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RESEARCH ARTICLE

Weed management efficacy of herbicide mixtures in transplanted rice under varied nutrient levels

E. Priyankabai[1*], G. Karuna Sagar[2], D. Subramanyam[1], M. Sreenivasa Chari[1], P. Lavanya Kumari[3], B. Sandhya Rani[4] and V. Chandrika[1]

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ABSTRACT

A field experiment was carried out at S.V. Agricultural College Farm, Tirupati, Andhra Pradesh, India during *Kharif* seasons of 2022-23 and 2023-24 to determine weed management efficacy of herbicide mixtures in transplanted rice under varied nutrient levels and to identify the best option to realize higher rice productivity. Among three tested nutrient levels, 100% recommended dose of fertilizer (RDF) recorded the lowest weed density and biomass with higher weed control efficacy. Amongst weed management treatments, hand weeding twice at 20 and 40 days after transplanting (DAT) recorded significantly lower density and biomass of all weed categories and higher weed control efficiency, followed by pre-emergence application (PE) of triafamone + ethoxysulfuron (ready-mix) 67.5 g/ha followed by (*fb*) post-emergence application (PoE) of halosulfuron-methyl 67.7 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) at 20 DAT, which was statistically comparable to bensulfuron-methyl + pretilachlor (ready-mix) 660 g/ha PE *fb* hand weeding at 40 DAT. The use of 150% RDF resulted in higher rice grain yield, straw yield, net returns and benefit cost ratio. Hand weeding twice at 20 and 40 DAT was statistically equivalent to triafamone + ethoxysulfuron (ready-mix) 67.5 g/ha PE *fb* halosulfuron-methyl 67.7 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT.

Keywords: Bensulfuron-methyl + pretilachlor, Halosulfuron-methyl + fenoxaprop-p-ethyl, Triafamone + ethoxysulfuron, Nutrient levels, Transplanted rice, Weed management

INTRODUCTION

Rice (*Oryza sativa* L.) is the world's most significant cereal crop, providing a staple food for 70% of the world's population and playing a critical part in global economic and social stability. Rice is grown on 47.8 million hectares in India, with a total production of 206.7 million tons and a productivity of 4.3 t/ha in 2023 (FAOSTAT 2025). One of the most common methods of establishing rice in an irrigated environment is by transplanting in puddle soil. This method is very important for enhancing the productivity of the rice.

In order to achieve a sustainable rice production, proper nutrient management is also important. The use of chemical fertilizer is the better approach to slow the rate of nutrient mining from soil. Blanket fertilizer application contributes to excess or insufficient nutrient balance in rice soils for realizing crop yield potential. Nutrient deficit is caused by poor fertilizer use, timing and manner of application, weed infestation, and crop weed competition (Swain *et al.* 2023).

Weeds are the key impediment in realizing optimal crop productivity (Rao 2022). Weed-related yield loss varies greatly according to the nature, extent and degree of weed problems, as well as the ecosystem in which the rice crop is cultivated (Rao *et al.* 2017). Manual weeding is exceedingly difficult and uneconomical during the cropping season due to continuous rains, scarcity, and high worker wages during peak weeding operations, particularly in the crop's early stages. Farmers seek a low-cost weed management technique for broad-spectrum weed control and higher rice yield. Thus, herbicides have emerged as a valuable and dependable weed management technique and ready-mix herbicides are available to manage mixed weed flora. Hence, this study was conducted with an objective to determine weed management efficacy of herbicide mixtures in transplanted rice under varied nutrient levels to

[1] S.V. Agricultural College, Tirupati, ANGRAU, Andhra Pradesh 517502, India

[2] Dean of Student Affairs, ANGRAU, Lam, Guntur, Andhra Pradesh 522034, India

[3] Agricultural College, Bapatla, ANGRAU, Andhra Pradesh 522101, India

[4] DAATT Centre, Chittoor, Andhra Pradesh 517001, India

* Corresponding author email: e.priyanka127@gmail.com

identify the best option to realize higher transplanted rice productivity.

MATERIAL AND METHODS

A field experiment was conducted at S.V. Agricultural College's wet land farm in Tirupati during the *Kharif* seasons of 2022-23 and 2023-24. The soil had a sandy clay loam texture, a neutral reaction, low electrical conductivity, low organic carbon, low available nitrogen, medium available phosphorus and potassium. The experiment was laid up in split-plot design, with three nutritional levels *viz.*, 100% recommended dose of fertilizer (RDF), 125% RDF and 150% RDF under main plots and six weed management practices assigned to sub plots *viz.*, pre-emergence application (PE) of pretilachlor 750 g/ha followed by (*fb*) post-emergence application (PoE) of bispyribac-sodium 25 g/ha + pyrazosulfuron-ethyl 25 g/ha (tank-mix) at 20 days after transplanting (DAT), penoxsulam + butachlor 820 g/ha (ready-mix) PE *fb* bispyribac-sodium 25 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT, triafamone + ethoxysulfuron (ready mix) 67.5 g/ha PE *fb* halosulfuron-methyl 67.7 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT, bensulfuron methyl + pretilachlor (ready-mix) 660 g/ha PE *fb* hand weeding at 40 DAT, hand weeding twice at 20 and 40 DAT and unweeded check. The recommended fertilizer dose (RDF) for rice crops in southern agroclimatic zone of Andhra Pradesh is 120 N, 60 kg P, and 60 kg K/ha. The rice variety "*NLR-34449*" was used. Twenty-seven-day-old seedlings were transplanted at a spacing of 20 x 10 cm, two seedlings per hill. Nutrients were applied in accordance with the treatments in the form of urea, single superphosphate and muriate of potash. Nitrogen was applied in three stages: the initial, tillering and panicle initiation. The entire amount of phosphorus was supplied at the time of transplanting, whereas potassium was applied in two parts, half at the time of transplanting and the other half during the panicle initiation stage.

The needed amounts of PE and PoE herbicides were administered at one and 20 DAT, respectively, using 500 L/ha water and a battery-operated backpack sprayer fitted with a flat fan nozzle. The data collected on various crop factors during the study was statistically evaluated using the analysis of variance approach proposed by Panse and Sukhatme (1985). Statistical significance was determined using the F test at the 5% level of probability and treatment averages were compared using the crucial difference method. Weed density and biomass data was collected following standard recommended procedures. To standardize the distribution of weeds, the data was transformed using square roots. The weed control efficiency was computed using a standard formula and then transformed angularly.

RESULTS AND DISCUSSION

Weed growth

The predominant weed species noticed in the experimental transplanted rice field during both the years of study were: *Cynodon dactylon*, *Echinochloa colonum* and *Panicum repens* among grasses, *Cyperus iria* and *Cyperus rotundus* were the two dominant sedges and *Ammania baccifera*, *Bergia ammannioides*, *Commelina benghalensis*, *Eclipta alba* and *Marsilea quadrifolia* were broad-leaved weeds.

Nutrient levels and weed management approaches had a substantial impact on weed density and biomass, as well as improved weed control efficiency (**Table 1**). In terms of nutrient levels, using 100% RDF resulted in lower density and biomass of all categories of weeds, as well as increased weed control efficiency. The next best nutrient level was 125% RDF. Optimum nutrition availability may have fostered good crop growth, resulting in lower weed density and biomass, and hence improved weed control efficiency. This could be owing to a lack of nutrients, which resulted in poor weed growth as reported by Kumari *et al.* (2021). The highest density and biomass of all weed categories, as well as lowest weed control efficacy, were observed with 150% RDF across both years of study owing to higher growth and development of all weed categories at higher level of nutrients.

Significantly lower density and biomass of grasses, sedges, broad-leaved weeds and total weeds as well as higher weed control efficiency was recorded with hand weeding twice at 20 and 40 DAT than rest of the weed management treatments. Among the herbicide treatments, the lowest weed density and biomass of all categories of weeds and higher weed control efficiency was recorded with triafamone + ethoxysulfuron (ready-mix) 67.5 g/ha PE *fb* halosulfuron-methyl 67.7 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT, which was statistically at par with bensulfuron-methyl + pretilachlor (ready-mix) 660 g/ha PE *fb* hand weeding at 40 DAT. Effective management of all categories of weeds during the critical stages with hand weeding might have reduced the weed density at later stages of the crop growth and similarly sequential application of pre-and post-emergence herbicides might have killed the germinated weeds from weed seed bank resulting in lower number of weeds and higher weed control efficiency in the herbicide treated plots confirming the findings of Mir *et al.* (2023) and Shah *et al.* (2023). The next best weed management practice in recording lower weed density and biomass as well as higher weed control efficiency was penoxsulam + butachlor (ready-mix) 820 g/ha PE *fb* bispyribac-sodium 25 g/ha + fenoxaprop-p-ethyl (tank-mix) 60 g/ha PoE at 20 DAT, which was however statistically comparable with pretilachlor 750 g/ha PE *fb* bispyribac-sodium 25 g/ha + pyrazosulfuron-ethyl (tank-mix) 25 g/ha PoE at 20 DAT. Effective control of all categories of weeds at critical period of crop-weed competition resulted lower density and biomass and higher weed control efficiency. Pre-emergence application of ready-mix herbicides, *viz.* penoxsulam + butachlor, triafamone + ethoxysulfuron and bensulfuron-methyl + pretilachlor, which are selective, translocated broad-spectrum herbicides, effectively controlled all categories of weeds with their respective mode of action at early stages of crop growth. Post-emergence application of tank-mix herbicides halosulfuron-methyl + fenoxaprop-p-ethyl effectively reduced the later emerged weeds compared to bispyribac-sodium+ fenoxaprop-p-ethyl (tank-mix) and bispyribac-sodium + pyrazosulfuron-ethyl (tank-mix). Significantly higher density and biomass of weeds lower weed control efficiency were recorded with unweeded check due to continuous germination and development of all category weeds resulting in heavy wed infestation as no weed management practice was carried out from transplanting of rice to harvesting.

Rice grain yield and yield attributes

Number of rice panicles/m², number of rice grains/panicle, 1000 rice grain weight, rice grain and straw yield of transplanted rice were significantly influenced by nutrient levels and weed management practices (**Table 2**). Among different nutrient levels tested, higher number of panicles/m², number of grains / panicle, rice grain and straw yield were recorded with 150% RDF, which was significantly superior to 125% RDF with significant disparity. This might be attributable to the fact that adequate nutrition availability which enabled substantial proportion of tillers becoming effective tillers due to better accumulation of photosynthates, resulting in the generation of more number of panicles/m² confirming the findings of Adilakshmi *et al.* (2022). In terms of 1000 grain weight, there was no significant difference between the nutrient levels listed above due to enhanced production and translocation of

Table 1. Density and biomass of weeds and weed control efficiency at harvest as influenced by nutrient levels and weed management treatments in transplanted rice (average of two years)

Treatment	Weed density (no./m^2)				Weed biomass (g/m^2)				Weed control efficiency (%)
	Grasses	Sedges	BLWs	Total	Grasses	Sedges	BLWs	Total	
Nutrient levels									
100% RDF	4.90 (23.94)	4.84 (23.52)	4.30 (18.17)	8.07 (65.62)	3.97 (15.54)	4.72 (22.40)	4.56 (20.53)	7.62 (28.47)	50.49 (59.26)
125% RDF	5.20 (27.26)	5.21 (27.57)	4.61 (21.13)	8.64 (75.96)	4.50 (20.21)	5.12 (26.54)	5.05 (25.39)	8.43 (72.14)	44.73 (49.74)
150% RDF	5.58 (31.55)	5.53 (31.49)	4.96 (24.76)	9.24 (87.81)	4.91 (24.26)	5.47 (30.70)	5.42 (29.43)	9.09 (84.38)	37.25 (41.21)
LSD (p=0.05)	0.28	0.28	0.25	0.50	0.27	0.30	0.30	0.53	3.68
Weed management treatment									
Pretilachlor 750 g/ha PE *fb* bispyribac-sodium 25 g/ha + pyrazosulfuron-ethyl 25 g/ha (tank-mix) PoE at 20 DAT	5.63 (31.18)	5.49 (29.67)	4.78 (22.43)	9.15 (83.27)	4.91 (23.62)	5.50 (29.79)	5.41 (28.87)	9.09 (82.29)	40.77 (42.67)
Penoxsulam + butachlor 820 g/ha (ready-mix) PE *fb* bispyribac-sodium 25 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT	5.43 (29.07)	5.25 (27.09)	4.62 (20.92)	8.80 (77.08)	4.72 (21.87)	5.17 (26.30)	5.23 (26.98)	8.68 (75.15)	43.63 (47.64)
Triafamone + ethoxysulfuron 67.5 g/ha (ready-mix) PE *fb* halosulfuron-methyl 67.7 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT	4.75 (22.12)	4.58 (20.51)	4.24 (17.55)	7.78 (60.19)	4.06 (16.09)	4.49 (19.73)	4.65 (21.20)	7.57 (57.02)	50.96 (60.28)
Bensulfuron-methyl + pretilachlor 660 g/ha (ready-mix) PE *fb* hand weeding at 40 DAT	4.91 (23.69)	4.82 (22.73)	4.33 (18.30)	8.07 (64.72)	4.28 (17.99)	4.73 (21.94)	4.83 (22.98)	7.95 (62.91)	48.58 (56.17)
Hand weeding twice at 20 and 40 DAT	4.14 (16.76)	4.05 (16.02)	3.97 (15.30)	6.95 (48.08)	3.46 (11.55)	3.95 (15.23)	4.15 (16.80)	6.62 (43.58)	56.68 (69.64)
Unweeded check	6.51 (42.68)	6.99 (49.14)	5.81 (33.63)	11.14 (125.45)	5.34 (28.90)	6.79 (46.28)	5.79 (33.88)	10.35 (109.05)	24.30 (24.02)
LSD (p=0.05)	0.30	0.31	0.23	0.43	0.28	0.28	0.28	0.52	3.19

Data in parentheses are original values, which are transformed to $\sqrt{x+0.5}$ and analysed statistically; PE = pre-emergence application; PoE = post-emergence application; *fb*= followed by; DAT = days after transplanting; BLWs = broad-leaved weeds photosynthates at higher nutrient levels, which facilitated improved grain filling and hence increased 1000 grain weight. Application of 100% RDF recorded the lowest number of panicles/m², number of grains/panicle and 1000 grain weight, rice grain and straw yield, which was significantly lower than rest of the nutrient levels during both the consecutive years of study as well in pooled mean. This might be due to less availability of nutrients.

Amongst weed management treatments, significantly more number of panicles/m², number of grains/panicle, 1000 grain weight, rice grain and straw yield were observed with hand weeding twice at 20 and 40 DAT, which was at par with triafamone + ethoxysulfuron (ready-mix) 67.5 g/ha PE *fb* halosulfuron-methyl 67.7 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT due to maintenance of weed free environment throughout the crop growth period leading to increased availability of growth resources resulting in more total number of tillers/m², which inurn lead to the production of higher number of productive tillers/m² and rice grain yield because of maintenance of better source sink relationship in these treatments (Jaswal and Singh 2019, Jaiswal and Gupta 2020 and Mohapatra *et al.* 2021). The next best weed management treatment in recording higher rice yield parameters, grain and straw yield was bensulfuron-methyl + pretilachlor (ready-mix) 660 g/ha PE *fb* hand weeding at 40 DAT, which was followed by penoxsulam + butachlor (ready-mix) 820 g/ha PE *fb* bispyribac-sodium 25 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT and pretilachlor 750 g/ha PE *fb* bispyribac-sodium 25 g/ha + pyrazosulfuron-ethyl 25 g/ha (tank-mix) PoE at 20 DAT. This might be due to better translocation of photosynthates from source to rice grains. Significantly lower number of panicles/m², number of grains/panicle, 1000 grain weight, grain and straw yield were observed with unweeded check due to severe competition from uncontrolled weeds at critical stages resulting in lesser availability of growth resources, which in turn ended up with lower number of rice yield parameters.

Economics

Net returns and benefit-cost ratio of transplanted rice was significantly influenced due to nutrient levels and weed management practices (**Table 2**). Application of 150% RDF resulted in higher benefit-cost ratio, which was significantly higher than rest of the nutrient levels. The next best nutrient level in recording higher benefit-cost ratio was 125% RDF. This might be attributed to higher grain yield due to précised application of nutrients at different stages of crop growth confirming the findings of Kumari *et al.* (2021). The lowest benefit-cost ratio was recorded with 100% RDF. Among

Table 2. Yield attributes, yield and economics of transplanted rice as influenced by nutrient levels and weed management treatments

Treatment	No. of panicle/m^2			No. of grains/panicle^2			1000 grain weight (g)			Grain yield (kg/ha)	Straw yield (kg/ha)	Net returns (₹/ha)	B:C ratio
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled				
Nutrient levels													
100% RDF	244	229	236	109	101	105	14.0	13.3	13.7	4729	5397	49791	1.96
125% RDF	275	260	268	126	118	122	14.9	14.0	14.4	5172	6008	57262	2.08
150% RDF	311	296	304	140	132	136	15.3	14.5	14.9	5671	6416	65661	2.20
LSD (p=0.05)	26	24	25	11	10	11	0.7	0.6	0.6	285	340	6281	0.10
Weed management treatment													
Pretilachlor 750 g/ha PE *fb* bispyribac-sodium 25 g/ha + pyrazosulfuron-ethyl 25 g/ha (tank-mix) PoE at 20 DAT	241	226	234	106	98	102	14.0	13.2	13.6	4355	5244	42957	1.86
Penoxsulam + butachlor 820 g/ha (ready-mix) PE *fb* bispyribac-sodium 25 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT	265	250	258	120	112	116	14.5	13.7	14.1	5307	5697	60536	2.18
Triafamone + ethoxysulfuron 67.5 g/ha (ready-mix) PE *fb* halosulfuron-methyl 67.7 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT	312	297	305	147	139	143	15.5	14.7	15.1	6156	6909	75109	2.37
Bensulfuron-methyl + pretilachlor 660 g/ha (ready-mix) PE *fb* hand weeding at 40 DAT	288	273	281	135	127	131	15.0	14.2	14.6	5731	6280	66593	2.22
Hand weeding twice at 20 and 40 DAT	331	316	324	153	145	149	16.0	15.2	15.6	6259	7162	74631	2.29
Unweeded check	224	209	216	90	82	86	13.4	12.5	12.9	3335	4351	25602	1.56
LSD (p=0.05)	21	22	21	8	9	8	0.9	0.8	0.9	290	295	5660	0.10

PE = pre-emergence application; PoE = post-emergence application; *fb*= followed by; DAT = days after transplanting different weed management treatments, significantly higher net returns and higher benefit-cost ratio were observed with triafamone + ethoxysulfuron (ready-mix) 67.5 g/ha PE *fb* halosulfuron-methyl 67.7 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT, which was statistically comparable with HW twice at 20 and 40 DAT. Higher net returns with herbicides was due to higher grain and straw yield coupled with reduced cost of cultivation as reported by Mohapathra *et al.* (2021) and Jaiswal and Gupta (2020). The next best weed management practices in recording higher net returns and higher benefit-cost ratio were bensulfuron-methyl + pretilachlor (ready-mix) 660 g/ha PE *fb* HW at 40 DAT, which was followed by penoxsulam + butachlor (ready-mix) 820 g/ha PE *fb* bispyribac-sodium 25 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT and pretilachlor 750 g/ha PE *fb* bispyribac-sodium 25 g/ha + pyrazosulfuron-ethyl (tank-mix) 25 g/ha PoE at 20 DAT with significant differences among them. Significantly lower net returns and benefit-cost ratio were observed with unweeded check due to higher density of uncontrolled weeds.

It can be concluded that 100% RDF and triafamone + ethoxysulfuron (ready-mix) 67.5 g/ha PE *fb* halosulfuron-methyl 67.7 g/ha + fenoxaprop-p-ethyl 60 g/ha (tank-mix) PoE at 20 DAT usage results in lower weed density and biomass, higher weed control efficiency, higher rice yield attributes, higher rice grain yield of transplanted rice and higher net returns.

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