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Effect of new generation herbicides on mixed weed flora and yield of direct seeded rice (*Oryza sativa* L.)

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Abstract

A field experiment was conducted during the "Navarai" season of 2019 and 2020 at Experimental Farm of the Department of Agronomy, Annamalai University, Annamalai Nagar, to find out the effect of new generation herbicides on direct seeded rice (*Oryza sativa* L.). The herbicide used were pre-emergence application of pyrazosulfuron-ethyl 10% WP at 200 g ha^{-1}, pre-emergence application of metsulfuran-methyl 10% + chlorimuron-methyl 10% WP at 20g ha^{-1}, pre-emergence application of pretilachlor 50% EC at 1250 ml ha^{-1}, Early post-emergence application of pretilachlor 6% + pyrazosulfuran-ethyl 0.15% G at 615g ha^{-1}, Early post-emergence application of bispyribac-sodium at 300 ml ha^{-1}. The experimental result revealed that the new generation herbicide has a significant influence on weed flora and yield attributes and yield of direct seeding rice. The result indicated that application of Bispyribac-sodium 10% SC at 300 ml ha^{-1} at 15 DAS + one Hand weeding at 30 DAS recorded the lowest weed population, weed dry matter production and higher weed control index (WCI) and yield. Then twice hand weeding at 15, and 30 DAS was next in order. The lowest weed control index and yield were recorded with un-weeded control.

Keywords: Direct seeded rice, grain yield, weed control index, herbicide

Introduction

Rice is the staple food of more than 60% of the world's population. It is globally grown in 155.62 m ha area with a production of 432.4 m tonnes. India ranks first in the acreage with 43.81 m ha but second in production with 96.43 m t, after china (Singh *et al*., 2019). Direct seeded rice (DSR) is one of the oldest methods of rice cultivation. In the 21st century, scarcity of agricultural land and water and a continuing shortage of labour would encourage a shift toward a direct-seeding method of the rice production system (Mortimer *et al*., 2005). Manual removal of weeds is labour intensive and sometimes, rice mimicking certain grassy weeds, hand weeding is not effective. Weed removal at the critical stage of the crop-weed competition is not possible due to the non-availability of labour and sometimes bad weather conditions. Hence the chemical method of weed control is considered to be an alternative to hand weeding (Singh *et al*., 2007). The chemical method of weed control is effective in controlling the weeds; besides, it reduces the total energy requirement for rice cultivation. The present study was undertaken to study the effect of pre and early post-emergence on weed management and yield in direct-seeded rice.

Materials and Methods

A field experiment was conducted during the "Navarai" season of 2019 and 2020 at the Experimental farm of the Department of Agronomy, Annamalai University, Annamalai Nagar, to find out the influence of pre- and early post-emergence herbicide on weed management in direct sown rice (*Oryza sativa* L.) under wet condition. The soil was clay loam, low in available nitrogen (232.5 kg ha^{-1}), medium in available phosphorus (19.2 kg ha^{-1}) and high in potassium (324.6 kg ha^{-1}), with organic carbon 0.70 % and pH 7.5. The Experiment was laid out in a randomized block design with three replications using a variety of CO-51 as

the test crop. The treatments include T_1- Un-weeded check, T_2- Twice Hand weeding at 15 and 30 DAS, T_3- Pre-emergence application of Pyrazosulfuron-ethyl 10% WP at 200g ha^{-1} at 7 DAS + one Hand weeding at 30 DAS T_4- Pre-emergence application of Metsulfuran-methyl 10% + Chlorimuron-methyl 10% WP at 20g ha^{-1} at 7 DAS + one Hand weeding at 30 DAS T_5-Pre-emergence application of Pretilachlor 50% EC at 1250 ml ha^{-1} at 7 DAS + one Hand weeding at 30 DAS T_6- Early post-emergence application of Pretilachlor 6% + Pyrazosulfuran-ethyl 0.15% G at 615g ha^{-1} at 15 DAS. T_7- Early post-emergence application of Bispyribac-sodium 10% SC at 300 ml ha^{-1} 15 DAS T_8- Early post-emergence application of Pretilachlor 6% + Pyrazosulfuran-ethyl 0.15% G at 615g ha^{-1} at 15 DAS + one Hand weeding at 30 DAS T_9- Early post-emergence application of Bispyribac-sodium 10% SC at 300 ml ha^{-1} at 15 DAS+ one Hand weeding at 30 DAS. The rice variety …… was raised under optimum conditions for agronomic practices and plant protection measures in the field. Observation of individual weed count, total weed flora and weed biomass were taken at 30 and 60 days after sowing (DAS) and also the final yield was taken at the time of harvesting.

Results and Discussion

The major weed flora of the experimental field consist of grasses *Echinochloa colonum* (L.), *Echinochloa crus-Galli* (L.), and *Leptochloa Chinensis* (L.) followed by sedges, *Cyperus rotundus* (L.) and *Cyperus difformis* (L.). Under the category of broad-leaved weeds, *Marsilea quadrifolia* and *Eclipta alba* (L.) were predominant.

Effect of weed control measures on weed population

Different weed control measures significantly influenced the weed population. The data on weed population recorded at 30 and 60 DAS in 2019 and 2020 is furnished in **Table 1**. Among the various weed control measures, early post-emergence application of Bispyribac-sodium 10% SC at 15 DAS + one Hand weeding at 30 DAS recorded the lowest weed population in both the years (6.77 and 8.83 on 30 and 60 DAS in 2019 and 5.12 and 6.58 on 30 DAS and 60 DAS in 2020) and significantly superior to the other treatments. Twice Hand weeding at 15 and 30 DAS was next in order. This might be due to the mode of action of bispyribac-sodium which is selective, systemic, post-emergence herbicide, and it is been absorbed by foliage and roots. Spraying of bispyribac-sodium efficiently destroyed the weeds and it may be ascribed to the trans-laminar activity of bispyribac-sodium. According to Madhulika and Paikra (2014), Bispyribac-sodium is translocated in the plant both by the downward movement to the roots and rhizomes and also an upward movement to the meristem; once the bispyribac-sodium arrives in the meristematic region, it attacks EPSP synthase, an enzyme of the tyrosine, phenylalanine and tryptophan; these amino acids are essential to protein synthesis and cell wall formation. This enzyme blockage might have led to a massive phytotoxic build-up of shikimic acid and benzoic acid, which inhibits respiration, bud development, chlorophyll synthesis and transpiration, leading to the eventual death of the plants, so the weed population is reduced. The highest weed population was recorded in un-weeded control. Because weeding operations are not carried out in un-weeded plots, the weed population is not reduced.

Effect of weed control measures on weed dry matter production (DMP)

All the treatments significantly influenced the weed DMP. The data on weed dry matter production recorded at 60 DAS in 2019 and 2020 is furnished in **Table 2**. Application of early post-emergence herbicide Bispyribac-sodium 10% SC at 15 DAS + one Hand weeding at 30 DAS recorded the lowest weed DMP of 24.87 at 60 DAS on 2019 and 18.53 at 60 DAS on 2020, respectively. Hand weeding twice at 15 and 30 DAS was next in order. This might be due to the fact that the better placement of herbicides on the interspacing provided and the better efficacy of herbicides in controlling the emerging weeds led to the suppression of weeds from the beginning. Bispyribac effectively controlled all categories of weeds and reduced the weed population. There was no phytotoxicity symptom observed during the observation, even at higher doses of this herbicide (Gosh *et al*., 2013). The highest dry matter production was recorded in un-weeded control. Because the weed population was not reduced the weed dry matter also increased.

Table 1. Effect of new generation herbicides on weed population

Treatments	2019		2020	
	Weed population on 30 DAS	Weed population on 60 DAS	Weed population on 30 DAS	Weed population on 60 DAS
T_1- Un-weeded control	106.08 (10.29)	143.29 (11.99)	92.18 (9.60)	121.31 (11)
T_2- Twice Hand weeding at 15 and 30 DAS	12.99 (3.60)	17.74 (4.27)	10.01 (3.16)	13.19 (3.63)
T_3- Pre-emergence application of pyrazo sulfuron-ethyl 10 % WP at 200g ha^{-1} at 7 DAS + one Hand weeding at 30 DAS	44.67 (6.68)	59.45 (7.74)	38.17 (6.17)	45 (6.70)
T_4- Pre-emergence application of metsulfuron-methyl 10% + chlorimuron-ethyl 10 % WP at 20 g ha^{-1} at 7 DAS + one hand weeding at 30 DAS	39.10 (6.25)	53.03 (7.31)	32.53 (5.70)	39.15 (6.25)
T_5- Pre-emergence application of pretilachlor 50 % EC at 1250 ml ha^{-1} at 7 DAS + one Hand weeding at 30 DAS	42.70 (6.53)	56.01 (7.51)	36.15 (6.01)	42.67 (6.53)
T_6- Early post-emergence application of pretilachlor 6% + pyrazosulfuron-ethyl 0.15% G at 615g ha^{-1}at 15 DAS	59.81 (7.73)	88.36 (9.42)	52.33 (7.26)	76.82 (8.76)
T_7- Early post-emergence application of bispyribac-sodium 10% SC at 300 ml ha^{-1} at 15 DAS	74.82 (8.64)	93.67 (9.70)	63.10 (7.94)	81.10 (9.0)
T_8- Early post-emergence application of pretilachlor 6% + pyrazosulfuron-ethyl 0.15% G at 615g ha^{-1}+ one hand weeding at 30 DAS	24.09 (4.91)	30.29 (5.54)	20.18 (4.49)	22.33 (4.72)
T_9- Early post-emergence application of bispyribac-sodium 10% SC at 300 ml ha^{-1} + one Hand weeding at 30 DAS	6.77 (2.60)	8.83 (3.05)	5.12 (2.26)	6.58 (2.56)
S.Ed	0.47	0.59	0.35	0.51
CD (p=0.05)	0.97	1.21	0.73	1.03

Figures in parenthesis are original values; values are square root transformed ($\sqrt{x} + 0.5$)

Effect of weed control measures on weed control index (WCI)

All the treatments significantly influenced the weed control index (WCI). The data on the weed control index in 2019 and 2020 is furnished in **Table 2**. Application of early post-emergence herbicide Bispyribac-sodium 10% SC at 15 DAS + one Hand weeding at 30 DAS recorded the highest weed control index of 92.40% on 2019 and 93.31% on 2020, respectively. Followed by Hand weeding twice at 15 and 30 DAS was next in order. This might be due to the synergistic and cumulative effect of the application of early post-emergence herbicide followed by mechanical weeding. This herbicide effectively controlled the weeds, reduced the weed population and dry matter production and hence the weed control index was high. The last weed control index was recorded with un-weeded control.

Yield parameters

Number of panicle m^{-2}

The effect of herbicide treatment on the number of filled grains panicle^{-1} was found to be highly significant. The data on the number of panicles m^{-2} in 2019 and 2020 is furnished in **Table 3**. Thus, the highest number of panicles was recorded from the plots sprayed with bispyribac-sodium 10% SC on 15

Table 2. Effect of new generation herbicides on weed dry matter production and weed control index

Treatments	2019	2020	2019	2020
	Weed dry matter production on 60 DAS	Weed dry matter production on 60 DAS	Weed control index (WCI)	Weed control index (WCI)
T_1- Un-weeded control	327.38	276.16	---	---
T_2- Twice Hand weeding at 15 and 30 DAS	37.53	27.90	88.53	89.93
T_3- Pre-emergence application of pyrazosulfuron-ethyl 10 % WP at 200g ha^{-1} at 7 DAS + one Hand weeding at 30 DAS	114.26	86.49	65.09	68.80
T_4- Pre-emergence application of metsulfuron-methyl 10% + chlorimuron-ethyl 10 % WP at 20 g ha^{-1} at 7 DAS + one hand weeding at 30 DAS	109.43	80.79	66.57	70.85
T_5- Pre-emergence application of pretilachlor 50 % EC at 1250 ml ha^{-1} at 7 DAS + one Hand weeding at 30 DAS	112.11	85.41	65.75	69.18
T_6- Early post-emergence application of pretilachlor 6% + pyrazosulfuron-ethyl 0.15% G 615g ha^{-1} at15 DAS	157.54	136.96	52.53	50.58
T_7- Early post-emergence application of bispyribac-sodium 10% SC at 300 ml ha^{-1} at 15 DAS	155.39	134.54	51.87	51.46
T_8- Early post-emergence application of pretilachlor 6% + pyrazosulfuron-ethyl 0.15% G 615g ha^{-1}+ one hand weeding at 30 DAS	46.72	34.44	85.72	87.57
T_9- Early post-emergence application of bispyribac-sodium 10% SC at 300 ml ha^{-1} + one Hand weeding at 30 DAS	24.87	18.53	92.40	93.31
S.Ed	3.27	2.81	---	---
CD (p=0.05)	6.65	5.72	---	---

Figures in the parenthesis indicate the original values

Table 3. Effect of new generation herbicides on number of panicle m^{-2}, thousand-grain weight, grain yield (kg ha^{-1})

Treatments	2019	2020	2019	2020	2019	2020
	Number of panicle m^{-2}	Number of panicle m^{-2}	Thou-sand-grain weight	Thou-sand-grain weight	Grain yield (kg ha^{-1})	Grain yield (kg ha^{-1})
T_1- Un-weeded control	216.90	235.10	16.41	16.58	2289.7	2474.66
T_2- Twice Hand weeding at 15 and 30 DAS	403.79	419.97	16.69	16.76	5287.37	5869.52
T_3- Pre-emergence application of pyrazosulfuron-ethyl 10 % WP at 200g ha^{-1} at 7 DAS + one Hand weeding at 30 DAS	385.64	354.45	16.51	16.59	4654.81	5017.63
T_4- Pre-emergence application of metsulfuron-methyl 10% + chlo-rimuron-ethyl 10 % WP at 20 g ha^{-1} at 7 DAS + one hand weeding at 30 DAS	352.38	371.31	16.58	16.63	4784.34	5218.28
T_5-Pre-emergence application of pretilachlor 50 % EC at 1250 ml ha^{-1} at 7 DAS + one Hand weeding at 30 DAS	346.09	363.86	16.53	16.60	4701.2	4936.13
T_6- Early post-emergence applica-tion of pretilachlor 6% + pyrazo-sulfuron-ethyl 0.15% G 615g ha^{-1} at15 DAS	318.53	336.02	16.48	16.59	3804.76	4066.85
T_7-Early post-emergence applica-tion of Bispyribac-sodium 10% SC at 300 ml ha^{-1} at 15 DAS	312.34	329.10	16.46	16.61	3633.85	3925.44
T_8- Early post-emergence applica-tion of pretilachlor 6% + pyrazo-sulfuron-ethyl 0.15% G 615g ha^{-1}+ one hand weeding at 30 DAS	385.64	403.09	16.60	16.70	5045.92	5638.46
T_9- Early post-emergence applica-tion of Bispyribac-sodium 10% SC at 300 ml ha^{-1}+ one Hand weeding at 30 DAS	415.42	436.11	16.72	16.75	5674.91	6230.71
S.Ed	6.64	7.71	NS	NS	90.71	104.50
CD	13.49	15.65	NS	NS	184.16	212.14

DAS + one Hand weeding at 30 DAS, which produced 415.42 panicle m^{-2} in 2019 and 436.11 panicle m^{-2} in 2020 and these treatments followed by Hand weeding twice at 15 and 30 DAS produced maximum panicles. The lowest number of filled grains panicle^{-1} were found in the case of weedy check plots. These results are in conformity with that of Iqbal *et al.,* (2017).

1000 grain weight

The results showed that the thousand-grain weight was not influenced by the treatments. Since thousand-grain weight is mainly governed by the inherent genetic makeup of the cultivar, the treatment effect was not reflected in character.

Grain yield

The yield of rice crop was significantly improved by the application of herbicides in direct-seeded rice. The data on grain yield in 2019 and 2020 is furnished in **Table 3**. Application of Bispyribac-sodium 10% SC at 15 DAS + one Hand weeding at 30 DAS recorded maximum yield of 5674 kg ha^{-1} in 2019 and 6230 kg ha^{-1} in 2020 than all other treatments. The application of this combination improved the availability of natural resources and critical inputs for the establishment of rice crop by reducing the germination of weeds as well as suppressing the weed growth with a proper, efficient mode of action in the initial days of critical crop weed competition. In direct seeded rice, yield and yield attributes were tremendously increased due to the timely control of weeds in a critical period of crop weed competition that has enhanced the availability of nutrients, light and moisture to the crop and also increased the crop yield with timely application of these broad-spectrum herbicides combination. Rao *et al.,* (2019) reported similar results in herbicides usage in direct-seeded rice. The hand weeding twice at 15, and 30 DAS was next in order. The lowest yield was recorded with un-weeded control because of the highest weed population.

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