A SURVEY OF RICE -- FIELD WEEDS IN RATNAPURA AND KURUNEGALA DISTRICTS OF SRI LANKA

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Abstract: A survey of rice-field weeds was carried out in the Districts of Ratnapura and Kurunegala during the 'Yala' and 'Maha' seasons of 1986. Two hundred and thirty four fields of the Ratnapura District and 196 fields of the Kurunegala District were sampled at a time when the rice was at heading to flowering and farmers had carried out weeding or herbicide applications for weed control. One hundred and forty seven species of weeds belonging to 95 genera and 37 plant families were recorded from the two districts, indicating a very rich diversity in the weed-flora. Of these, 38 species occurred in less than 10% of the fields; 65 species in 10-20% of the fields and 44 species in 20% or more fields. By far the commonest and problematic weeds were monocotyledons of the families Poaceae (Gramineae) and Cyperaceae. Three grass species *Echinochloa crus-galli* (L.) Beauv., *Echinochloa colonum* (L.) Link. and *Ischaemum rugosum* Salisb. emerged as the most abundant species in both districts, both in terms of frequency of occurrence and levels of infestation. *Fimbristylis miliacea* (L.) Vahl, *Cyperus pilosus* Vahl and *Cyperus iria* L. of the Cyperaceae were also very common in both Districts. Dicotyledonous weeds, although common in occurrence, generally did not present major problems to farmers, except *Ludwigia byssopifolia* (G. Don) Exell in the Ratnapura District. No major differences in the weed-flora of the two Districts were seen, despite the fact that the climate in Kurunegala was much drier than in Ratnapura. Farmer interviews during the survey revealed that the farmer populations in the areas surveyed lacked adequate knowledge of weeds, problems caused by weeds and effective means of weed control.

1. Introduction

Rice-fields are invaded by terrestrial, semi-aquatic or aquatic plants depending on the type of rice-culture and the cropping season.⁵ In rain-fed rice-fields, all three groups of plants occupy the same physical location at different times of the year. During the cultivation of lowland rice, fields are subjected to flooding, ploughing and turning up of the soil, followed by a period of rice monoculture. Between the periods of rice culture, the fields are rapidly invaded by weeds which are mainly terrestrial in nature. During rice culture, a large number of aquatic or semi-aquatic weeds grow in the fields along with the rice. A knowledge of the composition of the weed-flora, community patterns and effects of edaphic, climatic and biotic factors on growth and reproduction of weeds, helps to gain an insight into their mechanisms of specialization and distribution, and is hence important for their management and control.

During 1984 and 1985/1986, the author completed surveys of rice-field weeds in the Colombo, Gampaha, Kalutara and Galle Districts, all of which are located in the low-country Wet Zone of Sri Lanka. Comprehensive up-dated check lists of the rice-field weed flora in these Districts have

been prepared as a result of this work. In addition to the floristic composition, evaluations of the abundance of rice-field weeds were also done, and the weeds ranked according to their relative abundance.^{2,3} One new species record for the island, viz. *Ludwigia decurrens* Walt., presently a major rice-field weed in the low country wet zone, was made in this work.⁴

The present project concentrated on two other Districts, namely Ratnapura and Kurunegala. The Ratnapura District is situated in the mid-southern quarter of the island and the Kurunegala District in the North-West (Figure 1). Both Districts are large in extent. Each has a fairly large part of its land located in the intermediate climatic zone, while parts of both are situated in the Dry Zone, as well as in the Wet Zone (Figure 1).

Rice cultivation is extensively done in the Kurunegala District, which is characterized by flat, undulating landscape, frequent droughts, and generally high air temperatures (30–37°C). Rice culture in the Kurunegala District is mostly rainfed, but a very significant proportion of its fields receive water from major and minor irrigation schemes (Table 1) and the numerous small 'village tanks' spread throughout much of the District. Many of these are connected to form fairly extensive localized networks of irrigation. Rain received from both the North-East monsoon (November–February) and South-West monsoon (April–August) is used for rice-culture over two seasons. In this district, cultivation is heavier during the North-East monsoon time, in the 'Maha' season. In general, Kurunegala District is widely regarded as one of the most productive rice-growing districts (Table 1), in addition to being important for its extensive coconut plantations.

Ratnapura District still has a fairly extensive wet zone forest cover within its boundaries. Plantation agriculture, mainly rubber and tea, also take up a fair extent of its land. The land rises up to mid-elevations of about 500–700 m above mean sea level in several parts of the District. Rice culture is mainly done on the flatter terrain, generally close to the multitude of towns and along the sides of the major transport routes. Rice-cultivation in the District is mainly dependent on rainfall received from both monsoons. Heavier cultivation is during the South-West monsoon in the 'Yala' season. However, water from minor and major irrigation schemes is also used for rice culture (Table 1).

The overall objective of the survey, as described previously,^{2,3} was to improve the status of knowledge regarding the floristic composition of the rice-field weed flora of the two Districts, and to make an evaluation of the relative abundance of each species, in order to rank them according to importance.

Figure 1. A Map of Sri Lanka indicating the Dry, Intermediate and Wet Zones of the island and the two Districts surveyed, (1) Ratnapura and (2) Kurunegala Districts. Gampaha, Colombo, Kalutara and Galle Districts which were surveyed earlier are also indicated.

Table 1. Statistics on Rice—production in Ratnapura and Kurunegala Districts (1985–1986)

Season	District	(a) Gross Extent sown and harvested, and yield			
		Gross extent sown (ha)	Gross extent harvested (ha)	Average Yield (Kg/ha)	Total Rice Production (Metric Tons)
Yala, 1986	Ratnapura	14,799	14,647	2885	35,907
	SRI LANKA	342,239	309,897	3287	906,966
Maha, 1986	Kurunegala	56,580	18,100	3663	66,305
	SRI LANKA	507,830	432,694	3678	1390,298
(b) Extent sown (ha) classified according to Source of water for Rice—cultivation					
Season	District	Source of water for Rice—cultivation			Total
		Major Irrigation	Minor Irrigation	Rainfed	
Yala, 1986	Ratnapura	1509	8175	5115	14,799
Maha, 1986	Kurunegala	10,070	19,917	26,593	56,580

Source: Paddy Statistics, Yala, Maha, 1986/1987; Department of Census & Statistics, Govt. of Sri Lanka.

2. Materials and Methods

Rice—field weed surveys were carried out mainly in the Yala, 1986 (Ratnapura District) and Maha, 1986/1987 (Kurunegala District) seasons.

The two Districts and their major road networks are given in Figures 2 and 3. Only fields adjacent to the motorable roads were assessed in this survey, mainly because of the very large extents of the two Districts. Villages for sampling of their rice—fields were selected at random by driving along the roads marked on the maps. In areas where large acreages were under rice, fields were assessed at approximately 1 km intervals and wherever possible on alternate sides of the road. Where the rice growing areas were few and scattered, fields were assessed irrespective of the distance between two sites. However, in all cases efforts were made to ensure that at least a gap of 1 km separated two successive sampling sites. In each village where sampling was done, two rice—fields were assessed. In the present work, 98 villages (196 fields) from the Kurunegala District and 117 villages (234 fields) from the Ratnapura District were surveyed.

At the time of survey, the rice was most commonly found to be at the heading to flowering stage. It was found that in the great majority of the sampled fields, farmers had already carried out some degree of weed control. Thus, the species recorded here were those that had survived the farmers' control measures, or those which had been overlooked. Some weeds recorded in the survey, however, could have grown out of seeds that germinated after the farmers had carried out their control measures.

Each field was surveyed by walking along bunds and recording all weed species which were present. Several 'liyaddes' ('liyadde' is an area surrounded by an earthen bund) in each field were examined. Weeds growing in the rice—field which were visible above or among the rice canopy, were scored for infestation level by scanning the whole field. Those occurring below the canopy of rice were scored by carefully examining a minimum of four approximately 1 m areas selected at random within each field. Scores were then averaged over the four plots. The following rating scale, based mainly on percentage cover with respect to the whole field, was used for infestation levels: 0 = species not present ; 1 = a few scattered plants; 2 = 1-25% weed cover, moderately infested; 3 = 26-50% weed cover, serious infestation ; 4 = 51-75% weed cover, very serious infestation; 5 = 76-100% weed cover, weed species completely dominant and masking the crop. The frequency of occurrence with respect to the total number of sample fields studied per District was computed for each species, along with relative abundance in each rating category.

Wherever possible, the farmers who had cultivated the fields sampled were interviewed and questioned regarding the weed species that were usually present, control practices used, and their general know—how about weeds and weed management.

RATNAPURA DISTRICT : Land area = 3233.73 Km² (6th largest)

Figure 2. A Map of Ratnapura District showing major towns and roads travelled during the survey.

3. Results and Discussion

Table 2 provides a complete list of all weed species encountered in the field and bund habitats of the rice-fields sampled from the two Districts. A total of 147 weed species, assigned to 95 genera and 37 families, were recorded in the present survey. Of these, 38 species occurred in less than 10% of fields sampled: 65 species occurred in 10–20% fields; and 44 species occurred in 20% or more fields. The families to which the commonest rice-field weeds belonged were: Cyperaceae (33 spp.) and Poaceae (24 spp.). Other families such as Asteraceae (11 spp.), Scrophulariaceae (9 spp.), Fabaceae (9 spp.), Onagraceae (5 spp.) and Rubiaceae (5 spp.) were also well represented within the rice-agroecosystem in the samples studied.

Table 2. Floristic Composition of rice-field weeds in Ratnapura and Kurunegala Districts, indicating their occurrence and major habitat in the rice-agroecosystem (Yala, Maha seasons, 1986).

Species & Family	Occurrence	Major Habitat
1. ACANTHACEAE		
<i>Asteracantha longifolia</i> (L.) Nees	occasional	B
2. AIZOACEAE		
<i>Mollugo oppositifolia</i> L.	occasional	B
3. AMARANTHACEAE		
<i>Alternanthera sessilis</i> (L.) DC.	frequent	B,F
<i>Amaranthus spinosus</i> L.	occasional	B
<i>Gomphrena celosioides</i> Mart.	frequent	B
4. APIACEAE		
<i>Centella asiatica</i> (L.) Urb.	frequent	B
5. ARACEAE		
<i>Pistia stratiotes</i> L.	occasional	F,D
<i>Typhonium trilobatum</i> (L.) Schult.	frequent	B
6. ASTERACEAE		
<i>Acanthospermum hispidum</i> DC.	occasional	B
<i>Ageratum conyzoides</i> L.	frequent	B
<i>Eclipta prostrata</i> (L.) L.	widespread	B,F
<i>Emilia sonchifolia</i> (L.) DC. ex Wight	occasional	B
<i>Epaltes divaricata</i> (L.) Cass.	occasional	B
<i>Sphaeranthus africanus</i> L.	frequent	B,F
<i>Sphaeranthus indicus</i> L.	frequent	B,F
<i>Spilanthes paniculata</i> Wall. ex DC.	occasional	B

(Table 2. contd.)

Species & Family		Occurrence	Major Habitat
	<i>Synedrella nodiflora</i> (L.) Gaertn.	frequent	B
	<i>Tridax procumbens</i> L.	frequent	B
	<i>Vernonia cinerea</i> (L.) Less.	widespread	B
7.	BORAGINACEAE		
	<i>Heliotropium indicum</i> L.	frequent	B
8.	BUTOMACEAE		
	<i>Limncharis flava</i> (L.) Buchen.	widespread	F,B,D
9.	CAPPARIDACEAE		
	<i>Cleome burmani</i> Wight & Arn.	frequent	B
	<i>Cleome viscosa</i> L.	frequent	B
10.	COMMELINACEAE		
	<i>Commelina benghalensis</i> L.	frequent	B
	<i>Commelina diffusa</i> Burm. f.	widespread	B,F,D
11.	CONVOLVULACEAE		
	<i>Ipomoea aquatica</i> Forsk.	frequent	B,D
	<i>Ipomoea triloba</i> L.	frequent	B,F
12.	CYPERACEAE		
	<i>Cyperus compressus</i> L.	frequent	B
	<i>Cyperus difformis</i> L.	occasional	F,B
	<i>Cyperus distans</i> L.F.	occasional	F,D
	<i>Cyperus haspan</i> L.	widespread	F,B,D
	<i>Cyperus iria</i> L.	widespread	F,B,D
	<i>Cyperus pilosus</i> Vahl	widespread	F,B,D
	<i>Cyperus procerus</i> Rottb.	frequent	B
	<i>Cyperus rotundus</i> L.	widespread	B
	<i>Cyperus sphacelatus</i> Rottb.	frequent	B
	<i>Eleocharis acutangula</i> (Roxb.) Schult.	frequent	F
	<i>Eleocharis dulcis</i> (Burm.f.) Trin. ex Henschel	widespread	B
	<i>Fimbristylis acuminata</i> Vahl	widespread	B,F
	<i>Fimbristylis dichotoma</i> (L.) Vahl	widespread	B,F
	<i>Fimbristylis ferruginea</i> (L.) Vahl	widespread	B
	<i>Fimbristylis umbellaris</i> (Lam.) Vahl	occasional	B,F
	<i>Fimbristylis miliacea</i> (L.) Vahl	widespread	F,B,D
	<i>Fimbristylis schoenoides</i> (Retz.) Vahl	widespread	B,F
	<i>Fimbristylis tetragona</i> R. Br.	widespread	B,F,D
	<i>Fuirena ciliaris</i> (L.) Roxb.	occasional	B,F
	<i>Fuirena umbellata</i> Rottb.	frequent	F,B

(Table 2. contd.)

Species & Family	Occurrence	Major Habitat
<i>Fuirena capitata</i> (Burm.f.) T.Koyama	frequent	B,F
<i>Kyllinga brevifolia</i> Rottb.	widespread	B,F,D
<i>Kyllinga nemoralis</i> (J.R. & G. Forst.) Dandy ex Hutchinson & Dalziel	frequent	B
<i>Kyllinga bulbosa</i> Beauv.	widespread	B
<i>Mariscus compactus</i> (Retz.) Boldingh	occasional	B,D
<i>Mariscus panicus</i> (Rottb.) Vahl	occasional	B
<i>Pycnus polystachyos</i> (Rottb.) Beauv.	frequent	B
<i>Pycnus pumilus</i> (L.) Nees	occasional	B
<i>Rhynchospora corymbosa</i> (L.) Britton	occasional	B,D,F
<i>Schoenoplectus articulatus</i> (L.) Palla	occasional	F
<i>Schoenoplectus juncoides</i> (Roxb.) Palla	widespread	F,B,D
<i>Schoenoplectus grossus</i> (L.f.) Palla	frequent	F,B,D
<i>Scleria poaeformis</i> Retz.	occasional	B,F
13. ERIOCAULACEAE		
<i>Eriocaulon quinqueangulare</i> L.	widespread	F
<i>Eriocaulon sexangulare</i> L.	widespread	F
14. EUPHORBIACEAE		
<i>Croton birtus</i> L'Herit	frequent	B
<i>Euphorbia birta</i> L.	frequent	B
<i>Phyllanthus debilis</i> Klein ex Willd.	frequent	F,B
<i>Phyllanthus urinaria</i> L.	frequent	B
15. FABACEAE (LEGUMINOSAE)		
<i>Aeschynomene aspera</i> L.	frequent	F,B
<i>Aeschynomene indica</i> L.	frequent	F,B
<i>Alysicarpus vaginalis</i> DC.	frequent	B
<i>Cassia tora</i> L.	occasional	B
<i>Desmodium heterocarpum</i> (L.) DC.	frequent	B,D
<i>Desmodium heterophyllum</i> (Willd.) DC.	frequent	B,D
<i>Desmodium triflorum</i> (L.) DC.	frequent	B,D
<i>Mimosa pudica</i> L.	widespread	B
<i>Tephrosia purpurea</i> (L.) Pers.	occasional	B
16. GENTIANACEAE		
<i>Nymphoides indica</i> (L.) O.K.	frequent	B
17. HYDROCHARITACEAE		
<i>Blyxa octandra</i> (Roxb.) Planch. ex Thw.	occasional	D,F
<i>Hydrilla verticillata</i> (L.f.) Royle	frequent	D
<i>Ottelia alismoides</i> (L.) Pers.	occasional	D,F

(Table 2. contd.)

	Species & Family	Occurrence	Major Habitat
18.	HYDROPHYLLACEAE <i>Hydrolea zeylanica</i> (L.) Vahl	occasional	F
19.	LAMIACEAE (LABIATAE) <i>Hyptis capitata</i> Jacq. <i>Hyptis suaveolens</i> (L.) Poit. <i>Leucas zeylanica</i> (L.) R. Br.	occasional frequent widespread	B B B
20.	LENTIBULARIACEAE <i>Utricularia reticulata</i> Sm.	frequent	F
21.	LYTHRACEAE <i>Ammania baccifera</i> L. <i>Rotala densiflora</i> (Roth ex Roem. & Schult.) Koehne	occasional frequent	B, F F
22.	MALVACEAE <i>Sida rhombifolia</i> L. <i>Urena lobata</i> L.	frequent frequent	B B
23.	MARSILIACEAE <i>Marsilea quadrifolia</i> L.	frequent	F, D
24.	NYCTAGINACEAE <i>Boerhavia erecta</i> L.	occasional	B
25.	ONAGRACEAE <i>Ludwigia adscendens</i> (L.) Hara <i>Ludwigia decurrens</i> Walt. <i>Ludwigia byssopifolia</i> (G. Don) Exell <i>Ludwigia octovalvis</i> (Jacq.) Raven <i>Ludwigia perennis</i> L.	occasional widespread widespread occasional frequent	F, D F, B F, B B F, B
26.	POACEAE (GRAMINEAE) <i>Alloteropsis cimicina</i> (L.) Stapf <i>Axonopus affinis</i> Chase <i>Axonopus compressus</i> (Sw.) Beauv. <i>Echinochloa colonum</i> (L.) Link. <i>Echinochloa crus-galli</i> (L.) Beauv. <i>Eleusine indica</i> (L.) Gaertn. <i>Eragrostis gangetica</i> (Roxb.) Steud. <i>Eragrostis tenella</i> (L.) Beauv. ex Roem & Schult	frequent widespread frequent widespread widespread widespread frequent occasional	B B, D B, D F, B, D F, B B, D B, D B

(Table 2. contd.)

Species & Family	Occurrence	Major Habitat
<i>Eragrostis unioides</i> (Retz.) Nees ex Steud.	widespread	B,F
<i>Isachne globosa</i> (Thunb.) Kuntze	widespread	F,B,D
<i>Ischaemum indicum</i> (Houtt.) Merr.	frequent	B
<i>Ischaemum rugosum</i> Salisb.	widespread	F,B
<i>Leersia hexandra</i> Sw.	frequent	B,D,F
<i>Leptochloa chinensis</i> (L.) Nees	frequent	B,D
<i>Oryza rufipogon</i> Griff.	occasional	F
<i>Panicum maximum</i> Jacq.	occasional	B
<i>Panicum repens</i> (L.) Beauv.	widespread	B,F,D
<i>Paspalum commersonii</i> Lam.	widespread	B,F
<i>Paspalum conjugatum</i> Berg.	widespread	B
<i>Pennisetum polystachyon</i> (L.) Schult.	frequent	B
<i>Sacciolepis indica</i> (L.) Chase	widespread	B,F
<i>Sacciolepis interrupta</i> (Willd.) Stapf	widespread	F,B
<i>Setaria geniculata</i> (Lam.) Beauv.	frequent	B,F
<i>Sporobolus diandrus</i> (Retz.) Beauv.	frequent	B
27. POLYGONACEAE		
<i>Polygonum barbatum</i> L.	frequent	B,D
<i>Polygonum glabrum</i> Willd.	occasional	B,D
28. PONTEDERIACEAE		
<i>Eichhornia crassipes</i> (Mart.) Solms	frequent	D
<i>Monochoria vaginalis</i> (Burm.f.) Kunth	widespread	F,D,B
29. RUBIACEAE		
<i>Borreria alata</i> (Aubl.) DC.	widespread	B
<i>Hedyotis corymbosa</i> (L.) Lamk.	frequent	B
<i>Knoxia zeylanica</i> L.	frequent	B
<i>Mitracarpus hirtus</i> (L.) DC.	frequent	B
<i>Spermacoce hispida</i> L.	frequent	B
30. SALVINIACEAE		
<i>Azolla pinnata</i> Lam.	occasional	F,D
<i>Salvinia molesta</i> D.S. Mitchell	widespread	F,D
31. SCROPHULARIACEAE		
<i>Bacopa monnieri</i> (L.) Pennell	frequent	F,B
<i>Limnophila aquatica</i> (Roxb.) Alston	frequent	F,D
<i>Limnophila aromatica</i> (Lam.) Merr.	occasional	F,D
<i>Limnophila repens</i> (Benth.) Benth.	widespread	F,B,D
<i>Lindernia anagallis</i> (Burm.f.) Pennell	frequent	F,B

(Table 2. contd.)

Species & Family	Occurrence	Major Habitat
<i>Lindernia antipoda</i> (L.) Alston	frequent	F,B
<i>Lindernia byssopioides</i> (L.) Haines	widespread	F,B,D
<i>Lindernia rotundifolia</i> (L.) Alston	widespread	F,B,D
<i>Scoparia dulcis</i> L.	widespread	B
32. SOLANACEAE		
<i>Physalis angulata</i> L.	occasional	B
33. SPHENOCLEACEAE		
<i>Sphenoclea zeylanica</i> Gaertn.	occasional	B
34. STERCULIACEAE		
<i>Melochia corchorifolia</i> L.	widespread	B,F
35. TILIACEAE		
<i>Triumfetta rhomboidea</i> Jacq.	occasional	B
36. VERBENACEAE		
<i>Phyla nodiflora</i> (L.) Green	occasional	B
<i>Stachytarpheta indica</i> (L.) Vahl	frequent	B
<i>Stachytarpheta jamaicensis</i> (L.) Vahl	frequent	B
37. XYRIDACEAE		
<i>Xyris indica</i> L.	frequent	F,D

^a widespread = most common and widely distributed; frequent = less common, yet frequently found also with wide distribution; occasional = least common, patchy in appearance

^b B = Bund; D = Ditch (irrigation channel); F = Field

3.1 Ratnapura district

3.1.1 Monocotyledonous weeds

Table 3 gives the occurrence of the commonest monocotyledonous weeds present in the District. Thirteen species were observed with a frequency of 50% or more in the fields surveyed. *Echinochloa crus-galli* and *Echinochloa colonum* were the most frequently recorded weeds. Both were present in 90% or more of the fields surveyed. However, at the time of sampling only 18% of fields had *E. crus-galli* at serious infestation levels of 3 and above. This figure was 10% for *E. colonum*. Therefore it was clear that in the majority of the fields sampled these two top ranking species showed low to moderate levels of infestation.

Table 3. The occurrence of the most frequent monocotyledonous weeds in 234 rice fields in the Ratnapura District (Yala, 1986), classified into five levels according to infestation

Species	0	1	2	3	4	5	Total fields infested	Frequency of Occurrence
1. <i>Echinochloa crusgalli</i>	17	103	69	37	8	0	217	92.7
2. <i>Echinochloa colonum</i>	23	86	103	22	0	0	211	90.2
3. <i>Ischaemum rugosum</i>	34	78	82	38	2	0	200	85.5
4. <i>Fimbristylis miliacea</i>	41	74	82	37	0	0	193	82.5
5. <i>Isachne globosa</i>	43	78	103	10	0	0	191	81.6
6. <i>Sacciolepis interrupta</i>	73	104	57	0	0	0	161	68.8
7. <i>Cyperus iria</i>	74	102	38	20	0	0	160	68.4
8. <i>Fimbristylis tetragona</i>	96	102	24	12	0	0	138	59.0
9. <i>Commelina diffusa</i>	102	74	39	19	0	0	132	56.4
10. <i>Paspalum commersonii</i>	105	69	42	18	0	0	129	55.1
11. <i>Eriocaulon sexangulare</i>	112	74	39	9	0	0	122	52.1
12. <i>Leptochloa chinensis</i>	114	99	14	7	0	0	120	51.3
13. <i>Leersia hexandra</i>	116	102	14	2	0	0	118	50.4
14. <i>Cyperus haspan</i>	118	49	53	14	0	0	116	49.6
15. <i>Monochoria vaginalis</i>	122	112	0	0	0	0	112	47.9
16. <i>Cyperus pilosus</i>	128	96	4	6	0	0	106	45.3
17. <i>Limnorcharis flava</i>	158	36	40	0	0	0	76	32.5
18. <i>Schoenoplectus juncoides</i>	161	33	39	1	0	0	73	31.2

0 = weed species not observed; 1 = a few plants; 2 = occasional patches; 3 = weed widespread throughout field; 4 = a dense and severe infestation; 5 = weed completely dominant and masking crop.

Ischaemum rugosum appeared as the third top—ranking species of the Ratnapura District rice—weed flora, with a frequency of occurrence of 85% from the fields surveyed. Of these infestations 20% received a score of 3 or more indicating its seriousness as a major weed. The farmer interviews clearly revealed that this weed had rapidly become the one that caused the greatest concern to the farmers in the District.

Fimbristylis miliacea and *Isachne globosa*, two weeds which were ranked as the top two in Colombo, Gampaha, Kalutara and Galle Districts of the low—country Wet Zone,³ were also present at high frequency in the Ratnapura District, the frequencies of occurrence being 82% and 81% respectively of the fields surveyed. Their infestations were however low to moderate and it was also apparent that towards the latter part of the growing season of rice, both these weeds were less dominant. *Fimbristylis miliacea* is known to complete its life cycle in the first three months of the season, and *I. globosa* generally spreads and dominates the rice agro—ecosystem, mainly during the fallow period between two seasons.

Sacciolepis interrupta a weed which ranked 5th in Kalutara and Galle Districts, but was not a major weed in Gampaha and Colombo Districts,^{2,3} was ranked 6th in Ratnapura with a frequency of occurrence of 69%. However, its infestation level was not very high and none of the fields examined received a score of 3 or above.

Cyperus iria, a very common sedge—weed which ranked 3rd in Colombo and Gampaha Districts, and 7th in Kalutara and Galle, was recorded from 68% of fields in Ratnapura. Of these infestations, 12% received a score of 3 and above indicating that *C. iria* was a serious weed in many situations.

Several other common monocotyledonous weeds also had frequencies of occurrence greater than 50% in the District. This list included *Fimbristylis tetragona*, *Commelina diffusa*, *Paspalum commersonii*, *Eriocaulon sexangulare*, *Leptochloa chinensis* and *Leersia hexandra*. However, as shown in Table 3, in the majority of these situations, these weeds were present only in small numbers or as occasional patches in the fields sampled. Widespread infestations were recorded only for *F. tetragona*, *C. diffusa* and *P. commersonii* which received scores above 3 for 8—14% of the fields sampled.

Table 4. The occurrence of the most frequent dicotyledonous weeds in 234 rice-fields in the Ratnapura district (Yala, 1986), classified into five levels according to infestation

Species	Levels of Infestation					Total fields infested	Frequency of Occurrence
	0	1	2	3	4	5	
1. <i>Lindernia byssopoides</i>	19	146	58	11	0	0	215 92.0
2. <i>Lindernia rotundifolia</i>	22	153	52	7	0	0	212 90.6
3. <i>Eclipta prostrata</i>	41	159	31	3	0	0	193 82.5
4. <i>Ludwigia byssopifolia</i>	78	109	43	4	0	0	156 67.0
5. <i>Bacopa monnieri</i>	92	102	32	8	0	0	142 61.0
6. <i>Limnophila repens</i>	103	94	36	1	0	0	131 56.0
7. <i>Lindernia anagallis</i>	112	99	23	0	0	0	122 52.1
8. <i>Sphaeranthes indicus</i>	129	79	26	0	0	0	105 44.9
9. <i>Ludwigia decurrens</i>	143	68	21	2	0	0	91 38.9

0 = weed species not observed; 1 = a few plants; 2 = occasional patches; 3 = weed widespread throughout field; 4 = a dense and severe infestation; 5 = weed completely dominant and masking crop.

Cyperus haspan, a sedge—weed which was ranked 8th in Colombo and Gampaha, and 10th in Kalutara and Galle, occurred in 49.6% fields sampled in Ratnapura and 12% of these infestations were heavy. *Cyperus pilosus*, another very prominent sedge—weed ranked 4th in Colombo, Gampaha, Kalutara and Galle Districts, was found only in 45% of fields in Ratnapura and in these too at low to moderate infestation levels.

Monochoria vaginalis, *Limnocharis flava* and *Schoenoplectus juncoides* with frequencies of occurrence of 48%, 32.5% and 31% respectively, were the other noteworthy monocotyledonous weeds in the rice—fields of the District. In general, the most important monocotyledonous weeds of the Ratnapura District were the same as in Colombo, Gampaha, Kalutara and Galle Districts.

3.1.2 Dicotyledonous weeds

Of the dicotyledonous species recorded, the most important ones and their levels of abundance are given in Table 4. Two species of *Lindernia*, namely *Lindernia hyssopioides* and *Lindernia rotundifolia* and *Eclipta prostrata* took the top three positions, with frequencies of occurrence ranging from 82—92%. Their infestations were however not heavy, and hence these three species probably do not pose major problems to the farmer.

Ludwigia hyssopifolia, ranked 1st in all four Districts previously studied,^{2,3} occurred in 67% of fields and was the fourth most prevalent dicotyledonous weed in Ratnapura. Surprisingly, unlike in other Districts, heavy infestations were few (4 out of 156 fields) in the fields examined. Its close ally, *Ludwigia decurrens*, occurred in 39% of fields, establishing the fact that this relatively recently introduced weed¹ has now expanded its distribution. A third species of *Ludwigia*, *Ludwigia perennis*, was found only at Embilipitiya in several fields. Embilipitiya is located in the South—East corner of the Ratnapura District, in the dry zone, and these habitats were noted to be generally drier than the rest of the District.

Other common dicotyledonous weeds recorded from the field habitat were generally similar to those found in the Districts studied previously. *Bacopa monnieri*, *Limnophila repens*, *Lindernia anagallis* and *Sphaeranthes indicus* were recorded from 45—61% of fields sampled. However, these species too were found mainly at low levels of infestation and as such do not present major problems in the rice—culture of the District.

3.2 Kurunegala District

A very large number of rice—fields in the District was found to be receiving inadequate moisture during both the Yala (1986) and the more important Maha season (1986). Drought conditions prevailed during much of the cultivation season in most parts of the District, except in its South—east corner (Mawathagama—Kandy road).

3.2.1. Monocotyledonous weeds

Ischaemum rugosum, the aggressive grass-weed, was found to be the most dominant weed in the District (Table 5). It occurred in 93% of fields examined and 1/5 th of its infestations were heavy receiving scores of 3 or more. The farmers interviewed expressed the view that in recent decades this weed had become one of the most troublesome weeds of the area. As revealed in the present survey, *I. rugosum* appeared to dominate rice-fields under a wide range of moisture conditions, varying from wet, through semi-dry to very dry. This weed has probably acquired greater significance during the last decade, since Weerakoon and Gunawardena in their survey of 1975 recorded this weed only in 25–50% of fields surveyed and stated its relative abundance as fairly moderate in both the dry and wet zone of the island. In the present surveys, *I. rugosum* occurred as the 3rd ranking weed in Ratnapura, Kalutara and Galle Districts, while in Gampaha and Colombo its position was 9th.^{2,3}

The two species of the grass genus *Echinochloa*, namely *E. crus-galli* and *E. colonum*, were also found at high levels of occurrence with low to moderate infestations. *Echinochloa crus-galli* was recorded from 88% of the fields sampled and *E. colonum* from 83% of fields. In the majority of situations however, these weeds occurred as isolated plants or occasional patches, rather than as widespread infestations.

Cyperus pilosus, *F. miliacea*, *C. iria* and *I. globosa*, which were major weeds of the four Districts studied previously,³ all occurred at frequencies of occurrence in the range of 51–53% in the fields of Kurunegala District. In general the infestations were noted to be low and not as heavy as recorded from the wetter Districts in 1984 and 1985.

As indicated in Table 5, all other monocotyledonous weeds occurred at less than 50% frequency in the rice-fields sampled. The majority of these were found to be at low to moderate infestation levels, unlike in the wetter Districts of Gampaha, Colombo, Kalutara, Galle and Ratnapura.

3.2.2 Dicotyledonous weeds

The dicotyledonous weed-flora of the rice-field habitat was also found to be not very variable and not heavy in infestation levels (Table 6). The two species of *Lindernia*, *L. hyssopioides* and *L. rotundifolia*, occurred in 81–84% of fields sampled, but generally only as scattered patches which never reached problematic proportions.

Table 5. The occurrence of the most frequent monocotyledonous weeds in 196 rice—fields in the Kurunegala Districts (Maha, 1986), classified into five levels according to infestation

Species	0	1	2	3	4	5	Total fields infested	Frequency of Occurrence
1. <i>Ischaemum rugosum</i>	14	62	82	20	18	0	182	92.9
2. <i>Echinochloa crusgalli</i>	22	90	58	22	4	0	174	88.8
3. <i>Echinochloa colonum</i>	32	68	72	24	0	0	164	83.7
4. <i>Cyperus pilosus</i>	92	56	42	6	0	0	104	53.1
5. <i>Fimbristylis miliacea</i>	92	60	44	0	0	0	104	53.1
6. <i>Cyperus iria</i>	94	52	40	10	0	0	102	52.0
7. <i>Isachne globosa</i>	95	38	41	14	8	0	101	51.5
8. <i>Paspalum commersonii</i>	101	49	46	0	0	0	95	48.5
9. <i>Paspalum conjugatum</i>	103	57	36	0	0	0	93	47.5
10. <i>Cyperus haspan</i>	103	42	48	3	0	0	93	47.5
11. <i>Commelina diffusa</i>	105	38	49	4	0	0	91	46.4
12. <i>Fimbristylis tetragona</i>	106	44	32	14	0	0	90	45.9
13. <i>Eriocaulon sexangulare</i>	120	56	20	0	0	0	76	38.8
14. <i>Monochoria vaginalis</i>	126	39	31	0	0	0	70	35.7
15. <i>Schoenoplectus juncoides</i>	131	40	18	7	0	0	65	33.2
16. <i>Fuirena ciliaris</i>	131	46	19	0	0	0	65	33.2
17. <i>Limncharis flava</i>	142	39	15	0	0	0	54	27.5
18. <i>Kyllinga brevifolia</i>	142	41	13	0	0	0	54	27.5
19. <i>Fimbristylis dichotoma</i>	144	39	12	1	0	0	52	26.5

0 = weed species not observed; 1 = a few plants; 2 = occasional patches; 3 = weed widespread throughout field; 4 = a dense and severe infestation; 5 = weed completely dominant and masking crop.

Table 6. The occurrence of the most frequent dicotyledonous weeds in 196 rice-fields in the Kurunegala District (Maha, 1986), classified into five levels according to infestation

Species	Levels of Infestation					Total fields infested	Frequency of Occurrence
	0	1	2	3	4	5	
1. <i>Lindernia byssopioides</i>	32	98	53	13	0	0	83.7
2. <i>Lindernia rotundifolia</i>	38	109	48	1	0	0	80.6
3. <i>Ludwigia byssopifolia</i>	69	78	45	4	0	0	64.8
4. <i>Eclipta prostrata</i>	78	91	25	2	0	0	60.2
5. <i>Limnophila repens</i>	87	86	20	3	0	0	55.6
6. <i>Polygonum barbatum</i>	98	69	26	3	0	0	50.0
7. <i>Bacopa monnieri</i>	103	68	19	6	0	0	47.4
8. <i>Ludwigia perennis</i>	150	41	5	0	0	0	23.5
9. <i>Sphaeranthus indicus</i>	153	38	5	0	0	0	21.9
10. <i>Lindernia anagallis</i>	165	22	9	0	0	0	15.8

0 = weed species not observed; 1 = a few plants; 2 = occasional patches; 3 = weed widespread throughout field; 4 = a dense and severe infestation; 5 = weed completely dominant and masking crop.

Ludwigia hyssopifolia emerged as the 3rd most frequent dicotyledonous weed with a frequency of occurrence of 65%. However, its infestations too were not found to be very heavy. *Ludwigia perennis*, which was found only in the drier part of the Ratnapura District, occurred in 23% of fields sampled in Kurunegala, mainly towards the East and South—East border of the District, under similar semi—dry to wet conditions. In the present rice—field weed surveys this species has not been found in the wet to very—wet rice—fields of the Gampaha, Colombo and Galle Districts, while it was recorded in only one rice—field sampled in the Kalutara District (unpublished data). The third species, *L. decurrens*, was not found in the Kurunegala District in any of the fields studied or in nearby habitats, suggesting that this species has not yet spread to the District.

Among the dicotyledonous weeds of the rice—fields in the District, a *Polygonum* species, namely *Polygonum barbatum*, acquired importance in 50% of fields sampled. This species was found to infest bund habitats of many fields and invading the field—habitat also quite frequently.

Weed—flora of Rice—field Bunds

Table 2, which records the habitat occupied by the weeds, indicates the species which were prevalent on the bunds. The more important species of this habitat for the two Districts are given in Tables 7 and 8. As in the Districts studied previously, weeds of the bund habitat consisted mainly of a large number of semi—aquatic and terrestrial species. In both Districts the commonest weeds of the bunds were *I. globosa* and *Eragrostis unioloides*. *Eragrostis unioloides* was noted to be occupying only the bund habitat, while nearly all the other species were recorded in the field habitat as well. *Fimbristylis miliacea*, *P. commersonii*, *Panicum repens* and *C. diffusa* were also very common on the bunds of rice—fields in both districts.

Lindernia hyssopioides, *L. rotundifolia*, *E. prostrata*, *Leucas zeylanicus*, *Ludwigia hyssopifolia*, and *Borreria alata* were the commonest dicotyledonous weeds present on the bunds of both Districts.

However, in the drier Kurunegala District, very often a large number of cosmopolitan, terrestrial weed species were found to have invaded the rice—agroecosystem, occupying the bund habitat. Among these were: *Gomphrena celosioides*, *Ageratum conyzoides*, *Tridax procumbens*, *Vernonia cinerea*, *Heliotropium indicum*, *Cleome viscosa*, *Euphorbia hirta*, *Mimosa pudica*, *Hyptis suaveolens*, *Urena lobata*, *Sida rhombifolia*, *Phylla nodiflora* and *Stachytarpheta indica*. In the Ratnapura District as well, such weeds were common in the drier regions of the south—east. Since these are generally opportunistic species it is probable that their presence in the rice agro—ecosystem is only incidental and does not cause much concern to rice culture.

Table 7. The occurrence of the most frequent monocotyledonous and dicotyledonous weeds on the bunds of 234 rice-fields of the Ratnapura District (Yala, 1986), classified into five levels according to infestation

Species	Levels of Infestation					Total fields infested	Frequency of Occurrence
	0	1	2	3	4	5	
1. <i>Isabne globosa</i>	9	56	74	91	4	0	96.2
2. <i>Eragrostis unioides</i>	17	78	109	30	0	0	92.7
3. <i>Fimbristylis miliacea</i>	28	137	56	13	0	0	88.0
4. <i>Panicum repens</i>	33	119	72	6	4	0	85.9
5. <i>Commelina diffusa</i>	47	118	35	34	0	0	79.9
6. <i>Lindernia byssopioides</i>	51	166	17	0	0	0	78.2
7. <i>Lindernia rotundifolia</i>	55	160	19	0	0	0	76.5
8. <i>Ludwigia byssopifolia</i>	62	107	56	9	0	0	73.5
9. <i>Paspalum commersonii</i>	69	115	32	18	0	0	70.5
10. <i>Cyperus iria</i>	74	91	41	28	0	0	68.4
11. <i>Lindernia anagallis</i>	77	129	28	0	0	0	67.1
12. <i>Eclipta prostrata</i>	88	114	32	0	0	0	62.4
13. <i>Sacciolepis indica</i>	96	119	19	0	0	0	59.0
14. <i>Kyllinga brevifolia</i>	103	116	15	0	0	0	56.0
15. <i>Scoparia dulcis</i>	105	123	6	0	0	0	55.1
16. <i>Pycnus polystachyos</i>	116	98	20	0	0	0	50.4
17. <i>Axonopus affinis</i>	121	90	23	0	0	0	48.3
18. <i>Ludwigia decurrens</i>	129	79	21	5	0	0	44.9
19. <i>Leucas zeylanicus</i>	132	99	3	0	0	0	43.6
20. <i>Cyperus pilosus</i>	140	47	31	16	0	0	40.2

0 = weed species not observed on bund; 1 = a few plants; 2 = occasional patches of weed on bund; 3 = weed wide-spread on bund habitat; 4 = weed forming dense infestation on bund; 5 = weed completely covering other species on bund

Table 8. The occurrence of the most frequent monocotyledonous and dicotyledonous weeds on the bunds of 196 rice-fields of the Kurunegala District (Maha, 1986), classified into five levels according to infestation

Species	0	1	Levels of Infestation				Total fields infested	Frequency of Occurrence
			2	3	4	5		
1. <i>Isachne globosa</i>	12	61	76	31	7	9	184	93.9
2. <i>Eragrostis unioloides</i>	14	65	87	17	13	0	182	92.9
3. <i>Paspalum commersonii</i>	19	87	74	16	0	0	177	90.3
4. <i>Panicum repens</i>	24	78	52	42	0	0	172	87.8
5. <i>Fimbristylis miliacea</i>	28	102	57	9	0	0	168	85.7
6. <i>Commelina diffusa</i>	35	89	54	18	0	0	161	82.1
7. <i>Cyperus iria</i>	41	90	42	23	0	0	155	79.1
8. <i>Sacciolepis indica</i>	44	85	59	8	0	0	152	77.6
9. <i>Axonopus affinis</i>	47	94	39	16	0	0	149	76.1
10. <i>Lindernia hyssopioides</i>	51	87	53	5	0	0	145	74.0
11. <i>Lindernia rotundifolia</i>	53	93	42	8	0	0	143	73.0
12. <i>Pycnus polystachyos</i>	56	76	64	0	0	0	140	71.4
13. <i>Leucas zeylanicus</i>	59	104	33	0	0	0	137	69.9
14. <i>Borreria alata</i>	63	55	59	19	0	0	133	67.9
15. <i>Eclipta prostrata</i>	64	102	30	0	0	0	132	67.3
16. <i>Cyperus pilosus</i>	66	92	26	12	0	0	130	66.3
17. <i>Ludwigia hyssopifolia</i>	69	58	65	4	0	0	127	64.7

0 = weed species not observed on bund; 1 = a few plants; 2 = occasional patches of weed on bund; 3 = weed wide-spread on bund habitat;

4 = weed forming dense infestation on bund; 5 = weed completely covering other species on bund

4. General Observations

As explained previously, the present survey was carried out in fields when the rice was at heading to flowering stages, and after the farmers had manually weeded the fields, or had applied herbicides for weed control. Hence, the majority of the species recorded in the survey were probably those weeds which had survived control efforts of the farmers. It was also possible that some of the weeds recorded had grown out of seeds which germinated after the farmers had carried out their control measures. It is logical to think that the species which survived control measures were the ones that are most likely to pose the greatest problems as weeds. However, it is noted that successful weed control by either method would have led to an underestimation of the actual abundance of weeds in the present survey.

Major differences in the weed-flora were not observed between the two Districts. Nearly all the major weed species were common to both Districts. It was obvious from the survey that rice-fields contain a wide variety of weeds in both Districts. Information on the extent of yield reduction caused by them, or other adverse effects of such a diverse flora, is not presently available.

Three monocotyledonous species, namely *E. crus-galli*, *E. colonum* and *I. rugosum*, represented the most troublesome weeds. Not only were these species abundant in terms of frequency of occurrence, but also in terms of the levels of their infestations, which were generally heavy. *Ischaemum rugosum* is undoubtedly a very important weed in both Districts, and despite the fact that a fair proportion of fields in Kurunegala were found suffering due to inadequate moisture in mid-season, this weed was well established. Pablico and Moody⁶ in a recent study of rice-weeds in the Central and Southern Philippines, stated that *I. rugosum* was a much less important component of the weed-flora in the dry-season than in the wet-season. However, in Sri Lanka the domination achieved by *I. rugosum* points to the fact that the weed is able to adjust itself to a wide range of moisture situations.

Ludwigia hyssopifolia was the most important dicotyledonous weed found in the two Districts. It is probable that this weed too is able to withstand a wide range of moisture conditions and become well established.

The farmer interviews clearly indicated that the farmers lacked adequate knowledge about the weeds, their adverse effects and effective management. The majority of farmers only carried out several hand-weeding operations, while others used the herbicides MCPA and 3,4-DPA (Propanil) for early-season weed control. A small percentage of farmers was found to have used Paraquat, the defoliant, desiccant herbicide for killing mainly the grass-weed cover dominated by *I. globosa*, just prior to land preparation. Many farmers expressed the view that the agricultural extension service was not effective enough with advice, and that this was a major problem faced by them.

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