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RESEARCH ARTICLE

Weed management efficacy and rice nutrient uptake as influenced by pyrazosulfuron-ethyl + oxaziclomefone in transplanted rice

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ABSTRACT

An experiment was conducted at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during the *kharif* seasons of 2021 and 2022, to evaluate the weed management efficacy and rice nutrient uptake as influenced by pyrazosulfuron-ethyl 8.4% + oxaziclomefone 20% WP (pyrazosulfuron-ethyl and + oxaziclomefone) (ready-mix) in transplanted rice. The pre-emergence application (PE) of pyrazosulfuron-ethyl + oxaziclomefone at 21+50 g/ha was at par with its higher dose of 26.25+62.5 g/ha and also with weed-free check in significantly lowering total weed density and biomass at 30 and 45 days after transplanting with higher weed control efficiency and lower weed index. Lower removal of N, P and K by total weeds, higher uptake of N, P and K by rice crop, higher rice grain yield and straw yield were also recorded with pyrazosulfuron-ethyl + oxaziclomefone 26.25+62.5 and 21+50 g/ha, which were comparable to the uptake done by rice in weed free. Thus, pyrazosulfuron-ethyl + oxaziclomefone 21+50 g/ha PE was proved to be the most effective option for controlling weeds efficiently and producing higher rice productivity in transplanted rice.

Keywords: Bioefficacy, Nutrient uptake, Pyrazosulfuron + oxaziclomefone, Transplanted rice, Weed management

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population. About 90% of the total rice is grown and consumed in Asia. Globally, this crop ranks first in area and second to wheat in total production. It is one of the most important food crop grown extensively in India and plays a key role in the livelihood, food and economic security of the farmer's and contributes to about 43% of total food grain production. India had 51 million hectares of land area under rice cultivation, with production and productivity of 150 million tons and 4.41 t/ha (Anonymous 2024a). In Himachal Pradesh, the area under rice was targeted at 88.16 thousand hectares with a production and productivity of 199 thousand tons and 2.2 t/ha, respectively (Anonymous 2024b).

Among the prominent factors responsible for the low productivity of rice in Himachal Pradesh, inadequate weed control is the major one. Weeds compete with rice due to their high adaptability, faster growth and dominate the crop habitat, resulting in reduced rice productivity (Rao *et al.* 2017). Weeds compete for nutrients, moisture, light and space with crop. As per an estimate, weeds can deprive the crops nutrient uptake of 47% N, 42% P, 50% K, 39% Ca and 24% Mg and reduce the yield potential by harbouring the number of crop pests. Keeping the fields weed free during the critical competition period is essential for obtaining optimum yield of rice. This can be achieved by removing weeds manually, mechanically, chemically or by their combinations. Weed growth is relatively less in transplanted rice compared to direct-seeded rice (Rao *et al.* 2007; Khare *et al.* 2014; Rao *et al.* 2015).

In the recent past, several pre-and post-emergence herbicides have been recommended for controlling weeds in rice, out of which butachlor and cyhalofop-butyl have been popular among farmers. However, pretilachlor and pyrazosulfuron have also become popular among the rice farmers in different areas. Herbicides like butachlor and pretilachlor used in rice fields are required in large dosages of active ingredients and these herbicides may leave more residues in the soil, which may deteriorate soil and human health (Cai *et al.* 2014).

Repeated use of any single herbicide in any crop results in the development of resistant weeds for particular weedicide and results in the shift of weed flora, leading to the dominance of secondary weeds (Chauhan 2012, Chauhan and Opena 2012). For instance, *Echinochloa crus-galli* has developed resistance to several herbicides, including butachlor

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and quinclorac, due to their continuous use in rice (Heap 2025). This necessitates using other herbicides that are quite effective against associated and resistant weeds. Moreover, for broader spectrum weed control, reduced phytotoxicity on crop and in efforts to inflict minimum harm to the environment, it is advantageous to enhance the herbicides efficacy by using herbicides mixtures for broader and effective weed management.

In view of this, newer herbicides that can be used at lower doses are being added each year to alleviate environmental and health concerns and meet stringent regulatory requirements. Similarly, in this context, a new ready-mix herbicide combination of pyrazosulfuron-ethyl and oxaziclomefone, a pre-emergence broad spectrum herbicide was reported to have efficacy to control grasses, sedges and broad-leaved weeds in different rice cultures (Shi *et al.* 2024). Pyrazosulfuron-ethyl belongs to the sulfonylurea chemical family and is classified under HRAC Group/ 2 (ALS inhibitors); it acts by inhibiting acetolactate synthase (ALS), disrupting the biosynthesis of branched-chain amino acids vital for protein synthesis and cell division (Ma et al. 2021). Oxaziclomefone, relatively newer, is an isoxazole family herbicide grouped under HRAC Group/ E (cell division inhibitors); it impedes microtubule assembly during mitosis, preventing cell division in germinating weed seedlings. The dual action—prevention of amino-acid synthesis and interruption of cell division—not only broadens weed spectrum control but also helps to delay resistance development and ensures crop safety and environmental compatibility. The component oxaziclomefone in this combination, blocks plant growth by inhibiting plant cell expansion in grass roots and pyrazosulfuron-ethyl which is a sulfonylurea herbicide, gives very good control of all three types of weeds (grassy, broad-leaved weeds and sedges) by inhibiting acetolactate synthase in transplanted rice (Ramesha *et al.* 2017a).

Thus, in this study a new herbicide combination product *i.e.* pyrazosulfuron-ethyl 8.4% + oxaziclomefone 20% WP (pyrazosulfuron-ethyl + oxaziclomefone) was tested and compared with other pre-emergent herbicides *viz.* pretilachlor and pyrazosulfuron applied either alone or in their combination. The objective of this study was to evaluate the weed management efficacy and rice nutrient uptake as influenced by pyrazosulfuron-ethyl + oxaziclomefone (ready-mix) in transplanted rice.

MATERIALS AND METHODS

The field experiments were conducted during the *Kharif* seasons of 2021 and 2022 at the Experimental Research Farm of the Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experimental site is situated at latitude 32° 6' N, longitude 76° 3' E and altitude of 1290.8 m above mean sea level in the North-West Himalayan region.

The experiment consisting of eight weed control treatments *viz.* pre-emergence application (PE) of pyrazosulfuron-ethyl + oxaziclomefone at three doses *i.e.* 15.75+37.5, 21+50 and 26.25+62.5 g/ha; pyrazosulfuron-ethyl 70 WDG (pyrazosulfuron-ethyl) 21 g/ha; pretilachlor 50 EC (pretilachlor) 750 g/ha; pretilachlor 30% + pyrazosulfuron-ethyl 0.75% WG (pretilachlor + pyrazosulfuron-ethyl) 600+15 g/ha; weed free and weedy check. A randomized block design with three replications was used. The soil of the experimental field was silty clay loam (sand 20.7%, silt 42.6% and clay 36.3%) in texture having an acidic pH (5.28). The soil was with medium in available nitrogen (326.14 kg/ha), high in available phosphorus (23.65 kg/ha) and medium in available potassium (256.74 kg/ha). Rice variety 'PAC 807+' was transplanted at a spacing of 20 cm × 15 cm and the rice crop was raised with a recommended package of practices except for treatments during both years. The net plot area was 9.69 m^2.

All herbicides were applied as pre-emergence at 3 days after transplanting (DAT) with a knapsack sprayer delivering a spray volume of 750 litres/ha using the flat-fan nozzle. The data on total weed density (no./m^2) and dry weight (weed biomass) were recorded at 30 and 45 DAT in each plot from randomly placed two quadrats of 0.5 m × 0.5 m. Total weeds were counted from that area and density was expressed as weed density (no./m^2). The collected weeds were sun-dried and then kept in an electric oven at 65 ^{0}C till the weight became constant and total weed biomass is expressed as g/m^2. The observed data were subjected to square root transformation using the formula $\sqrt{x+1}$, since the data on weed density and biomass showed high variation and the statistical analysis was done as per the procedures given by Gomez and Gomez (1984). The grain and straw yields of rice were recorded from the net plot area and were expressed into t/ha at 14% moisture content using the formula.

The samples of total weeds collected at 90 DAT were dried and used to estimate the N, P and K removal by total weeds and likewise, the samples of rice grain and straw were collected at harvest, dried in sun and then dried in an oven at 70 °C for estimation of nitrogen, phosphorus and potassium content by Li (1966).

Uptake of N, P and K by total weeds for individual treatment was determined by multiplying the values of respective nutrient content with the corresponding dry matter of total weeds.

RESULTS AND DISCUSSION

Effect on weeds

All the weed control treatments were proved to be significantly superior to the weedy check and significantly reduced both total weed density and biomass as reflected by their higher weed control efficiency and lower weed index values during both years **(Table 1)**. Complete removal of weeds was done in weed free.

Among herbicidal treatments, pyrazosulfuron + oxaziclomefone 21+50 g/ha and 26.25+62.5 g/ha were at par with each other in significantly lowering weed density and biomass in comparison to the rest of the treatments in both the years. Next best treatments were pyrazosulfuron + oxaziclomefone 15.75+37.5 g/ha and pretilachlor + pyrazosulfuron-ethyl 600+15 g/ha with both having statistically similar efficacy in managing weeds. The superior efficacy of these treatments in reducing the weed density and biomass can be attributed to the broad-spectrum action of these herbicides, which effectively targeted a wide range of weeds. Pal (2012) also recorded significantly lower weeds density with pyrazosulfuron-ethyl 42 g/ha in transplanted rice. The combination provides prolonged control, reducing weed regrowth and competition with the rice crop.

Among the herbicide treatments, the highest WCE in the range of 96.72 to 100% was recorded by pyrazosulfuron-ethyl + oxaziclomefone 26.25+62.5 g/ha at both stages of observation and during both years of experimentation and followed by pyrazosulfuron-ethyl + oxaziclomefone at 21+50 g/ha having corresponding values in the range of 92.63 to 98.77%. The weedy check had lowest WCE, indicating unmanaged abundant weed growth.

Weed index (WI), which quantifies yield loss due to weed competition, was lowest under the weed-free condition. Among herbicide treatments, pyrazosulfuron-ethyl + oxaziclomefone at 26.25+62.5 g/ha, recorded lowest WI values of 1.81% in 2021 and 2.68% in 2022 and followed by pyrazosulfuron-ethyl + oxaziclomefone at 21+50 g/ha, with corresponding values of 2.94 and 1.79%, reflecting minimal yield loss. Pretilachlor + pyrazosulfuron-ethyl 600+15 g/ha had higher WI (13.35 and 10.07%) than rest of other treatments. The weedy check recorded the highest WI (29.41 and 28.86%), indicating substantial yield loss due to severe weed competition.

Table 1. Effect of different weed control treatments on total weed density and biomass in transplanted rice (2021 and 2022)

Treatment	Total weed density (no./m^2)				Total weed biomass (g/m^2)			
	30 DAT		45 DAT		30 DAT		45 DAT	
	2021	2022	2021	2022	2021	2022	2021	2022
Pyrazosulfuron-ethyl + oxaziclomefone 15.75+37.5 g/ha	5.72(32.0)	5.19(26.7)	7.27(52.0)	5.72(32.0)	2.28(4.2)	2.11(3.4)	2.77(6.7)	2.57(5.7)
Pyrazosulfuron-ethyl + oxaziclomefone 21+50 g/ha	1.67(2.7)	1.67(2.7)	2.96(11.7)	2.19(6.7)	1.14(0.3)	1.07(0.2)	1.45(1.4)	1.31(1.8)
Pyrazosulfuron-ethyl + oxaziclomefone 26.25+62.5 g/ha	1.00(0.0)	1.00(0.0)	2.45(6.7)	1.41(1.3)	1.00(0.0)	1.00(0.0)	1.25(0.6)	1.20(0.4)
Pyrazosulfuron 21 g/ha	7.26(52.0)	5.61(30.7)	8.27(68.0)	6.50(41.3)	2.69(6.2)	2.22(4.0)	3.19(9.3)	2.93(7.6)
Pretilachlor 750 g/ha	7.15(50.3)	5.74(32.0)	8.23(66.7)	6.88(46.7)	2.65(6.1)	2.33(4.5)	3.18(9.1)	3.17(9.1)
Pretilachlor + pyrazosulfuron-ethyl 600+15 g/ha	5.97(36.0)	4.32(18.7)	7.13(51.3)	5.80(33.3)	2.23(4.1)	1.89(2.7)	2.81(7.0)	2.66(6.2)
Weed free	1.00(0.0)	1.00(0.0)	1.00(0.0)	1.00(0.0)	1.00(0.0)	1.00(0.0)	1.00(0.0)	1.00(0.0)
Weedy check	9.78(94.7)	9.28(85.3)	12.07(144.7)	10.87(117.3)	3.75(13.1)	3.74(13.0)	4.53(19.5)	5.05(24.6)
LSD (p=0.05)	1.22	1.00	2.26	1.61	0.36	0.28	0.60	0.49

LSD- least significant difference at the 5% level of significance, DAT- days after transplanting, the figures in the parentheses are the means of original values

Effect on rice yield

During both years, weed control treatments have recorded significantly higher grain and straw yields **(Table 1)**. The percentage increase in grain yield due to different weed control treatments over weedy check ranged from 21.3 to 41.5% and 23.5 to 40.2% during the first and second year of study, respectively, while the corresponding increase in straw yield was in the range of 18.4 to 36.9% and 21.3 to 33.3%.

Among herbicide treatments, the combination of pyrazosulfuron + oxaziclomefone 21+50 and 26.25+62.5 g/ha had significantly higher grain and straw yield of rice, during both years, over the rest of all treatments and were statistically equivalent to the weed free. The rice grain yield of rice recorded with pyrazosulfuron + oxaziclomefone 21+50 g/ha was 37.5 and 37.8% higher than that recorded with weedy check during the first and second year, respectively. The corresponding increase in straw yield was 23.5 to 40.2%. The same herbicide combination applied at a higher dose of 26.25+62.50 g/ha caused 36.5 to 38.9% increase in grain yield and 29.5 to 35.7% increase in straw yield over the weedy check during the first and second year, respectively. The increased rice grain and straw yield can be attributed to improved utilization of available nutrients, light, and water confirming the findings of Ramesha *et al.* (2017b).

All the other remaining weed control treatments, being at par among themselves, were found significantly superior over weedy checks with regard to recording high grain and straw yield of rice during both the years of study. In transplanted rice, pyrazosulfuron-ethyl was reported as the most effective herbicide for increasing grain yield (Patel *et al.* 2023; Gupta *et al.* 2023) and Gupta *et al.* (2023) reported pretilachlor 500 g/ha also as most effective herbicide.

Effect on nutrient uptake by weeds

All the weed control treatments resulted in significantly lower uptake of nutrients (N, P and K) by total weeds over weedy check during both the years of experimentation **(Table 2)**. Due to the complete control of weeds in weed free check by their removal, no uptake was made by the weeds during both the years. Among herbicidal treatments, significantly lower uptake of N, P and K by total weeds in rice was recorded with pyrazosulfuron +

Table 2. Effect of different weed control treatments on weed control efficiency, rice yield (grain and straw) and weed index (WI) in transplanted rice (2021 and 2022)

Treatment	Weed control efficiency (%) 30 DAT		Weed control efficiency (%) 45 DAT		Rice grain yield (t/ha)		Rice straw yield (t/ha)		Weed index (%)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Pyrazosulfuron-ethyl + oxaziclomefone 15.75+37.5 g/ha	67.76	73.44	65.76	76.96	3.79	3.98	5.59	4.40	14.25	10.96
Pyrazosulfuron-ethyl + oxaziclomefone 21+50 g/ha	97.47	98.77	92.99	92.63	4.29	4.39	6.19	4.75	2.94	1.79
Pyrazosulfuron-ethyl + oxaziclomefone 26.25+62.5 g/ha	100.00	100.00	96.72	98.17	4.34	4.35	6.30	4.66	1.81	2.68
Pyrazosulfuron 21 g/ha	52.14	69.52	52.61	68.99	3.76	3.96	5.55	4.34	14.93	11.41
Pretilachlor 750 g/ha	53.60	65.67	53.38	63.04	3.74	3.93	5.51	4.33	15.38	12.08
Pretilachlor + pyrazosulfuron-ethyl 600+15 g/ha	68.76	79.21	63.92	74.60	3.83	4.02	5.50	4.36	13.35	10.07
Weed free	100.00	100.00	100.00	100.00	4.42	4.47	6.35	4.79	0.00	0.00
Weedy check	0.00	0.00	0.00	0.00	3.12	3.18	4.64	3.59	29.41	28.86
LSD (p=0.05)	-	-	-	-	0.37	0.26	0.43	0.36	-	-

LSD- least significant difference at the 5% level of significance, DAT- days after transplanting

Table 3. Effect of weed control treatments on N, P and K uptake (kg/ha) by total weeds in transplanted rice

Treatment	Nitrogen (kg/ha)		Phosphorus (kg/ha)		Potassium (kg/ha)	
	2021	2022	2021	2022	2021	2022
Pyrazosulfuron-ethyl + oxaziclomefone 15.75+37.5 g/ha	4.60	4.45	0.91	0.88	5.81	5.61
Pyrazosulfuron-ethyl + oxaziclomefone 21+50 g/ha	1.37	1.17	0.25	0.21	1.78	1.52
Pyrazosulfuron-ethyl + oxaziclomefone 26.25+62.5 g/ha	1.32	0.85	0.26	0.18	1.75	1.18
Pyrazosulfuron 21 g/ha	5.18	5.88	1.03	1.17	6.40	7.26
Pretilachlor 750 g/ha	6.05	6.54	1.15	1.24	7.60	8.20
Pretilachlor + pyrazosulfuron-ethyl 600+15 g/ha	4.61	3.92	0.82	0.70	5.40	4.59
Weed free	0.00	0.00	0.00	0.00	0.00	0.00
Weedy check	14.47	14.09	2.59	2.53	17.93	17.47
LSD (p=0.05)	1.09	1.29	0.36	0.38	1.16	1.39

LSD- least significant difference at the 5% level of significance

Table 4. Effect of weed control treatments on nitrogen, phosphorus and potassium uptake (kg/ha) by transplanted rice (grain, straw and total)

Treatment	Nitrogen uptake (kg/ha)						Phosphorus uptake (kg/ha)						Potassium uptake (kg/ha)					
	Grain		Straw		Total		Grain		Straw		Total		Grain		Straw		Total	
	2021	2022	2021	2021	2022	2021	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Pyrazosulfuron-ethyl + oxaziclomefone 15.75+37.5 g/ha	48.4	51.3	40.1	31.5	88.5	82.8	6.4	6.8	12.9	10.1	19.3	16.9	8.4	9.2	70.2	54.9	78.6	64.1
Pyrazosulfuron-ethyl + oxaziclomefone 21+50 g/ha	52.1	53.7	43.8	33.6	95.9	87.3	6.9	7.0	15.3	11.7	22.2	18.8	10.5	11.2	78.7	59.8	89.3	71.0
Pyrazosulfuron-ethyl + oxaziclomefone 26.25+62.5g/ha	53.2	53.8	45.2	33.3	98.4	87.1	7.2	7.2	15.7	11.6	23.0	18.8	10.6	10.8	81.4	59.7	92.0	70.4
Pyrazosulfuron 21 g/ha	47.3	50.1	39.6	31.0	86.9	81.1	6.0	6.3	11.9	9.3	17.9	15.6	9.1	10.1	68.4	53.0	77.5	63.0
Pretilachlor 750 g/ha	47.8	50.6	38.2	30.0	86.0	80.6	5.8	6.1	12.0	9.5	17.8	15.5	8.8	9.6	67.0	52.2	75.7	61.8
Pretilachlor + pyrazosulfuron-ethyl 600+15 g/ha	48.3	50.8	39.0	30.9	87.3	81.8	5.9	6.2	12.0	9.5	17.9	15.7	9.1	9.8	67.7	53.3	76.9	63.2
Weed free	53.4	54.4	45.5	34.3	98.9	88.7	7.4	7.5	17.0	12.8	24.4	20.3	11.1	11.5	84.4	63.1	95.5	74.6
Weedy check	41.6	42.8	29.0	22.4	70.6	65.2	5.2	5.3	9.2	7.1	14.4	12.4	7.4	7.6	52.4	40.2	59.8	47.8
LSD (p=0.05)	4.3	2.4	4.1	2.2	5.5	3.1	0.9	0.7	2.3	1.4	2.6	1.7	1.3	0.9	5.5	5.0	5.9	5.2

LSD- least significant difference at the 5% level of significance

oxaziclomefone 21+50 and 26.25+62.5 g/ha PE, which were on par with each other statistically during both the years. These treatments resulted in the savings of 13.10 to 13.15 and 12.92 to 13.24 kg N/ha during the first year and second year, respectively. Similarly, the corresponding savings in phosphorus were 2.33 to 2.34 and 2.32 to 2.35 kg P/ha and 16.15 to 16.18 and 15.95 to 16.29 kg K/ha with these treatments.

Combination of pyrazosulfuron + oxaziclomefone 15.75+37.5 g/ha was at par with pretilachlor + pyrazosulfuron 600+15 g/ha were found to be the other best treatments, which have resulted in lower nutrient uptake of N, P and K by total weeds during both the years. Moreover, during the first year, for significantly reduced uptake of phosphorus and potassium, pyrazosulfuron 21 g/ha was also at par with those treatments and with pretilachlor 750 g/ha which had recorded significantly lower uptake of phosphorus by total weeds. These results correspond closely with the findings of Babar and Velayutham (2012).

Effect on nutrient uptake by rice

All weed control treatments were significantly superior over weedy check and recorded higher uptake of major nutrients *i.e.* N, P and K in grain and straw of rice, thereby total uptake by crop during both the years of experimentation **(Table 3)**. Pyrazosulfuron + oxaziclomefone 21+50 and 26.25+62.5 g/ha were at par with each other in recording significantly higher uptake of nitrogen, phosphorus and potassium by rice grain, straw and thus total by crop, which was statistically similar to the uptake done by the crop grown in weed free check.

Among the rest of the treatments, pyrazosulfuron + oxaziclomefone 15.75+37.5 g/ha had significantly higher uptake of nitrogen and phosphorus by rice grain and straw which was at par to the above said superior treatments, during both the years. The significantly higher uptake of nitrogen, phosphorus and potassium by the rice crop with pyrazosulfuron + oxaziclomefone 21+50 and 26.25+62.5 g/ha can be attributed to effective weed control. These treatments effectively reduced weed competition, allowing the rice plants to have better access to these resources with sustained weed control throughout the growing season, minimizing nutrient losses to weeds and maximizing the availability of nutrients for the rice crop. The improved nutrient absorption and utilization by rice lead to enhanced rice growth and higher nutrient uptake.

Conclusion

It may be concluded that pyrazosulfuron + oxaziclomefone 21+50 g/ha PE resulted in effective control of complex weed flora in transplanted rice with minimal uptake of major (N, P and K) nutrients by weeds and significantly higher uptake of N, P and K by rice and increased rice grain and straw yield.

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