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Sensitivity of Rice to *Ludwigia decurrens (L)*

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ABSTRACT. Ludwigia decurrens is an annual broad leaved weed with a profuse growth, which offers severe competition to rice, causing a serious problem in the low-country wet zone. Hence an experiment was conducted to study the growth and yield of rice plants with various densities of Ludwigia.

Ten factorial combinations composed of five Ludwigia populations (0, 1, 2, 4 and 8 plants/m^2 during Maha 1989/90, and 0, 2, 4, 8 and 16 plants/m^2 during Yala 1990) and two weed management practices (with and without other weed species) were tested on rice (variety BW-351) at the Regional Agricultural Research Centre, Bombuwala, Kalutara. Growth parameters of Ludwigia and growth and yield parameters of rice were recorded.

The grain yield of rice during Maha was significantly decreased from 2.51 to 1.69 mt/ha with increased densities of Ludwigia from 4 to 8 plants/m^2, and yield reduction of 33%. The presence of other weed species together with Ludwigia caused a 34% reduction in grain yield. During the Yala season, grain yield was significantly reduced by 33% when Ludwigia density was increased from 2 to 4 plants/m^2.

The presence of other weed species along with Ludwigia also caused a significant reduction in the number of panicles, and tiller and panicle length, the number of seeds per panicle, and the height of rice during both Yala and Maha seasons.

Ludwigia density above 4 plants/m^2 during Maha, and 2 plants/m^2 during Yala caused a significant yield loss in rice in the low-country wet zone.

INTRODUCTION

Ludwigia decurrens (family *Onagraceae*), is an annual broad leaf weed common to both highlands and lowlands in the temperate and tropical regions of South East Asia (Muhlburg, 1980; Moody, 1986). It is a problem in rice in India (Raju, 1986), Bangladesh (Alam and Karim, 1980), the Philippines (Moody, 1986), as well as in Sri Lanka, (Chandrasena and Amarasinghe, 1985; Weerakoon and Gunawardena, 1983). It is commonly known by rice farmers as "*Bimuni*", "*Walkarambu*" and "*Ganwaturagas*". *Ludwigia* is highly competitive due to its fast growth rate and extensive spongy root system. It emerges along with rice seedlings, and infests rice fields. It interferes with water management and other cultural practices affecting grain yield and its components. Its' prolific seed production has threatened rice cultivation in the low country and mid country rice production and is now spreading into other areas.

The degree of competition varies with density. Higher densities (125 and 625 plants/m^2) caused early heading by 1–5 days prior to normal time, shortening of culm length, decreased tiller number per plant and spikelet number per panicle, thereby causing a reduction in grain yield ranging from 50% in high tillering to 80% in moderately tillering varieties (Kim *et. al.*, 1977). Though *Ludwigia* has been recognized as a troublesome weed in low land rice, information on its effect on rice production is scanty. This study was, therefore conducted to determine the density effect of *Ludwigia* on grain yield and yield components of rice.

MATERIALS AND METHODS

This experiment was conducted in a lowland rice field during *Maha* 1989/90 and *Yala* 1990 at the Regional Agricultural Research Center, Bombuwala, Sri Lanka. The experimental site is 1m above sea level on low humic gley soil. The annual rain fall in 1989/90 was 3300 mm. Ten treatments composed of factorial combinations of five *L. decurrens* densities *viz* 0, 1, 2, 4 and 8 plants/m^2 and two types of weed stands (*Ludwigia* only and *Ludwigia* plus other weed species common in rice fields) were tested in 4 blocks during *Maha* 1989/90. The *Ludwigia* densities were changed to 0, 2, 4, 8 and 16 plants/m^2 during *Yala*, 1990.

Fourteen day-old rice seedlings of variety BW-351 were transplanted in plots 4mx4m. Seedlings of *Ludwigia* raised simultaneously in wet-bed nurseries were transplanted into rice plots. A basal dressing of 19 kg/ha N, 21 kg/ha P, and 41 kg/ha K were applied and incorporated prior to transplanting. Top dressing of 29 kg/ha N was applied at 3 weeks after transplanting (WAT) and 28 kg/ha of N plus 16 kg/ha of K at 6 WAT. *Carbofuran* (0.8 kg a.i./ha) was applied following transplanting, to control thrips, leaf folders and other insect pests. *Monocrotophos* (0.6 kg a.i./ha) was applied at the maximum tillering at 35 DAT to control leaf folders, and was repeated at the milk stage to control paddy bugs. Hand weeding was practiced to maintain weed densities and to keep only the required weed species. Water management by impounding water at weekly interval was adopted as recommended by the Department of Agriculture.

The tiller number/m^2 and height of rice plants were recorded from 16 selected rice hills at 45 DAT. Plant height of *Ludwigia* was also recorded. All rice plants and weeds in two quadrants of 0.5 m x 0.5 m were cut at the ground level in each plot to record crop and weed developments. Both rice and *Ludwigia* were uprooted in the above sample area for leaf area and biomass determinations at 50 DAT. Leaf area of rice was estimated by length and breadth method (Vivekanandan *et. al.*, 1972) while that of *Ludwigia* was estimated by the disc method (Nur, 1971). The total biomass of rice and weeds was recorded after drying the sample plants at 80-85 C for 3-4 days until a constant weight was reached. The yield parameters of rice such as panicle/m^2, spikelets/panicle, and 1000 grain weight were recorded. Grain yield was obtained from an area of 3mx3m in the centre of the plots. The analyses of variance was performed and mean separation was done using Fisher's protected LSD.

RESULTS

Weather

Weather was normal during both *Maha* and *Yala*. *Maha* was dry while *Yala* was wet (Figure 1).

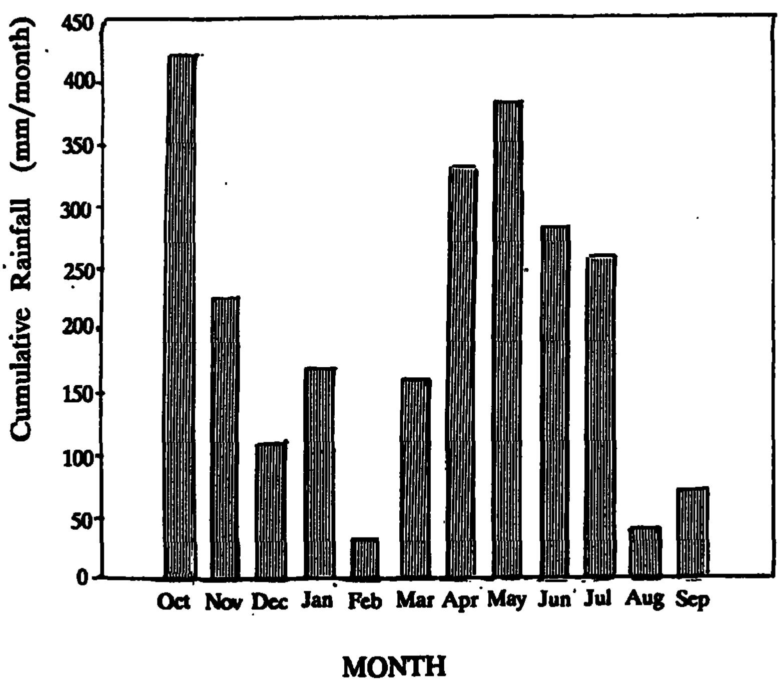

Figure 1. Monthly cumulative rainfall during October 1989 – September 1990 in the Regional Agricultural Research Station, Bombowala, Kalutara.

Plant height

Ludwigia

The height of *Ludwigia* did not significantly increase with an increase in weed density from 1 to 4 plants/m^2 (Table 1). However, an increase in the *Ludwigia* density from 4 to 8 plants/m^2 significantly increased the weed height during *Maha*.

Plant height in *Maha* 1989/90 was greater than in *Yala* (Table 1 and 2). A significant increase in the plant height resulted when plant density was increased from 2 to 4 plants/m^2 (Table 2).

In both seasons, *Ludwigia* height was not affected by the presence of other weed species. This shows the competitive ability of *Ludwigia* (Table 1 and 2). Among the other weed species the most prevalent were mostly *Cyperus iria* and *Monochoria vaginalis* but *Ludwigia* was the dominant weed in all plots. The other weeds were short lived since *Ludwigia* overtopped them and the rice crop.

Ludwigia grew faster during *Yala* than in *Maha*, probably due to rainy weather (Figure 1), resulting in a significant increase in *Ludwigia* height.

Rice

The average height of rice varied from 48.1 to 49.4 cm and increased density of *Ludwigia* did not affect the height of rice during *Maha* (Table 1). However, during *Yala*, the height of rice increased with increasing *Ludwigia* densities up to 16 plants/m^2 (Table 2).

The type of weed species associated with rice has a significant effect on height of rice: plant height was significantly greater with *Ludwigia* alone than when *Ludwigia* was present with other weed species during both *Maha* and *Yala*.

Table 1. Effect of Ludwigia density and weed type on plant height of Ludwigia and rice, tiller number, plant dry weight and LAI* during Maha 1989/90.

Treatment	Ludwigia height 45 DAT+ cm	Rice Height 45 DAT cm	Rice Tillers 45 DAT no/m2	Rice Dry weight 50 DAT kg/ha	Rice LAI 50 DAT
Number Ludwigia plants/m2					
0	-	48.1	271	2762	2.11
1	75.6	48.1	261	2430	1.76
2	77.8	49.0	231	2438	1.61
4	76.5	48.0	215	2342	1.64
8	85.0	49.4	197	2519	1.94
LSD (0.05)	7.0	NS	32	NS	N S
Type of weeds					
Ludwigia only	61.5	50.4	245	2689	1.98
Ludwigia + other spp.	64.5	46.8	226	2307	1.64
LSD (0.05)	ns	1.7	NS	374	NS
CV %	10.84	5.63	13.29	23.13	29.84

Where +/ Days after transplanting;

Table 2. Effect of Ludwigia density and weed type on plant height, tiller number, plant dry weight and LAI* of rice during Yala 1990.

Treatment	Ludwigia height 45 DAT+ cm	Rice: Height 45 DAT cm	Rice: Tillers 45 DAT no/m^2	Rice: Dry weight 50 DAT kg/ha	Rice: LAI 50 DAT
Number Ludwigia plants/m^2					
0	-	46.8	272	1776	1.96
2	54.3	50.3	256	1661	1.78
4	73.4	50.8	240	1491	1.70
8	81.0	53.0	233	1341	1.67
16	84.0	54.6	200	1142	1.49
LSD (0.05)	11.4	3.8	29	258	0.25
Type of weeds					
Ludwigia only	58.9	53.4	249	1564	1.82
Ludwigia + other spp.	58.1	48.8	232	1400	1.62
LSD (0.05)	ns	2.4	ns	ns	0.16
CV %	19.06	7.21	11.9	16.9	14.3

Tillers of rice

The number of tillers/m^2 was about 271 at 45 DAT without *Ludwigia* during both *Maha* and *Yala* (Table 1 and 2). Rice tillering decreased with increased density of *Ludwigia* up to 8 plants/m^2 in *Maha* and 16 plants/m^2 in *Yala* caused a significant reduction in the tiller number/plant. The suppression of tillering of rice remained the same during both seasons. Presence of other weed species reduced the tiller number in both *Yala* and *Maha*, but the difference was not significant. It was observed that *Ludwigia* suppressed all other weeds due to its fast growth and shading ability. Rice, having been established earlier, was able to tolerate the competition.

Leaf area index of rice

Leaf area index (LAI) of rice at 50 DAT was not affected by either *Ludwigia* alone or with other weed species during *Maha* (Table 1). But, LAI was 2.11 when weed free, and decreased with increasing *Ludwigia* densities.

During *Yala*, LAI was significantly reduced by *Ludwigia* alone and *Ludwigia* with other weeds. In *Maha*, the reduction was not statistically significant. LAI decreased with increasing *Ludwigia* densities to 16 plants/m^2. A significant reduction occurred when *Ludwigia* density was increased from 0 to 4 plants/m^2. LAI was also significantly decreased by the presence of other weed species.

Dry weight of rice

Dry weight of rice decreased from 2,762 to 2,342 kg/ha, but the difference was not significant during *Maha* (Table 1). However, *Ludwigia* with the other types of weed species caused a significant reduction in dry weight.

During *Yala*, a significant decrease in rice plant dry weight from 1,761 to 1,491 kg/ha occurred with an increase in *Ludwigia* density from 0 to 4 plants/m^2 and above. With other weed species during *Yala* the difference in dry weight of rice was not significant. This indicates that *Ludwigia* becomes more competitive during *Yala* than *Maha*, whereas other weed species are more competitive during *Maha*. The decrease in rice dry matter could be due to the reduction in the LAI and tiller number as a response to competition by *Ludwigia*.

Yield and yield components of rice

Panicle number

The number of panicles decreased but not significantly during *Maha* (Table 3). However, there was a significant decrease in the panicle number during *Yala*, 1990 (Table 4). Significant decreases occurred when the *Ludwigia* plant density increased beyond 2 plants/m^2.

Significant reductions in panicles/m^2 occurred during both *Maha* and *Yala* when *Ludwigia* was present with the other weed species (Tables 3 and 4).

Panicle length

Differences in panicle length was similar during both seasons. There was a significant decrease in panicle length with increasing *Ludwigia* densities (Table 3 and 4). Increasing the *Ludwigia* density from 2 to 4 during *Maha* and from 0 to 8 during *Yala* showed significant reductions of 5.5 and 5.9%, respectively. Panicle length was also decreased by other weed species in the presence of *Ludwigia*.

Number of spikelets

Ludwigia density did not significantly affect the spikelet number/m^2 during *Maha*. The spikelets/m^2 was significantly lowered, however, with increase in the *Ludwigia* density from 2 to 8 plants/m^2, during *Yala*.

During both seasons, spikelet number/m^2 was significantly reduced by the other weed species (Table 3 and 4). The difference was greater with mixed weed species than with *Ludwigia* alone. The spikelet number was lower during *Yala* (41 – 67 spikelets/m^2) than in *Maha* (86 – 99 spikelets/m^2).

Table 3. Effect of Ludwigia density and weed type on yield characteristics of rice during Maha 1989/90 at RARC, Bombuwela.

Treatment	Panicles no./m^2	Panicle length cm	Spikelets no./m^2	Grain yield t/m^2
Number Ludwigia plants/m^2				
0	204	22.9	99	2.51
1	201	23.6	91	2.28
2	188	22.3	88	2.15
4	190	21.8	93	2.11
8	182	21.8	86	1.69
LSD (0.05)	NS	1.0	NS	0.43
Type of weeds				
Ludwigia only	208	22.9	101	2.41
Ludwigia + other spp.	178	21.9	83	1.65
LSD (0.05)	18	0.7	8	0.27
CV %	15	4.5	15	20.3

Table 4. Effect of Ludwigia density and weed type on yield characteristics of rice during Yala 1990 at RARC, Bombuwela.

Treatment	Panicles no./m^2	Panicle length cm	Spikelets no./m^2	Grain yield t/m^2
Number Ludwigia plants/m^2				
0	222	22.2	67	2.45
2	215	21.6	63	2.29
4	187	21.2	61	1.64
8	165	20.9	55	1.42
16	137	19.3	41	0.79
LSD (0.05)	24	1.2	7	0.44
Type of weeds				
Ludwigia only	197	21.6	63	2.12
Ludwigia + other spp.	173	20.5	51	1.32
LSD (0.05)	26	0.8	5	0.29
CV %	12.7	5.5	11.9	24.7

Grain yield

Grain yield of rice was significantly reduced by *Ludwigia* density and other weed species during both *Maha* and *Yala* (Table 3 and 4). The grain yield varied from 1.69 to 2.41 mt/ha during *Maha* and from 2.45 to 0.79 during *Yala*. Increasing the *Ludwigia* density from 0-4 during *Maha* did not significantly affect rice yield, but the decrease in rice yield was significant (2.11 to 1.69 mt/ha) with increase in *Ludwigia* density from 4 to 8 plants/m^2. The rice yield was also affected by the type of weed species: *Ludwigia* plus other weed species decreased rice yield by 34% more than with *Ludwigia* alone.

During *Yala*, a significant decrease in rice yield from 2.29 to 1.64 mt/ha resulted in an increase in the *Ludwigia* density from 2 to 4 plants/m^2 and higher densities. During *Yala*, there was a 38% reduction in rice yield due to the competition from *Ludwigia* and other weed species.

Correlations between some characteristics of rice and Ludwigia

Plant height

A negative and significant correlation at the 5% level existed between *Ludwigia* plant height and rice tillers/m^2 ($r = -0.35$) during *Maha* (Table 5). During the *Yala* season, rice plant height was Positively correlated at the 1% level ($r = 0.52$). However, panicle length, panicle number m^{-2} tiller and spikelet number and grain yield had significant negative correlations.

Table 5. Correlation coefficients between plant height of Ludwigia and growth characteristics and yield and its components of rice during Maha and Yala, 1989/90.

Plant height of Ludwigia	Plant height of rice	Tillers per m^2	Panicle length	Panicles per m^2 panicle	Spikelets per	Grain Yield
Maha	-0.18	-0.35*	-0.18	-0.15	-0.10	-0.19
Yala	0.52**	-0.34*	-0.49*	-0.43*	-0.43*	-0.43*

Correlation coefficients are significant at 5% (*) and 1% (**) probability levels.

DISCUSSION

Ludwigia has a unique competitive ability: tall growth habit, rapid leaf development, profuse branching habit, extensive root system, rapid leaf development, *etc.* The profuse branching under high soil water levels was reported (Sharma *et. al.*, 1977). The plant grows up to a meter or higher and acquires a large area and hence is different from other weed species in rice. *Ludwigia* affected the growth, grain yield and yield components of rice due to such competitive characteristics. The other weed species such as *Cyperus iria*, *Monochoria vaginalis*, *etc.* are smaller weeds and appeared to amplify the affect during the initial period until *Ludwigia* covers both other weed species and rice.

An increase in the *Ludwigia* density increased the plant height of *Ludwigia* and rice. There was also a decrease in the height of rice when other weed species were present with *Ludwigia*. Increase in the height of weeds and crop plants as a response to shading under inter-specific competition for light has been reported by Holliday (1960). The height of rice increased during *Yala* but not in *Maha*. However, a significant increase occurred during *Yala* since the environment was more moist, and overcast (Figure 1). The rainy weather increased growth and branching of *Ludwigia*, and hence the competitive ability of plants (Sharma *et. al.*, 1977). As reported by Clements *et. al.*, (1929), in a crop-weed competition for light, plant height defines a very effective component, the difference of only a millimeter could be decisive since it could shade the other leaves. This helps the aggressive species to gain a competitive advantage against the less competitive species. The increased competitive ability of *Ludwigia* and other weed species significantly affected the growth of rice, thus reducing dry weight, the number of tillers and panicles per m^2, panicle length, spikelets/panicle and grain yield of rice during *Yala*.

During *Maha*, total rainfall was low and weather was dry when compared to *Yala*. Rainfall during the initial growth of rice was sufficient for tiller production resulting in usual tiller development and hence the panicle number. This reduction was further amplified by the prevalent dry weather towards the boot stage. In addition, height and branching of *Ludwigia* were also lower than *Yala*. The shading on rice was low and hence up to 4 plants there was no significant reduction in grain yield. However, *Ludwigia* densities at 4 and above plants caused a significant reduction in the panicle length and grain yield.

In *Yala*, the rainy weather and overcast condition may have promoted the growth and branching of *Ludwigia* reducing grain yield of rice above 2 plants/m^2. *Ludwigia* densities above 8 plants/m^2 reduced spikelets/m^2.

The results of this experiment reveal that *Ludwigia* is harmful to rice due to its competitive ability. It becomes more aggressive under moist and overcast weather as found during the rainy *Yala* period in the low-country wet zone. The suppression of growth of rice occurred in all its components such as tiller and panicle number, leaf area index, spikelet number per panicle and eventually grain yield. During the *Maha* (relatively dry), more than 4 *Ludwigia* plants/m^2 while during *Yala* more than 2 plants/m^2 caused significant reduction in grain yield of rice in the low-country wet zone.

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