Pre and Post Emergence Herbicides Influence on Productivity of Transplanted Rice

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ABSTRACT

Background: Uncontrolled weed growth reported to reduce rice yields by 33 to 45%, while manual weeding is labor-intensive, time-consuming and costly. Pre-emergence herbicides prevent weed establishment and post-emergence herbicides target established weeds, offering effective and less costly weed control. However, an integrated approach to weed management is crucial to ensure long-term agricultural sustainability and minimize environmental impacts and weed resistance development

Methods: An experiment was conducted at Post Graduate Research Farm, M.S. Swaminathan School of Agriculture, Centurion University, Paralakhemundi, Odisha during the *kharif* season of 2023 in randomized block design with fourteen treatments *viz.*, Pyrazosulfuron ethyl 10% WP @ 200 g/ha at 1-3 DAT(T_1), Bispyribac sodium 10%SC @ 250 ml/ha at 25 DAT(T_2), Penoxsulam 21.7%SC @ 166 ml/ha at 25 DAT (T_3), Metsulfuron methyl 10% + Chlorimuron ethyl 10%WP @ 4 g/ha at 25 DAT (T_4), Florpyrauxifen-benzyl 1.31% + Penoxsulam 2.1% @2027 ml/ha at 25 DAT (T_5), Pyrazosulfuron followed by Bispyribac sodium at 25 DAT (T_6), Pyrazosulfuron followed by Penoxsulam at 25 DAT (T_7), Pyrazosulfuron followed by Florpyrauxifen-benzyl + Penoxsulam 25 DAT (T_8), Pyrazosulfuron followed by Metsulfuron methyl 10%+ Chlorimuron ethyl 10% 25 DAT (T_9), Triafamone20%+ Ethoxysulfuron 10% WG@ 225 g/ha at 20 DAT (T_{10}), Pyriftalid 31.0% + Bensulfuron methyl 15.7% @375 ml/ha 20 DAT (T_{11}), Pyrazosulfuron followed by one hand weeding at 25 DAT (T_{12}), Hand weeding twice at 25 and 45 DAT (T_{13}) and Weedy check (T_{14}) which were replicated thrice.

Result: At 30 and 60 DAT, the total weed density and dry weight was significantly low in hand weeding twice at 25 and 45 DAT over all other treatments. At 30 DAT, the weed control efficiency was higher in the treatment Hand weeding twice at 25 and 45 DAT (T_{13}) followed by T_8 and T_{12} where the efficiency was more than 90%. At 30 DAT, the dry matter was significantly higher with T_{13} and T_8 over all other treatments.The grain yield observed with T_{13} was on par with that of T_8 and T_{10} and significantly superior over all other treatments. For getting higher yield and net returns in transplanted rice, application of T_8, T_{10}, or T_{13} is recommended for transplanted rice during *kharif* season. This paper is aligned with UN SDG 14.

Key words: Hand weeding, Herbicides, *Kharif* season, Transplanted rice, Weed index.

INTRODUCTION

Rice is one of the most important staple food crops in the world, providing nutrition to more than half of the global population. In India, rice occupies an area of 45.07 million hectares, 122.27 million tonnes production and 2713 kg/ha productivity (GoO, 2021). In Odisha, rice is cultivated in 4.03 million ha during *Kharif* and *rabi* / summer seasons with a production of 8.73 million tons and productivity of 2173 kg ha^{-1} (GoO, 2021). Reddy *et al.* (2003) from Hyderabad reported that the transplanted rice yield was reduced by 28-40% as a result of *Cyperus* spp., *Paspalum* spp., *Caesulia axillaris*, *Rotala densiflora* and *Monocharia vaginalis*.

The use of herbicides in agriculture has revolutionized weed management practices, significantly impacting crop productivity and overall agricultural sustainability (Bhattacharya *et al.,* 2021). Uncontrolled weed growth reported to reduce rice yield by 33 to 45% (Manhas *et al.,* 2012). Manual weeding in rice becomes difficult because labor scarcity (at specific time) as well as time consuming and costly (Singh *et al.,* 2012; Sanodiya and Singh, 2022). On the other hand, the weed control through herbicides is less costly and easy to apply more effectively.

Pre-emergence herbicides play a pivotal role in preventing weed establishment and competition with the transplanted rice. On the other hand, post-emergence herbicides are applied after both the crop transplanted and weed seedlings have emerged and these herbicides provide targeted control of established weeds that might have escaped pre-emergence treatments. However, a balanced and integrated approach to weed management is essential to ensure the long-term sustainability of agricultural practices while minimizing potential negative impacts on the environment and weed resistance development.

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MATERIALS AND METHODS

A field experiment on the “Effect of pre and post emergence herbicides on weed dynamics and productivity of

transplanted rice in south Odisha" was conducted at the Post Graduate Research farm, M.S. Swaminathan School of Agriculture, CUTM, Paralakhemundi, Odisha during the kharif season of 2023. The location is situated at 23°39′N latitude, 87°42′ E longitude with an altitude of 64 m above the mean sea level under typical sub-humid and sub-tropical climatic conditions. The experimental soil is sandy loam in nature having a pH of 6.27, organic carbon 0.4%, available N 115.40 kg ha^{-1}, available P 312 kg ha^{-1} and available K 530.73 kg ha^{-1}. The average annual rainfall of this area is 1400 mm and this region comes under a sub-tropical region with high humidity climatic conditions. The total rainfall received during the cropping season, August to November 2023, was 459 mm. The weather during the crop growth period indicates that the maximum temperature varied from 35.1°C to 29.7°C and the minimum temperature ranged from 18.6°C to 26.5°C. The minimum wind speed was 3.3 km/h, while the maximum wind speed observed during crop growth was 5.9 km/h. The bright sunshine hours ranged from 4.8 h/day to 11.0 h/day.

The weed management treatments consisting of fourteen combinations of pre and post emergence herbicides along with hand weeding and weedy check were tried in three replications (Table 1).

Transplanting of 35-day-old seedlings of RNR 15048 having a 125-day duration was done manually at a spacing of 20 cm × 15 cm in the third week of August 2023. To maintain uniform plant population, gap filling was done at 10 days after transplanting. The crop was irrigated as and when required to keep the land under saturated condition. Irrigation was given by flooding method.

A recommended dose of N, P_2O_5 and K_2O (100:60:60 kg/ha) were applied through urea, single super phosphate (SSP) and muriate of potash (MOP). Half dose of nitrogen and full doses of phosphorus and potassium were applied before transplanting as basal application. The remaining 50 percent of N was top dressed in two equal splits at active tillering (20 DAT) and panicle initiation (40 DAT) stages.

The observations on weeds (weed density, weed dry matter), crop (plant height, tiller number, crop dry matter, yield attributes) were recorded by adopting standard procedures. The crop was harvested at maturity and the grain yield was recorded at 14% moisture. The statistical analysis of the data was carried out as per the standard procedure for analysis of variance as described by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

Weeds

The major grassy weeds observed were *Echinochloa colona, E. crusgalli, Leptochloa chinensis;* broad leaved weeds were *Caesulia axillaris, Alternanthera sessilis, Ammania baccifera* and *Cyperus rotundus, C. iria, C. difformis* and *Fimbristylis miliaceae* among sedges.

When Compared to all other treatments, hand weeding twice at 25 and 45 DAT resulted in a considerably lower total weed density at 30 DAT. The weed density observed in T_{12}, T_8 and T_5 are comparable with each other and significantly lower over T_1, T_2, T_3, T_4, T_7 and T_{11}.

At 30 DAT, T_{13} treatment recorded significantly lower weed dry weight as compared to T_8 which in turn recorded

Table 1: Weed density (no/0.25 m^2) and weed dry weight (g/0.25 m^2) as affected by different weed control treatments are various stages of rice crop during *Kharif* season, 2023.

Treatment	Days after transplanting			
	Weed density, no./0.25 m^2		Weed dry weight, g /0.25 m^2	
	30	60	30	60
T_1	17.00 (4.18)	8.33 (2.97)	5.43 (2.43)	4.37 (2.11)
T_2	13.33 (3.72)	8.00 (2.92)	5.07 (2.36)	2.80 (1.81)
T_3	15.00 (3.72)	8.33 (2.97)	5.97 (2.54)	3.60 (2.02)
T_4	13.67 (3.76)	6.00 (2.55)	4.60 (2.26)	3.23 (1.93)
T_5	7.00 (2.73)	4.67 (2.27)	2.37 (1.69)	2.87 (1.83)
T_6	11.00 (3.39)	7.33 (2.80)	3.73 (2.06)	3.30 (1.95)
T_7	13.00 (3.67)	7.33 (2.80)	3.80 (2.07)	2.57 (1.75)
T_8	5.67 (2.47)	3.00 (1.87)	0.70 (1.09)	0.93 (1.20)
T_9	10.33 (3.28)	6.67 (2.68)	1.73 (1.49)	3.77 (2.07)
T_{10}	9.33 (3.11)	5.00 (2.34)	1.27 (1.33)	2.13 (1.62)
T_{11}	10.33 (3.29)	5.67 (2.48)	1.70 (1.48)	4.07 (2.14)
T_{12}	7.33 (2.79)	5.67 (2.48)	1.03 (1.24)	3.23 (1.93)
T_{13}	0.00 (0.71)	2.00 (1.56)	0.00 (0.71)	2.77 (1.63)
T_{14}	26.00 (5.15)	24.33 (4.98)	11.37 (3.44)	11.70 (3.49)
S. Em.±	(0.11)	(0.08)	(0.04)	(0.16)
CD at 5%	(0.31)	(0.22)	(0.108)	(2.11)
CV%	(5.58)	(4.90)	(3.43)	(0.45)

( ) figures in the brackets are transformed values.

lower dry weight over all other treatments. Significantly, higher weed dry weight was observed in weedy check over all other treatments.

At 30 DAS, the weed control efficiency was higher in treatment T_{13} followed by T_8 and T_{12} where the efficiency was more than 90%. On the other hand, it was between 80 to 90% in treatment T_9, T_{10} and T_{11} it was 79% in T_5.

The weed index was higher under T_{14} (43.9%) followed by T_4, T_3 and T_2 which ranged between 28.5% to 29.5%.

Crop

The plant height at 30 and 60 DAT and harvest did not vary significantly among different weed control treatments. The plant height ranged from 80 to 86 cm, 116 to 130 cm and 119 to 133 cm at 30 and 60 DAT and harvest respectively.

At 60 DAT, dry matter recorded under T_{13} was comparable with T_8, T_9, T_{10}, T_{11}, T_3 and T_5 and significantly higher over all other treatments (Table 2).

Table 2: Drymatter and yield attributes as affected by different weed control treatments are various stages of rice crop during *Kharif* season, 2023.

Treatment	No. of panicles m^{-2}	Panicles length (cm)	No. of spikelet/ panicles	Per cent of filled spikelet	1000 grain weight, g	Dry matter, g m^{-2} at 60 DAT
T_1	330	26	219	87	19	750
T_2	299	25	214	88	18	782
T_3	283	24	230	87	19	799
T_4	308	24	274	87	19	791
T_5	340	26	254	91	20	843
T_6	328	24	249	87	19	771
T_7	339	24	253	89	19	781
T_8	356	26	279	92	19	867
T_9	336	24	233	87	20	842
T_{10}	352	26	267	93	20	867
T_{11}	330	26	238	89	19	830
T_{12}	344	24	213	85	20	776
T_{13}	359	27	275	93	19	884
T_{14}	295	23	172	78	19	703
S. Em. ±	15	1	15	2	0.23	30
CD at 5%	44	-	44	6	0.66	87
CV%	8	8	11	4	2.02	6

Table 3: Yield (kg/ha) of rice as affected by different weed control treatments are various stages of rice crop during *Kharif* season, 2023.

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index, %
T_1	4071	6746	10818	40.49
T_2	3638	6415	10053	36.19
T_3	3621	6542	10163	35.63
T_4	3588	6382	9970	35.99
T_5	4084	7027	11111	36.75
T_6	3836	6928	10765	35.63
T_7	4150	7193	11343	36.58
T_8	4674	7552	12231	38.21
T_9	3935	6945	10880	36.16
T_{10}	4383	7391	11774	37.23
T_{11}	3770	6614	10384	36.31
T_{12}	4051	6912	10962	36.95
T_{13}	5093	7639	12732	40.00
T_{14}	2857	5870	8730	32.72
S. Em. ±	314	275	529	-
CD at 5%	915	798	1537	-

Significantly, higher number of panicles were observed with T_{13} as compared to T_2, T_3, T_4 and T_{14} and comparable with other treatments (Table 2).

The number of spikelets per panicle observed with T_{13} was comparable with that of T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11} and significantly superior over that of T_1, T_2, T_3, T_{12} and T_{14} (Table 2).

The grain yield observed with T_{13} was at par with that of T_7 and T_{10} and significantly superior over all other treatments. The increase in yield observed in T_{13} over other treatments ranged from 23 to 42% under herbicide applied plots (Table 3).

The straw yield differed significantly among weed control treatments (Table 3). The straw yield observed in T_{13} was at par with T_8, T_{10}, T_9 and T_7 and significantly superior over all other treatments.

The biological yield differed significantly by weed (Table 3). The biological yield in T_{13} was at par T_7, T_8 and T10 and significantly superior over all the other treatments.

Under hand weeding twice treatment there was 92% decrease in weed intensity and 76% in weed dry matter content. There was negative correlation between grain yield and weed intensity and weed dry matter (Table 4). Due to lower weed competition in hand weeded plot as compared to other herbicide applied plots there was increase in yield under T_{13} (9 to 42%). Further, the panicle number, panicle length, grain number per panicle were significantly greater under hand weeding twice treatment as compared to other treatments (Table 1). More over these parameters had positive correlation with grain yield (Table 3) indicating that the improvement in these yield attributes under hand weeding improved the grain yield. Further, there was also improvement in dry matter production at 30 and 60 DAT and harvest in hand weeded plot over other treatments (Table 1). The dry matter improvement at vegetative stage increases the yield attributing characters and there by grain yield. Dry matter at 30 and 60 DAT had positive correlation with grain yield. Further, the harvest index was also higher in hand weeding as compared to other treatments. In several experiments, it has been observed that hand weeding gives better weed control and higher grain yield (Menon *et al.,* 2016).

The harvest index was comparable in T_1 (40.49%) and T_{13} (40%) though the grain yield was significantly lower in former treatment than T_{13} due to proportionate increase in dry matter to that of grain yield. The harvest index in Hand weeding indicates that the lower weed intensity and weed growth in hand weeding resulted in higher biological yield proportionate to that of grain yield. The lowest harvest index was observed in Weedy check (32.72%) due to biological yield in proportion to grain yield (Table 2).

In the present study, the grain yield obtained with T_{10} was comparable with all other treatments and significantly superior over Weedy check due to lower weed intensity and weed dry matter which helped in increased yield attributes and thereby grain yield in the former treatment. Deivasigamani, (2016) reported that the herbicides applied 15 days after planting, triafamone (225 g/ml/ha) and triafamone + ethoxysulfuron (200 g/ml/ha and 225 g/ml/ha), showed zero weed counts of individual species, such as grasses, sedges and broad leaf weeds, as well as weeddry matter production and weed control index favoring higher grain yield.

Triafamone combined with ethoxy sulfuron was shown to have the highest grain yield, the lowest weed dry matter generation and the most effective weed control (Menon *et al.,* 2020) and also application of pyriftalid + bensulfuron methyl @ 450 ml ha^{-1} at 9 DAT (Mondal *et al.,* 2020).

The grain yield observed with T_8 was significantly superior over T_2, T_3, T_4 and T_{14} and comparable with that of all other herbicide treated plots (Table 3). In the former treatments there was greater weed density, weed dry weight as compared to all other herbicide treatments. This helped in higher dry matter production of rice crop due to the higher tillering (Table 2). As a result of its higher tillering, the treatment T_8 resulted higher number of panicles, accumulated more dry mass there by higher yield attributes like panicle length and grains per panicle (Table 2). The increase of yield attributes has resulted increased yield in with T_8 over latter treatments. The reports indicate that Pyrazosulfuron-ethyl at 42.0 g/ha applied at 3 DAT alone was most effective in managing associated weed species and yielded maximum grain yield of rice with lower weed index as compared to weedy check (Pal *et al.,* 2012). The highest rice grain yield was recorded in application of Pyrazosulfuron ethyl 70% WDG @ 30 g ha^{-1} as post emergence (Raju *et al.,* 2020).

T_2, T_3 and T_4 recorded 2727 and 26% higher yield over weedy check. The lower yield in the weedy check was due to higher weed growth and intensity, lower rice plant height, dry matter accumulation at different stages there by lower yield attributes in these treatments and ultimately less yield

Table 4: Correlation between grain yield and growth of weeds, crop and yield attributes of rice.

Grain yield, kg ha^{-1} vs	Correlation coefficient (r)	Significant
Dry matter of weeds at 30 DAT	-0.87	**
Dry matter of weeds at 60 DAT	-0.80	**
Weed control efficiency at 30 DAT	0.84	**
Weed control efficiency 60 DAT	0.68	**
Plant height harvest	0.87	**
Dry matter accumulation 30 DAT	0.82	**
Dry matter accumulation 60 DAT	0.78	**
No. of panicles	0.85	**
No. of filled spikelets	0.79	**
1000 grain weight, g	0.22	NS
Straw yield, kg ha^{-1}	0.96	**
Biological yield, kg ha^{-1}	0.99	**

**Significant at 1% per cent.

as compared to the former herbicide treatments. It has been reported the under transplanted conditions higher doses of penoxsulam 25.0 g/ha and 22.5 g/ha recorded significantly higher grain yield over unweeded control (Sasna *et al.,* 2016, Singh *et al.,* 2009). Further, application of Bispyribac Sodium 10% SC @ 20 g *a.i.* ha^{-1} kept the weed density and dry weight bellow the economic threshold level and increased the grain yield in rice (Rajib Das *et al.,* 2015).

CONCLUSION

Based on this research, it can be said that for getting higher yield and net returns application of Pyrazosulfuron followed by Florpyrauxifen-benzyl + Penoxsulam 25 DAT(T_8) or Triafamone 20%+ Ethoxysulfuron 10% WG@ 225 g/ha at 20 DAT(T10) or hand weeding is recommended for transplanted rice during kharif season.

Conflict of Interest

The authors declare that there is no conflict of interest related to this article.

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