Effect of Cultivars and Herbicides on Weed Growth and Yield of Boro Rice (*Oryza sativa* L.)

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Abstract

The field experiment was conducted during the *boro* seasons of 2008-09 and 2009-10 on clay loam soil of Agricultural Research Farm at Banaras Hindu University (BHU) campus, Varanasi, India to test the efficacy of herbicides under different *boro* rice cultivars. All the herbicidal treatments were significantly superior to unweeded control. Weed count and dry matter under 'Prabhat' was lower than that with other two cultivars, viz. 'Gautam and 'Krishna Hamsa'. Weed control efficiency with 'Prabhat' was higher than other two cultivars. Significantly higher grain yield of 4149.07 kg ha^{-1} was obtained in 'Gautam' cultivar. Pretilachlor @ 1.0 kg (pre emergence) fb (followed by) azimsulfuron @ 35 g a.i. ha^{-1} at 15 DAT with grain yield of 4353.51 kg ha^{-1} was significantly superior to ethoxysulfuron @ 18 g ai ha^{-1}+fenoxaprop @ 56 g ai ha^{-1} at 15 DAT as well as pyrazosulfuron @ 20 g ai ha^{-1} (pre-emergence) fb bispyribac @ 25 g ai ha^{-1} at 25 DAT and was statistically similar to hand weeding twice at 30 and 50 DAT. Among herbicidal treatments, the maximum weed control efficiency of 62.87% and 63.37% in pretilachlor fb azimsulfuron and 84.02% in ethoxysufuron+fenoxaprop were recorded for broad leaved, grasses and sedges, respectively. 'Gautam' cultivar with highest net return of ₹ 24898.94 ha^{-1} and benefit cost ratio of 1.19 and pretilachlor fb azimsulfuron with net return of ₹ 27461.32 ha^{-1} and benefit cost ratio of 1.32 were most profitable among cultivars and herbicidal treatments, respectively.

1. Introduction

Characteristically *boro* (summer) rice is winter season, photo-insensitive, transplanted rice cultivated on supplemental irrigation, often under conditions where farmers' are not able to take any other *rabi* season crop. Uttar Pradesh is the second largest rice growing state in the country, grown in over an area of 6.03 mha and produces 13.10 mt with productivity of 2171 kg ha^{-1}, which is almost near to national productivity (2178 kg ha^{-1}), but much less than productivity of 4022 kg ha^{-1} of Punjab (Anonymous, 2010). Productivity of *boro* rice in eastern Uttar Pradesh is only two third (2.0 t ha $^{-1}$) as against the average productivity of 3.0 t ha^{-1} of eastern India. Butachlor, pretilachlor and anilofos are most commonly used herbicides for control of weeds in transplanted rice. However, continuous and indiscriminate use of herbicides for a longer period may result in the build up of problematic weeds and also development of herbicide resistance in weeds (Srinivasan et al., 1992). Varieties differ in their characters such as growth, vigor and smoothering effects in suppressing the weed growth in *boro* rice cultivation. It is therefore, necessary to evaluate the performance of different rice cultivars along with promising herbicides for appropriate weed management program.

2. Materials and Methods

The field experiment was conducted during *boro* seasons of 2008-09 and 2009-10 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India. The soil of the experimental field was Gangetic alluvial and clay loam in texture with pH 7.49. It was moderately fertile, being medium in available organic carbon (0.51%), low in available nitrogen (196 kg ha^{-1}), and medium in available phosphorus (24.05 kg ha^{-1}) and available potassium (230.05 kg ha^{-1}). The experiment was laid out in split-plot design with three cultivars, viz. Gautam, Prabhat and Krishna Hamsa in main plots and nine weed control treatments, unweeded control, weed free, and weeding twice at 30 and 50 DAT, butachlor @ 1500 g a.i. ha^{-1} (pre-emergence) fb (followed by) 2,4-D @ 500 g a.i. ha^{-1} + NIS (non-ionic surfactants) (0.25 %) at 20-25 DAT , pretilachlor @ 1.0 kg a.i. ha^{-1} fb azimsulfuron @ 35 g a.i. ha^{-1} + NIS (0.2%) at 15 DAT, penoxsulam @ 22.5 g a.i. ha^{-1} + NIS (0.25 %) at 15 DAT, ethoxysulfuron @ 18 g a.i. ha^{-1} + fenoxaprop + safener @ 56 g a.i. ha^{-1} + (NIS 0.25%) at 15 DAT, propanil @ 3000 g a.i. ha^{-1} + trichlorpyr @ 500 g a.i. ha^{-1} + NIS (0.25 %) at 20-25 DAT and pyrazosulfuron @

20 g a.i. ha^{-1} (pre-emergence) fb bispyribac @ 25 g a.i. ha^{-1} + NIS (0.25 %) at 25 DAT in sub-plots. All the herbicides were applied in saturated soil moisture as per protocol of application time. Two to three seedlings $hill^{-1}$ were transplanted at a spacing of 20x10 cm on 27 January, 2009 and 2 February, 2010. Crop was supplied with nutrients @ 120, 60, 60 and 5 kg ha^{-1} (N, P_2O_5, K_2O and Zn). Full quantity of P_2O_5, K_2O and Zn through diammonium phosphate, muriate of potash and zinc sulphate and one half of N was applied as basal dose at the time of puddling. Remaining N in form of urea was top dressed in two equal splits, at 30 and 55 DAT. The data on weed density and dry weight (80 DAT) were recorded with the help of a quadrate (0.5x0.5 m) at two places $plot^{-1}$ and then converted into m^{-2}. The data on weeds were subjected to square root transformation. N-use efficiency is the amount of rice grain produced by each kg of nitrogen applied. Weed control efficiency (%) was calculated by the formula-

$$\text{Weed control efficiency} = \frac{\text{DMC - DMT}}{\text{DMC}} \text{ X } 100$$

Where,
DMC=Dry weight of weeds in unweeded check
DMT=Dry weight of weeds in weed control treatments

3. Results and Discussion

3.1. Effect on weed

The most dominant weed species found in the experimental field throughout the crop growth in rice were grasses (*Cynodon dactylon*, *Echinochloa* spp.), sedges (*Cyperus* spp.) and broad leaved weeds (*Ipomea acquatica*, *Marsilea minuta*, *Nymphaea nouchali*, *Pistia stratiotes*, *Veronica anagallis-aquatica*, *Ranunculus sceleratus* L.) The broad leaved weeds constituted 12.13%, grasses 63.02% and sedges 24.85% of total weed population. The pooled analysis of two years (Table 1) indicated that 'Prabhat' cultivar registered significantly lower number of weeds and total weed dry matter accumulation. The population of broad leaved and sedges in 'Prabhat' were statistical similar with that of 'Gautam' cultivar. Vigorous crop growth and droopy lower leaves of 'Prabhat' cultivar was responsible for curtailing the sunlight for profuse weed growth which ultimately reduced weed infestation. These observations are in agreement with those of Pillai (1977), Thakur et al. (1995) and Singh et al. (2004). The higher weed control efficiencies of 56.12, 55.10 and 67.67% for broad leaved, grasses and sedges, respectively in 'Prabhat' cultivar were might be due to

Table 1: Weed count, weed dry matter and weed control efficiency in *boro* rice as influenced by cultivars and herbicides (pooled data of two years)

Treatment	Total weed population (number $m^{-2)}$			Total dry matter (g^{-1})	Weed control efficiency (%)		
	Broad leaved	Grasses	Sedges		Broad leaved	Grasses	Sedges
Cultivars							
Gautam	1.20(1.81)	4.41(24.59)	2.30(10.00)	7.14(66.23)	45.57	54.43	62.41
Prabhat	1.01(0.85)	3.95(19.96)	2.10(7.52)	6.22(47.94)	56.12	55.10	67.67
Krishna Hamsa	1.34(2.41)	5.20(36.78)	2.83(15.22)	8.20(88.60)	43.46	46.09	58.27
SEm±	0.07	0.09	0.11	0.06	-	-	-
CD (*p*=0.05)	0.23	0.31	0.35	0.21	-	-	-
Herbicides							
Unweeded	2.12(5.44)	9.47(95.78)	6.44(43.11)	14.24(208.27)	0.00	0.00	0.00
Weed free	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	100.00	100.00	100.00
Hand weeding twice at 30 and 50 DAT	1.40(2.22)	2.33(6.00)	2.27(6.67)	3.96(16.50)	41.35	73.78	69.55
Butachlor fb 2,4-D	1.02(0.89)	4.90(25.78)	1.24(2.22)	8.41(75.11)	56.12	41.65	81.39
Pretilachlor fb azimsulfuron	0.86(0.33)	3.61(13.44)	2.73(12.89)	5.38(29.66)	62.87	63.37	65.41
Penoxsulam	1.04(1.00)	4.06(17.22)	1.73(6.89)	7.7563.83)	56.54	53.18	70.86
Ethoxysufuron + fenoxaprop	1.00(1.33)	4.94(25.22)	0.93(0.78)	6.41(42.41)	54.85	46.23	84.02
Propanil + Trichlopyr	1.57(3.33)	6.05(39.00)	4.28(23.33)	10.52(115.91)	33.76	32.35	31.77
Pyrazosulfuron fb bispyribac	0.94(0.67)	4.59(21.56)	1.38(2.33)	7.27(56.64)	59.92	49.70	75.38
SEm±	0.15	0.15	0.26	0.15	-	-	-
CD (*p*=0.05)	0.43	0.41	0.73	0.42	-	-	-

Data are subjected to square root transformation √(X + 0.5); Values within parentheses are original; fb=followed by

lower weed dry matter accumulation as compared to other two cultivars. Among weed control treatments, all the herbicidal treatments except propanil + trichlopyr were equally effective in minimizing the population and the growth of broad leaved weeds, where as pretilachlor fb azimsulfuron was significantly effective in controlling grassy weeds, but ethoxysulfuron + fenoxaprop, butachlor fb 2,4-D and pyrazosulfuron fb bispyribac had better performance in reducing the population of sedges. After weed free and hand weeding twice at 30 and 50 DAT, the total dry matter of weeds were significantly lower under the treatment of pretilachlor fb azimsulfuron followed by ethoxysulfuron + fenoxaprop and pyrazosulfuron fb bispyribac. The highest weed control efficiencies was achieved with pretilachlor fb azimsulfuron recording a WCE of 62.87% for broad leaved, 63.37% for grasses and 84.02% with ethoxysulfuron + fenoxaprop for sedges.

3.2. Effect on nitrogen uptake and N-use efficiency

The highest N-use efficiency, which is the efficiency of N-utilization by rice (kg grain kg^{-1} N applied), was recorded under 'Gautam' followed by the other two cultivars. Among weed control treatments, the highest N-use efficiency (39.36%) was obtained in weed free conditions (Table 2) followed by hand weeding twice (36.85%). Herbicidal treatment pretilachlor fb azimsulfuron (36.19%) was significantly superior to rest of herbicides in recording N-use efficiency followed by ethoxysulfuron + fenoxaprop (34.57%) and pyrazosulfuron fb bispyribac (32.79%) treatments. The lowest N uptake was under unweeded control. The N-uptake by weeds followed the reverse trend. Effective weed control measures reduced the weed biomass which in turn might have reduced weed competition thereby resulting in the improvement of N-uptake by crop. Similar results were also reported by Bali et al. (2006).

3.3. Effect on yield attributes and yield

Almost all cultivars and weed control treatment combinations significantly outnumbered and out-weighted the weedy check in respect to yield and yield attributes, viz. panicles $hill^{-1}$, panicle weight and grains $panicle^{-1}$ (Table 2). The highest value of panicles $hill^{-1}$, panicle weight and grains $panicle^{-1}$ and grain yield were recorded in 'Gautam' as compared to other two cultivars despite of higher weed count and dry matter

Table 2: Yield, yield attributes, N-uptake, N-use efficiency and economics in boro rice as influenced by cultivars and herbicides (pooled data of two years)

Treatments	Panicles $hill^{-1}$	Panicle weight (g)	Grains $panicle^{-1}$	Grain yield (kg ha^{-1})	N-uptake (kg ha^{-1})		NUE (kg grain kg^{-1} N applied)	Net returns (₹ ha^{-1})	Benefit: cost ratio
					Crop	Weeds			
Cultivars									
Gautam	6.94	1.99	77.50	4149	66.55	13.94	34.58	24899	1.19
Prabhat	6.71	1.87	71.17	3781	62.34	11.46	31.51	21352	1.01
Krishna Hamsa	6.21	1.87	73.04	3654	58.24	16.48	30.45	19852	0.94
SEm±	0.20	0.09	1.39	28	0.65	0.43	-	306	0.02
CD (p=0.05)	0.54	N.S.	4.02	91	2.11	1.40	-	999	0.05
Herbicides									
Unweeded	4.28	1.62	60.64	2416	36.07	45.80	20.27	9202	0.50
Weed free	8.25	2.21	86.06	4658	83.41	0.00	39.36	25794	1.00
Hand weeding at 30 and 50 DAT	7.59	2.05	81.82	4413	75.59	3.63	36.85	26804	1.21
Butachlor fb 2,4-D	6.22	1.83	70.27	3600	54.71	18.80	29.77	20573	1.05
Pretilachlor fb azimsulfuron	7.27	2.02	79.17	4354	71.43	5.76	36.19	27461	1.32
Penoxsulam	6.52	1.86	71.91	3850	59.95	12.34	32.08	23089	1.17
Ethoxysufuron + fenoxaprop	7.03	1.95	75.17	4121	67.14	7.27	34.57	25784	1.30
Propanil + Trichlopyr	5.59	1.78	66.88	3389	50.43	21.89	27.73	17855	0.89
Pyrazosulfuron fb bispyribac	6.85	1.89	73.24	3952	62.64	10.17	32.79	21747	0.98
SEm±	0.26	0.06	1.66	39	0.84	0.62	-	407	0.02
CD (p=0.05)	0.60	0.18	4.71	109	2.355	1.75	-	1144	0.06

Values within parentheses are original; fb=followed by; NUE: N-use efficiency

than 'Prabhat' which was also reported by Singh et al. (2004). Among the weed control treatments, maximum yield attributes and yield were recorded in weed free and hand weeding twice at 30 and 50 DAT with an increase of 92.84% and 82.69% in yield over unweeded control. Pretilachlor fb azimsulfuron was most effective in obtaining highest panicles hill^{-1}, panicle weight, grains panicle^{-1} and realizing 80.22% higher grain yield over unweeded control which was also statistically similar to hand weeding twice. Ethoxysulfuron + fenoxaprop combination was next to most effective herbicidal treatment obtaining an increase of 70.60% in grain yield over control. Better control of weeds facilitated the crop for better absorption of nutrients, as evident from N-uptake by crop and weeds. The weed control measures also reduced the weed biomass substantially, which in turn resulted in better N-uptake by crop which might have helped in realizing higher grain yield of rice. Rao (1995) and Jacob and Syriac (2005) also reported similar findings.

3.4. Economics

On the basis of two years mean, the maximum net return and benefit: cost ratio was obtained by 'Gautam' followed by 'Prabhat' cultivar. The corresponding values for net return and benefit: cost ratio were ₹ 24898.94 ha^{-1} and 1.19, and ₹ 21352.30 ha^{-1} and 1.01, respectively. Among herbicides, pretilachlor fb azimsulfuron recorded the highest net returns (₹ 27461.32 ha^{-1}) and benefit: cost ratio (1.32) which was closely followed by ethoxysulfuron + fenoxaprop with net return of ₹ 25783.87 ha^{-1} and benefit: cost ratio of 1.30. Though, weed free condition and hand weeding twice gave the higher yield but net return and benefit: cost ratio was not highest due to involvement of more labour, thus higher cost involved.

4. Conclusion

'Prabhat' followed by 'Gautam' was found to be the most effective *boro* rice cultivar in respect of minimizing weed count of broad leaved weeds, grasses and sedges, total dry matter of weeds, weed control efficiencies and N-uptake by weeds. The cultivar 'Gautam' showed its significant superiority over 'Prabhat' and 'Krishna Hamsa' in respect of yield attributes and yield and had significantly higher N content and uptake. The herbicidal treatment pretilachlor @ 750 g a.i. ha^{-1} (pre-emergence) fb azimsulfuron @ 35 g a.i. ha^{-1} + NIS (0.25%) at 15 DAT was most effective in reducing the population and dry matter of broad leaved weeds and grasses where as ethoxysulfuron @ 18 g a.i. ha^{-1} + fenoxaprop + safner @ 56 g a.i. ha^{-1} + (NIS 0.25%) at 15 DAT was most effective in population of sedges. 'Gautam' cultivar gave significantly higher net return (₹ 24898.94 ha^{-1}) and benefit: cost ratio (1.19) over 'Prabhat' and 'Krishna Hamsa'. Pretilachlor @ 750 g a.i. ha^{-1} (pre-emergence) fb azimsulfuron @ 35 g a.i. ha^{-1} + NIS (0.25%) at 15 DAT recorded significantly higher N-uptake by crop, N-use efficiency due to yield attributes and yield.

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