number of *S. juncoides* and *F. miliacea* seeds were respectively 39 and 18% of the total weed seed population. Twelve weed species in the wet- and dry-seeded rice fields and 13 in the volunteer seedling fields contributed less than 1% each to the total seed population in the respective soils. They represented 5.1, 3.3, and 5.9% of the total seeds found in wet-seeded, dry-seeded and volunteer seedling fields, respectively. The total number of weed seeds declined with increasing depth, i.e. was lower at 10-15 cm than at 0-5 cm. However, the highest numbers of seeds were buried at depths of 0-10 cm. Seventy-seven per cent of weed seeds in volunteer seedling fields, 69% in wet-seeded fields and 72% in dry-seeded fields were found in the top 10 cm of soil.

DISCUSSION

Ahmed and Moody (1982) reported that the composition of rice weed communities is strongly influenced by water management and cropping system. This was supported by De Datta (1988), who reported that in a given environment, the weed vegetation is at least partly affected by such cultural practices as water management, the cultivar grown and the weed control strategies adopted by farmers. Clearly, the transformation in crop establishment technique from transplanting to direct-seeding rice culture, which involves

TABLE 2
Estimation of the total weed seed population in soil of wet-seeded, dry-seeded and volunteer seedling rice fields

Species	Depth (cm)				% of the total seeds
	0 - 5	5 - 10	10 - 15	0 - 15	
	seeds/m²				
Wet-seeded					
Utricularia aurea	106,796	88,477	85,619	280,892	39.4
Sphenoclea zeylanica	55,217	56,906	61,453	173,576	24.4
Fimbristylis miliacea	32,351	11,173	17,020	60,544	8.5
Monochoria vaginalis	21,567	15,331	14,032	50,930	7.2
Najas graminea	10,394	14,551	7,406	32,351	4.5
Ischaemum sp.	15,201	5,327	7,406	27,934	3.9
Unidentified	-	12,472	10,394	22,934	3.2
Ludwigia hyssopifolia	4,547	5,327	2,079	11,953	1.7
Scirpus juncoides	4,158	2,458	1,169	7,785	1.1
Rotala indica	-	2,858	4,547	7,405	1.0
Seed < 1% (12 species)	18,710	10,394	6,888	35,992	5.1
Total	268,941	225,274	218,013	712,228	
Dry-seeded					
Utricularia aurea	179,942	167,860	138,757	486,559	52.1
Sphenoclea zeylanica	63,142	53,528	48,980	165,650	17.7
Fimbristylis miliacea	33,260	27,042	18,709	79,011	8.5
Unidentified	20,788	14,941	12,472	48,201	5.2
Cyperus iria	13,252	9,874	9,874	33,000	3.5
Ischaemum sp.	14,941	4,937	9,874	29,752	3.2
Monochoria vaginalis	8,315	7,795	3,638	19,748	2.1
Najas graminea	6,626	4,937	4,937	16,500	1.8
Echinochloa crus-galli	3,248	6,626	1,169	11,043	1.5
Scirpus juncoides	3,248	3,248	3,638	10,134	1.1
Seed < 1% (12 species)	12,472	11,174	7,666	31,312	3.3
Total	359,234	311,962	259,714	930,910	
Volunteer seedling					
Scirpus juncoides	103,028	119,658	84,320	307,006	38.6
Fimbristylis miliacea	62,363	56,126	26,114	144,603	18.2
F. alboviridis	33,260	41,055	4,547	78,862	9.9
Utricularia aurea	23,256	26,114	19,488	68,858	8.7
Echinochloa colonum	23,646	19,358	7,016	50,020	6.3
Fuirena umbellata	10,784	17,799	6,626	35,209	4.4
Echinochloa crus-galli	11,953	9,874	4,158	25,985	3.3
Cyperus haspan	7,016	2,858	2,468	12,342	1.6
Cyperus babakan	2,468	390	9,484	12,342	1.6
Cyperus iria	4,158	4,158	2,468	10,784	1.5
Seed < 1% (13 species)	15,201	17,619	14,331	47,151	5.9
Total	297,133	315,009	181,020	793,162	

different water management and cropping systems, has resulted in dramatic changes in the type and distribution of weeds in the Muda area (Ho and Md Zuki 1988).

However, the areas with these three methods of seeding showed no marked variation in weed species composition even though their SDR values were different. The dominance of certain species in specific areas could be related to management factors which favour the establishment of that species. Generally, species of Poaceae and Cyperaceae are more numerous than those of other families, which are represented by only one species per family in all three seeding methods. This is due to moist or saturated soil conditions favouring the emergence and growth of grasses and sedges which, once established, are difficult to control by flooding (De Datta 1981). The results of this survey showed that grasses and sedges are more problematic than broadleaved weeds in direct-seeded rice fields irrespective of seeding method.

According to Drost and Moody (1982), the soil moisture after planting is the major factor influencing the composition of the weed flora and the dominance patterns of the major weed species in the community. Water supplied to wet and dry rice fields as early as 2-4 days after seeding hinders the establishment of sedges and grasses. The SDR values reflect this as the value for broadleaf weeds is more than double those of sedges and grasses. Flooding has a major suppressive effect on stand establishment and growth when applied at early growth stages of *C. iria* and *E. colonum* (Civico and Moody 1979) and *E. crus-galli* (Smith and Fox 1973); at field capacity, satisfactory stands of *E. crus-galli* developed (Smith and Fox 1973). On the other hand, flooding favoured the growth of broadleaf weeds over grasses and sedges (Ho and Itoh 1991). Submerged weeds such as *U. aurea* and *N. graminea* are dominant under flooding conditions. In volunteer seedling fields, where water is introduced into the field gradually as the seeds begin to germinate and grow, weed problems are more troublesome. Under these conditions, grasses, especially *E. colonum* and sedges, grow simultanuously with the rice plants. Thus, sedges and grasses are more dominant in volunteer seedling fields, where SDR values of broadleaf species are less than 5%.

Twenty-five out of the 55 weed species recorded by Itoh (1991) in the Muda area were found in the direct-seeded fields at Kampung Tandop. However, five species (*B. monnieri, Cyperus digitatus* Roxb., *F. alboviridis, H. diffusa* and *S. juncoides*) were not recorded ealier by Itoh (1991). In some cases their SDR values were considerably higher than those previously reported. Farm machinery can easily transport weed seeds, rhizomes and stolons from one place to another (Klingman *et al.* 1975). In addition, weed seeds can be transported in surface runoff, streams and rivers, and irrigation and drainage canals (Wilson 1980). It is probable that these previously unrecorded weed species were introduced from other weed-infested rice fields outside the Muda area by tractors and combine harvesters. Field inspections revealed that cultivation equipment and tractor tyres often carry dirt and soil contaminated with weed seeds, rhizomes and stolons from infested rice fields. Besides, the recycling of 12-14% of the total water requirement in the Muda area, could further contribute to weed dissemination.

The total numbers of buried seeds reported here are extremely high compared with 16,000/m^2 from an arable soil in Scotland (Warwick 1984), 48,700/m^2 from a vegetable field in Indonesia (Satroutomo and Yusron 1987), or 80,400/m^2 in rice fields in the Philippines (Vega and Sierra 1970). However, the numbers reported here are total numbers, including both viable and non-viable seeds.

Degree of tillage appears to affect not only weed populations but also the number of seeds in the soil. The type and frequency of cultivation influences the composition and density of the weed flora. Typically, the rate of seed decline is lower in uncultivated than in cultivated soil (Roberts and Dawkins 1967). According to Zorner *et al.* (1984), deep ploughing buries seeds deep in the soil, reducing their rate of emergence. Seeds at or just below the soil surface often have a higher germination rate than seeds buried deeper (Herr and Stroube 1970). In the study area, ploughing was done to a depth of about 10 cm. The soil was ploughed twice before seeding in the wet-seeded and volunteer seedling fields, but only once in the dry-seeded rice fields. Tillage increases germination of seeds in the soil seed bank, reducing the seed reservoir in the soil (Roberts 1968).

General observation indicated that weeds were more serious and problematic in dry-seeded rice fields than in fields cultivated by other methods. Weeds in the area, especially *U. aurea*, contributed more seeds to the soil of dry-seeded rice fields. Moody (1980) reported a much wider range and intensity of weed problems in rice sown in dry soil, since the dry-seeded crop emerges at the same time as the weeds.

The higher number of *U. aurea* seeds in wet- and dry-seeded rice fields was expected because this species was the most dominant weed in dry-seeded as well as in wet-seeded fields. This species is fast-growing and produces many seeds. In volunteer seedling rice fields, seeds of *F. miliacea* and *F. alboviridis* were dominant. Although, seeds of *S. juncoides* were the dominant species in the volunteer seedling field, the SDR value was small (Table 1). This may be due to the water supply to the area containing a large number of these seeds or be due to a build-up of the soil seedbank over seasons coupled with low germination rate. However, further studies are required to verify this observation.

The presence of submerged species such as *U. aurea* and *N. graminea* should be taken into account in the weed control programmes in the Muda area. These weed species were consistently found to be more abundant in all three types of rice culture studied. Also, the abundance of their seeds buried in soil may make them especially difficult to control.

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