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Efficacy of different herbicides over manual weeding in controlling weeds in transplanted rice

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Abstract

An experiment was conducted on transplanted Aman (monsoon) rice at the Sher-e-Bangla Agricultural University farm Dhaka ($90^0$33´ E longitude and $23^0$77´ N latitude), Bangladesh during June-November, 2005. There were seven different weed control treatments viz. T_1= Amchlor® 5G @ 15 kg ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}, T_2= Ronstar® 25EC @ 1.25 L ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}, T_3= IR5878® 50 WP @ 150 g ha^{-1}, T_4= IR5878® 50 WP @ 120 g ha^{-1}, T_5= Set-off® 20WG @ 50 g ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}, T_6= Two hand weeding and T_7= Weedy check. There were 14 different weed species infested the field among which *Panicum repens* was the most important. Among the herbicides T_2 was the most efficient with the lowest weed population and weed dry weight. The yield and the yield contributing characters (plant height, number of effective tillers per hill, panicle length and no. of filled grains) were influenced according to the effectiveness of the treatments, with T_2 being the highest yielding herbicide treatment, reaching the yield level of the hand weeding treatments (T_6). Maximum benefit-cost ratio with T_2 suggested that this herbicidal treatment can be used as an alternative when labour is a limiting factor in producing transplant Aman rice.

Keywords: transplanted rice, herbicide, weed control, yield, profitability

Abbreviations: G-Granular; EC- Emulsifiable concentrate; WP- Wettable powder; DAT- Days after transplanting; BCR- Benefit-cost ratio

Introduction

Rice (*Oryza sativa* L.) is the vital food for more than two billion people in Asia and four hundreds of millions of people in Africa and Latin America (IRRI, 2006). The people in Bangladesh depend on rice as staple food and have tremendous influence on agrarian economy of Bangladesh. Rice alone constitute of 95% of the food grain production in Bangladesh (Julfiquare *et al*., 1998). Among different groups of rice transplant Aman (T. Aman) rice cover about 48.67% of total rice area and it contributes to

Table 1. Importance value and relative density of different weed species growing in the transplanted Aman rice

Weed species	Family	Importance value (%)		Relative density (%)	
		25 DAT	50 DAT	25 DAT	50 DAT
Panicum repens	Gramineae	38.40	40.80	35.98	30.32
Digitaria sanguinalis	Gramineae	14.36	14.92	9.06	8.27
Leersia hexandra	Gramineae	14.35	12.23	24.19	20.57
Cyperus difformis	Cyperaceae	11.03	8.11	7.63	7.29
Ludwigia hyssopifolia	Onagraceae	6.78	4.40	5.98	4.66
Fimbristylis miliacea	Cyperaceae	5.95	3.87	9.83	7.12
Rottboellia protensa	Gramineae	5.38	3.78	4.77	3.95
Commelina benghalensis	Commelinaceae	3.67	-	2.51	-
Echinochloa crusgalli	Gramineae	-	5.90	-	2.67
Monochoria vaginalis	Pontederiaceae	-	4.14	-	5.51
Hymenache pseudointerupta	Gramineae	-	2.40	-	2.07
Cyperus esculentus	Cyperaceae	-	1.35	-	3.16
Fimbristylis diphylla	Cyperaceae	-	1.06	-	1.95
Oxalis europea	Oxalidaceae	-	0.97	-	2.23

42.8% of the total rice production in the country (BBS, 1998). Transplant Aman covers the largest area of 5713 thousand hectare with a production of 11249 thousand metric ton and average yield was about 1.951 ton ha^{-1} (BBS, 2001). The average yield of rice in Bangladesh is 2.45 t ha^{-1} (BRRI, 2006), which is approximately 50% of the world average rice grain yield. Infestation of weed is one of the most important causes for low yield of rice. In Bangladesh, weed infestation reduces the grain yield by 70-80% in *Aus* rice (early summer), 30-40% for Transplanted (T) Aman rice (late summer) and 22-36% for modern *Boro* rice cultivars (winter rice) (BRRI, 2006; Mamun, 1990). Production cost of rice increased due to increases in weed control cost. The prevailing climatic and edaphic conditions are highly favorable for numerous species of weeds that strongly compete with the rice crop.

In Bangladesh the traditional methods of weed control practices include preparatory land tillage, hand weeding by hoe and hand pulling. Usually two or three hand weeding are normally done for growing a rice crop depending upon the nature of weeds, their intensity of infestation and the crop grown. Weed control in transplant Aman rice by mechanical and cultural methods is expensive. Especially at periods of labor crisis late weeding can cause drastic losses in grain yield. In contrast, chemical weed control is sufficient. Nowadays the use of herbicides is gaining popularity in rice culture due to their rapid effects and lower costs compared to traditional methods. The available herbicides in controlling weeds in rice field are of overseas origin. The country depends on foreign multinational companies for the supply of herbicides and the companies do not supply the same brand of herbicides for long time. So, continuous evaluation is necessary for the benefit of the farmers of this country.

Therefore, the study was undertaken to observe the performance of different herbicides compared with manual weeding in controlling weeds of transplanting Aman rice.

Materials and methods

Experimental site

An experiment was conducted on Transplanted (T) Aman rice at the Sher-e-Bangla Agricultural University farm Dhaka ($90^0 33´$ E longitude and $23^0 77´$ N latitude), Bangladesh during Aman season (June-November) of 2005. The soil of the experimental site was clay loam with a pH of 5.47-5.63.

Experimental design and treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 4 replications; comprising seven different weed control treatments

Table 2. Effect of different weed control methods total weed population, weed dry matter and weed control efficiency of transplanted Aman rice

Treatments	Total weed population m^{-2}		Total weed dry weight ($g\ m^{-2}$)		Weed control efficiency (%)	
	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT
T_1	29.45 d	43.12 d	9.21 c	14.48 e	66.39 c	70.97 c
T_2	15.82 e	25.74 e	5.05 d	10.14 f	81.57 b	82.93 b
T_3	46.94 b	65.96 b	14.03 b	23.57 c	48.81 d	52.74 d
T_4	44.09 c	67.55 b	13.44 b	24.20 b	50.97 d	51.48 d
T_5	28.57 d	52.18 c	9.11 c	18.38 d	66.76 c	63.15 c
T_6	0.00 f	0.00 f	0.00 e	0.00 g	100.00 a	100.00 a
T_7	79.63 a	122.63 a	27.41 a	49.88 a	0.00 e	0.00 e
$S_{\bar{x}}$	0.96	1.86	0.17	0.21	1.87	2.88
LSD	2.60	5.04	0.46	0.56	5.07	7.82
Levels of significance	0.01	0.01	0.01	0.01	0.1	0.1

In a column the values having common letter(s) do not differ significantly. T_1= Amchlor 5G @ 15 kg ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_2= Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_3= IR5878 50 WP @ 150 g ha^{-1}, T_4= IR5878 50 WP @ 120 g ha^{-1}, T_5= Set-off 20WG @ 50 g ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_6= Two hand weeding T_7= Weedy check

viz. T_1= Amchlor® 5G @ 15 kg ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}, T_2= Ronstar® 25EC @ 1.25 L ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}, T_3= IR5878® 50 WP @ 150 g ha^{-1}, T_4= IR5878® 50 WP @ 120 g ha^{-1}, T_5= Set-off® 20WG @ 50 g ha^{-1} + IR5878® 50 WP @ 120 g ha^{-1}, T_6= Two hand weeding and T_7= Weedy check. The common name of Amchlor®, Ronstar®, Set-off® and IR5878® are Butachlor, Oxadiazon, Cinosulfuron and Orthosulfamuron, respectively. Amchlor®, Ronstar®, Set-off® were preemergence herbicides which applied at 4 days after transplanting (DAT). IR5878 (postemergence herbicide) was applied at 2-3 leaf stage of grass weeds.

Methods of cultivation

Seeds of transplanting Aman rice cv. BRRI dhan 31 were sown in seed bed on June 28, 2005 which was transplanted in the main field on July 28, 2005. The planting distance was maintained at 25 cm (row-row) × 15 cm (hill-hill). Fertilizers at 65:10:28:8:1 NPKSZn kg ha^{-1} were applied. Fifty percent N and all PKS were applied before transplanting and remaining 50% N was top-dressed at maximum tillering stage of rice plants. Intercultural operations such as gap filling, irrigation, and plant protection were carried out as required.

Data Collection and analysis

Data regarding weeds were recorded at 25 and 50 days after transplanting (DAT). Dry weights of weeds were taken by drying them in electric oven (Perkin-Elmer Corporation, USA) at 60^0 C for 72 hours followed by weighing by digital balance (Kaifeng Group Co., Ltd., China). Relative weed density (RWD) and Importance value of weed (IVW) and Weed control efficiency (WCE) was calculates as follows:

$$\text{RWD} = \frac{\text{Density of individual weed species in the community}}{\text{Total density of all weed species in the community}} \times 100$$

$$\text{IVW} = \frac{\text{Dry weight of a given oven dried weed species}}{\text{Dry weight of all oven dried weed species}} \times 100$$

$$\text{WCE} = \frac{DWC - DWT}{DWC} \times 100$$

Where; DWC = dry weight of weeds in weedy check plots and DWT = dry weight of weeds in treated plots

Table 3. Effect of different weed control methods on the yield contributing characters of transplanted Aman rice

Treatments	Plant height (cm)	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of filled grain panicle^{-1}	1000-grain weight (g)
T_1	137.91 b	10.38 bc	22.68 b	83.07 c	22.01
T_2	143.46 a	12.24 a	22.76 ab	88.44 a	22.02
T_3	133.77 bc	10.55 b	22.38 b	84.30 bc	21.90
T_4	135.95 b	10.60 b	22.93 ab	87.70 ab	21.87
T_5	135.88 bc	11.13 ab	22.40 b	83.53 c	21.59
T_6	137.66 b	11.10 ab	23.98 a	87.67 ab	22.03
T_7	130.62 c	9.23 c	20.65 c	73.70 d	21.45
$S_{\bar{x}}$	1.96	0.47	0.47	1.44	0.35
LSD	5.31	1.27	1.27	2.90	
Levels of significance	0.01	0.01	0.01	0.01	NS

In a column the values having common letter(s) do not differ significantly. T_1= Amchlor 5G @ 15 kg ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_2= Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_3= IR5878 50 WP @ 150 g ha^{-1}, T_4= IR5878 50 WP @ 120 g ha^{-1}, T_5= Set-off 20WG @ 50 g ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_6= Two hand weeding, T_7= Weedy check

At harvest, plant characters and yield data were recorded. For yield measurement 1 m^2 at the middle of the plot was harvested. The data were analysed following Analysis of Variance (ANOVA) technique and mean separations were adjusted by the Multiple Comparison test (Gomez and Gomez, 1984) using the statistical computer programme MSTAT-C v.1.2 (Russel, 1986).

Results and discussion

Weed infestation

Fourteen weed species infested the experimental plots which belong to 6 families (Table 1). The weds that grown in transplant Aman rice field are aquatic, semi-aquatic, broadleaves, grasses and few sedges, which can withstand water logging and usually enough to decrease crop yield very significantly if do not controlled timely (Mian and Gaffer, 1968). Among the fourteen weed species, four were broad-leaved, six were grasses and the rest of four were sedges. It might be seed that the most prominent weeds in the experiment were *Panicum repens.* The second most important was *Digitaria sanguinalis* and *Leersia hexandra*; and the lowest one *Oxalis europea*. The appearance of weeds was not occurred at a time. At 25 DAT only 8 weed species was appeared while another 6 additional weed species were appeared at 50 DAT. It was also found that the importance values and relative density of *Panicum repens* was height at both 25 and 50 DAT where the lowest importance value and relative density was observed in case of *Fimbristylis diphylla* and *Oxalis europea* (Table 1).

Weed control

The significant effect on total weed population m^{-2} was found due to different herbicidal treatments at 25 and 50 DAT (Table 2). The weed population (79.63 m^{-2}) was found in T_7 treatment (weedy check) and lowest weed population (15.82) was found in T_2 (Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}) at 25 DAT. Similar results were noticed at 50 DAT. In T_6 (Two hand weeding) treatment, very negligible numbers of weeds was obtained at both the dates. It was due to efficient control of weeds by manual weeding intensively. Al-Kothayri and Hasan (1990) reported that all herbicidal treatments reduced weed population significantly compared with weedy check. Ghua (1991), Hoque (1993) and BRRI (1990) observed that Ronstar 25EC @ 2 L ha^{-1} controlled weed in transplanted Aman rice most effectively. However, as Ronstar 25EC was not applied alone in

Table 4. Effect of different weed control methods on the yield and harvest index of transplanted Aman rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
T_1	4.78 b	7.65 bc	39.50 a
T_2	5.11 a	7.79 ab	39.62 a
T_3	4.18 c	6.86 d	37.77 b
T_4	4.15 c	6.93 d	37.37 bc
T_5	4.69 b	7.47 c	38.53 ab
T_6	5.12 a	7.95 a	39.37 a
T_7	3.34 d	5.83 e	36.35 c
$S_{\bar{x}}$	0.06	0.09	0.45
LSD	0.16	0.24	1.21
Levels of significance	0.01	0.01	0.01

In a column the values having common letter(s) do not differ significantly.T_1= Amchlor 5G @ 15 kg ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_2= Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_3= IR5878 50 WP @ 150 g ha^{-1}, T_4= IR5878 50 WP @ 120 g ha^{-1}, T_5= Set-off 20WG @ 50 g ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_6= Two hand weeding, T_7= Weedy check

this experiment rather it was combined with IR5878. The credit of treatment T_2 is not clear whether it is solely due to Ronstar 25EC or not. From the treatment T_3 and T_4 it is clear that IR5878 50 WP could not control weeds effectively when it was applied alone.

The significant effect on total dry weight of weed was found due to different herbicidal treatments at 25 and 50 DAT (Table 2). The height weed dry weight was found in T_7 (weedy check) at both 25 DAT (27.41 g m-2) and 50 DAT (49.88 g m^{-2}). The lowest dry weight, however found to be the lowest with T_2 (Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}) at both 25 DAT (5.05 g m^{-2}) and 50 DAT (10.14 g m^{-2}). It was observed that the lowest proportion (7%) of total weed dry weight was obtained by the application of treatment T_2 and the maximum proportion (35%) of total weed dry weight was found by the T_7 treatment. Other herbicides resulted higher weeds dry weight than the T_2 treatment. In terms of weed control efficiency, the treatment T_2 (Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}) was the best in comparison to other herbicides which provided 81.57% and 82.93.67%control at 25 and 50 DAT (Table 2). However, the treatment of two hand weeding (T_6) provided the complete control of weeds. This result supported by the results of Singh and Pillai (1993). Patanker *et al.* (1992) also observed best weed control in rice with Ronstar 25EC. Very negligible amount of weeds were found in those plots.

Yield contributing characters

Among the yield contributing characters plant height, number of effective tillers per hill, panicle length and no. of filled grain were significantly influenced by different herbicide treatments (Table 3). Among the treatment T_2 (Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}) produced the tallest plant where the lowest plant height was observed from T_7 (weedy check). The treatment T_2 gave the efficient weed control in the experimental plots which ultimately gave the maximum no. of effective tillers hill^{-1} (12.24) and it was followed by T_5 and T_6 while the minimum number of effective tillers (9.23) was observed in T_7 (weedy check). In case of panicle length the treatment T_6 (two hand weeding) showed the best result but it was statistically at per with T_2 and T_4. As the treatment T_2 provided the best weed control thus assimilates accumulation was more in this treatment. That's why number of filled grain per panicle was found to be the maximum with the treatment T_2 which was statistically similar to T_4 and T_6 (Table 3). However, 1000-grain weight was remained statistically unchanged due to different treatments. These results were supported by Antigua *et al.* (1988).

Yield and harvest index

As the treatment T_6 (two hand weeding) showed almost the total control of weed, the ultimate

Table 5. Effect of different weed control methods on the cost of production, returns and benefit-cost ratio of transplanted Aman rice

Treatments	Cost of production (US $)			Gross return (US $)	Net profit (US $)	BCR
	Variable cost	Weeding cost	Total cost			
T_1	583.60	22.15	605.75	913.38	307.62	1.51
T_2	583.60	24.17	607.76	971.97	364.20	1.60
T_3	583.60	7.33	590.93	800.69	209.75	1.35
T_4	583.60	6.11	589.71	796.31	206.60	1.35
T_5	583.60	17.69	601.29	895.76	294.47	1.49
T_6	583.60	69.06	652.66	975.53	322.87	1.49
T_7	583.60	0	583.59	643.79	60.20	1.10

In a column the values having common letter(s) do not differ significantly. T_1= Amchlor 5G @ 15 kg ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_2= Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_3= IR5878 50 WP @ 150 g ha^{-1}, T_4= IR5878 50 WP @ 120 g ha^{-1}, T_5= Set-off 20WG @ 50 g ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}, T_6= Two hand weeding, T_7= Weedy check

reflection of this treatment was appeared as the highest grain yield (5.12 t ha^{-1}) of transplanted Aman rice in this experiment (Table 4). It was statistically similar with T_2 (Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}). It might be the resultant effects of highest tillers hill^{-1} and grains panicle^{-1} with those treatments (Table 3). It revealed that the herbicide application has similar effect to hand weeding regarding the weed control in Aman rice. Straw yield also significantly affected by different treatments (Table 4). In this study, the highest straw yield was obtained from the treatment T_6 which was followed by T_2. Both of the grain yield and straw yield was observed from the treatment T_7 (weedy check). The grain yield obtained from T_6 and T_2 was 53.445 and 53.14% higher over weedy check. Therefore it was clear that maximum weed infestation in T_7 suppressed the growth of rice plant. Harvest index was differed significantly with different treatments where T_2 (Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}) gave the highest index (39.62%) which was followed by T_1 and T_6 whereas weedy check (T_7) gave the lowest index (Table 4). These results corroborated with the results of Ahmed *et al*. (2005) and Smith and Moody (1979).

Economic efficiency

By economic analysis it was observed that the maximum cost of weeding was involved in case of hand weeding (W_6). The treatment T_2 (Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}) needed the second highest cost (Table 5) which was almost one-third of T_6. Due to the differences of cost of weed control among the treatments, the total cost of production was varied in this experiment. The treatment T_6 involved the maximum cost of production whereas the lowest cost of production was involved in T_7 (Table 5). The net return from Aman rice cultivation was found to be the maximum with the treatment T_6 (two hand weeding) which was almost similar with T_2 followed by T_1 and T_5 (Table 5). Net profit was highest from the treatment T_2 (Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}) which was even higher than T_2 (two hand weeding). The lowest net profit was obtained from T_7 (weedy check) due to its lowest production of grain and straw. The economic analysis also showed that the application of T_2 maximized the profit and benefit-cost ratio (BCR) was the height (1.60) in the treatment (Table 5). The second highest BCR (1.51)

was obtained from the treatment T_1 whereas the lowest BCR (1.10) was obtained from weedy check (T_7). This is due to the lowest yield of grain and straw.

It may therefore be concluded that herbicidal treatments were more profitable than hand weeding. The use of herbicides may be an alternative in controlling weeds more easily and cheaply when there is a labour crisis. From this study it may therefore be concluded that the treatment T_2 ((Ronstar 25EC @ 1.25 L ha^{-1} + IR5878 50 WP @ 120 g ha^{-1}) was the most profitable treatment and can be used as an alternative when labour is a limiting factor in producing transplant Aman rice.

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