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Effect of Spacing and Weed Management Practices on Yield Parameters and Yield of Direct-seeded Rice

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ABSTRACT

Background: Field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Thiruchirappalli, Tamil Nadu during the *rabi* season of 2022-23 to evaluate the effect of spacing and weed management practices of yield parameters and yield of direct seeded rice (DSR) under sodic soil using three levels of spacing and seven weed management strategies.

Methods: The main plots were spacing of 20 × 15 cm, 20 × 20 cm and 25 × 25 cm. Sub-plot consisted of weed management practices in DSR *viz*., pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS, pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + cono weeding at 20 DAS + hand weeding (HW) at 40 DAS, pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + cono weeding at 20 DAS and 40 DAS, pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium at 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS, pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium at 25 g ha^{-1} at 20 DAS + HW at 40 DAS, hand weeding at 20 and 40 DAS and unweeded control. The field experiment was laid out in split plot design with three replications.

Result: The results indicated that lower total weed density (40.39 no. m^{-2}), dry weight of weeds (85.52 g m^{-2}) and higher WCE (77.5%) were registered under 20 × 15 cm which was on par with spacing of 20 × 20 cm. The higher number of productive tillers m^{-2} (389), number of grains $panicle^{-1}$ (192), number filled grains $panicle^{-1}$ (187), grain yield (4546 kg ha^{-1}) and straw yield (6714 kg ha^{-1}) were observed under spacing of 20 × 20 cm. Application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS possessed the lowest total weed density (7.67 no. m^{-2}), dry weight of weeds (12.63 g m^{-2}), higher WCE (97.0) at 45 DAS and significantly improved the yield parameters and yields compared to unweeded control. The highest grain and straw yields were recorded from interaction between 20 × 20 cm and pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS.

Key words: Direct seeded rice, Spacing, Weed management practices, Yield, Yield attributes.

INTRODUCTION

Rice (*Oryza sativa* L.) is the stable food for more than 60 per cent of the world population and its cultivation secures a livelihood for more than two billion people (Manisankar *et al*., 2020). Rice is grown on 167 million ha worldwide, with Asia accounting for 146 m ha. Above 90 per cent of the globally produced rice is consumed in Asia. In India, rice is grown in an area of 45.7 m.ha with a production of 124.3 m.t and an average productivity of 2.7 t ha^{-1}. In Tamil Nadu, rice is cultivated in an area of 2.2 m.ha with a production of 7.9 m.t and a productivity of 3566 kg ha^{-1} (Indiastat, 2021).

In Tamil Nadu, rice is being cultivated under different ecosystems *viz*., transplanted puddled lowland rice, direct seeded lowland rice (Wet seeded rice in puddled soil and Dry seeded rice in un-puddled soil), dry seeded upland rice and deep water rice. Most of the farmers in the intensive cropping areas are shifting from conventional transplanting to System of Rice Intensification (SRI) and direct seeded rice due to shortage of labour and scarcity of water (Rathika and Ramesh, 2018). Direct seeded rice (DSR) is one of the crop establishment methods in the field that involves sowing the seeds directly rather than transplanting the seedling from a nursery (Kaur and Singh, 2017). It is the best alternative method, which, in the absence of transplant shock, requires only 35 to 57 per cent water. DSR has one week earlier crop maturity and lowers the laborious cost over transplanted rice (Patel *et al.,* 2018). DSR is subject to more severe weed infestation than transplanted lowland rice, because in DSR weeds germinate simultaneously with rice (Ramesh and Rathika, 2020). Weeds are a major biotic constraint to the success of direct-seeded rice compared to conventional method of rice cultivation because emerging DSR seedlings are less competitive with concurrently emerging weeds, which compete with rice for moisture, nutrients and light

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(Kumar *et al.,* 2008). The control of weeds during critical period of crop-weed competition is very important so as to avoid yield loss (Ramesh and Rathika, 2016). In direct seeded rice (DSR) under puddled condition, grasses cause maximum yield reduction followed by sedges and broad leaved weeds (Rathika *et al*., 2020). Mechanized drum seeders with increased row-to-row spacing allow for an improved integrated weed management strategies *viz.,* chemical, mechanical and manual weeding, during the critical period of crop-weed competition for effective, long-term and sustainable weed control in the DSR system (Prakash *et al.,* 2015). Application of combined weed management practices can ensure control weeds in direct seeded rice resulting higher uptake of nutrients by the crop to produce higher grain yields to the farmers. Hence the present investigation has been carried out to develop proper spacing along with weed management for direct seeded rice cultivation under sodic soil condition.

MATERIALS AND METHODS

The field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Thiruchirappalli, Tamil Nadu, India and study area location was 10°45′N latitude, 78°36′E longitude and 85 m above MSL. The soil of the experimental site was sandy clay loam in texture with pH of 9.0 and EC 0.2 dSm^{-1}. The initial soil fertility status showed that low organic carbon (0.47 per cent), low available N (223 kg ha^{-1}), medium available P_2O_5 (14.2 kg ha^{-1}) and high available K_2O (284 kg ha^{-1}). The field experiment was laid out in split plot design with three replications. The main plots were spacing of 20 × 15 cm, 20 × 20 cm and 25 × 25 cm. Sub-plot consisted of weed management practices in DSR *viz*., pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS (S_1), pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + cono weeding at 20 DAS + hand weeding (HW) at 40 DAS (S_2), pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + cono weeding at 20 DAS and 40 DAS (S_3), pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS (S_4), pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium at 25 g ha^{-1} at 20 DAS + HW at 40 DAS (S_5), hand weeding at 20 and 40 DAS (S_6) and unweeded control (S_7). The medium-duration variety TNAU Rice TRY 3 was chosen for this field experiment. The rice variety (TNAU Rice TRY 3) was developed by crossing ADT 43 with Jeeraga samba. Seed rates were required 25, 21 and 18 kg ha^{-1} while using 20 × 15, 20 × 20 and 25 × 25 cm of drum seeder, respectively. Sprouted seeds were directly sown in puddled soil under waxy conditions using different spaced drum seeders. Weed management practices were obtained through different weed management strategies such as pre-emergence, post-emergence herbicides, mechanical weeding (cono weeder) and manual weeding.

The observation on yield attributes *viz*., number of productive tillers m^{-2}, panicle length, number of grains panicle^{-1}, number of filled grains panicle^{-1} and test weight were recorded at harvest stage. The grain and straw yields were calculated from each treatment of net plot was harvested, threshed, cleaned and weighted at 14 per cent of moisture content. The straw was harvested from each plot, sun dried for three days. Grain and straw yields were expressed as kg ha^{-1}. The data collected from the field experiment was statistically analyzed using the procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Weed flora

The dominated weed species presented in the experimental site are *Cynodon dactylon, Echinochola colona* and *Echinochloa crus-galli* among the grasses, *Cyperus iria*, *Cyperus difformis* and *Cyperus rotundus* among the sedges and *Eclipta alba* and *Ammannia baccifera* among the broad leaved weeds. Similar weed flora have been observed in direct seeded rice under sodic soil condition as reported by Kokilam (2017); Rathika and Ramesh (2019); Palani *et al.* (2020).

Effect of spacing on weed dynamics

Plant spacing had significant effect on total weed density, total weed biomass and weed control efficiency in direct seeded rice (Table 1). Spacing of 20×15 cm recorded significantly the lowest total weed density (40.39 no. m^{-2}), total weed dry weight (85.52 g m^{-2}) and higher weed control efficiency (77.5%). This was on par with 20×20 cm of spacing which was registered the lowest total weed density (41.70 no. m^{-2}), total weed dry weight (87.28 g m^{-2}) and higher WCE (77.2%) at 45 DAS as compared with spacing of 25 × 25 cm. This might be due to spacing of 25 x 25 cm which allows weed seeds to germinate and to develop vigorous weed population under lower density of crops. However, 20 × 15 cm and 20 × 20 cm of spacing increases the light interception by the plants, which lowers the availability of sunlight for weed growth under the canopy of the crop and stimulate the ability of crop to suppress the weeds. This is in agreement with the findings of Khan *et al.* (2017) and Daba *et al.* (2022).

Effect of weed management practices on weed dynamics

Total weed density

The application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS registered the lowest weed density (7.67 no. m^{-2}) at 45 DAS and it was on par with pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium at 25 g ha^{-1} at 20 DAS + HW at 40 DAS and hand weeding at 20 and 40 DAS (7.95 and 8.08 no. m^{-2}, respectively). The next best treatment was significantly recorded the lower weed density by application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + cono weeding at 20 DAS and 40 DAS which was on par with pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + cono weeding at 20 DAS + hand weeding at 40 DAS (20.69 and 20.96 no. m^{-2}, respectively). This might be due to the fact that application of pre-

Table 1: Effect of spacing and weed management practices on total weed density, weed dry weight and WCE at 45 DAS.

	Total weed density (No. m-^{2})				Weed dry weight (g m^{-2})				Weed control efficiency (%)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	7.90 (61.94)	8.06 (64.47)	9.60 (91.63)	8.55 (72.68)	11.10 (122.71)	11.25 (125.97)	13.18 (173.34)	11.88 (140.67)	67.7	67.1	61.9	65.5
S_2	3.99 (15.45)	4.21 (17.25)	5.54 (30.17)	4.63 (20.96)	5.98 (35.21)	6.14 (37.16)	7.36 (53.64)	6.52 (42.00)	90.7	90.3	88.2	89.7
S_3	3.98 (15.38)	4.20 (17.11)	5.49 (29.60)	4.60 (20.69)	5.95 (34.90)	6.11 (36.85)	7.32 (53.11)	6.49 (41.62)	90.8	90.4	88.3	89.8
S_4	2.26 (4.61)	2.33 (4.93)	3.74 (13.48)	2.86 (7.67)	2.99 (8.44)	3.12 (9.21)	4.56 (20.25)	3.62 (12.63)	97.8	97.6	95.5	97.0
S_5	2.29 (4.73)	2.37 (5.14)	3.81 (13.98)	2.91 (7.95)	3.05 (8.79)	3.16 (9.50)	4.59 (20.57)	3.67 (12.95)	97.7	97.5	95.5	96.9
S_6	2.30 (4.81)	2.39 (5.22)	3.83 (14.20)	2.93 (8.08)	3.09 (9.05)	3.17 (9.58)	4.63 (20.93)	3.70 (13.19)	97.6	97.5	95.4	96.8
S_7	13.28 (175.81)	13.35 (177.76)	14.93 (222.40)	13.87 (191.99)	19.49 (379.54)	19.57 (382.66)	21.33 (454.41)	20.15 (405.54)	0.0	0.0	0.0	
Mean	6.39 (40.39)	6.50 (41.70)	7.74 (59.35)		9.27 (85.52)	9.37 (87.28)	10.69 (113.75)		77.5	77.2	75.0	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	1.00	1.33	2.36	2.30	2.53	3.12	5.62	5.41	-	-	-	-
CD (P=0.05)	2.78	2.70	5.10	4.68	7.04	6.34	12.25	10.98	-	-	-	-

emergence herbicides prohibits weed seed germination in the initial stage; similarly, post-emergence controls the weeds efficiently at the later stages and also adoption of cono weeding effectively incorporate the weeds while concurrently improved the soil aeration, which resulted in lower total weed density of grasses, sedges and broad leaved weeds. Unweeded control recorded higher weed density (192 no. m^{-2}). The corroborated with the findings of Rathika and Ramesh (2018) and Kokilam *et al.* (2020).

Weed dry weight

Application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS registered the lowest weed dry weight of 12.63 g m^{-2}. It was on par with pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + HW at 40 DAS and hand weeding at 20 and 40 DAS (12.95 and 13.19 g m^{-2}, respectively) at 45 DAS. This finding might be due to lower crop-weed competition throughout the crop weed competition period because of broad spectrum herbicides and periodical weed control strategies to DSR. This is in agreement with the findings of Sangeetha (2006) and Sivakumar *et al.* (2021). Unweeded control recorded higher weed dry weight of 405.54 g m^{-2}.

Weed control efficiency

Application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS recorded higher weed control efficiency (97.0%). This was on par with pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + HW at 40 DAS and hand weeding at 20 and 40 DAS (96.9 and 96.8%, respectively) at 45 DAS. This finding was similar to that reduction of weed biomass was attained due to pre emergence and post emergence supplemented with mechanical weeding and hand weeding in DSR. The corroborated with the findings of Kokilam *et al.* (2020) and Sivakumar *et al.* (2021).

Interaction effect on weed dynamics

The interaction effect of spacing and weed management practices were significantly influenced the weed density, dry weight of weeds. The lowest weed density and dry weight of weeds was found direct seeded rice sown at spacing of 20 × 15 or 20 × 20 cm with application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS, which was statistically on par with application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + HW at 40 DAS compared to unweeded control. The finding clearly indicated that density of crop population with appropriate weed management strategy suppress the weed dynamics under DSR situation. The interaction between spacing and weed management was in correlation with result of Nayak *et al.* (2014).

Effect on yield attributes

Among spacing, the highest yield attributes were significantly recorded with spacing of 20 × 20 cm (Table 2). This was followed by 20 × 15 cm. The highest number of productive tillers m^{-2} (389), panicle length (27.2 cm), number of grains $panicle^{-1}$ (192), number filled grains $panicle^{-1}$ (187) and test weight (24.7 g) were registered under spacing of 20 × 20 cm, which was followed by spacing of 20 x 15 cm while the lowest yield attributes were recorded in spacing of 25 x 25 cm under sodic soil condition. The finding revealed that spacing of 20 × 20 cm provided significantly higher yield attributes compared to 20 × 15 cm and 25 × 25 cm of spacing. This might be due to lower intra-crop competition helps to avail the essential resources *viz*., solar radiation, nutrients, moisture and photosynthetic translocation which leads to higher yield attributes. This is in agreement with the findings of Chadhar *et al.* (2020).

Among the weed management practices yield attributes were significantly influenced under sodic soil condition. The highest yield component *viz*., number of productive tillers m^{-2} (401), panicle length (26.5 cm), number of grains $panicle^{-1}$ (202), number filled grains $panicle^{-1}$ (191) and test weight (25.1 g) were recorded with application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS which was on par with application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + HW at 40 DAS and hand weeding at 20 and 40 DAS. The next best treatment significantly registered on pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + cono weeding at 20 and 40 DAS which was on par with pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + cono weeding at 20 DAS + hand weeding at 40 DAS and lower yield attributes were recorded with unweeded control. This is might be due to lesser crop weed competition resulted weed free condition during critical period of DSR and boosted the nutrient uptake, space and light positively increased yield attributes. This is in agreement with the findings of Prasanth *et al.* (2015) and Manisankar *et al.* (2019).

Grain and straw yield

The grain and straw yield of DSR drastically influenced by spacing (Table 3). The highest grain and straw yields (4546 and 6714 kg ha^{-1}) was achieved under 20 × 20 cm of spacing which was followed by 20 × 15 cm of spacing, while least grain and straw yield (3616 and 5975 kg ha^{-1}) was noted in 25 × 25 cm of spacing. The finding indicated that spacing of 20 × 20 cm substantially higher the grain and straw yield compared to 20 × 15 cm and 25 × 25 cm. The probable cause for the higher grain and straw yield under spacing of 20 × 20 cm could be due to diminished crop-weed competition and lower intra - crop competition is increased the number of productive tillers and other yield components which was led the yield of grain and straw yield of DSR. The similar result in agreement with Daba *et al.* (2022).

On the other hand frequency of weed management practices significantly increased the grain and straw yields

Table 2: Effect of spacing and weed management practices on yield parameters of direct seeded rice under sodic soil.

	Productive tillers m^{-2}				Panicle length (cm)				Total grains $panicle^{-1}$				No. of filled grains$panicle^{-1}$				Test weight (g)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	320	351	292	321	24.51	25.58	20.25	23.4	137	167	109	138	125	159	94	126	23.5	24	23.2	23.6
S_2	367	394	347	369	26.05	27.25	21.92	25.1	169	194	142	168	157	192	124	158	24.2	24.5	23.9	24.2
S_3	373	400	354	376	26.24	27.44	22.25	25.3	173	198	147	173	161	188	132	160	24.5	24.8	24.1	24.5
S_4	401	424	379	401	27.35	28.58	23.58	26.5	203	218	185	202	190	214	169	191	25.1	25.4	24.8	25.1
S_5	395	418	374	396	27.2	28.42	23.42	26.3	197	212	181	197	187	210	166	188	25	25.3	24.7	25.0
S_6	388	412	366	389	27.08	28.17	23.21	26.2	192	207	177	192	185	207	163	185	24.8	25.1	24.5	24.8
S_7	292	325	239	285	22	24.8	19.49	22.1	116	149	87	117	104	141	72	106	23.2	23.7	23.0	23.3
Mean	362	389	336		25.8	27.2	22.0		170	192	147		158	187	131		24.3	24.7	24.0	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	5.15	4.82	9.29	8.35	0.24	0.29	0.53	0.51	3.19	3.48	6.43	6.03	3.37	3.09	5.99	5.35	0.46	0.95	1.6	1.66
CD (P=0.05)	14.32	9.7	20.99	16.94	0.67	0.60	1.17	1.04	8.85	7.06	14.23	12.24	9.37	6.27	13.59	10.86	NS	NS	NS	NS

of DSR. The highest grain and straw yield (4667 and 6898 kg ha^{-1}) was obtained under application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS which was on par with application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + HW at 40 DAS and hand weeding at 20 and 40 DAS. The next greatest treatment significantly found under pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + cono weeding at 20 and 40 DAS which was on par with pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + cono weeding at 20 DAS + hand weeding at 40 DAS. This might be due to application of PE, PoE herbicides, mechanical weeding and hand weeding were lower the total weed density, weed dry weight acquired under weed free situation culminated in decreased the nutrient removal by weeds and improved the nutrient uptake of crop and finally enhanced the grain and straw yields of direct seeded rice. The corroborated with the findings of Prashanth *et al.* (2016) and Manisankar *et al.* (2021). The lowest grain and straw yields (2995 and 5231 kg ha^{-1}) was recorded with unweeded control.

Interaction effect on yield parameters and yield

The interaction effect of spacing and weed management practices on yield parameters, grain and straw yields was significant. The highest productive tillers m^{-2}, panicle length, total grains panicle^{-1} and yield of grain and straw was found in the interaction between spacing of 20 × 20 cm and

Table 3: Effect of different spacing and weed management practices on yield of direct seeded rice under sodic soil.

	Grain yield (kg ha^{-1})				Straw yield (kg ha^{-1})			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	3548	3996	3000	3515	5606	6193	5140	5646
S_2	4137	4599	3650	4129	6405	6902	6002	6436
S_3	4234	4686	3709	4210	6495	6971	6046	6504
S_4	4659	5058	4285	4667	6933	7100	6661	6898
S_5	4554	4979	4158	4564	6856	7067	6599	6841
S_6	4460	4870	4055	4462	6801	7020	6590	6804
S_7	2889	3637	2458	2995	5160	5745	4788	5231
Mean	4069	4546	3616		6322	6714	5975	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	79.91	55.24	119.31	95.68	104.66	94.24	183.83	163.24
CD (P=0.05)	221.89	112.05	282.05	194.08	290.6	191.16	417.47	331.11

Table 4: Effect of different spacing and weed management practices on economics of DSR.

Treatment	Cost of cultivation (` ha^{-1})	Gross income (` ha^{-1})	Net income (` ha^{-1})	B:C ratio
M_1S_1	45.666	62.939	17.273	1.38
M_1S_2	48.571	72.999	24.428	1.50
M_1S_3	45.661	74.531	28.870	1.63
M_1S_4	47.606	81.362	33.756	1.71
M_1S_5	50.516	79.771	29.255	1.58
M_1S_6	50.271	78.317	28.046	1.56
M_1S_7	40.571	53.042	12.471	1.31
M_2S_1	45,562	70.530	24.968	1.55
M_2S_2	48.467	80.337	31.870	1.66
M_2S_3	45.557	81.835	36.278	1.80
M_2S_4	47.502	86.402	38.900	1.82
M_2S_5	50.412	85.449	35.037	1.70
M_2S_6	50.167	84.267	34.100	1.68
M_2S_7	40.467	64.281	23.814	1.59
M_3S_1	45.484	53.784	8.300	1.18
M_3S_2	48.389	65.342	16.953	1.35
M_3S_3	45.479	66.350	20.871	1.46
M_3S_4	47.424	75688	28.264	1.60
M_3S_5	50.334	73990	23,656	1.47
M_3S_6	50.089	72.865	22.776	1.45
M_3S_7	40.389	44.631	4.242	1.11

application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS which was on par with application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + HW at 40 DAS. Lowest yield parameters, grain and straw yields were found in the interaction between spacing of 25 × 25 cm and unweeded control. Test weight was did not superiorly influenced by interaction of spacing and weed management practices. Khan *et al.* (2017) concluded that spacing and weed management practices influenced the yield component of rice which positively enhanced yield of rice.

Economics of DSR

Economic parameters have been computed using the current market prices of inputs and outputs (Table 4). Notably, employing a spacing of 20 × 20 cm along with the application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS resulted in a higher gross income of ` 86,402 $ha^{-1}$, accompanied by a net income of ` 38,900 ha^{-1} with B:C ratio of 1.82. On the contrary, utilizing a spacing of 25 × 25 cm along with unweeded control approach obtained a lower gross income of ` 44,631 $ha^{-1}$. This was accompanied by a net income of ` 4,242 ha^{-1} and a B:C ratio of 1.11. This was in conformity with the result of Sivakumar *et al.*(2020).

CONCLUSION

It may be concluded that sowing in rows at 20 × 20 cm apart and application of pyrazosulfuron ethyl 20 g ha^{-1} at 3 DAS + bispyribac sodium 25 g ha^{-1} at 20 DAS + cono weeding at 40 DAS provided effective weed control and higher yield in direct-seeded rice.

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Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this article.

REFERENCES

Chadhar, A.R., Nadeem, M.A., Ali, H.H., Safdar, M.E., Raza, A., Adnan, M., Hussain, M., Ali, L., Kashif, M.S. and Javaid, M.M. (2020). Quantifying the impact of plant spacing and critical weed competition period on fine rice production under the system of rice intensification. International Journal of Agriculture and Biology. 24(5): 1142-1148. https://doi.org/10.17957/IJAB/15.1543.

Daba, B. and Mekonnen, G. (2022). Effect of row spacing and frequency of weeding on weed infestation, yield components and yield of rice (*Oryza sativa* L.) in bench maji zone, Southwestern Ethiopia. International Journal of Agronomy. 1-13. https://doi.org/10.1155/2022/5423576.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. International Rice Research Institute. A Wiley-interscience Publication. John Wiley and Sons, New York.

Indiastat. (2021). Indiastat Data Base. https://www.indiastat.com/.

Kaur, J. and Singh, A. (2017). Direct seeded rice: Prospects, problems/constraints and researchable issues in India. Current Agriculture Research Journal. 5(1): 13-32. http://dx.doi.org/10.12944/CARJ.5.1.03.

Kokilam, M.V. (2017). Evaluation of weed management practices in direct wet seeded rice under sodic soil. M.Sc.,(Ag) Thesis, Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Trichy, Tamil Nadu, India.

Kokilam, M.V., Rathika, S., Ramesh, T. and Baskar, M. (2020). Weed dynamics and productivity of direct wet seeded rice under different weed management practices. Indian Journal of Agricultural Research. 10: 1-5. DOI:10.18805/IJARe.A-5586.

Khan, M.Z.K., Hasan, A.K., Anwar, M.P. and Islam, M.S. (2017). Weeding regime and plant spacing influence on weed growth and performance of transplant aman rice variety Binadhan-7. Fundamental and Applied Agriculture. 2(3): 331-339. https://doi.org/10.5455/faa.281436.

Kumar, V., Bellinder, R., Gupta, R., Malik, R. and Brainard, D. (2008). Role of herbicide-resistant rice in promoting resource conservation technologies in rice-wheat cropping systems of India: A review. Crop Protection. 27(3-5): 290-301. https://doi.org/10.1016/j.cropro.2007.05.016.

Manisankar, G., Ramesh, T. and Rathika, S. (2020). Weed management in transplanted rice through pre plant application of herbicides: A review. Int. J. Curr. Microbiol. Appl. Sci. 9 (5): 684-692.

Manisankar, G., Ramesh, T. and Rathika, S. (2021). Effect of different weed management practices on nutrient removal, nutrient uptake and grain yield of transplanted rice (*Oryza sativa* L.) under sodic soil ecosystem. International Journal of Current Microbiology and Applied Sciences. 10(5): 378-389.

Manisankar, G., Ramesh, T., Rathika, S., Janaki, P. and Balasubramanian, P. (2019). Evaluation of sequential herbicide application on transplanted paddy under sodic soil. The Pharma Innovation Journal. 8(5): 633-638.

Nayak, B., Mujeeb, K.M., Mosha, K. and Prasuna, R.P. (2014). Plant spacing and weed management techniques influence weed Competitiveness of drum seeded rice (*Oryza sativa* L.). International Journal of Applied Biology and Pharmaceutical Technology. 5(3): 13-22.

Palani, R., Ramesh, T., Rathika, S. and Balasubramaniam, P. (2020). Evaluation of weed management techniques in drip irrigated aerobic rice. International Journal of Current Microbiology and Applied Sciences. 9(12): 2463-2471.

Patel, T., Vihol, K., Thanki, J., Gudaghe, N. and Desai, L. (2018). Weed and nitrogen management in direct-seeded rice. Indian Journal of Weed Science. 50(4): 320-323.

Prakash, R.J., Kumar, B. and Reddy, G. (2015). Fabrication and evaluation of 4 row drum seeder with 25 and 30 cm spacing. International Journal of Agricultural Sciences. 7 (9): 678-682.

Prashanth, R., Murthy, K., Kumar, V.M., Murali, M. and Sunil, C. (2016). Bispyribac-sodium influence on nutrient uptake by weeds and transplanted rice. Indian Journal of Weed Science. 48(2): 217-219. https://doi.org/10.5958/0974-8164.2016.00053.8.

Prashanth, R., Murthy, K., Murali, M., Ramachandra, C. and Sunil, C. (2015). Growth and yield of transplanted rice as influenced by application of bispyribac sodium 10 SC a post-emergence herbicide. International Journal of Tropical Agriculture. 33(1): 37-40.

Ramesh, T. and Rathika, S. (2016). Management of emerged weeds in irrigated blackgram (*Vigna mungo* L.) through post-emergence herbicides. Legume Research-An International Journal. 39(2): 289-292. doi: 10.18805/lr.v0iOF.6771.

Ramesh, T. and Rathika, S. (2020). Effect of weed management techniques on drip irrigated aerobic rice. Plant Archives. 20(2): 4462-4466.

Rathika, S. and Ramesh, T. (2018). Weed management effect in system of rice intensification. Indian Journal of Weed Science. 50(4): 388-390.

Rathika, S. and Ramesh, T. (2019). Weed management in direct wet seeded rice. Journal of Pharmacognosy and Phytochemistry. 8(2S): 978-981.

Rathika, S., Ramesh, T. and Shanmugapriya, P. (2020). Weed management in direct seeded rice: A review. International Journal of Chemical Studies. 8(4): 925-933.

Sangeetha, S. (2006). Studies on weed control in drum seeded rice under lowland ecosystem. M. Sc., (Ag.) Thesis, Tamil Nadu Agricutural University, Coimbatore, Tamil Nadu, India.

Sivakumar, C., Krishnaveni, A. and Pandiyan, M. (2021). Efficiency of pre and post emergence herbicides with mechanical weeding on direct seeded rice in north western zone of Tamil Nadu. International Journal of Chemical Studies. 9(1): 1403-1409. https://doi.org/10.22271/chemi.2021.v9.i1t.11422.

Sivakumar,C., Pandiyan, M., Tamilselvan, N. and Krishnaveni. (2020). Chemical and non chemical weed management effects on weed spectrum, yield and economics of direct seeded ricein North western zone of Tamil Nadu. Indian Journal of Weed Science. 52(4): 309-312.