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Research Article

Control of complex weed flora in direct seeded rice using bispyribac-sodium in combination with other herbicides

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Abstract

Field experiments were conducted to identify the suitable chemical weed control options in direct seeded rice (DSR) with farmers' participatory research mode at Amrik Farm, Hajwana (Kaithal, Haryana, India) during *kharif* seasons of 2012, 2013 and 2014. The weed control treatments included bispyribac sodium at 25 g ha^{-1}, pendimethalin at 1.0 Kg ha^{-1}, pendimethalin at 1.0 Kg ha^{-1} followed by (*fb*) bispyribac sodium 25 g ha^{-1} + pyrazosulfuron 25 g ha^{-1}, ethoxysulfuron at 18.75 g ha^{-1}, bispyribac sodium at 25 g ha^{-1} *fb* ethoxysulfuron 18.75 g ha^{-1}, weedy and weed free check. The major weeds present in experimental plots consisted of grasses (*Dactyloctenium aegyptium*, *Echinochloa colona*, *Echinochloa crus-galli*, *Leptochloa chinensis*), sedges (*Cyperus difformis*, *Cyperus rotundus*, *Fimbristylis miliacea*) and broad-leaved (*Trianthema portulacastrum*, *Ammannia bacciferra*, *Digera arvensis*, *Eclipta prostrata*, and *Phyllanthus niruri*) weeds. Among herbicide treatments, maximum effective tillers (387 m^{-2}), panicle length (23.6 cm), grains per panicle (76.7), thousand grain weight (22.57 g) and grain yield (3794 Kg ha^{-1}), were recorded with application of pendimethalin at 1.0 Kg ha^{-1} *fb* bispyribac sodium 25 g ha^{-1} + pyrazosulfuron 25 g ha^{-1} and this treatment was statistically at par to weed free conditions. The uncontrolled weed competition caused an average 74.3 per cent grain yield reduction as compared to weed free environment. Among herbicides treatments, weed control efficiency (91.8 %), weed control index (88.0 %) and herbicide efficiency index (23.65%) were highest when pendimethalin at 1.0 Kg ha^{-1} *fb* bispyribac sodium 25 g ha^{-1} + pyrazosulfuron 25 g ha^{-1} were applied to control weeds whereas; weed index (1.20 %) was lowest in this treatment.

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1. Introduction

Rice (*Oryza sativa* L.) is a major source of food for more than half of the world population (Davla *et al*., 2013) especially in South and Southeast Asia and Latin America. In India, rice was grown over an area of approximately 44 m ha with a total production of 109.7 m tones and productivity 2494 Kg ha^{-1} during 2016-17 (Anonymous, 2019). In most of the South Asia, common practice of establishing rice in the rice-wheat system is through puddling followed by manual transplanting. Due to water and labour scarcity, farmers are really concerned about the existing practices of puddling and manual transplanting rice and have started thinking about direct seeding of rice. The direct seeded rice (DSR) is a labour, fuel, time and cost effective technology as compared to transplanted rice. Direct seeded rice has received much attention, because of low input demandincluding labor and

Table 1: Effect of different treatments on weed count, weed dry weight, herbicide and weed indices (Three years' pooled data).

Treatments	Dose (g ha^{-1})	Weed density (no. m^{-2})	Weed dry weight (g m^{-2})	Weed Index (%)	Weed control efficiency (%)	Weed control index (%)	Herbicide efficiency index (%)
Bispyribac sodium	25	6.8(46)*	8.16(65.7)	26.5	53.1	58.4	4.47
Pendimethalin	1000	7.8(60)	9.39(87.3)	36.3	38.8	44.7	2.68
Pendimethalin *fb* bispyribac sodium + Pyrazosulfuron	1000 *fb* 25+25	3.0(8)	4.47(19.0)	1.2	91.8	88.0	23.65
Ethoxysulfuron	18.75	8.0(63)	9.62(91.7)	36.5	35.7	42.0	2.53
Bispyribac sodium *fb* ethoxysulfuron	25 *fb* 18.75	6.2(37)	7.91(61.7)	12.0	62.2	61.0	6.21
Weedy check	-	9.9(98)	12.60(158.0)	74.3	0.0	-	-
Weed free check	-	1.0(0)	1.00(0)	0	100.0	100.00	-
CD at 5%	-	0.5	0.54				

*Values in parentheses are original values as observed and were square root (√x+1) transformed before statistical analysis.

water and both of them are going to be scarce in the coming years (Farooq *et al*., 2011)

Weed dynamics change with the change in the establishment methods. Aerobic soil conditions and dry tillage methods coupled with alternative wetting and drying conditions in DSR boost germination and growth of all type of weeds leading to longer critical period of weed competition from 15 to 50 DAS as against 20-40 DAT in puddle transplanted rice. The lower critical period of weed competition in puddle transplanted rice (PTR) is due to a competitive benefit of one month old rice seedlings over newly emerged weeds compared with emerging DSR seedlings (Rao *et al*., 2007). It is well established fact now that weed competition is more severe under DSR compared to puddle transplant. Major weed flora recorded by various workers (Chhokar *et al*., 2014; Rao *et al*., 2007) under DSR consisted of *Echinochloa crus-galli*, *Echinochloa colona*, *Leptochloa chinensis*, *Eragrostis tenella*, *Brachiaria reptans*, *Dactyloctenium aegyptium*, *Paspalum* sp., *Digitaria ciliaris*, *Eleusine indica* among grasses and *Trianthema portulacastrum*, *Eclipta alba*, *Caesulia axillaries*, *Commelina* sp., *Lindernia crustaceae*, *Euphorbia hirta*, *Phylanthus niruri*, *Amaranthus viridus*, *Celosia argentia*, *Digera arvensis* among broad leaf weeds and *Cyperus rotundus*, *C. diffotmis*, *C. iria*, *Fimbristylis miliaceae* among sedges.

In dry seeded aerobic rice, relative yield loss caused by weeds is as high as 50-91% (Rao *et al*., 2007; Sunil *et al*., 2010; Jayadeva *et al*., 2011), while in PTR, yield loss has been estimated to be only 13% (Azmi, 1992). Thus direct-seeded aerobic rice is highly vulnerable to

Table 2: Effect of different treatments on yield and yield attributing characters (Three years' pooled data).

Treatments	Dose (g ha^{-1})	Effective tillers m^{-2}	Panicle length (cm)	Grains/ panicle	1000 grain weight (g)	Straw Yield (Kg ha^{-1})	Grain Yield (Kg ha^{-1})	Harvest Index (%)
Bispyribac sodium	25	303	22.3	72.0	21.33	4843	2822	36.8
Pendimethalin	1000	285	21.7	69.0	21.13	4315	2447	36.2
Pendimethalin fb bispyribac sodium + Pyrazosulfuron	1000 fb 25+25	387	23.6	76.7	22.57	6145	3794	38.2
Ethoxysulfuron	18.75	292	21.7	69.7	21.10	4357	2437	35.9
Bispyribac sodium *fb* ethoxysulfuron	25 *fb* 18.75	344	23.2	73.3	21.50	5577	3381	37.7
Weedy check	-	102	19.5	46.7	20.60	1751	987	36.1
Weed free check	-	386	23.8	76.7	22.63	6258	3840	38.0
CD at 5%	-	15	1.0	5.0	0.64	243	141	0.2

weeds compared with other rice ecosystems (Anwar *et al.*, 2011).

The present field studies were conducted to identify the suitable herbicides and their combination for effective control of weeds in DSR.

2. Methods and materials

Field experiments were conducted with farmers' participatory research mode at Amrik Farm, Hajwana (Kaithal, Haryana, India) during *kharif* seasons of 2012, 2013 and 2014. The soil of the experimental field was clay loam in texture, low in organic carbon and available nitrogen, medium in phosphorus and high in potash with a pH of 8.2. The experiment was laid out in randomized block design with seven weed control treatments and three replications. Rice cultivar CSR 30 was sown using seed rate of 20 Kg ha^{-1} with seed-cum-fertilizer drill having inclined plates at a row spacing of 20 cm under optimum moisture conditions maintaining sowing depth of 3-4 cm. The treatments included bispyribac sodium at 25 g ha^{-1}, pendimethalin at 1.0 Kg ha^{-1}, pendimethalin at 1.0 Kg ha^{-1} *fb* bispyribac sodium at 25 g ha^{-1} + pyrazosulfuron at 25 g ha^{-1}, ethoxysulfuron at 18.75 g ha^{-1}, bispyribac sodium at 25 g ha^{-1} *fb* ethoxysulfuron at 18.75 g ha^{-1}, weedy and weed free checks.

Pendimethalin as pre-emergence was sprayed just after seeding whereas, bispyribac sodium and pyrazosulfuron at 15 days after seeding (DAS) and ethoxysulfuron at 25 DAS. The individual herbicides were first dissolved individually in the container, and then these were mixed in the sprayer tank for tank mix application of two herbicides. A knapsack sprayer fitted with flat fan nozzle using 375-400 litres of water per hectare was used for spraying the herbicide. Weed population was counted by quadrate method and dry weight was recorded after sun drying of the weeds. Observations on weed dry weight and their density were recorded on 60 DAS by placing a quadrat of 50 cm x 50 cm at two places in each plot. Data on total weed count and weed dry weight were subjected to square root ($\sqrt{x+1}$) transformation to normalize the distribution. The grain yield of rice was recorded at harvest from the net plot area. The various impact assessment indices namely weed control efficiency (WCE), weed index (WI), herbicide efficiency index (HEI) and weed control index (WCI) were calculated as per formulae suggested by Mani *et al.* (1973), Gill and Kumar (1966), Krishnamurthy *et al.* (1975) and Mishra and Tosh (1979), respectively. First irrigation was applied 14 DAS with follow up irrigations at 6-9 days interval. Other cultural practices were as per recommendations for the rice crop.

3. Results and discussion

Rice crop was infested with grassy, sedges and broad-leaved weeds. The major weeds present in experimental site were *Dactyloctenium aegyptium* (Crowfoot grass), *Echinochloa colona* (Jungle rice), *Echinochloa crus-galli* (Barnyard grass), *Paspalum distichum* (Knot grass), *Cynodon dactylon* (Bermuda grass), *Leptochloa chinensis* (Red sprangletop), *Cyperus difformis (*smallflower umbrella-sedge), *Cyperus iria* (rice flatsedge), *Cyperus rotundus* (purple nutsedge), *Fimbristylis miliacea* (fringerush), *Trianthema portulacastrum* (horsepurslane), *Ammannia bacciferra* (Monarch redstem), *Digera arvensis*, *Lindernia spp*., *Eclipta prostrata* (false daisy), *Euphorbia hirta* (garden spurge) and *Phyllanthus niruri* (gale of the wind) and similar weeds were also reported by Singh *et al.* (2016).

3.1 Effect on weeds

All the herbicides applied led to significant lesser count and dry matter of weeds as compared to weedy check at 60 DAS (Table 1). Among herbicide treatments, the lowest weed count (8 m^{-2}) and dry weight (19 g m^{-2}) of weeds was recorded with pre-emergence pendimethalin at 1.0 Kg ha^{-1} *fb* post-emergence bispyribac sodium 25 g ha^{-1} + pyrazosulfuron 25 g ha^{-1} due to diverse weed flora control *(*grasses, sedges and broad leaf weeds). Similar results were also reported by Singh *et al.* (2016). Bispyribac sodium provided effective control of *Echinochloa* sp., some control of broad leaf weeds and *Cyperus difformis*, whereas; growth of *Cyperus rotundus* was checked for some time. Pre-emergence application of pendimethalin at 1.0 Kg ha^{-1} gave good control of some grasses and broad leaf weeds during early growth stage. Ethoxysulfuron @ 18.75 g ha^{-1} gave good control of broad leaf weeds and some sedges. Similar results were also observed by Mann *et al.* (2007). Moreover, *Cynodon dactylon* was not controlled by any herbicide and *Leptochloa chinensis*, *Eragrostis japonica* and *Dactyloctenium aegyptium* were also have some escape.

Among herbicides treatments, weed control efficiency (91.81%), weed control index (87.97%) and herbicide efficiency index (23.65%) were highest with application of pendimethalin at 1.0 Kg ha^{-1} *fb* bispyribac sodium 25 g ha^{-1} + pyrazosulfuron 25 g ha^{-1}, whereas; weed index (1.20 %) was lowest in this treatment (Table 1). Among the herbicides, the post-emergence single application of bispyribac-sodium compared to pendimethalin or ethoxysulfuron application resulted in higher weed control efficiency, weed control index and herbicide efficiency index.

3.2 Effect on yield and yield ttributing characters

The pooled data of all the three years (Table 2) revealed that all herbicide treatments were significantly superior over weedy check in term of effective tillers m^{-2}, panicle length, grains $panicle^{-1}$ and thousand grain weight. Among herbicide treatments, maximum effective tillers (387 m^{-2}) , panicle length (23.6 cm), grains per panicle (76.7) and thousand grain weight (22.57 g) were recorded with application of pre-emergence pendimethalin @ 1.0 Kg ha^{-1} *fb* post-emergence bispyribac sodium 25 g ha^{-1} + pyrazosulfuron 25 g ha^{-1} and these parameters were statistically at par to weed free conditions. The highest grain yield (3794 Kg ha^{-1}), straw yield (6145 Kg ha^{-1}) and harvest index (38.2 %) were also observed in the same treatment (Table 2). The uncontrolled weed population in weedy checks plots resulted in grain yield reduction of 74.3 per cent as compared to weed free environment. Similar results were also reported by Jabran *et al.* (2012). The increase in rice grain yield with application of pendimethalin at 1.0 Kg ha^{-1} *fb* bispyribac sodium 25 g ha^{-1} + pyrazosulfuron 25 g ha^{-1} ranged from 12.2 to 55.7% over other herbicidal treatments. The sequential applications of pre-emergence *fb* post-emergence herbicides enhanced the weed control and resulted in higher grain yield compared to single application of either pre or post-emergence herbicide. However, the single post-emergence application of bispyribac-sodium resulted in significantly higher grain yield compared to pendimethalin or ethoxysulfuron applications. These results are in accordance to the results reported by Singh *et al.* (2016). This yield gain was associated with superior yield attributes (effective tillers, grains $panicle^{-1}$ and grain weight) of the crop.

4. Conclusions

Based on this study, it can be concluded that application of pendimethalin at 1.0 Kg ha^{-1} fb bispyribac sodium 25 g ha^{-1} + pyrazosulfuron 25 g ha^{-1} is highly effective against grass, broad leaf and sedges group of weeds. Bispyribac sodium can effectively be used to control *Echinochloa* spp., and ethoxysulfuron for the control of broad leaf weeds. However, it is better to integrate as many weed management strategies as possible to achieve effective, sustainable, and long-term weed control in DSR. Continuous monitoring to identify the emergence of new weed species and changing weed flora is necessary for economically viable integrated weed management system in DSR.

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