Original Research Article

Weed control by new generation herbicide and its influence on yield and nutrient uptake in transplanted rice

ABSTRACT

A field experiment was conducted during kharif season 2019 and 2020 at research farm of Bihar Agricultural University, Sabour, Bhagalpur to evaluate the effect of different herbicide on weed attributes, yield attributes, yield and nutrient uptake in transplanted rice. The experiment comprised six treatment T_1 (pyrazosulfuron ethyl 10 % WP 15 g a.i. ha^{-1}), T_2 (pyrazosulfuron ethyl 10 % WP 30 g a.i. ha^{-1}), T_3 (carfentrazone ethyl 25 g a.i. ha^{-1}), T_4 (carfentrazone ethyl 50 g a.i. ha^{-1}), T_5 (weed free) and T_6 (weedy) with four replications in randomized block design. The significantly lesser weed density (37.75 $No.m^{-2}$), weed dry weight (22.87 gm^{-2}), weed index (3.41) and higher weed control efficiency (80.58 %) were recorded with the application of pyrazosulfuron ethyl 30 g a.i. ha^{-1} at 30 DAT than other treatments. Crop growth parameters (plant height, number of effective tillers, dry matter accumulation), yield attributes (panicle length, effective tillers, number of grains, test weight), nutrient uptake and grain yield were recorded highest in weed free plot (57.88 q ha^{-1}) followed by pyrazosulfuron ethyl 10 % WP 30 g a.i. ha^{-1}. However, least grain yield was recorded under weedy plot. The results suggested that pyrazosalfuron ethyl 10 % WP 30 g a.i. ha^{-1} were best broad spectrum effective herbicide in order to minimized the diverse weed flora in transplanted rice.

KEYWORDS: Herbicide, rice, weed and nutrient uptake

INTRODUCTION

Rice as a staple food crop plays important role in food as well as nutritional security particularly in Asian countries. The demand for food grain is expected to increase with rise in world population.To sustain and safeguard food security in the country, the productivity of rice has to be enhanced under limited resources. Various biotic and abiotic stresses are the limiting factors in enhancing rice productivity. The major stress is imposed by competition due to weeds for water, nutrient, light and space. Hence, weed management is indispensable in crop production.In the rice ecosystem of this region weeds play a dominant role by competing for nutrients, water and space with the rice crop. Based on research findings it was estimated that extent of yield reduction in rice due to weeds alone is about 15-20 per cent for transplanted rice(Koushik et al. 2019).Scarcity and high cost of labour for hand weeding has resulted in an increase in the use of herbicide in rice. Herbicidal weed control is efficient and less expensive compared to the other methods.(Kumar et at. 2010) reported that the reduction in grain yield of rice due to uncontrolled weeds in weedy plot was 70.4 % during 2006 and 67.4 percent as compared to weed control treatments (Puniya et al. 2007) noticed that the highest loss of nutrients were occurred in unweeded (42.07, 10.00 and 21.80 kg NPK ha^{-1}) due to more density and dry weight of weeds in rice during kharifseasion.Scarcity and high cost of labour for hand weeding has resulted in an increase in the use of herbicide in rice. Herbicidal weed control is efficient and less expensive compared to the other methods.Carfentrazon ethyl and pyrazosulfuron ethyl new generation of herbicide. Pyrazosulfuron ethyl belong to Sulfonyl urea group of herbicides which are highly

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Include results of other previous studies, in addition the general objective is not observed at the end of the introduction

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effective at very low rate of application, is gaining popularity among the farming community. This group comprises the most widely used herbicides in the present time in agriculture(Singh et al. 2011). With these herbicides there is a possibility of reducing the dose of the chemical by 100 to 1000 times over traditional herbicides (Brown et al. 1990) making them environmentally safe. Hence this group of herbicides is also called as low dose high efficacy (LDHE) herbicides. The various (LDHE), herbicides Pyrazosulfuron ethyl (PSE) is very effective against grasses, sedges and broad-leaved weeds in rice crop (Moorthy et al. 2002).

MATERIALS AND METHODS

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More procedurally describe the experiment setup process so that readers can replicate the experiment

parameters evaluated?
used statistical analysis and software?

list the formulas used

Two years fields experiment was conducted during 2019-2020 at research farm of Bihar Agricultural University, Sabour, Bihar. The soil of the experimental site was sandy loam with 0.46 % organic carbon, pH 7.8, available N, P and K content in the soil was 193.43, 13.74, 132.78 kg ha^{-1}, respectively. Rice variety Rajendramahshuri (150 days crop duration) seed of 15 kg ha^{-1} were showing in nursery then 21 days after transplanting manually in rows at 20×10 cm planting geometry during both the years. The crop was subjected to 120:60:40 kg N, P_2O_5 and K_2O. K_2O and P_2O were applied at basal and nitrogen was applied with three splits (50% at basal, 25% at tillering and 25% panicle initiation stage, respectively). The experiment was laid out in randomized block design with six treatments T_1 (pyrazosulfuron ethyl 10 % WP 15 g a.i ha^{-1}), T_2 (pyrazosulfuron ethyl 10 % WP 30 g a.i ha^{-1}), T_3 (carfentrazone ethyl 40 % DF 25 g a.i. ha^{-1}), T_4 (carfentrazone ethyl 40% DF 50 g a.i. ha^{-1}), T_5 (weed free), T_6 (weedy) and four replications.The treatments were consisted of pyrazosulfuron ethyl 10 % WP at different dosages (15, 30 g a.i. ha^{-1}) and carfentrazone ethyl 40 % DF with single and double recommended dose (25, 50 g a.i. ha^{-1}) along with weed free and weedy plot. For the weed free treatment, two hand weeding (20 DAT and 40 DAT). In the weedy control, no weeding was done.The amount of the herbicides was calculated as per treatments on the basis of gross plot area. Both herbicides were applied as solution in water at the rate of 600 litres ha^{-1}. The herbicide solutions were sprayed uniformly in the experimental plots as per treatments with the help of knapsack sprayer. Pyrazosulfuron ethyl 10 % WP with their different doses were applied at 3 days after transplanting and carfentrazone ethyl 40 % DF applied at 23 days after transplanting. At sampling time (30 days after transplanting) a quadrate of 0.5×0.5 m was placed at two places in each plot to determine the weed density and weed dry weight of different weeds. Weed dry weight was recorded after drying the weed samples at 70 °C for 48 h. Weed controlefficiency and weed index was calculated based on the data recorded at 30 DAT in rice as per standard formula.

Weed control efficiency has been calculated with the formula

$$WCE\ (\%) = X\text{-}Y/X \times 100$$

Where, X = Weed dry weight in control plot (unweeded plot)

Y = Weed dry weight in treated plots

Weed index has been calculated with the formula

$$\text{Weed index} = X - Y/X \times 100$$

Where, X = Yield from weed free plot (hand weeded plot)

Y = Yield from treated plot

Growth parameters *viz*. plant height (cm), number of tillers (m^{-2}) and dry matter accumulation (q ha^{-1}) were measured at active tillering, maximum tillering, panicle initiation and at harvest stage of rice crop.No. of effective tillers (m^{-2}), panicle length (cm), No. of grain per panicle, test weight (g) and grain, straw yield and harvest index were recorded just before harvesting.The chemical properties of experimental soil viz., pH, EC, oxidisableorganic carbon, available N, P and K were estimated by Glass electrode pH meter (Jackson, 1973), Walkley and Black method (1934), Alkaline potassium permanganate method (Subbaiah and Asija 1956), Olsen's method (1954), and 1 N NH_4OAc Extraction Method (Hanway and Heidel, 1952) respectively. Total uptake of N, P and K in rice was calculated from dry matter obtained at different stages and after harvesting (grain and straw) stages as:

$$\text{Nutrient uptake (Kg ha}^{-1}\text{)} = \text{Nutrient content (\%)} \times \text{Grain weight (kg ha}^{-1}\text{)}/100$$

All the recorded data were analyzed statistically as per the method advised by (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

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Improve considering material and methods

Weed flora

The dominant weeds under experimental field among were *Echinochloacrusgalli*, *Echinochloscolona*, broad leaved weeds *Caesulia axillaries*, *Partheniunhysterophorus*, *Ecliptaprostrata* and sedges like *Cyperusiria* and *Cyperuscompressus* during both of years and rest of weed were considers others weed.

Effect on weed

Weed density and weed dry weight varied significantly due to application of herbicidal treatments Table 1. All herbicidal treatments recorded significantly lesser weed density then weedy plot. The application of pyrazosalfuron ethyl 10 % WP 30 g a.i. ha^{-1} noticed significantly lower (37.75 No. m^{-2}) weed density in each other treatments but satitically similar T_4 with the application of (carfentrazone ethyl 40 DF 50 g a.i. ha^{-1}). Among the application of pyrazosalfuron ethyl 10 % WP 30 g a.i. ha^{-1} gave significantly lower (22.87 gm^{-2}) weed dry weight as compared to all other treatments at 30 days after transplanting. In general, all the herbicidal treatments have observed lower weed density than weedy plots. The application of herbicidal treatment significant influenced on weed control efficiency. The significantly highest (80.58%) weed control efficiency recorded under the treatment T_2(Pyrazosulfuron ethyl 10% WP 30 g *a.i* ha^{-1}) followed by T_4(Carfentrazone zone ethyl 40% DF 50 g *a.i.* ha^{-1}),T_3(Carfentrazone

zone ethyl 40% DF 25 g *a.i.* ha^{-1}), T_1 (Pyrazosulfuron ethyl 10% WP 15 g *a.i* ha^{-1}) over weedy, respectively. Weed index indicate the reduction in yield due to weed competition as compared to the maximum attained grain yield. Weed index had remarkably influenced by weed management practices. Maximum weed index recorded under unweededcontrol (28.99) whereas minimum weed index were T_2 (pyrazosulfuron ethyl 10% WP 30 g a.iha^{-1}) over rest of the treatment. Similar result was found that (Nandi et al. 2006) this was due to the fact that herbicides at higher doses exhibited better control of weeds due to their greater persistence in soil.Application of pre-emergence and post-emergence herbicides controlled the weeds effectively resulted in lesser weed dry weight and higher weed control efficiency. Minimum weed dry weight and higher weed control efficiency were recorded with applicationof pendimethalin 0.5 kg + imazethapyr 50 g ha^{-1} (Sangwan et al. 2016). Our result showed that the application of pyrazosulfuron ethyl 10% WP at 30 g a.i. ha^{-1} was comparatively more effective against broad-leaved, grassy and sedge weeds in transplanted rice (Ramesha et al 2017).The persistence of pretilachlor + pyrazosulfuron ethyl herbicides could have contributed significantly in controlling weeds because pretilachlor with a half-life of 15.06 days and pyrazosulfuron ethyl with 24.75 days (Nagwanshi et al. 2016). Similar results (Shinde et al. 2018)noticed that carfentrozone ethyl 40% DF @ 25 g a.i. ha^{-1} at 30 DAS to obtainted maximum weed control efficiency. There was no phytotoxicity effect observed in any of the doses of the testing carfentrozone ethyl 40% DF in transplanted rice crop.

Effect on crop growth

The growth parameters of rice crop have significantly influenced by herbicidal treatments. Plant height of rice crop increased with the advancement of crop growth and reached to maximum at harvest stage, irrespective of the treatments Table 2. The significantly tallest (133.25 cm) plant height recorded under the treatment T_5 (weed free) followed by T_2 (Pyrazosulfuron ethyl 10 % WP 15 g a.i. ha^{-1}), T_3 (Carfentrazone ethyl 40 % DF 30 g a.i. ha^{-1}), over control respectively in all stage of rice crop except for active tillering stage.Generally, herbicidal treatments which received pyrazosalfuran and carfentrazone ethyl produced significantly shorter plants than weed free. Weedy plot produced significantly shorter plants each other treatments mainly due to higher weed competition.Taller plant under herbicidal treatments was might be due to the fact that plant faced least crop weed competition thus plant got maximum availability of nutrient, sunlight and moisture which helped the plants to grow more vigorously (Ali et al. 2018). The significantly a greater number of productive tillers and dry matter accumulation were recorded in weed free plot in all progressive stage followed by T_1 (Pyrazosulfuron ethyl 10 % WP 15 g a.i. ha^{-1}), T_2 (Pyrazosulfuron ethyl 10 % WP 30 g a.i. ha^{-1}), T_3 (Carfentrazone ethyl 25 g a.i. ha^{-1}), T_3 (Carfentrazone ethyl 25 g a.i. ha^{-1}) over weedy plot, respectively. Similar results were observed by (Rathour et al. 2015;Kamdi, 2014;Prasad, 2014). However, minimum number of productive tillers dry matter accumulation were recorded in the weedy check treatment.

Yield attributes and yield

The yield attributes were also significantly influenced by herbicidal treatments Table 3. Highest No. of effective tillers, panicle length, number of grains per panicle, test weight (250.37 m^{-2}, 30.16 cm, 139.87,21.25 g, respectively) recorded under the weed free plot which was at par with pyrazosulfuron ethyl 10 WP 30 g a.i. ha^{-1} and carfentrazone ethyl 25 g a.i. ha^{-1}). The better expression of yield attributes in the above treatments was mainly due to the broad-spectrum control of weeds resulting in comparatively low competition from weeds. The competition free environment might have allowed the crop to express its full genetic potential (Dayaram et al. 2016).The significantly highest grain and straw yield (57.88, 71.67 q ha^{-1}) recorded in weed free plot, which was statistically at par with all herbicidal treatments over control. The application of different herbicidal treatments with control (weedy) did not show significant effect on harvest index of rice crop. The highest harvest index (45.84%) received in the treatment T_3(Carfentrazone zone ethyl 40% DF 25 g *a.i.* ha^{-1}) followed by T_4(Carfentrazone zone ethyl 40% DF 50 g *a.i.* ha^{-1}), T_2 (Pyrazosulfuron ethyl 10% WP 30 g *a.i* ha^{-1}),T_1 (Pyrazosulfuron ethyl 10% WP 30 g *a.i* ha^{-1}), T_5 (weedy free) over weedy (control), respectively. The lower grain yield under weedy may be due to the high weed interference and less yield attributing parameters. Weedy plot competes with rice plants for light, nutrients, moisture and space resulting reduction in grain yield. These results are in conformity by (Kiran et al. 2010;Rawat et al. 2012).

Nutrient uptake

The uptake of nitrogen, phosphorus and potassium in different stage of rice crop like active tillering stage, panicle initiation stage, grain and straw in a product of their nitrogen, phosphorus and potassium contents with respective dry matter and yield Table 4. Significantly highest uptake of nitrogen, phosphorus and potassium were recorded under the treatment (T_5) weed free plot. Amongst the application of herbicidal treatments, significantly highest uptake of nitrogen, phosphorus and potassium with the application under the treatment T_2 (pyrazosulfuron ethyl10% WP 30 g a. i. ha^{-1}) followed by T_3 (carfentrazone ethyl 40% DF 25 g a. i. ha^{-1}), T_1 (pyrazosulfuron ethyl 10% WP 15 g a. i. ha^{-1}), T_4 (carfentrazone ethyl 40% DF 25 g a. i. ha^{-1}) compared to T_6 (weedy), respectively. This was perhaps due to more dry matter production by crop and less nutrient (N, P and K) depletion by weeds and subsequently more availability of these nutrients to crop. The minimum uptake of these nutrients was observed in weedy check (T_5), simply because of low shoot dry matter production and low availability of these nutrients as major amount of nutrient were depleted by weeds(Sreelakshmi et al. 2016:Chaudhary et al.2020). The application of herbicidal treatment better control of weeds during active crop growth stages, which helps in minimizing the crop weed competition and help the crop to utilize more nitrogen and other nutrients and led to better crop growth. Lower nutrient uptake noticed in weedy (T_6) might be due to severe competition offered by weeds for nutrients throughout the crop growth period which suppress the crop and severely affecting the crop growth (Singh et al. 2007). This was fact that effective weed control measure increased the uptake of nutrients by the crop and decreased their removal by weeds. Finally, the weed free crop absorbs higher quantity of nutrient from the soil than weedy check. However, in chemical weeding systems, lower depletion was recorded at early stage when steadily increased towards later stages of crop growth. Because of their persistence in soil, it controls the weeds over an extended period of time. As the degradation of herbicides occurs due to various chemical and bio-chemical processes, the killing effect also tend to decrease resulted in accumulation of high dry matter later stages of crop growth. Some finding was confirmed by (2018).

Table 1. Effect of herbicidal treatment on weed density, weed dry weight, weed control efficiency and weed index in rice (Pooled data of 2019 and 2020)

Treatments	Weed density (No.m^{-2})	Weed dry weight (gm-2)	Weed control efficiency (%)	Weed Index
	30 DAT	30 DAT	30 DAT	
T_1 - Pyrazosulfuron ethyl 10% WP 15 g a. i. ha^{-1}	92.87	68.75	41.69	8.8
T_2 - Pyrazosulfuron ethyl 10% WP 30 g a. i. ha^{-1}	37.75	22.87	80.58	3.41
T_3 - Carfentrazone ethyl 40% DF 25 g a. i. ha^{-1}	92.25	61.25	48.13	5.35
T_4 - Carfentrazone ethyl 40% DF 50 g a. i. ha^{-1}	41.25	24.87	78.85	12.3
T_6 - Weed Free and	53.25	44.62	62.16	0
T_6 - Weedy	163.5	118.12	0	28.97
SEm ±	1.47	1.47	1.09	2.13
CD at 5 %	4.81	4.71	3.16	6.8

Table 2. Effect of herbicidal treatment on plant height (cm), No. of tillers (m^{-2}) and dry matter accumulation (q ha^{-1}) in rice at different stages (Pooled data of 2019 and 2020)

Treatments	Plant height (cm)				No. of tillers (m^{-2})				Dry matter accumulation (q ha^{-1})			
	AT Stage	MT Stage	PI Stage	At harvest	AT Stage	MT Stage	PI Stage	At harvest	AT Stage	MT Stage	PI Stage	At harvest
T_1	30.38	77.06	93.80	125.30	108	248	336	296	8.40	14.45	65.54	117.26
T_2	30.28	81.25	96.59	128.00	107	251	324	299	8.66	15.53	68.56	122.97
T_3	29.53	80.25	96.65	125.75	109	254	325	286	8.51	14.34	64.23	111.64
T_4	28.78	77.88	94.84	121.75	106	242	324	279	8.32	13.80	62.24	108.06
T_5	30.20	84.13	98.35	133.25	113	256	351	315	8.51	17.02	71.33	126.34
T_6	29.24	70.83	79.75	110.21	109	208	231	217	8.46	10.45	43.28	82.54
Mean	29.73	78.56	93.33	124.04	108.66	243.16	315.16	282	8.47	14.26	62.53	111.46
SEm ±	1.25	1.51	1.36	1.88	1.72	1.79	3.34	2.58	0.40	0.77	1.57	1.73
CD at 5 %	NS	4.59	4.11	5.68	NS	5.42	10.05	7.80	NS	2.35	4.76	5.22

Treatment Details: T_1 - Pyrazosulfuron ethyl 10% WP 15 g a. i. ha^{-1}, T_2 - Pyrazosulfuron ethyl 10% WP 30 g a. i. ha^{-1}, T_3 - Carfentrazone ethyl 40% DF 25 g a. i. ha^{-1}, T_4 - Carfentrazone ethyl 40% DF 50 g a. i. ha^{-1}, T_5 – Weed Free and T_6 – Weedy, AT Stage– Active tillering stage, MT stage – Maximum tillering stage, PI Stage – Panicle initiation stage.

Table 3. Effect of herbicidal treatment on yield attributes, yield and harvest index in rice (Pooled data of 2019 and 2020)

Treatments	Yield attributes				Yields (q ha^{-1})			Harvest index (%)
	No. of effective tillers m^{-2}	Panicle length (cm)	No. of grain per panicle	Test weight (g)	Grain	Straw	Biological	
T_1	243.12	27.62	133.37	20.40	52.80	63.68	116.48	45.32
T_2	248.25	29.13	135.62	21.07	55.93	67.36	123.29	45.36
T_3	242.37	26.48	137.12	20.88	54.66	64.58	119.24	45.84
T_4	235.75	26.86	129.12	20.86	50.77	60.76	111.53	45.52
T_5	250.37	30.16	139.87	21.25	57.88	71.67	129.55	44.67
T_6	167.00	23.96	103.12	19.31	41.11	56.35	97.46	42.18
Mean	231.14	27.37	129.70	20.63	52.19	64.07	116.26	44.82
SEm ±	6.57	0.85	4.85	0.57	2.23	2.50	4.10	0.01
CD at 5 %	18.04	2.60	13.33	NS	6.13	6.88	11.26	NS

Table 4. Effect of herbicidal treatment on nutrient uptake (kg ha^{-1}) at different stage in rice (pooled data of 2019 and 2020)

Treatments	Nitrogen uptake (kg ha^{-1})				Phosphorus uptake (kg ha^{-1})				Potassium uptake (kg ha^{-1})			
	A.T. Stage	P.I. Stage	Grains	Straw	A.T. Stage	P.I. Stage	Grains	Straw	A.T. Stage	P.I. Stage	Grains	Straw
T_1	20.41	24.74	69.30	57.63	2.48	4.26	14.52	8.20	15.99	24.72	16.04	57.47
T_2	21.22	26.86	74.11	66.69	2.66	4.77	16.29	9.43	16.84	26.63	17.69	65.84
T_3	20.70	24.70	72.15	57.48	2.32	3.91	15.17	8.23	16.52	24.27	16.94	59.82
T_4	20.11	23.57	66.51	54.68	2.20	3.66	13.90	7.37	15.81	23.36	15.17	55.14
T_5	21.15	30.21	78.86	69.88	2.81	5.62	17.87	9.94	16.64	30.02	20.55	69.61
T_6	20.19	18.41	54.67	52.96	2.29	2.83	11.51	6.76	16.00	17.82	12.33	51.27
Mean	20.63	24.75	69.27	59.89	2.46	4.18	14.88	8.32	16.30	24.47	16.45	59.86
SEm ±	0.60	0.85	1.17	2.09	0.13	0.15	0.96	0.43	0.49	0.79	1.01	2.08
CD at 5 %	NS	2.57	3.55	6.31	0.41	0.46	2.91	1.32	NS	2.39	3.04	6.29

Treatment Details: T_1 - Pyrazosulfuron ethyl 10% WP 15 g a. i. ha^{-1}, T_2 - Pyrazosulfuron ethyl 10% WP 30 g a. i. ha^{-1},T_3 - Carfentrazone ethyl 40% DF 25 g a. i. ha^{-1},T_4 - Carfentrazone ethyl 40% DF 50 g a. i. ha^{-1}, T_5 – Weed Free and T_6 – Weedy.

CONCLUSION

It was concluded that on the basis of two year filed experiment significantly highest growth parameters, yield attributes, yield (57.88 q ha^{-1}) and nutrient uptake of rice crop recorded under weed free plot, which was statically at with all herbicidal treatments and significantly lower in weedy plot. Whereas, the application of pyrazosalfuron ethyl 10 % WP 30 g a.i. ha^{-1} recorded lower weed density, weed dry weight and weed index (37.75 m^{-2}, 22.87 gm^{-2}, 3.41 respectively) and highest weed control efficiency 80.58 %. Pyrazosalfuron ethyl 10 % WP 30 g a.i. ha^{-1}, it was best option for weed control in transplanted rice.

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