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Efficacy of new generation herbicides on weeds in direct seeded rice (*Oryza sativa* L.)

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ABSTRACT

A field study was conducted during Kuruvai season of 2020 to evaluate the efficacy of new generation herbicides at Pattathikadu village, Karambakudi Taluk, Pudukkottai district, Tamil Nadu. Eleven treatments were evaluated in RBD design and replicated thrice. Early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS fb hand weeding on 40 DAS suppressed both weed population (20.16 m^{-2})andweed dry matter production (33.59 kg ha^{-1}) and recorded highest weed control index (90.70 %) at 60 DAS over unweeded check. Growth and yield attributes of ricewere significantly improved with early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS fb hand weeding on 40 DAS. Growth attributes viz., plant height (48.80, 78.56 cm at 30, 60 DAS and 94.54 cm at harvest respectively), leaf area index at flowering stage (6.89), number of panicle m^{-2} (434.14), number of tillers hill^{-1} (26.21), dry matter production (6,946, 11,917 and 13,646 kg ha^{-1} at 30, 60 DAS and harvest respectively) and yield attributes viz., number of filled grain panicle^{-1} (94.14)and grain (6540 kg ha^{-1}) and straw (8522 kg ha^{-1}) yieldswere recorded under early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS fb hand weeding on 40 DAS hence appeared to be a viable strategy for weed control in direct seeded rice.

Key words: Direct seeded rice, weeds, new generation herbicides and weed control index

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to family Poaceae and accounts around 40-42 % of the India's total food production. In India, rice is grown on 43.7 million hectares area with a production of 118.26 million tonnes (Directorate of Economics and Statistics, 2019). In Tamil Nadu rice is cultivated in an area of 17.59 lakh hectares and production of 65.26 lakh metric tonnes with productivity of 3.63 t ha^{-1}. Transplanting of rice seedlings in the puddled field is a traditional method of rice cultivation followed in India. Such rice cultivation requires large quantity of water and labour source for nursery preparation and management, pulling out seedlings, transporting and distribution of seedlings to main field(Mahajan and Chauhan, 2016). Direct seeded rice is gaining technology in India due to acute labour shortage during the peak period of transplanting and shortage of water. Direct seeding of rice refers to the process of establishing the crop from seeds sown in the field rather than by transplanting seedlings from the nursery. The three principal system of establishing the direct seeded rice *viz.,* dry seeding, wet seeding and water seeding. Among the various system of rice cultivation, wet-seeded rice (sowing pre-germinated seeds on puddled soil) offers good alternative establishment to transplanting system. Exposal of mechanization, rapid and easy sowing, reduced labour requirement and drudgery, earlier crop maturity, increased water use efficiency, higher tolerance to water deficit, lower methane emission and often higher profit in the areas with assured water supply are the advantages of direct-seeded rice (DSR) over transplanted rice (Chauhan *et al.,* 2012).

Weeds are major problem in direct seeded rice due to simultaneous germination of crop and weed, which exerts competition from the beginning of the crop for nutrients and space. It adversely affects the yield of direct seeded rice due to poor establishment of rice seedlings. In India yearly loss of rice grain production is around 15 million tonnes due to heavy weed infestation (Singh *et al.*, 2018). Weed management is an important practice in rice production which is done through various methods *viz.,* mechanical, biological and chemical method. Biological weed control can be used irrigated low land rice only which is less effective due to poor adaptability and less multiplication of biocontrol agents. Manual and mechanical methods used to control weeds in rice could not find much place among farmers because of the high labour cost, scarcity of labour during the critical period of weed competition and unfavourable weather at weeding time. Under such situation, chemicals have been tremendous contributor to agriculture. In large scale rice farming, herbicide-based weed management has become the smartest and most viable option due to scarcity and high wages of labour (Anwar *et al.*, 2012). Hence, the present study was carried out using rice as test crop.

MATERIALS AND METHODS

The experiment was conducted during *Kuruvai* season of 2020 at Pattathikadu village, Karambakudi Taluk, Pudukkottai district, Tamil Nadu. The field is geographically located at 10°40'N, latitude and 79°11'Elongitude at an altitude of +93 m above Mean Sea Level. The soil of the field was sandy clay loam and neutral in pH (6.2), medium in organic carbon content (5.4 g kg^{-1}), low in nitrogen (245 kg ha^{-1}), medium in phosphorus (21 kg ha^{-1}) and potassium (323 kg ha^{-1}). There were eleven treatments *viz.,* T_1 - Unweeded check, T_2 - Twice hand weeding on 20 and 40 DAS, T_3 - Pre emergence application of penoxsulam + butachlor (0.97% W/W+38.8%W/W SE) @ 2000 ml ha^{-1} on 7 DAS, T_4 - Early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on15 DAS, T_5 - Post emergence application of fenoxaprop-p-ethyl 6.9 % EC (6.7%W/W) @ 875 ml ha^{-1} on 30 DAS, T_6 - Pre emergence application of penoxsulam + butachlor (0.97% W/W+38.8%W/WSE) @ 2000 ml ha^{-1} on 7 DAS fb twice hand weeding on 20 and 40 DAS, T_7 - Early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS fb hand weeding on 40 DAS, T_8 - Hand weeding on 20 DAS fb post emergence application of fenoxaprop-p-ethyl 6.9 % EC (6.7%W/W) @ 875 ml ha^{-1} on 30 DAS, T_9 - Pre emergence application of penoxsulam + butachlor (0.97% W/W+38.8%W/WSE) @ 2000 ml ha^{-1} on 7 DAS fb Early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS, T_{10} - Pre emergence application of penoxsulam + butachlor (0.97% W/W+38.8%W/WSE) @ 2000 ml ha^{-1} on 7 DAS fb Post emergence application of fenoxaprop-p-ethyl 6.9 % EC (6.7%W/W) @ 875 ml ha^{-1} on 30 DAS, T_{11} - Early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS fb post emergence application of fenoxaprop-p-ethyl 6.9 % EC (6.7%W/W) @ 875 ml ha^{-1} on 30 DAS. These eleven treatments were laid out in randomized block design with three replications.Pre germinated seeds of short duration rice variety ADT 37 were sown with spacing of 15×10 cm on well puddled and levelled field with a seed rate of 40 kg ha^{-1}. The crop was fertilized with 120:40:40 kg $N:P_2O_5:K_2O$ ha^{-1} and 50 % nitrogen, entire dose of phosphorous and potassium was applied as basal. The remaining 50 % of the nitrogen was top dressed at two equal splits at tillering and panicle initiation stage. Herbicides were sprayed with flat fan nozzle with 500 litres volume of water per hectare using knapsack sprayer. The observations on weed population and dry matter production of weeds were taken at 30 and 60 DAS. The data on weed population was analyzed after subjecting to square root transformation by adding 0.5 to original values prior to statistical analysis. Weed control index of each treatment was also calculated.

RESULTS AND DISCUSSION

Weed flora

The predominant weed flora of the experimental field consisted of *Echinochloacolona* (L.), *Echinochloacrusgalli* (L.) among grasses, *Cyperusrotundus* (L.), *Cyperusdifformis* (L.) among sedges and *Bergiacapensis, Eclipta alba* (L.) among broad leaved weeds (BLW)(Table 1).

Weed population and weed dry matter production

All the weed management practices significantly reduced the weed population and weed dry matter production of *Echinochloacolonum, Echinochloacrus-galli*among grasses, *Cyperusdifformis, Cyperusrotundus* among sedges, *Bergiacapensis, Eclipta alba among* broad leaved weeds and total weeds as compared with unweeded check (Table 1). Among the weed management practices, early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS fb hand weeding on 40 DAS (T_7) recorded lower individual weed population (m^{-2}) of 2.25, 2.68, 3.27, 3.21, 2.82 and 2.11 and 2.86, 3.16, 5.42, 3.92, 2.61, and 2.79 weeds *viz., Echinochloacolonum, Echinochloacrusgalli*, *Cyperusrotundus*, *Cyperusdifformis*, *Bergiacapensis and Eclipta alba* respectively on 30 and 60 DAS. The above treatment (T_7)recorded lower total weed population of16.34 and 20.16 weeds m^{-2} at 30 and 60 DAS respectively and lower weed dry matter production (29.44 and 33.59 kg ha^{-1} at 30 and 60 DAS respectively) as compared to other weed management practices. Higher weed population and weed dry matter production were recorded in unweeded check. These results were in conformity with the findings of Veeraputhiranand Balasubramanian (2013). Among grasses, *Echinochloacolonum* was most dominant weed followed by *Echinochloacrusgalli* at different growth stages of rice crop. *Cyperusrotundus* and *Cyperusdifformis* were the predominant weeds among all the sedges at various stages of crop growth. Among broad leaved weeds, *Bergiacapensis* was the prevalent weed at the experimental site throughout the crop development stages. Similar weed flora under direct seeded rice condition was also observed by Bharathalakshmi *et al.* (2019).

Table 1: Efficacy of new generation herbicides on individual weed population (m^{-2}) on 30 and 60 DAS

Treatments	30 DAS						60 DAS					
	Echinochloa colonum	*Echinochloa crusgalli*	*Cyperus rotundus*	*Cyperus difformis*	*Bergia capensis*	*Eclipta alba*	*Echinochloa colonum*	*Echinochloa Crusgalli*	*Cyperus rotundus*	*Cyperus difformis*	*Bergia capensis*	*Ecliptaalba*
T_1	3.71 (13.26)	3.64 (13.28)	6.40 (41.02)	4.49 (20.26)	2.93 (8.62)	2.13 (4.61)	5.44 (29.72)	4.91 (24.2)	7.31 (53.54)	5.22 (27.34)	3.65 (13.42)	3.47 (12.04)
T_2	1.90 (3.62)	2.11 (4.48)	2.15 (4.66)	2.19 (4.80)	1.90 (3.61)	1.60 (2.63)	2.02 (4.13)	2.52 (6.37)	2.83 (8.01)	2.53 (6.43)	2.04 (4.20)	1.87 (3.51)
T_3	2.89 (7.85)	3.23 (10.51)	3.93 (15.51)	3.32 (11.21)	2.37 (5.68)	1.93 (3.78)	4.03 (16.32)	4.38 (19.22)	4.70 (22.12)	4.54 (20.70)	3.06 (9.42)	2.41 (5.82)
T_4	2.37 (5.11)	2.39 (5.86)	2.59 (6.82)	2.58 (6.71)	2.16 (4.71)	1.71 (3.01)	3.12 (9.76)	3.01 (9.11)	4.23 (17.91)	3.78 (14.35)	2.51 (6.37)	2.52 (6.38)
T_5	3.38 (10.92)	3.43 (11.82)	4.49 (20.25)	4.04 (16.34)	2.50 (6.30)	2.02 (4.14)	4.14 (17.21)	4.65 (21.70)	5.49 (30.23)	4.91 (24.20)	3.22 (10.41)	2.47 (6.12)
T_6	1.87 (3.52)	2.10 (4.45)	2.16 (4.68)	2.19 (4.82)	1.90 (3.61)	1.62 (2.63)	1.99 (4.01)	2.47 (6.12)	2.82 (7.98)	2.44 (6.02)	2.00 (4.04)	1.83 (3.37)
T_7	1.66 (2.25)	1.61 (2.68)	1.79 (3.27)	1.77 (3.21)	1.66 (2.82)	1.42 (2.11)	1.67 (2.86)	1.77 (3.16)	2.32 (5.42)	1.96 (3.92)	1.59 (2.61)	1.67 (2.79)
T_8	2.23 (4.47)	2.22 (5.10)	2.37 (5.65)	2.42 (5.93)	2.00 (4.04)	1.78 (3.24)	2.53 (6.46)	2.66 (7.10)	3.37 (11.38)	3.09 (9.61)	2.14 (4.63)	1.97 (3.88)
T_9	2.53 (5.90)	3.03 (9.21)	3.66 (13.46)	3.06 (9.42)	2.30 (5.34)	1.85 (3.48)	2.79 (7.82)	3.21 (10.32)	3.86 (14.91)	3.26 (10.67)	2.27 (5.21)	2.15 (4.66)
T_{10}	2.55 (6.0)	3.05 (9.38)	3.76 (14.21)	3.10 (9.66)	2.25 (5.13)	1.86 (3.51)	2.84 (8.12)	3.29 (10.88)	3.88 (15.12)	3.32 (11.06)	2.31 (5.40)	2.17 (4.77)
T_{11}	1.81 (2.74)	1.79 (3.26)	1.96 (3.91)	2.00 (4.05)	1.77 (3.20)	1.50 (2.34)	1.83 (3.41)	1.93 (3.74)	2.50 (6.26)	2.18 (4.77)	1.89 (3.64)	1.74 (3.06)
SEm±	0.04	0.05	0.05	0.04	0.02	0.02	0.03	0.04	0.04	0.03	0.02	0.01
CD (P=0.05)	0.13	0.16	0.15	0.14	0.06	0.06	0.10	0.12	0.14	0.16	0.08	0.04

(Figures in paranthesis are original values)

T_1 - Unweeded check, T_2 –twice hand weeding on 20 and 40 DAS, T_3 - Pre emergence application of penoxsulam + butachlor (0.97% W/W+38.8%W/W SE) @ 2000 ml ha^{-1} on 7 DAS, T_4 - Early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on15 DAS, T_5 - Postemergence application of fenoxaprop-p-ethyl 6.9 % EC (6.7%W/W) @ 875 ml ha^{-1} on 30 DAS, T_6 - Pre emergence application of penoxsulam + butachlor (0.97% W/W+38.8%W/W SE) @ 2000 ml ha^{-1} on 7 DAS fb twice hand weeding on 20 and 40 DAS, T_7 - Early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS fb hand weeding on 40 DAS, T_8 - Hand weeding on 20 DAS fb post emergence application of fenoxaprop-p-ethyl 6.9 % EC(6.7%W/W) @ 875 ml ha^{-1} on 30 DAS, T_9 - Pre emergence application of penoxsulam + butachlor (0.97% W/W+38.8%W/W SE) @ 2000 ml ha^{-1} on 7 DAS fb early post emergence application bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS, T_{10} - Pre emergence application of penoxsulam + butachlor (0.97% W/W+38.8%W/W SE) @ 2000 ml ha^{-1} on 7 DAS fb post emergence application of fenoxaprop-p-ethyl 6.9 % EC(6.7%W/W) @ 875 ml ha^{-1} on 30 DAS and T_{11} - Early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS fb post emergence application of fenoxaprop-p-ethyl 6.9 % EC(6.7%W/W) @ 875 ml ha^{-1} on 30 DAS

Effective weed control in rice ecosystem by rational measures such as early post emergence application of bispyribac sodium 10% SC on 15 DAS accompanied by one hand weeding at 40 DAS might have minimized weed competition for light, moisture and nutrients. Note worthy observation was that sedges were also controlled to a remarkable extent. *Cyperusrotundus, Cyperusdifformis* were effectively controlled, which may be attributed to rapid translocation of bispyribac sodium through apoplast and symplast movement through cortex and epidermis cells from foliage and roots of underground organs and inhibition of amino acid biosynthesis pathways. This coupled with reduced availability of photosynthesis to rhizomes might have decreased the food reserves in the rhizomes of these sedges inhibiting sprouting of rhizomes. This was in line with the findings of Das *et al.,* (2014). The result of study showed that early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS followed by hand weeding on 40 DAS markedly reduced the weed population, weed dry matter production and weed control index. The effective broad spectrum control of weeds, particularly grasses, sedges and broad leaved weeds by bispyribac sodium 10 % SC @ 200 ml ha^{-1}on 15 DAS followed by one hand weeding on 40 DAS due to blocking of their perennation process and inhibition of their further rejuvenation and growth might have resulted in lesser weed population and weed DMP. Moreover, mode of action of bispyribac sodium is selective, systemic, early post emergence herbicide and it has been absorbed by foliage and roots. These findings are in line with the studies of Madhulika Singh and Paikra, (2014).

Table 2: Efficacy of new generation herbicides on total weed population (m^{-2}), weed dry matter production on 30 and 60 DAS, weed control index at 60 DAS and yield in direct seeded rice

Treatments	Weed population (m^{-2})		Weed dry matter production (kg ha^{-1})		WCI	Grain yield	Straw yield
	30 DAS	60 DAS	30 DAS	60 DAS	(%)	(kg ha^{-1})	(kg ha^{-1})
T_1	10.03 (100.71)	12.65 (160.20)	210.31	361.52	----	2412	3805
T_2	4.88 (23.81)	5.68 (32.65)	40.32	58.18	83.90	5633	7661
T_3	7.38 (54.54)	9.67 (93.60)	83.78	146.50	59.47	3543	5315
T_4	4.64 (21.52)	7.99 (63.88)	36.13	137.25	62.03	3965	5715
T_5	8.35 (69.77)	10.48 (109.87)	129.25	159.13	55.98	3191	4866
T_6	4.87 (23.71)	5.61 (31.54)	37.13	55.08	84.76	5795	7823
T_7	4.02 (16.34)	4.48 (20.16)	29.44	33.59	90.70	6540	8522
T_8	5.33 (28.43)	6.56 (43.06)	47.37	69.01	80.91	5265	7340
T_9	6.84 (46.81)	7.34 (53.99)	65.89	76.13	78.94	4549	6581
T_{10}	6.92 (47.89)	7.43 (55.29)	66.48	76.90	78.72	4336	6260
T_{11}	4.41 (19.50)	4.98 (24.88)	32.81	41.74	88.45	6190	8201
SEm±	0.07	0.11	1.10	1.44	-	72.30	107.4
CD (p=0.05)	0.22	0.33	3.28	4.30	-	214.75	319

(Figures in paranthesis are original values)

Among the different weed management practices, the application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS fb one hand weeding on 40 DAS performed superior than the others by registering lower total weed population and weed dry weight(Table 2). This might be due to the fact that the better placement of herbicides on the inter spacing provided and the better effect of herbicide in controlling the emerging weeds let to suppression of weeds from the beginning. There was no phyto toxicity symptom observed during the observation by using the herbicide bispyribac sodium 10 % SC on 15 DAS (Ghosh *et al.,* 2013). The weed control index at 60 DAS was maximum in early post emergence application of bispyribac sodium 10 % SC @ 200 ml ha^{-1} on 15 DAS fb hand weeding on 40 DAS (90.70 %). Similar findings were also reported by Madhulika Singh and Paikra, (2014).

The data on yield and yield attributes were significantly improved by the application of herbicides in direct seeded rice. Among the different weed management practices, the application of bispyribac sodium 200 ml ha^{-1} on 15 DAS fb hand weeding on 40 DAS recorded maximum number of paniclesm^{-2} (434.14), number of filled grains panicle^{-1} (94.14), grain (6540kg ha^{-1}) and straw (8522 kg ha^{-1}) yield and harvest index (43.37) than all other treatments. By reducing the weed population stable environment for direct seeded rice has enhanced the uptake of essential nutrients and translocation of photosynthates from the source to sink which influenced the yield attributes positively. These findings are in conformity with Jeet *et al.* (2020).

It may be concluded that the results strongly emphasis the role of new generation early post emergence herbicide in controlling weeds in direct seeded rice. The timely application of early post emergence herbicide bispyribac-sodium fb one hand weeding on 40 DAS was found to be a feasible practice for direct seeded rice cultivation in managing weeds by increasing weed control efficiency.

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