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Evaluation of Weed Management Approaches on Weed Dynamics, Yield and Economics of Puddled Rice under different Plant Techniques

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ABSTRACT: The development of high-yield crop varieties has been hindered in recent years due to poor weed management, resulting in decreased potential. Maximum crop yields cannot be achieved without effective weed management, particularly in rice. This study delves into various weed management practices and planting techniques tailored for rice cultivation. A field experiment was conducted from January to May 2022 (*Navarai*) to find out the effective weed management practices in puddled rice. The experiment was carried out in a split-plot design, which included two planting techniques, *viz*., drum-seeded rice and system of rice intensification (SRI) in the main plot, as well as eight weed management practices, *viz*., hand weeding, cono weeding, pretilachlor, bispyribac sodium and fenoxaprop – p – ethyl as pre and post-emergence application in subplot. The results of the experiment demonstrated that among the planting techniques and weed management practices tested, the system of rice intensification and sequential application of pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1} has revealed the lowest weed density and highest weed control efficiency, yield and gross and net income. However, drum-seeded rice resulted in a higher return^{-1} rupee invested due to the lower cost of cultivation.

Keywords: drum seeded rice, bisyribac sodium, puddled rice, pretilachlor, SRI.

INTRODUCTION

Rice is the most significant staple food crop for more than half of the world's population, particularly in densely populated areas experiencing fast expansion. In irrigated lowland rice, transplanting is the most common and traditional establishment technique. Increasing water scarcity is becoming a real threat to rice cultivation; hence water-saving technology, which also maintains soil health and sustainability and as well as economically beneficial needs to be developed (Hugar *et al.*, 2010).

Drum-seeded rice under puddled conditions has significant relevance in modern production systems since it saves time, labour, energy, and profitability while increasing cropping intensity by lowering turnaround time and avoiding onerous activities like nursery preparation and hand transplanting. The SRI method of cultivation is slowly gaining momentum all over the world, including in India. The SRI is a methodology to increase rice productivity by modifying micro-climate and soil conditions and also decreases the use of input such as water and labour is reported to have 20 - 30 per cent higher or even more grain yield compared to the conventional method of cultivation in India (Mohanty *et al.*, 2014).

Weeds are the primary cause of poor production and economic loss in agroecosystems. About 60% of weeds emerge during 7 to 30 days after transplanting and severely compete with rice plants up to tillering stage (Sai Kumar *et al.*, 2022). Weeds are unwanted plants that compete with agricultural lands for nutrients, water, space, and light. Chemical weed management is increasingly popular and is the ideal alternative to manual weeding since hand weeding is labour-intensive, tedious, time-consuming, and impracticable in adverse weather. Using herbicides was the more appealing choice as the operation would be finished in one application and save time. It also reduces herbicide injury and usage rate to crops, broadens the spectrum of weed control in a single application and reduces the cost of application (Guru *et al.*, 2020).

In this perspective, the present study was carried out on the “Evaluation of weed management approaches on weed dynamics, yield and economics of puddled rice under different plant techniques”.

MATERIALS AND METHODS

A field experiment was carried out in experimental farm of Faculty of Agriculture, Annamalai University during the *Navarai* season of 2022 which is located at 11°24′N latitude and 79°44′E longitude at an altitude ± 5.79 MSL. The climate of the experimental area is humid tropic, with an average rainfall of 1500 mm and maximum and minimum temperatures recorded during the planting season were 22.6°C and 32.3°C, respectively. The experiment was laid out in split plot design consisting of two planting techniques – drum seeded rice, system of rice intensification (SRI) in the main plot and eight weed management practices – weedy check, Hand weeding twice, Conoweeding thrice, Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Conoweeding on 30 DAS/DAT, Fenoxaprop – p – ethyl @ 56.60 g a.i ha^{-1} *fb* Conoweeding on 40 DAS/DAT, Bispyribac sodium @ 20 g a.i ha^{-1} *fb* Conoweeding on 40 DAS/DAT, Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Fenoxaprop – p – ethyl @ 56.60 g a.i ha^{-1}, Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Bispyribac sodium @ 20 g a.i ha^{-1} in sub plot and was replicated thrice. ADT 43 variety was used as test crop.

In drum seeding, sprouted seeds were planted using a manually operated rice drum seeder with a spacing of 20 × 10 cm. In SRI, 14-days-old seedlings were manually transplanted at a spacing of 25 × 25 cm @ 2 seedlings $hill^{-1}$. Hand weeding was done twice, once on 20 DAS/DAT and second on 40 DAS/DAT. Conoweeding was done thrice at 10 days interval starting from 20, 30 & 40 DAS/DAT. Pretilachlor was applied as pre emergence on 8 DAS in drum seeding and 3 DAT in SRI method of planting while both Fenoxaprop – p – ethyl @ 56.38 g ha^{-1} and Bispyribac sodium @ 20 g ha^{-1} as a post-emergence herbicide with 500 l of water ha^{-1} were applied on 20 DAS/DAT. The observations on weed density and weed control efficiency were recorded on 30DAS/DAT and 60DAS/DAT. Yield parameters were taken from five randomly selected places using 1 m^2 quadrant from net plot area. Square root of transformation was done for weed density by using the formula $\sqrt{(x+0.5)}$, the data relating to weed control efficiency was transformed by arc sin transformation. All the observations recorded in the experiment were statistically analysed by AGRES software.

RESULTS AND DISCUSSION

Weed flora of the experiment site. The major weeds appeared in the experimental field at all stages of observation were *Echinochloa colona, Echinochloa crusgali, Leptochloa chinensis* among grasses and in sedges viz., *Cyperus difformis, Cyperus iria, Cyperus rotundus* and among broad leaved weeds viz., *Eclipta alba, Sphenoclea zelyancia, Bergia capensis and Marsilea quadrifolia*.

Weed density. Weed density was significantly affected by different weed management practices and planting techniques (Table 1). Among the planting techniques, the SRI method of planting recorded the lowest weed density on both 30 and 60 DAS/DAT (39.67 and 71.25 no. m^{-2}). This might be due to SRI resulting in lower weed density due to puddling, which buries weeds into the lower layer of the mud where they can be decomposed by anaerobic action resulting in lesser emergence of deeply placed weed seeds (Kumar *et al.,* 2021). While in drum seeded rice, Weed competition was immense in drum-seeded rice because the weeds and rice grew concurrently, making weed management harder. This resulted in the generation of a more significant number of weed population. These are in conformity with the findings of Bhat *et al.* (2011).

Irrespective of the weed management practices evaluated, the combined application of pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1} as resulted in the lowest weed density (17.02 and 33.97 no. m^{-2}). This might be attributed to pretilachlor, as PE is particularly effective on grasses and sedges. When sprayed, it penetrates predominantly by the sprouting shoots and secondly through the roots, with translocation throughout the plant resulting in the impact on weed seed at early stages. While Bispyribac sodium, as a PoE herbicide is particularly effective against sedges, grasses and broadleaf weeds because it is absorbed by the plant's leaves and roots. It is an ALS (acetolactate synthase) inhibitor that interferes with the production of a plant enzyme required for growth and limits plant amino acid synthesis, resulting in weed control at later stage of the crop. These results were in consistent with findings of Suryakala *et al.* (2019).

Weed control efficiency. The data in Table 1 shows that among the planting techniques followed, the highest weed control efficiency was registered by SRI method of planting (68.55 and 65.78 on 30 and 60DAS/DAT). This might be because the smothering effect of rice seedlings on developing weeds resulted in minimal weed emergence. These are conformity with the findings of Hassan *et al.* (2010).

The sequential application of pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1} had registered the highest weed control efficiency (86.72 and 83.87 on 30 and 60DAS/DAT). This might be owing to the persistence of pretilachlor *fb* bispyribac sodium, which could have considerably helped to control the weeds for longer period. Pretilachlor was reported to have a half-life period of 7.52-9.58 days (Kaur *et al.,* 2015) and bispyribac sodium is comparatively more persistent with a half-life of 9.93 days (Ramprakash *et al.,* 2015) and persists up to 42-115 days (Singh and Singh 2015) in soil and may have delivered the highest weed control efficiency. These findings were in agreement with the findings of Chinnamani *et al.* (2018); Rathika and Ramesh (2018).

Grain and Straw yield. The highest grain yield was registered by SRI method of planting (Table 2). This is likely owing to the immense root volume, profuse and robust tillers with longer and more panicles with higher grain weight which boosted grain output. These findings agree with those of Kumar *et al.* (2015); Nath and Dev (2018); Kuotsu and Singh (2020).

The SRI technique of transplanting produced the highest straw yield (7.16 t ha^{-1}). This might be because of the wider spacing and younger seedlings let the plant develop vigorously during its vegetative period, causing the plant to focus more on the source than the sink, resulting in increased biomass production and a larger straw yield. However, limited root space resulted in decreased biomass production and low straw yield in drum-seeded rice. Similar findings were reported by Zhimomi *et al.* (2021).

The grain yield was significantly affected by different weed management practices. Among the weed management practices the application of pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1} (5.47 t ha^{-1}). This could be due to the sequential application of pretilachlor @ 0.5 kg a.i ha^{-1} as a PE herbicide, which effectively controlled the weeds during the germination phase, and bispyribac sodium @ 20 g a.i ha^{-1} as a PoE, which further reduced the late germinating weeds, resulting in an increase in plant biomass and productive tillers, resulting in the highest grain yield. These are congruent with the findings of Walia *et al.* (2012); Kumaran *et al.* (2013).

The application of pretilachlor @ 0.5 kg a.i ha^{-1}*fb* bispyribac sodium @ 20 g a.i ha^{-1} resulted in a greater straw yield (8.49 t ha^{-1}). This might be attributed to improved rice plant growth under reduced crop weed competition caused by appropriate nutrition delivery accompanied by effective weed management, resulting in maximum straw production. In comparison, weedy check produced less straw yield. It is possible that the increased weed population discouraged the crop owing to crop weed competition, resulting in reduced straw output. These are congruent with the findings of Mewada *et al.* (2016).

Economics. The SRI method of planting along with pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1} produced the highest gross income of ₹ 121160 and net income of ₹ 64336. However, Drum-seeded rice along with pretilachlor @ 0.5 kg a.i ha^{-1}*fb* bispyribac sodium @ 20 g a.i ha^{-1} had the highest return rupee^{-1} invested of 2.21 due to lower cost of cultivation.

Table 1: Effect of planting techniques and weed management practices on weed density and weed control efficiency on 30 and 60 DAS/DAT.

Treatments	Weed density		Weed control efficiency	
	30 DAS/DAT	60 DAS/DAT	30 DAS/DAT	60 DAS/DAT
Planting techniques				
Drum seeded rice	7.14 (50.53)	9.53 (90.33)	60.97 (51.34)	49.27 (57.42)
SRI	6.34 (39.67)	8.47 (71.25)	68.55 (55.89)	54.20 (65.78)
S.Ed	0.06	0.08	0.85	0.83
C.D (p=0.05)	0.28	0.36	3.68	3.56
Weed management practices				
Weedy check	11.32 (127.75)	14.52 (210.19)	67.21 (84.99)	65.14 (82.33)
Hand weeding twice	4.44 (19.92)	6.14 (37.21)	59.59 (74.38)	57.17 (70.61)
Conoweeding thrice	5.78 (32.86)	7.91 (61.94)	50.95 (60.30)	48.22 (55.62)
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Conoweeding on 30 DAS/DAT	7.16 (50.79)	9.69 (93.40)	51.41 (61.09)	48.92 (56.83)
Fenoxaprop – p – ethyl @ 56.60 g a.i ha^{-1} *fb* Conoweeding on 40 DAS/DAT	7.09 (49.79)	9.56 (90.85)	61.90 (77.81)	59.73 (74.59)
Bispyribac sodium @ 20 g a.i ha^{-1} *fb* Conoweeding on 40 DAS/DAT	5.38 (28.40)	7.35 (53.50)	58.54 (72.77)	56.16 (68.99)
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Fenoxaprop – p – ethyl @ 56.60 g a.i ha^{-1}	5.95 (34.85)	8.11 (65.27)	68.63 (86.72)	66.32 (83.87)
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Bispyribac sodium @ 20 g a.i ha^{-1}	4.19 (17.02)	5.87 (33.97)	67.21 (84.99)	65.14 (82.33)
S.Ed	0.22	0.29	1.41	1.36
C.D (p=0.05)	0.45	0.60	2.88	2.78

(Weed density: Figures in the parenthesis are original values; Values are square root transformed values)
(Weed control efficiency: Figures in the parenthesis are original values; Values are arc-sine transformed values)

Table 2: Effect of planting techniques and weed management approaches on grain and straw yield.

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Planting techniques		
Drum seeded rice	3.98	6.32
SRI	4.55	7.16
S.Ed	0.07	0.11
C.D (p=0.05)	0.31	0.48
Weed management approaches		
Weedy check	2.54	4.12
Hand weeding twice	5.35	8.34
Conoweeding thrice	4.52	7.13
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Conoweeding on 30 DAS/DAT	3.58	5.75
Fenoxaprop – p – ethyl @ 56.60 g a.i ha^{-1}*fb* Conoweeding on 40 DAS/DAT	3.68	5.88
Bispyribac sodium @ 20 g a.i ha^{-1}*fb* Conoweeding on 40 DAS/DAT	4.72	7.43
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Fenoxaprop – p – ethyl @ 56.60 g a.i ha^{-1}	4.27	6.76
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Bispyribac sodium @ 20 g a.i ha^{-1}	5.47	8.49
S.Ed	0.14	0.21
C.D (p=0.05)	0.28	0.44

Table 3: Effect of different planting techniques and weed management practices on economics.

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	RRI
M_1S_1	46865	52646	5781	1.12
M_1S_2	54365	106890	52526	1.97
M_1S_3	53765	82818	29053	1.54
M_1S_4	50215	70168	19953	1.40
M_1S_5	52105	71754	19649	1.38
M_1S_6	51165	94848	43684	1.85
M_1S_7	50855	85330	34476	1.68
M_1S_8	49915	110326	60411	2.21
M_2S_1	53774	55040	1266	1.02
M_2S_2	61274	119602	58328	1.95
M_2S_3	60674	108851	48177	1.79
M_2S_4	57124	81787	24663	1.43
M_2S_5	59014	84127	25113	1.43
M_2S_6	58074	105181	47107	1.81
M_2S_7	57764	95772	38008	1.66
M_2S_8	56824	121160	64336	2.13

CONCLUSIONS

The results of the field experimentation concluded that the SRI strategy of planting, along with the application of PE pretilachlor @ 0.5 kg ha^{-1} *fb* PoE bispyribac sodium @ 20 g ha^{-1} reduced the infestation of dominant weed species and these practises could be suggested as an efficient, economically viable, ecologically desirable and practically feasible management system for controlling weed species in the puddled rice wetland ecosystem.

FUTURE SCOPE

The present study suggests exploring the following aspects for a perfect understanding of weed species. To study the effect of weed management techniques under herbigation in dry-seeded rice under drip irrigation and also to find out the impact of herbicide persistence in the management of weeds.

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Conflict of Interest. None.

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