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IMPACT OF OXADIAZON AND PYRAZOSULFURON-ETHYL ON RICE AND ASSOCIATED WEEDS IN DRY SEASON RICE CULTIVATION

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ABSTRACT

An experiment was conducted at Bangladesh Rice Research Institute (BRRI), Gazipur Bangladesh in the dry season of 2009 (January-May) to study the efficacy of different postemergence herbicides and select the cost-effective treatment as an option for weed control in dry season rice. Ten different weed control treatments viz. T_1 = Zealus 10 WP at 125 g ha^{-1}, T_2 = Amaraj 10 WP at 150 g ha^{-1}, T_3 = Siniron 10WP at 187 g ha^{-1}, T_4 = Herbikill 10 WP at 150 g ha^{-1}, T_5 = Res Q 25 EC at 1.2 L ha^{-1}, T_6 = Remover 10 WP at 187 g ha^{-1}, T_7 = Safety 10 WP at 200g ha^{-1}, T_8 = Laser 10 WP at 125 g ha^{-1}, T_9 = hand weeding at 15, 30, and 45 DAT and T_{10} = weedy check were compared. The active ingredient of Res Q 25 EC is oxadiazon, whereas the active ingredient of the other products is pyrazosulfuron-ethyl. Eight different weed species were present in the experimental field among which Scirpus maritimus followed by Echinochloa crus-galli were the most dominant in terms of density and importance value. Among the treatments, T_6 (Remover 10 WP) gave the lowest weed density, dry weed biomass and weed index, and the highest weed control efficiency. The yield and yield components of rice (e.g. No. of panicles m^{-2}, No. of grains per panicle, grain and straw yield) were greatly influenced by the treatments. Herbicide treatment T_6 (Remover 10 WP) produced similar yield to hand weeding (T_9), but the weeding cost of T_6 was almost one-sixth of T_9. Maximum marginal return rate with T_6 (Remover 10 WP) suggests that this treatment could be used as alternative tool when labor is a limiting factor in dry season rice cultivation.

Key words: Oxadiazon and pyrazosulfuron-ethyl, herbicide, dry season, weed and rice.

INTRODUCTION

Rice (*Oryza sativa* L.) is the vital food for more than two billion people in Asia and four hundreds millions of people in Africa and Latin

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America (IRRI, 2006). The people in Bangladesh depend on rice as staple food with a tremendous influence on the agrarian economy of Bangladesh. Rice alone constitutes 95% of the food grain production in Bangladesh (Julfiquar *et al*., 1998). Among different groups of dry season rice, *Boro* rice covers about 43.6% of the total rice area and it contributes to 61.3% of the total rice production in Bangladesh (BBS, 2008). *Boro* covers the second largest area of 4.61 million hectares with a production of 17.72 million metric tonnes and the average yield is about 3.84 t ha^{-1} (BBS, 2008). The average yield of rice in Bangladesh is 2.73 t ha^{-1} (BRRI, 2006), which is almost 50% of the average rice grain yield per ha worldwide.

Weed infestation and interference is a serious problem in rice fields that significantly decreases yield. In Bangladesh, weeds reduce rice grain yield by 70-80% in *Aus* rice (early summer), by 30-40% for transplanted (T) *Aman* rice (late summer) and by 22-36% in modern *Boro* rice cultivars (winter rice) (BRRI, 2006; Mamun, 1990). The prevailing climatic and edaphic conditions are highly favorable for numerous weed species that strongly compete with the rice crop. In Bangladesh, the traditional methods of weed control include preparatory land tillage and hand weeding. Usually two or three hand weedings are done in the growing season depending on the nature of weeds, their intensity, and the vigor of rice plants. Mechanical and cultural weed control methods in transplant *Boro* rice are expensive. Especially during periods of labor shortage, late weeding can cause drastic losses in grain yield, while chemical weed control is available, easy to implement, and efficient.

Nowadays the use of herbicides is gaining popularity in rice fields due to their rapid effects and the lower costs compared with the traditional methods (Karim, 2008). The available herbicides for weed control in rice are of overseas origin. The country depends on foreign multinational companies for the supply of herbicides, but usually the companies do not supply the same brand of herbicides for long time. Thus, continuous evaluation of the available herbicides in rice is necessary for the benefit of the farmers of this country. Therefore, the objective of this study was to examine the performance of different postemergence herbicides in comparison with manual weeding for the control of weeds in *Boro* rice.

MATERIALS AND METHODS

An experiment was conducted at Bangladesh Rice Research Institute, Bangladesh during *Boro* season rice (January-May) of 2009. The soil of the experimental field was clay loam with pH of 5.47-5.63. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The plot size was 4m X 4m. Ten different weed control treatments were applied: T_1=Zealus 10 WP at 125 g ha^{-1}, T_2=Amaraj 10 WP at 150 g ha^{-1}, T_3=Siniron 10WP at 187 g ha^{-1}, T_4=Herbikill 10 WP at 150 g ha^{-1}, T_5=Res Q 25 EC at 1.2 L ha^{-1}, T_6=Remover 10 WP at 187 g ha^{-1}, T_7=Safety 10 WP at 200g ha^{-1}, T_8=Laser 10 WP at125 g ha^{-1}, T_9=three hand weedings at 15, 30 and 45 DAT (days after transplanting) and T_{10}=weedy check. The active ingredient of Res Q 25 EC is oxadiazon, whereas the active ingredient of the other products is pyrazosulfuron-ethyl. All the tested commercial herbicides were postemergence and applied at 2 to 3-leaf stage of weeds. Seeds of *Boro* rice cv. 'BRRI dhan29' were sown in the seedbed on December 20, 2008 and transplanted in the main field on January 28, 2009. The planting distance in the field was 20 cm (row-row) × 20 cm (hill-hill). The field was fertilized with urea, triple super phosphate, potassium chloride, gypsum, and zinc sulphate at 220, 100, 60, 60 and 10 kg ha^{-1}, respectively. Except urea, all fertilizers were added during land preparation. Urea was top dressed in three rates at 15, 30 and 45 DAT. Other cultural operations such as gap filling, irrigation, and plant protection were carried out as required. Data regarding weeds were recorded at 50 DAT. Dry weed biomass was determined by drying them in an electric oven at 60^{o}C for 72 hours. Relative weed density (RWD), importance value of weed (IVW), weed control efficiency (WCE), weed index (WI) and marginal rate of return (MRR) were calculated according to the following formulae:

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

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

$$WCE = \frac{\text{Dry weight of weeds in weedy check plots - Dry weight of weeds in treated plots}}{\text{Dry weight of weeds in weedy check plots}} \times 100$$

$$WI = \frac{\text{Grain yield in weed free plot- Grain yield in treated plot}}{\text{Grain yield in treated plot}} \times 100$$

$$MRR = \frac{\text{Marginal gross margin of a treatment}}{\text{Marginal variable cost of that treatment}} \times 100$$

At harvest, various characters of rice plants and yield data were recorded. The data were analyzed following analysis of variance (ANOVA) and mean separations were made by the Multiple Comparison test (Gomez and Gomez, 1984) using the statistical computer program MSTAT-C v.1.2 (Russel, 1986).

RESULTS AND DISCUSSION

Weed infestation

The favorable conditions for dry season rice cultivation are also favorable for the growth of numerous weed species that compete with crop plants. Different weed species from various botanical families infested the experimental plots. The weed species that were present in the experimental field were grasses, broadleaf weeds, and sedges. Most of them belonged to the families Poaceae, Cyperaceae, Pontederiaceae and Oxalidaceae (Table-1). The relative density and importance value of these weed species were also different. The most important weeds in the experimental field were *Scirpus maritimus* followed by *Echinochloa crus-galli*, whereas the least important was *Leptochloa chinensis*. Among the existed weed species, the maximum relative weed density was observed for *Scirpus maritimus*, whereas the minimum relative weed density was observed in the case of *Leptochloa chinensis*. As regards broadleaf weeds, it was observed that these were not dominant in this study.

Table-1. Importance value and relative weed density of the weed flora in the dry season rice.

Weed species	Family	Weed type	Relative weed density (%)	Importance value (%)
Scirpus maritimus L.	Cyperaceae	Sedge	25.21	24.70
Echinochloa crus-galli L.	Poaceae	Grass	21.14	17.60
Monochoria vaginalis L.	Pontederiaceae	Broadleaf	13.65	16.31
Oxalis europea L.	Oxalidaceae	Broadleaf	10.24	14.55
Cynodon dactylon (L.) Pers.	Poaceae	Grass	9.58	10.43
Cyperus difformis L.	Cyperaceae	Sedge	14.09	9.86
Leersia hexandra L.	Poaceae	Grass	3.96	5.25
Leptochloa chinensis L.	Poaceae	Grass	2.13	1.30

Weed control

Weed density was significantly affected by different herbicidal treatments (Fig. 1). Weed density was highest in weedy check plots (T_{10}). Different treatments significantly reduced weed population. Among the treatments, T_8 exhibited the highest reduction (93.6%) of weed density m^{-2}. T_5 and T_9 also showed the same result. Similarly, T_6 and T_9 gave identical results in relation to weed density. Al-Kothayri and Hasan (1990) found that all herbicide treatments significantly reduced the weed populations compared with the weedy check. Similar results were obtained by Hasanuzzaman *et al*. (2008). Significant differences in weed dry weight were observed due to the different weeding treatments (Table-2). Among the treatments, T_6 produced the lowest weed dry matter, which was identical to the other treatment effect. This shows that use of the studied postemergence herbicides reduced the weed biomass effectively. The second lowest weed dry matter was recorded in T_8. The highest weed dry matter (79.6 g m^{-2}) was produced by the weedy check (T_{10}). Weed control efficiency above 80% was found in each treatment. Among the treatments, T_6 showed the best result (92%), which was superior to all the other treatments (Table-2). This may be due to the emergence of fewer weed species. The treatments T_3, and T_4 produced similar results. The lowest weed control efficiency (81%) was shown in T_5. This result was partially supported by the findings of Hasanuzzaman *et al*. (2008). A significant effect on weed index (%) was found due to the different herbicide treatments (Table-2). The lowest weed index (11.6%) was found in T_5, which was identical to the other herbicide treatments. This was due to efficient control of weeds by the herbicide treatments. The highest weed index (88.9%) was found in case of the weedy check.

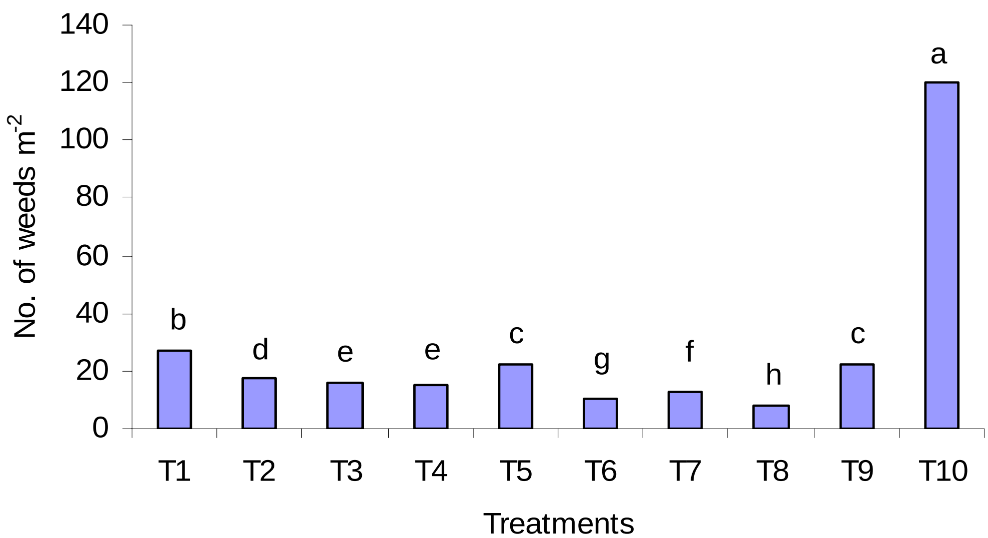

Figure 1. Weed density in rice field as affected by weed control options.

[T_1=Zealus 10 WP at 125 g ha^{-1}, T_2=Amaraj 10 WP at 150 g ha^{-1}, T_3=Siniron 10WP at 187 g ha^{-1}, T_4=Herbikill 10 WP at 150 g ha^{-1}, T_5=Res Q 25 EC at 1.2 L ha^{-1}, T_6=Remover 10 WP at 187 g ha^{-1}, T_7=Safety 10 WP at 200g ha^{-1}, T_8=Laser 10 WP at125 g ha^{-1}, T_9=Three hand weeding at 15, 30 and 45 DAT and T_{10}=Weedy check].

Table-2. Weed dry matter, weed control efficiency, and weed index as affected by the different weed control treatments.

Treatments	Total weed biomass (g m^{-2})	Weed control efficiency (%)	Weed index (%)
T_1=Zealus 10 WP at 125 g ha^{-1}	9.7 b	88.0 e	31.0 b
T_2=Amaraj 10 WP at 150 g ha^{-1}	10.6 b	87.0 f	20.2 b
T_3=Siniron 10WP at 187 g ha^{-1}	8.6 b	89.0 d	27.2 b
T_4=Herbikill 10 WP at 150 g ha^{-1}	8.3 b	90.0 cd	27.1 b
T_5=Res Q 25 EC at 1.2 L ha^{-1}	15.3 b	81.0 h	11.6 b
T_6=Remover 10 WP at 187 g ha^{-1}	6.6 b	92.0 a	14.3 b
T_7=Safety 10 WP at 200g ha^{-1}	11.2 b	86.0 g	23.6 b
T_8=Laser 10 WP at125 g ha^{-1}	7.5 b	90.6 b	23.5 b
T_9=Three hand weeding	8.3 b	89.8 c	-
T_{10}=Weedy check	79.6 a	-	88.9 a
$LSD_{0.05}$	12.9	0.54	20.7

In a column the values having common letter(s) do not differ significantly by LSD test at $P \leq 0.05$.

Yield components

Yield components such as the number of panicles m^{-2} and the number of grains per panicle were significantly influenced by the different weed control treatments used in this experiment (Table-3). Variables such as plant height, panicle length, sterility percent and 1000-grain weight did not differ significantly in the different weeding methods. Among the weeding methods, T_7 had the tallest rice plants (96.5 cm), whereas the non-weeded control plots had the shortest. Apparently, plant height reduction in the non-weeded check was due to competition for longer period of time which prevented rice plants from becoming taller. Higher number of panicles m^{-2} (234) were found in T_5, although statistically similar to T_2, T_4, T_6, T_7, and T_9. This was because the proper control of weeds reduced the weed density and allowed crop plants to have sufficient space, light, nutrients and moisture, which resulted in increased number of panicles m^{-2}. The lowest number of panicles m^{-2} (129.67) were recorded in the weedy check (T_{10}). The treatment T_9 produced the highest panicle length followed by T_5. The shortest panicle length was found in the weedy check (T_{10}). Weeds always compete with crops for the available resources like light, water, nutrients, etc. which are necessary for plant growth to produce more grains (Antigua *et al*., 1988). In this study, the highest weed infestation in the non-weeded plots resulted in the lowest number of grains per panicle. The treatment T_9 produced the maximum number of grains per panicle, although statistically similar to T_5, T_6, T_7, and T_8 (Table-3). This was mainly due to the weed free conditions in these treatments. Hasanuzzaman *et al.* (2008) and Ahmed *et al*. (2005) found that the application of any herbicide resulted in similar number of grains per panicle. In this study, 1000-grain weight was not significantly affected by the weeding treatments. The highest grain weight was observed in T_9 followed by T_3, whereas the lowest in T_{10}. Also, sterility (%) was not significantly affected by the weeding treatments. However, the highest percentage of grain sterility was observed with T_{10} and the lowest with T_1.

Table-3. Plant characters and yield components of transplanted rice as affected by the different weed control treatments.

Treatments	Plant height (cm)	Panicle m^{-2}	Panicle length (cm)	Grains $panicle^{-1}$	1000-grain weight (g)	Sterility (%)
T_1=Zealus 10 WP at 125 g ha^{-1}	96.2	165.7 bc	23.9	99.3 abc	23.8	12.7
T_2=Amaraj 10 WP at 150 g ha^{-1}	96.3	201.7 ab	23.7	100.3 abc	23.1	14.5
T_3=Siniron 10WP at 187 g ha^{-1}	93.1	178.7 b	23.7	91.0 bc	24.1	13.8
T_4=Herbikill 10 WP at 150 g ha^{-1}	93.3	197.3 ab	23.3	83.3 c	24.2	14.5
T_5=Res Q 25 EC at 1.2 L ha^{-1}	95.9	233.7 a	24.0	103.7 ab	23.8	13.1
T_6=Remover 10 WP at 187 g ha^{-1}	95.3	197.3 ab	23.3	103.7 ab	23.6	14.5
T_7=Safety 10 WP at 200g ha^{-1}	96.5	207.3 ab	23.9	99.7 ab	23.6	14.1
T_8=Laser 10 WP at 125 g ha^{-1}	95.8	174.7 bc	23.1	108.7 ab	23.3	14.3
T_9=Three hand weeding	96.0	192.3 ab	24.3	111.3 a	24.1	13.9
T_{10}=Weedy check	91.8	129.7 c	23.1	66.3 d	23.06	17.40
$LSD_{0.05}$		44.94		16.10		

In a column the values having common letter(s) do not differ significantly.

Yield and harvest index

The maximum level of weed control provided by T_9 (three hand weedings) was reflected on the maximum grain yield (5.52 t ha^{-1}) of the transplanted rice cultivation in the dry season (Table-4). However, yield in T_9 did not differ statistically from T_5 and T_6, which might be due to the higher number of panicles m^{-2} and the higher number of grains per panicle in those treatments (Table-3). T_5, T_6, and T_9 produced 40.6%, 39.3, and 46.7% higher yield than the non-weeded control, respectively. This finding is partially supported by Hasanuzzaman *et al.* (2008). Straw yield was also significantly affected by the weeding treatments (Table-4). The highest straw yield was observed with T_9, which however was statistically similar to T_5 and T_6. This shows that the herbicide application was equally effective to the hand weeding treatments. Weedy check plots produced the lowest straw yield. No significant differences in terms of harvest index were found in this study. However, the highest harvest index was observed in T_1 (Zealus 10 WP), where the lowest harvest index was observed in T_{10} (weedy check).

Table-4. Yield and harvest index of dry season rice as affected by the different weed control treatments.

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
T_1=Zealus 10 WP at 125 g ha^{-1}	4.27 b	5.66 c	43.0
T_2=Amaraj 10 WP at 150 g ha^{-1}	4.64 b	6.54 abc	41.44
T_3=Siniron 10WP at 187 g ha^{-1}	4.37 b	6.05 bc	42.1
T_4=Herbikill 10 WP at 150 g ha^{-1}	4.37 b	6.30 bc	41.0
T_5=Res Q 25 EC at 1.2 L ha^{-1}	4.95 ab	6.77 ab	42.2
T_6=Remover 10 WP at 187 g ha^{-1}	4.84 ab	6.75 ab	41.8
T_7=Safety 10 WP at 200g ha^{-1}	4.53 b	6.60 abc	40.6
T_8=Laser 10 WP at125 g ha^{-1}	4.50 b	6.57 abc	40.6
T_9=Three hand weeding	5.52 a	7.39 a	42.9
T_{10}=Weedy check	2.94 c	4.40 d	40.0
$LSD_{0.05}$	0.72	0.96	

In a column the values having common letter(s) do not differ significantly.

Economic analysis of weed control options in dry season rice

Different weed control treatments involved different weed control costs, which affected the total production cost in dry season rice cultivation (Table-5). The economic analysis indicated that the maximum cost of weeding was hand weeding (T_9) due to increased labour requirement. This finding is also supported by Hasanuzzaman *et al.* (2008). The treatment T_5 recorded the second highest cost, which was almost one-third of T_9. The maximum gross return from dry season rice cultivation was found in T_9 (three hand weedings) followed by T_5 (Res Q 25 EC) and T_6 (Remover 10 WP). The lowest gross return was obtained from the weedy check due to its lowest production of grain and straw. The highest gross margin was received from the treatment T_6 (Remover 10 WP) which was even higher than T_9 (Table-5). By cost dominant analysis, it was found that five treatments T_2, T_3, T_5, T_7, and T_9 were cost dominated. In these treatments the cost was higher, but the gross margin was lower than that of many other treatments (Table-6). The marginal analysis of non-dominated treatments showed that the highest marginal rate of return (2630.02%) was found in T_6 (Remover 10 WP) (Table-7). This finding indicates that the highest marginal rate of return (MRR) on investment was obtained by the herbicide Remover 10 WP, which means that this herbicide treatment was more profitable than hand weeding.

Table-5. Treatment wise variable cost (herbicide and labor), gross return, and gross margin of the dry season rice.

Treatments	Variable cost (US $ ha^{-1})	Gross return (US $ ha^{-1})	Gross margin (US $ ha^{-1})
T_1=Zealus 10 WP at 125 g ha^{-1}	16.27	833.4	817.2
T_2=Amaraj 10 WP at 150 g ha^{-1}	29.63	908.4	878.8
T_3=Siniron 10WP at 187 g ha^{-1}	35.15	854.8	819.6
T_4=Herbikill 10 WP at 150 g ha^{-1}	19.45	856.6	837.1
T_5=Res Q 25 EC at 1.2 L ha^{-1}	49.36	967.6	918.3
T_6=Remover 10 WP at 187 g ha^{-1}	26.75	947.1	920.3
T_7=Safety 10 WP at 200g ha^{-1}	37.64	888.4	850.8
T_8=Laser 10 WP at125 g ha^{-1}	24.39	882.6	858.3
T_9=Three hand weeding	158.36	1077.9	919.6
T_{10}=Weedy check	00.00	577.4	577.4

Table-6. Treatment wise cost dominant analysis.

Treatments	Gross margin (US $ ha^{-1})	Variable cost (US $ ha^{-1})	Cost dominated treatments
T_6=Remover 10 WP at 187 g ha^{-1}	920.32	26.75	
T_9=Three hand weeding	919.57	158.36	*
T_5=Res Q 25 EC at 1.2 L ha^{-1}	818.28	49.36	*
T_2=Amaraj 10 WP at 150 g ha^{-1}	878.80	29.63	*
T_8=Laser 10 WP at125 g ha^{-1}	858.25	24.39	
T_7=Safety 10 WP at 200g ha^{-1}	850.79	37.64	*
T_4=Herbikill 10 WP at 150 g ha^{-1}	837.12	19.45	
T_3=Siniron 10WP at 187 g ha^{-1}	819.64	35.15	*
T_1=Zealus 10 WP at 125 g ha^{-1}	817.16	16.27	
T_{10}=Weedy check	577.43	0.00	

Table-7. Marginal analysis of non-dominated treatments.

Treatments	Gross margin (US$ ha^{-1})	Variable cost (US $ ha^{-1})	Marginal variable cost (US $ ha^{-1})	Marginal gross margin (US $ ha^{-1})	Marginal rate of return (%)
T_6=Remover 10 WP at 187 g ha^{-1}	920.32	26.75	2.36	62.07	2630.02
T_8=Laser 10 WP at125 g ha^{-1}	858.25	24.39	4.94	21.13	427.76
T_4=Herbikill 10 WP at 150 g ha^{-1}	837.12	19.45	3.18	19.96	627.76
T_1=Zealus 10 WP at 125 g ha^{-1}	817.16	16.27	16.27	239.73	1473.45
T_{10}=Weedy check	577.43	0.00			

CONCLUSION

It might be concluded that the use of post-emergence herbicides may be an easy and cost-effective alternative for weed control. Application of Remover 10 WP for weed control in dry season rice cultivation maximized the rate of return to capital and can be used as an alternative weed control option in dry season rice cultivation.

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