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Effect of herbicides on weed infestation and yield in *boro* rice

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ABSTRACT

A field experiment was conducted at the agronomy field of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh, under wet land condition during December 2014 to May 2015. The aim was to see the effects of the weed control treatments on crop growth and yield in *boro* rice. Five selected herbicides (Metsulfuron-methyl 20 WG at 50 g/ha, pretilachlor 500 EC at 988 ml/ha, bensulfuran methyl 4%+acetachor 14% 18 WP at 800 g/ha, pyrazosulfuron-ethyl 10 WP at 125 g/ha and butachlor 5G at 25 kg/ha) were tested along with two hand weedings. Population density, fresh and dry weight of weed were taken. Eight weed species belonging to five families, namely, *Echinochloa colonum*, *Paspalums crobiculatum*, *Monochoria vaginalis*, *Leersia hexandra* L., *Scirpus mucronatus* L., *Digitaria sanguinalis*, *Cyperus rotundus* and *Eclipta alba* Hassk were found to grow in the experimental plots. Among the weed control treatments highest grain yield (5.73 t/ha) was produced with the treatment pyrazosulfuron-ethyl 10 WP at 125 g/ha followed by two hand weedings (5.50 t/ha). The increased yield due to application of herbicide contributed mainly from increasing the number of total tillers per plant, effective tillers per plant, filled grains per panicle and 1000-seed weight (g). Maximum benefit : cost ratio with pyrazosulfuron-ethyl 10 WP at 125 g/ha suggested that this herbicidal treatment could be used as an alternative when labour was a limiting factor in producing transplant *boro* rice.

Key words : Herbicide, rice yield, weed infestation

INTRODUCTION

Agriculture is facing numerous problems due to unfavourable weed infestation events and yield of rice production. 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 constitutes 95% of the food grain production in Bangladesh (Julfiquare *et al.,* 1998). In Bangladesh, among different groups of rice transplant, *boro* rice is grown in 4.68 million hectare of land with a production of 18.60 million metric tonnes (USDA, 2015).

Weeds are unwanted plants playing a very significant role in different agro-eco-systems and many of them cause direct and indirect losses. Weeds not only cause huge reduction in crop yield but also increase cost of cultivation, reduce input use efficiency, loss of potentially productive lands, loss of grazing areas and livestock production. These also result in heavy erosion following fires heavily invaded areas, choking of navigational and irrigation canals and reduction of available weeds in water bodies; interfere with crops, reduce quality, responsible for alternate hosts for several insect-pests, diseases, reduce aesthetic picture of ecosystem, loss of biodiversity, as well as affect human and cattle health. At the same time, the continuous use of the same group of herbicides over a period of time on a same piece of land leads to ecological imbalance in terms of weed shift, herbicide resistance in weeds and

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environmental pollutions (Gnanavel and Natarajan, 2014; Sharma, 2014; Kumar, 2014; Park *et al.*, 2014).

In Bangladesh, weed infestation reduces the grain yield by 70-80% in *aus* rice (early summer), 30-40% for transplanted *aman* rice (late summer) and 22-36% for modern *boro* rice cultivars (winter rice) (Mamun, 1990; BRRI, 2006). This loss is a serious threat for the food deficit countries like Bangladesh. So, proper weed management is essential for rice production in Bangladesh. In Bangladesh, traditional methods of weed control practices include preparatory land tillage and hand weeding. Usually two or three hand weedings are normally done for growing a rice crop depending upon the nature of weeds, their intensity of infestation and the crop grown.

Argold 10 EC, Ronstar 25 EC, Butabel, Aimchlor 5 G, Chinese herbicide, Rift 50 EC and Machete 5 G are good selective herbicides with pre- and post-emergence activity against mono and dicotyledonous weeds in rice field. Now-a-days, the chemical methods of weed control are gaining popularity all over the world because of their miraculous results in crop production. In Bangladesh, a very little information is available on the effectiveness of herbicides in controlling weeds in rice, especially in *boro* rice.

The present study was, therefore, undertaken to assess the weed control efficacy of different herbicides in *boro* rice and to assess the effect of herbicides on growth and yield parameters of *boro* rice.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the experimental farm of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh, during the period from December 2014 to May 2015. The soil of the experimental site was clay loam with a pH 5.47-5.63.

Experimental Design and Treatments

Five selected herbicides i.e. H_1–Metsulfuron-methyl 20 WG at 50 g/ha, H_2–Pretilachlor 500 EC at 988 ml/ha, H_3–Bensulfuran methyl 4%+Acetachor 14% 18 WP at 800 g/ha, H_4–Pyrazosulfuron-ethyl 10 WP at 125 g/ha and H_5–Butachlor 5 G at 25 kg/ha were tested along with two hand weedings (HW), 30 and 45 days after transplanting and control (H_0) treatments in a randomized complete block design (RCBD) experiment with three replications.

Methods of Cultivation

Seeds of transplanting *boro* rice cv. Binadhan-5 were sown in seed bed on December 6, 2014 which were transplanted in the main field on January 15, 2015. The planting distance was maintained at 20 × 15 cm. Fertilizer was applied to the plots at 100, 30, 60, 20 and 5 kg/ha of N, P, K, S, Z through urea, triple super phosphate, murate of potash, gypsum and zinc sulphate, respectively. The entire amount of triple super phosphate, murate of potash, gypsum and zinc sulphate was broadcast and incorporated in the soil at final land preparation. The whole amount of urea at 100 kg/ha N was applied as top dressing in three splits. The first split 30% of total amount of urea was applied at 11 days after transplanting (DAT). The second split 30% of total amount of urea was applied at 30 DAT and the last split 40% was applied at panicle initiation stage.

Data Collection and Analysis

In all the cases, herbicides were applied in 4-5 cm standing water in the plots. In case of manual weeding treatment, it included two weedings at 30 and 45 DAT, whereas in weed free treatment weeding was done by hand when they were found. The size of the individual plot was 3 × 3 m. Treatments were assigned in unit plots at random. Weed density was collected from each plot at vegetative stage of rice by using 0.5 × 0.5 m quadrate. The weeds within the quadrate were counted species-wise and converted to number/m^2 multiplied by four. After counting the weed density, the weeds inside each quadrate were uprooted, cleaned, separated species-wise and dried first in the sun and then in an electric oven for 72 h at a temperature of 80°C. The dry weight of each species was taken with an electric balance and expressed in g/m^2. The data on yield and yield components were collected at proper maturity of the crop. All the recorded data were statistically analyzed using a statistical package

MSTAT program of computer and the mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Eight weed species belonging to five families, namely, *E. colonum*, *P. scrobiculatum*, *M. vaginalis*, *L. hexandra* L., *S. mucronatus* L., *D. sanguinalis*, *E. rotundus* and *E. alba* Hassk were found to grow in the experimental plots. Among them, two were broad-leaved, four were grasses and two were sedges.

The effects of weed control treatments on weed density, weed fresh and dry weight (g/m^2) are presented in Table 1. The weed density was influenced by weed management practices. The highest weed density was found in the weedy check treatment, showing the highest weed population values of $48.7/m^2$ and the lowest weed density was found in the treatment with the recommended dose of pyrazosulfuron-ethyl 10 WP at 125 g/ha followed by two hand weedings when the values were 27.0 and $27.3/m^2$ at vegetative stage (Table 1). The weed population was the highest in the weedy check condition and under different weed management treatments, the weed population decreased. Al-Kothayri and Hasan (1990) and Rekha *et al.* (2003) and also reported that the weed population was lower in all weed management treatments compared to the control plot. The weed management practices at vegetative stage had a significant effect on the total fresh and dry weight. The highest weed fresh weight 72.77 g/m^2 was observed in control treatment and the lowest weed fresh weight 21.27 g/m^2 was observed with bensulfuran methyl 4%+acetachor 14% 18 WP at 800 g/ha (Table 1). The highest weed dry weight (g/m^2) was found in the weedy check condition, showing the highest weed dry weight values of 25.62 g/m^2 and the lowest was found in the condition of the recommended dose of two hand weedings followed by pyrazosulfuron-ethyl 10 WP at 125 g/ha treatment, showing the lowest values of 12.95 and 13.19 g/m^2 (Table 1).

Effect on plant characters and yield of *boro* rice plant characters such as plant height, number of total tillers per plant, number of effective tillers per plant, number of filled grains per panicle, number of unfilled grains per panicle, 1000-grain weight (g), grain and straw yields were significantly influenced by the weed control treatments (Table 2). The tallest plant in Binadhan-5 (23.8 cm) was obtained from pyrazosulfuron-ethyl 10 WP at 125 g/ha and the shortest plant height (23.0 cm) was attained by control treatment (Table 2). The shortest plant in the control plot was a result of higher competition for nutrient, air space, light and water between crop plants and weeds. Ghobrial (1983) and Patil *et al.* (1986) observed that increased weed competition in control plots reduced the plant height of *boro* rice. Result of this study showed that control treatment failed to produce more tillers due to severe infestation of weed in the field. Hasanuzzaman *et al.* (2009) reported similar results. The significant highest number of filled grains per panicle (120.0) was produced by pyrazosulfuron-ethyl 10 WP at 125 g/ha in the variety Binadhan-5 (Table 2). The lowest number of filled grains per panicle (102.7) was found due to control treatment. When the weed control treatments were considered, the highest grain yield (5.73 t/ha) was observed in Binadhan-5 treated with pyrazosulfuron-ethyl 10 WP at 125 g/ha that was followed by the treatments combination of two hand weedings (5.50 t/ha), butachlor 5 G at 25 kg/ha (5.20 t/ha), metsulfuron-methyl

Table 1. Effect of weed control treatments on weed density, weed fresh and dry weight at vegetative stage

Treatment	Weed density (No./m^2)	Weed fresh weight (g/m^2)	Weed dry weight (g/m^2)
HW–Hand weeding	27.3	41.66	12.95
H_0–Control	48.7	72.77	25.62
H_1–Metsulfuron-methyl 20 WG at 50 g/ha	37.0	52.25	20.32
H_2–Pretilachlor 500 EC at 988 ml/ha	36.0	42.89	17.0
H_3–Bensulfuran methyl 4%+Acetachor 14% 18 WP at 800 g/ha	28.7	21.27	11.94
H_4–Pyrazosulfuron-ethyl 10 WP at 125 g/ha	27.0	33.72	13.19
H_5–Butachlor 5G at 25 kg/ha	43.3	53.47	19.93
LSD (P=0.05)	NS	NS	NS
C. V. (%)	63.47	73.07	47.42

NS : Not Significant.

Table 2. Effect of herbicide and weed management on the yield and yield contributing characters of *boro* season

Treatment	Plant height (cm)	No. of total tillers/plant	No. of effective tillers/plant	No. of filled grains/panicle	No. of unfilled grains/panicle	1000-seed weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
HW	23.6	8.3	7.5	118.2	15.8	24.20	5.50	6.43
H_0	23.0	6.7	6.4	102.7	10.5	23.17	3.92	5.70
H_1	23.2	7.3	7.0	111.8	15.3	24.20	5.10	6.70
H_2	23.7	7.5	7.0	118.5	13.7	24.00	5.10	6.73
H_3	23.4	7.5	7.1	113.6	12.3	24.03	5.10	6.63
H_4	23.8	8.2	8.0	120.0	11.2	24.50	5.73	6.77
H_5	23.3	7.6	6.5	116.6	18.7	24.17	5.20	6.40
LSD (P=0.05)	1.87	0.62	0.58	2.11	1.64	0.25	0.32	0.19
C. V. (%)	0.70	3.25	3.31	0.74	4.71	0.42	2.36	1.17

20 WG at 50 g/ha, pretilachlor 500 EC at 988 ml/ha, bensulfuran methyl 4%+acetachor 14% 18 WP at 800 g/ha (5.10 t/ha) and the lowest grain yield (3.92 t/ha) was obtained in Binadhan-5 with control treatment (Table 2). This happened due to severe infestation of weeds which led to reduction in all yield components and finally the grain yield. When the weed control treatments were considered in Binadhan-5, the highest straw yield (6.77 t/ha) was observed, while treated with pyrazosulfuron-ethyl 10 WP at 125 g/ha. In the treatments, where weeds were controlled effectively and higher straw yield was recorded, it was due to less competition between weeds and crops for nutrient, water and light. Gaffer and Rikabder *et al.* (1975) and Won *et al.* (2015) also reported similar findings.

Economic Efficiency

By economic analysis, it was observed that the maximum cost of weeding was involved in case of the treatment H_2–Pretilachlor 500 EC at 988 ml/ha (Table 3). Due to the differences of cost of weed control among the treatments, the total cost of production varied in this experiment. The treatment H_2–Pretilachlor 500 EC at 988 ml/ha involved the maximum cost of production, whereas the lowest cost of production was involved in control treatment (Table 3). The net return from *boro* rice cultivation was found to be the maximum with the treatment H_4–Pyrazosulfuron-ethyl 10 WP at 125 g/ha followed by two hand weedings (Table 3). Net profit was highest from the treatment H_4–Pyrazosulfuron-ethyl 10 WP at 125 g/ha which was even higher than two hand weedings. The lowest net profit was obtained from control treatment due to its lowest production of grain and straw.

The economic analysis also showed that the application of H_4–Pyrazosulfuron-ethyl 10 WP at 125 g/ha maximized the profit and benefit : cost ratio (BCR) was the highest (1.72) in the treatment (Table 3). The second highest BCR (1.59) was obtained from two hand weedings (HW) in the treatment, whereas the lowest BCR (1.18) was obtained from control treatment. This was due to the lowest yield of grain and straw. It may, therefore, be concluded

Table 3. Effect of herbicide and weed management on the cost of production, returns and benefit : cost ratio (BCR) of *boro* season

Treatment	Cost of production (Tk/ha)			Gross returns (Tk/ha)	Net profit (Tk/ha)	BCR
	Variable cost (Tk/ha)	Weeding cost (Tk/ha)	Total cost (Tk/ha)			
HW	66,250	3000	69,250	1,10,000	40,750	1.59
H_0	66,250	0	66,250	78,4000	12,150	1.18
H_1	66,250	1450	67,700	10,2000	34,300	1.51
H_2	66,250	3550	69,800	10,2000	32,200	1.46
H_3	66,250	2000	68,250	10,2000	33,750	1.49
H_4	66,250	550	66,800	1,14,600	47,800	1.72
H_5	66,250	3400	69,650	1,0,4000	34,350	1.49

Tk : Taka and BCR : Benefit : cost ratio.

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 H_4–Pyrazosulfuron-ethyl 10 WP at 125 g/ha was the most profitable treatment and can be used as an alternative when labour is a limiting factor in producing *boro* rice.

CONCLUSION

The experiment was carried out at the experimental farm of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during the period from December 2014 to May 2015. The experiment was conducted with the variety of rice, Binadhan-5, with seven different weed management treatments, such as metsulfuron-methyl 20 WG at 50 g/ha, pretilachlor 500 EC at 988 ml/ha, bensulfuran methyl 4%+acetachor 14% 18 WP at 800 g/ha, pyrazosulfuron-ethyl 10 WP at 125 g/ha, butachlor 5 G at 25 kg/ha along with two hand weedings, 30 and 45 days after transplanting and control (H_0). Weed parameters such as the weed density (no./m^2), weed fresh weight (g/m^2) and weed dry weight (g/m^2) were recorded. The most dominant weed species in the experimental plots were : *E. colonum, P. crobiculatum, M. vaginalis,* L. *hexandra* L., *S. mucronatus* L., *D. sanguinalis, E. rotundus* and *E. alba* Hassk. Weed population, fresh weight and dry weight were not significantly affected by the weed management practices. A higher weed density/m^2, weed dry weight (g/m^2) and weed dry weight (g/m^2) were found in the control treatment.

Among these weed control treatments, the application of pyrazosulfuron-ethyl 10 WP at 125 g/ha, followed by the treatments of two hand weedings, resulted in the lowest weed population/m^2 weed fresh weight (g/m^2) and weed dry weight (g/m^2). Among the weed control treatments, highest grain yield (5.73 t/ha) was produced with the treatment pyrazosulfuron-ethyl 10 WP at 125 g/ha followed by two hand weedings (5.50 t/ha). The results of the present study suggest that Binadhan-5 variety could be grown with pyrazosulfuron-ethyl 10 WP at 125 g/ha, followed by the treatments of two hand weedings to maximize yield of *boro* rice. The economic analysis also showed that the application of pyrazosulfuron-ethyl 10 WP at 125 g/ha maximized the profit and benefit : cost ratio (BCR) was the highest (1.72) in the treatment (Table 3). The second highest BCR (1.59) was obtained from two hand weedings (HW) in the treatment, whereas the lowest BCR (1.18).

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