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Bio-efficacy of herbicides in direct-seeded rice

T.U. Patel*, D.H. Lodaya, A.P. Italiya, D.D. Patel and H.H. Patel
Department of Agronomy, N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat 396 450
**Email: tushagri.ank@nau.in*

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ABSTRACT

A field study was conducted during summer seasons of 2015 and 2016 to evaluate the efficacy of post-emergence herbicides at Navsari Agricultural University, Navsari. Total twelve treatments consisting of pretilachlor 1250 g/ha and pyrazosulfuron-ethyl 25 g/ha as pre-emergence (PE); bispyribac-sodium salt 50 g/ha and cyhalofop-butyl 100 g/ha at 20 DAS as post-emergence; stale seedbed, hand weeding and unweeded check were evaluated. Pretilachlor 1250 g/ha PE or pyrazosulfuron-ethyl 25 g/ha *fb* bispyribac-sodium salt 50 g/ha at 30 DAS suppressed both weed density and dry weight over control. Growth and yield attributes, *viz.* plant height, no. of tillers, no. of panicles/length of panicles and no. of grain/panicles were improved significantly with pretilachlor 1250 g/ha PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS and pyrazosulfuron-ethyl 25 g/ha *fb* bispyribac-sodium salt 50 g/ha at 30 DAS. Similarly, higher rice grain and straw yields and maximum net returns were also associated with these combinations. Pre- and post-emergence application of pretilachlor 1250 g/ha or pyrazosulfuron-ethyl 25 g/ha PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS appeared to be a viable strategy for weed control in direct-seeded rice with higher economic returns.

INTRODUCTION

Weed infestation in direct-seeded rice (DSR) remains the single largest constraint limiting its productivity. Recent estimates showed that average reduction in yield due to weeds varied from 12 to 72% depending upon weed flora and the extent of competition offered by weeds to the crop (Ramachandra *et al.* 2014). As the weeds and rice emerge simultaneously in DSR, the proper time and method of weed control remains a complex phenomenon. An effective early weed management tactic is imperative for any DSR production technology aiming at achieving higher productivity and profitability.

Manual weeding, although efficient in controlling weeds, has been restricted due to several economical and technological factors. Over the years, chemical weed control in DSR has emerged as promising solution of weed problem and expanded manifold as it is easy, quick, economical and feasible. Several pre-emergence herbicides applied either alone or supplemented with hand weeding have been reported to provide fairly adequate weed suppression in DSR. However, limited application time window (0-5 daysafter sowing), a critical water regimeand toxicity to main crop are associated challenges. In this scenario, post-emergence herbicides appear to offer alternate possibility. Mehta *et al.* (2010) reported good control of *Echinochloa crusgalli* with application of bispyribac-Na 30 g/ha at 30 DAS. Therefore, for complex weed flora, pre- and post-emergence herbicides combination help to target broad-spectrum weed control. Keeping above facts in view, the present study was undertaken to find out the suitable pre- and post-emergence herbicides for direct-seeded rice.

MATERIALS AND METHODS

The study was conducted at College Farm, NM College of Agriculture, Navsari Agricultural University, Navsari and Agronomic Research Farm, ASPEE Research Foundation, Mumbai. The soil pH was 7.6 and total soluble salts were 0.79 dS/m. Organic carbon, available nitrogen, phosphorus and potassium were 0.71%, 263, 46 and 412 kg/ha, respectively. A field vacated by maize crop was selected and previous field history reveals the presence of diversified weed flora of summer season.

The experiment was conducted during summers 2015 and 2016 and laid out in a randomized block design with three replications. Total twelve treatments comprising of stale seedbed by using glyphosate 1000 g/ha, pretilachlor 1250 g/ha PE, pyrazosulfuron-ethyl 25 g/ha PE, bispyribac-sodium salt 50 g/ha at 20 DAS, cyhalofop-butyl 100 g/ha at 20 DAS, pretilachlor 1250 g/ha PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS, pretilachlor 1250 g/ha PE *fb* cyhalofop-butyl 100 g/ha at 30 DAS, pyrazosulfuron-ethyl 25 g/ha PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS, pyrazosulfuron ethyl 25 g/ha PE *fb* cyhalofop-butyl 100 g/ha at 30 DAS, hand weeding twice at 20 and 40 DAS, hand weeding thrice at 20, 40 and 60 DAS and unweeded check were included for comparison.

The net plot size was 5 x 3 m. The seed of rice cultivar '*NAUR-1*' was soaked in water for 6 hrs prior to sowing The rice crop was sown in the first week of July with single row hand drill, using a seed rate of 50 kg/ha and maintaining 25 cm distance between crop rows. A basal fertilizer dose of 100:30 kg NP/ha was applied. The whole phosphorus and half of nitrogen were applied at the time of sowing and remaining half nitrogen was applied in two splits at tillering and panicle initiation, respectively. In stale seedbed treatment to facilitate weed emergence, light irrigation was applied in second week of June and the first flush of weeds was controlled by application of glyphosate 1000 g/ha. Herbicides were applied using a knapsack sprayer fitted with flat-fan nozzle with spray volume of 440 l/ha.

Data on weed dynamics (density, dry biomass) was recorded at 20, 40 DAS and at harvest from two randomly selected quadrates (1 x 1 m) from each experimental unit. Weeds were clipped from ground surface, and dried in an oven at 70 ºC for 48 h for determining dry weed biomass. Data on rice yield attributes were recorded from 10 randomly selected plants taken from each net plot and computing their average. Productive tillers/m^2 were counted from two randomly selected sites from each net plot and averaged. A random sample of grain was taken from the produce of each plot, 1000 grains were counted manually and weighed on an electric balance. Treatment wise economics were calculated by considering prevailing market price as, labour: ` 178/ day, one hand weeding: ` 2136/ha, glyphosate: ` 350/ L, pretilachlor: ` 515/L, pyrazosulfuron-ethyl: ` 3000/L, bispyribac-sodium salt: ` 1600/L, cyhalofop-butyl: ` 2200/L, nitrogen (Urea): ` 13.7/kg, phosphorus (SSP): ` 46.3/kg, rice seeds: ` 30/ kg and rice straw: ` 3/kg. The data were subjected to Fisher's analysis of variance technique using "*MSTATC*" statistical software and p d" 0.05 probabilities was applied to compare the differences among treatments' means.

RESULTS AND DISCUSSION

Weed flora

The major weed flora observed in the experimental field consisted of six grass species, five of broad-leaved weeds and one sedge. The grassy weeds were *Cynodon dactylon, Echinochloa colona, Echinochloa crus-galli, Brachiaria ramosa, Eleusine indica,* and *Dactyloctenium aegyptium. Cyperus rotundus* was only sedge and *Boerhavia diffusa, Euphorbia hirta, Alternanthera sessilis, Trianthema portulacastrum, Digera arvensis* and *Physalis minima* were the broad-leaved weeds.

Weed density and dry weight

The data on weed density at 20 days after sowing clearly indicated that weed population in treatment of stale seed bed and pre emergence herbicide treated plots either with pretilachlor 1250 g/ ha or pyrazosulfuron-ethyl 25 g/ha was significantly lower as compared to rest of the treatments (**Table 1**). It clearly indicated that pre-emergence application of herbicides significantly reduced the total weed population during initial periods of crop growth. Pretilachlor is used in various field crops for selective control of many annual and perennial grasses while pyrazosulfuron-ethyl is effective on grasses, dicots and sedges. Similarly at 40 DAS, the lower weed density was recorded with combination of pre- and post-emergence herbicides *i.e.* pretilachlor 1250 g/ha or pyrazosulfuron-ethyl 25 g/ha supplemented with bispyribac-sodium salt 50 g/ha or cyhalofop-butyl 100 g/ha at 30 DAS but these were at par with other treatments including two and three hand weeding for sedges. However, at harvest, the lower weed population was recorded with pretilachlor 1250 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS. Significantly maximum number of weeds was found under unweeded check. These results are in agreement with those reported by Singh *et al.* (2016).

Pretilachlor 1250 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS, pretilachlor 1250 g/ha as PE *fb* cyhalofop-butyl 100 g/ha at 30 DAS, pyrazosulfuron-ethyl 25 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS and pyrazosulfuron-ethyl 25 g/ha as PE *fb* cyhalofop-butyl 100 g/ha at 30 DAS were found equally effective and recorded significantly lower dry weight of weeds at 40 DAS and harvest (**Table 1**). Significantly the highest dry weight of weeds was recorded inunweeded check at 40 DAS and at harvest.

Weed control efficiency and weed index

Among various weed management treatments, significantly higher weed control efficiency were recorded with pretilachlor 1250 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS and pyrazosulfuron-ethyl 25 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS. Similar trend was also reported by Sunil *et al.* (2015).

Pretilachlor 1250 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS emerged as best treatment to suppress the total weed flora as it recorded the lowest weed population and dry weight of weeds as well as recorded highest weed control efficiency. Hence, it was considered as base treatment to calculate weed index. Lower weed index was observed under pretilachlor 1250 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS and pyrazosulfuron-ethyl 25 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS as well found most effective in controlling the weeds. However, the highest weed index and the lowest weed control efficiency was noted under unweeded check.

Crop study

Growth attributes: Plant height and number of tillers/m row length of rice at 60 DAS and at harvest were affected significantly by the different weed management treatments (**Table 2**). Significantly higher plant height and no. of tillers/m row length at 60 DAS and at harvest were recorded with application of pretilachlor 1250 kg/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS. Whereas, significantly the lowest plant height and no.of tillers/ m row length was recorded under unweeded check.

Yield and yield attributes

Pretilachlor 1250 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS and pyrazosulfuron-ethyl 25 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS were found equally effective and recorded significantly higher number of panicles/m row length and grains/panicle at harvest (**Table 2**). Similarly, length of panicle was also recorded higher under pretilachlor 1250 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS. This could be due to the impact of effective weed control. Whereas, the lowest value of all the yield attributes was noted in unweeded check at harvest.

Significantly higher grain (2.0 and 1.9 t/ha, respectively) and straw (4.5 and 4.1 t/ha, respectively) yields were recorded in plots treated with pretilachlor 1250 g/ha or pyrazosulfuron-ethyl 25 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS (**Table 2**). The increase in grain yield under these treatments was due to the fact that the weed population and weed growth remained suppressed during crop growth period, resulting in reduced weed competition which provided better environment for proper development of growth characters, *viz.* plant height and number of tillers/m row length and yield attributes, *viz.* number of panicles/m row length, panicle length and number of grains/panicle, ultimately enhanced the grain yield of rice. Result also revealed that effective weed control in early stages of crop growth is essential for higher grain yield in summer rice crop. The result of present investigation are also in agreement with the findings supported by Sunil *et al.* (2015) and Joshi *et al.* (2015). Contrary to this, unweeded check showed the lowest grain (0.7 t/ ha) and straw (1.7 t/ha) yields.

Table 1. Total weed count at 20 and 40 DAS and at harvest as influenced by weed management in direct-seeded rice (pooled data of two years)

Treatment	Total weeds no./m^2		Dry weight of weeds		Weed index %	WCE %
	40 DAS	at harvest	at 40 DAS g/m^2	at harvest kg/ha		
Stale seedbed by using glyphosate 1000 g/ha	7.3(53.0)	8.7(77.0)	59.0	935.8	47.4	48.1
Pretilachlor 1250 g/ha PE	7.5(55.7)	8.7(69.0)	61.5	926.6	47.1	48.6
Pyrazosulfuron-ethyl 25 g/ha PE	6.7(44.0)	7.9(57.3)	48.7	765.2	43.4	57.6
Bispyribac-sodium salt 50 g/ha at 20 DAS	5.3(27.3)	6.2(39.0)	33.0	479.6	38.0	73.4
Cyhalofop-butyl 100 g/ha at 20 DAS	6.2(38.0)	7.0(40.0)	42.6	601.0	47.7	66.7
Pretilachlor 1250 g/ha PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS	3.4(1067)	3.1(8.7)	11.6	110.2	-	93.9
Pretilachlor 1250 g/ha PE *fb* cyhalofop-butyl 100 g/ha at 30 DAS	3.5(11.3)	3.3(10.0)	12.9	122.8	27.9	93.2
Pyrazosulfuron-ethyl 25 g/ha PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS	3.3(10.0)	3.4(10.3)	11.2	125.5	7.7	93.0
Pyrazosulfuron-ethyl 25 g/ha PE *fb* cyhalofop-butyl 100 g/ha at 30 DAS	3.8(1367)	3.6(12.0)	15.3	144.2	30.5	92.0
Hand weeding twice at 20 and 40 DAS	5.3(2767)	6.7(44.3)	30.5	544.9	33.5	69.8
Hand weeding twice at 20, 40 and 60 DAS	5.5(2933)	4.3(17.3)	32.0	212.0	26.4	88.2
Unweeded check	10.8(117)	12.5(156)	118.5	1802.9	64.8	0.0
LSD (p=0.05)	1.0	1.1	11.2	164.9		

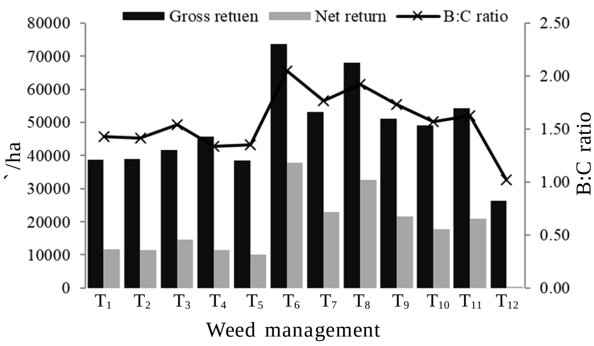
Figure in parentheses refers to original value and outside the parenthesis indicates transformed ($\sqrt{x+1}$) value

Table 2. Growth and yield attributes as influenced by weed management in direct-seeded rice (pooled data of two years)

Treatment	Plant height (cm)		No. of tillers/m^2		No. of panicles/m row length	Length of panicle (cm)	No. of grains/ panicle	Yield (t/ha)	
	60 DAS	at harvest	60 DAS	at harvest				Grain	Straw
Stale seedbed by using glyphosate 1000 g/ha	42.6	65.8	59.5	77.8	49.3	18.5	71.1	1.1	2.4
Pretilachlor 1250 g/ha PE	43.1	66.5	61.3	77.5	49.7	18.1	71.5	1.1	2.4
Pyrazosulfuron-ethyl 25 g/ha PE	42.3	69.5	61.5	78.2	51.2	19.8	74.3	1.1	2.5
Bispyribac-sodium salt 50 g/ha at 20 DAS	44.6	69.5	63.0	80.5	52.5	20.1	79.5	1.2	2.8
Cyhalofop-butyl 100 g/ha at 20 DAS	44.9	64.1	58.5	76.3	49.2	18.3	70.9	1.1	2.3
Pretilachlor 1250 kg/ha PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS	53.7	85.6	78.7	102.3	66.5	25.3	100.6	2.0	4.5
Pretilachlor 1250 g/ha PE *fb* cyhalofop-butyl 100 g/ha at 30 DAS	49.5	77.8	72.7	92.2	56.5	23.5	85.5	1.4	3.2
Pyrazosulfuron-ethyl 25 g/ha PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS	50.8	82.7	76.7	97.5	63.8	24.3	96.5	1.9	4.1
Pyrazosulfuron-ethyl 25 g/ha PE *fb* cyhalofop-butyl 100 g/ha at 30 DAS	48.4	77.5	72.5	90.3	55.3	22.4	84.1	1.4	3.1
Hand weeding twice at 20 and 40 DAS	47.9	72.2	65.8	83.5	54.5	20.8	81.7	1.3	3.0
Hand weeding twice at 20, 40 and 60 DAS	50.6	78.7	73.5	90.2	57.2	24.1	86.3	1.5	3.3
Unweeded check	31.1	43.1	41.7	58.8	40.7	14.9	57.9	0.7	1.7
LSD (p=0.05)	8.7	12.4	11.6	17.8	8.2	3.0	12.7	0.3	0.6

Economics

Pretilachlor 1250 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS secured maximum net returns of ` 37770/ha with the highest B: C ratio of 2.05, which was followed by pyrazosulfuron-ethyl 25 g/ha as pre-emergence *fb* bispyribac-sodium salt 50 g/ha at 30 DAS with net returns of ` 32586/ha and B: C ratio of 1.92 (**Figure 1**). Unweeded check recorded net profit of ` 468/ha with the lowest BCR of 1.02.



T_1: Stale seedbed by using glyphosate 1000 g/ha, T_2: Pretilachlor 1250 g/ha (PE), T_3: Pyrazosulfuron-ethyl 25 g/ha (PE), T_4: Bispyribac-sodium salt 50 g/ha at 20 DAS, T_5: Cyhalofop-butyl 100 g/ha at 20 DAS, T_6: Pretilachlor 1250 g/ha (PE) *fb* bispyribac-sodium salt 50 g/ha at 30 DAS, T_7: Pretilachlor 1250 g/ha (PE) *fb* cyhalofop-butyl 100 g/ha at 30 DAS, T_8: Pyrazosulfuron-ethyl 25 g/ha (PE) *fb* bispyribac-sodium salt 50 g/ha at 30 DAS, T_9: Pyrazosulfuron-ethyl 25 g/ha (PE) *fb* cyhalofop-butyl 100 g/ha at 30 DAS, T_{10}: Hand weeding twice at 20 and 40 DAS, T_{11}: Hand weeding twice at 20, 40 and 60 DAS, T_{12}: Unweeded check

Figure 1. Economics as influenced by weed management in direct-seeded rice

Combined application of either pretilachlor 1250 g/ha or pyrazosulfuron-ethyl 25 g/ha as pre-emergence and bispyribac-sodium salt 50 g/ha at 30 DAS effectively managed weeds for achieving higher and profitable grain yield of direct-seeded rice.

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