Weeds, herbicide use and resistance in rice fields of Sri Lanka

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Abstract

Weeds are a significant problem in rice culture, and increasing use of herbicides in the developing countries do pose problems of herbicide resistance. A study was undertaken to determine herbicide use patterns, weeds and the possible existence of resistance in the prominent weeds to the most popular herbicides used in two agroclimatic zones of Sri Lanka. The rice farmers could be categorized into non, suboptimal, optimal and excessive users of herbicides based on rates. The weed populations were greater in the dry season and grasses were predominant. The most common species were *Echinochloa* spp., *Ischaemum rugosum, Leptochloa chinensis,* Cyperus spp (sedges) and few broadleaved species. Selected populations of *E. crus-galli* and *I. rugosum* showed some resistance to Propanil and Nominee (bispyribac sodium), respectively, by assays determining seedling death, while there was no evidence of resistance in *E. colona*. Further research to examine the potential for herbicide resistance in rice fields with increasing use of herbicides is warranted.

Media summary

Grass weeds are more common in rice than broadleaved species, and there are indications of herbicide resistance in the prominent grass weeds.

Key Words

Rice, weeds, herbicides, grasses, resistance

Introduction.

Rice (*Oryza sativa* L.) is the main cereal crop cultivated in tropical Asia, principally in smallholdings (Valverde and Itoh, 2001). In Sri Lanka, rice is grown on 0.77 million ha in all agroclimatic zones by over 1.8 million farmer families producing 2.7 million tons per annum (Department of Agriculture, 2003).

Weeds reduce rice yields and effective management of these is a significant challenge to Asian rice farmers (FAO, 1996). Traditionally, weeding was carried out manually but recent economic growth has caused a shift of labour from agricultural to non-agricultural enterprises so farmers are now using herbicides (Naylor, 1994). Optimal methods of weed control in rice depend on economic, agroclimatic and technical problems (FAO, 1996). Some farmers use sub-optimal rates of the herbicides due to the rising costs of these chemicals. The impact has been the identification of resistance of many weeds to herbicides. Resistance to Propanil in *Echinochloa crus-galli* is reported in many Asian nations (Valverde and Itoh, 2001), including Sri Lanka (Marambe et al, 1997). Resistance to other herbicides could occur so studies were carried out in two major agroclimatic zones of Sri Lanka to determine weed populations, prominent weeds, herbicide use patterns, and the existence of possible resistance in the most prominent weed species.

Materials and Methods

From 1999 to 2002 a survey and laboratory studies were undertaken.

The survey was a structured questionnaire in two locations (Polonnaruwa – Dry Zone, and Uduwela, Wet Zone), using Agrarian Services Centers to identify 40 rice farmers in each region. Interviews were carried out to determine cultural practices, including herbicide use patterns. Regular visits were made to selected farms to determine weed populations and the most prominent species.

The survey identified the most common weeds, especially in the dry region, to be *Echinochloa crus-galli, E. colona* and *Ischaemum rugosum.* Seeds of populations of these species were collected from different fields in 2001 and tested for the existence of possible resistance to the most common herbicides used, Propanil and Nominee (bispyribac sodium). The concentrations used were 0 – 40,000 ?g/ml of Propanil, (recommended rate of application is 6750 ?g/ml), and 0 – 5000 in Nominee (recommended rate is 625 ?g/ml).

From each species, pre-germinated seeds were planted in black polythene bags filled with 4 kg of a sieved potting mixture, and the bags placed in a plant house with 30% shade. The mean temperature was 29.5?C, and the humidity 84%. The plants were watered daily. At the three leaf stage, plants were thinned to 5 – 7 per bag and the different concentrations sprayed with a pressurized hand sprayer to avoid any cross contamination of the rates and herbicides. Seedling mortality was determined 10 days later.

In this study, each species was considered a separate experiment, and all treatments were replicated 6 times within a randomised block design.

The data were subjected to statistical analysis and the ED50 values (the concentration showing 50% response) and resistance ratios (ED50R/ED50S) were calculated as described by Sibony et al (2001).

Results and Discussion

The survey identified four categories of farmers based on herbicide used as non-users, sub-optimal users, optimal users, and excessive users. These categories were based on the herbicides and dosages used by farmers in two seasons compared to the recommended rates of application. The most common herbicides were Gramoxone - paraquat; 3- 4 DPA - propanil; Facet - quinclorac; Nominee - bispyribac sodium; Whipsuper - fenoxaprop-ethyl, and MCPA - MCPA 40 EC K salt. Gramoxone, propanil and Nominee were very popular in the dry region, which is a major rice producing area of Sri Lanka. The farmers in the wet zone used less herbicide because of the small areas of lands cultivated.

The fields in the dry zone had a greater number of weeds per unit area (Table 1), especially in the dry season. In the dry zone, the lowest difference between weed populations in the dry and wet zones was in the fields of non-users. With increasing herbicide use, the difference increased, and there was no significant difference between the differences in weeds in the dry and wet zones between optimal and excessive users. The difference in weed populations between the wet and dry zones was lowest in the optimal user fields while the highest was in the excessive user fields. The causal factors for this were not identified and need further study. However, the lower numbers of weeds in the wet zone and also in the wet season in the dry zone could be attributed to the greater availability of water from rain and better growth of the crop that suppresses the weeds. In the dry season, farmers, especially those in the dry zone depend on irrigation water. The lack of sufficient water and absence of rains induce dry and moist periods, which coupled with higher temperatures, promote the development of weeds.

Table 1. Weed populations of rice fields (number/10m^2) in wet and dry seasons in two

agroclimatic zones of Sri Lanka.

Agroclimatic zone	Season	Non-users	Sub-optimal users	Optimal users	Excessive users*

Dry	Wet	103 ± 14.2	45 ± 2.6	38 ± 3.7	21 ± 2.1
	Dry	170 ± 12.8	79 ± 8.1	54 ± 4.3	43 ± 2.6
Wet	Wet	89 ± 6.9	45 ± 3.8	39 ± 3.9	15 ±.1.8
	Dry	138 ± 10.4	72 ± 5.1	56 ± 3.7	39 ± 2.0

± Std Deviation of weed numbers.

As expected fields of non-users of herbicides had greater weed numbers and diversity. The numbers of excessive users were also greater in the dry zone (5 vs. 2 in the sample). The most prominent weeds were grasses, especially *E. crus-galli, E. colona, I, rugosum, Leptochola* spp and *Panicum repens*. There also were also some Cyperus spp, and a few broadleaved species. The farmers in the dry zone stressed the occurrence of *Echinochloa* spp and *Ischaemum rugosum* in the recent past, with increasing use of herbicides.

The dose responses, and the ED50 values of all species differed significantly in terms of seedling mortality. In *E. crus-galli*, from the 30 seedling populations tested, 10 (33%) had ED50 values over the recommended rate of 6750 ?g/ml, for this herbicide (Table 2). The resistance ratios calculated on the basis of the ED50 values of the two populations (G10 and G16) had values ranging from 2.24 to 8.27, and 10 populations had values over 3.0. The highest resistance ratio values were in populations G15, G16, G22, and G31. These populations of *E. crus-galli* based on seedling mortality, confirm earlier reports (Marambe *et al.* 1997) of the resistance of this species to propanil. However, further studies will be required to confirm the process and identify causal factors.

Table 2. ED50 values for seedling mortality of selected populations of *Echinochloa crus-galli* and the resistance ratios in relation to two susceptible populations to propanil

Population	ED50 (?g/ml)	Resistance Ratio
G13	15950 ± 422	3.86
G14	22540 ± 221	5.45
G15	31250 ± 265	7.56
G16	29830 ± 522	7.22
G22	34160 ± 170	8.27
G24	28220 ± 380	6.83
G26	18010 ± 91	4.36

G31	31590 + 504	7.64
G35	20110 + 299	4.86
G41	15990 + 105	3.87

The mean ED50 value of the susceptible populations (G10 and G14) was 4130 ?g/ml.

Table 3. ED50 values for seedling mortality of selected populations of *Echinochloa colona* and the resistance ratios in relation to susceptible populations to propanil.

Population	ED50 (?g/ml)	Resistance Ratio
C10	14530 + 55	2.78
C32	18030 + 105	3.45

The mean ED50 value of the susceptible populations (C01and C15) was 5220 ?g/ml.

From the populations of *E. colona* tested, for possible resistance to propanil, only 2 had relatively high ED50 values and resistance ratios (Table 3). In addition, the values obtained were very low in comparison to those of *E. crus-galli*. Hence, the populations of *E. colona* tested do not seem to have resistance to propanil at this stage.

Table 4. ED50 values for seedling mortality of selected populations of *Ischaemum rugosum* and the resistance ratios in relation to susceptible populations to Nominee.

Population	ED50 (?g/ml)	Resistance Ratio
IR 20	2855 + 87	6.51
IR 28	3542 + 55	8.08
IR 31	4265 + 108	9.73
IR 32	4052 + 59	9.25
IR 42	4342 + 121	9.91
IR 45	3655 + 98	8.34
IR 52	3599 + 41	8.21

IR 55	4642 ± 75	10.59
IR 59	3484 ± 114	7.95

The mean ED50 value of the susceptible populations (IR 01 and IR 02) was 438 ?g/ml.

In *I rugosum*, among the 25 populations tested for seedling mortality by Nominee, 9 (36%) had high values of ED50 and resistance ratios (Table 4). The resistance ratios ranged from 6.51 to 10.59, and 5 populations (IR 28, IR 31, IR32, IR42 and IR55) had values over 9.0. These suggest the possible existence of resistance in this species to Nominee, as reported in Malaysia (Heap, 2003) and needs further confirmatory studies.

Conclusions.

The study carried out to determine weeds, herbicide use and possible resistance to common herbicides in two rice growing regions of Sri Lanka presented interesting results. The farmers were categorized into non-, sub- optimal, optimal and excessive users. In the major rice producing area farmers used more herbicides. Weed populations were higher in the dry regions and in the dry season in both seasons. Several major weeds were identified and grasses were predominant.

E. crus-galli populations showed some degree of resistance to propanil, and these populations were primarily from the dry regions. *E. colona* did not show resistance to this herbicide although the weed was present in the fields to which propanil had been applied. There was some degree of resistance in *I. rugosum* to Nominee, a herbicide that has been widely used in recent times.

Further studies are needed on herbicide resistance in major rice weeds because it is becoming widespread in most rice growing countries, particularly with grasses.

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