Biological Forum – An International Journal **13(4): 607-615(2021)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Performance of Herbicides on Weeds and Productivity of Transplanted Rice in Central Part of India

Anay K. Rawat[1*], Shri Rammu Lodhi[2], Ashish Tiwari[3] and Sidarth Nayak[1]
[1]Scientist, Department of Agronomy, College of Agriculture,
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, (Madhya Pradesh), India.
[2]M.Sc. Scholar, Department of Agronomy, College of Agriculture,
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, (Madhya Pradesh), India.
[3]Junior Scientist, Department of Agronomy, College of Agriculture,
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, (Madhya Pradesh), India.

(Corresponding author: Anay K. Rawat)*
(Received 23 August 2021, Accepted 04 November, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Enhancement of rice yield with more profit is major concern among scientists and round the clock efforts are being made to alleviate this situation. Competition between crop and weed is just struggle for nutrients, space, light and water resulted in poor yield. This competition not only affects yield but also increase cost of cultivation resulting in low profit over investment. Weed is considered one of the yield reducing factor. An experiment was conducted to evaluate a potent low dose herbicidal combination for broad spectrum weed management in transplanted rice during kharif 2015 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, (JNKVV), Jabalpur (M.P.) using randomized block design (RBD) with seven treatments and four replications. Critical parameters -Weed population (No. m^{-2}), Weed dry weight (g m^{-2}), Weed control efficiency (WCE, %) and weed index (WI, %) were observed to see the efficacy of applied chemicals.

Mixed application of weedicides Bensulfuron methyl 60 g with pretilachlor 600 g ha^{-1} was quite efficient to manage weeds in transplanted rice, It was also more remunerative as it gave lower weed index with more grain yield, net profit return, and B:C ratio. The findings of above experiments will definitely rice growers to manage weeds during critical crop weed competition stage ultimately which keep the investment in inputs at low level with higher profit.

Keywords: Bensulfuron-methyl, herbicide mixture, pretilachlor, transplanted rice, weed, yield.

INTRODUCTION

The world's total area under rice is 161.1 mha and production is about 480.3 mt along with the productivity of 2.98 t/ha (Statista-The statistics portal, 2017). Rice in India and occupies an area of about 43.95 million hectare with output of production of 106.54 million tones and productivity of 2424 kg ha^{-1}. In Madhya Pradesh, rice crop covers 1.93 million hectare area, with annual production of 2.78 million tones but average productivity (1438 kg ha^{-1}) which is far below if compared with national productivity (2424 kg ha^{-1}) of rice (Anonymous, 2015). Rice is first choice of the farmers and grown in more than 114 countries covering and an area of 150 Million hectares, which constitute nearly 11 percent of the world's cultivated land. If we see Indian scenario, rice is the second liking of farmers as kharif crop after wheat, and the country stands world's second largest producer of rice after China Savary *et al*., (2005).

Under Indian condition Rice is low productive crop which cannot guarantee food and nutritional security of more than 60% population that is still dependent on rice (Ram *et al*., 2014). Weed is a plant undesirable plant at a place where it flourishes and create hindrance (Patil *et al.,* 2010). Problems by problematic weed species is among one of the major factor in the loss of targeted yield in rice cultivation (Ganie *et al*., 2015). Transplanted rice is infested with wide range of weeds species viz., grasses, sedges and broad leaved weeds (Arthanari *et al.,* 2017). Weeds are good competitor with rice for all major factors responsible for potential yield like moisture, nutrients, light, temperature and space and uncontrolled weeds have caused yield reduction of 28 to 45% in transplanted rice **(**Singh *et al*., 2007; Manhas *et al*., 2012). Weeds grow profusely in the rice fields and reduce crop yields drastically (Sureshkumar *et al*, 2016). Weeds are the major barriers

to rice production because of their ability to compete for CO_2, space, moisture, sunlight and nutrients.

Heavy weedy crop sometimes leads to complete failure of the outcome (Singh *et al.,* 2005). It was also reported that Uncontrolled infestation of weeds in rice fields reduces the grain yield by 75.8, 70.6 and 62.6% in dry seeded rice, wet seeded rice and transplanted rice, respectively Singh *et al.,* (2005). In this competitive situation chemical may play an important role to manage the weeds with the target to save the potential yield of rice. Many studies showed synchronized emergence of weeds with the rice crop, pre-emergence herbicides should be applied, which allow rice crop to grow in a less weed infested environment during crop weed competition (Chauhan and Opena, 2013). According to research work done many scientists have reported that application of effective new herbicides that provide wide-spectrum of weed control would be desirable for effective weed control in rice (Arthanari *et al.,* 2017). In the findings of Rajkhowa *et al.,* (2007) weed control treatments improves the yield attributes of rice over unweeded control. The better expression of yield attributes by crop might be due to poor resurgence frequency and growth of weeds as evident from weed dry matter studies in plots treated with herbicides, as reported by Rani *et al.,* (2021).

MATERIALS AND METHODS

The experiment was conducted at Krishi Nagar Farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, (JNKVV), Jabalpur (M.P.), during kharif season of 2015 using rice variety JRH-5. The soil pH and electrical conductivity of the experimental field were normal where as organic carbon available nitrogen, available Phosphorus and available Potassium were medium.

In this experiment four herbicides were used in the experiment bensulfuron-methyl and pretilachlor, Butachlor and Pendimethalin. The herbicidal combination of bensulfuron methyl + pretilachlor is effective to control broad-leaved weeds, sedges and grasses also it does not show any phytotoxic symptoms in the crop hence it is being tested Sunil *et al*., (2010).

The experiment was laid in randomized block design (RBD) with seven treatments and four replications. The treatments consisted of (T_1) weedy check (control), (T_2) bensulfuron methyl + pretilachlor (48+480) g ha^{-1}, (T_3) bensulfuron methyl + pretilachlor (60+600) g ha^{-1}, (T_4) bensulfuron methyl + pretilachlor (72 + 720) g ha^{-1}, (T_5) pendimethalin 1300 g ha^{-1}, (T_6) butachlor 1500 g ha^{-1}, the treatment were applied three days after transplanting whereas(T_7) hand weeding was done at 20 and 40 days after transplanting.

One healthy seedling (15 days old) per hill were transplanted in field at spacing of 20cm × 20cm in all the plots uniformly. All the herbicides and herbicidal combination was applied using knapsack sprayer fitted with flat-fan nozzle. The recommended dose of NPK at the rate of 120: 60: 40 kg/ha were applied uniformly in all the plots. Half dose of the total recommended nitrogen (60kg N ha^{-1}) and full dose of phosphorus (60kg P_2O_5 ha^{-1}) and potassium (40kg K_2O ha^{-1}) was given as basal dose before transplanting and remaining quantity of nitrogen was splitted in two equal doses and top dressed at tillering and panicle initiation stage of the crop.

Weed population (No. m^{-2}) was observed at 30 days after transplanting and at harvest by quadrate count method. Weed dry weight (g m^{-2}) was also noted at 30 DAT and at harvest of the crop. Weed control efficiency (WCE, %) and weed index (WI, %) were also computed on the basis of data recorded.

RESULTS AND DISCUSSION

Weed density (No. m^{-2}) and relative density (%) are given in table 1 and depicted in Fig. 1. Data showed that that in weedy check plots of rice there was predominance presence of monocot and dicot weeds during *kharif* 2015. Different Species wise data also revealed presence of monocot (*Cyperus difformis, Cyperus iria* and *Echinochloa colona*) and broad leaved (*Ludwigia perennis , Eclipta alba and Monochoria vaginalis*) weeds in the experimental field.

Table 1: Weed density of different species (No. m^{-2}) and Relative density (%) in weedy check plots at 30DAT and harvest.

Weed species	Density (No. m^{-2})		Relative density(%)	
	30DAT	Harvest	30DAT	Harvest
Grasses				
Echinochloa colona	11.57	22.64	5.2	12.9
Cyperus difformis	106.5	51.76	47.83	29.5
Cyperus iria	49.94	46.75	22.43	26.65
Broad leaved weeds				
Ludwigia perennis	24.28	22.54	10.9	12.85
Eclipta alba	11.35	19.1	5.1	10.89
Monochoria vaginalis	19.01	12.65	8.54	7.21
Total	**222.64**	**175.44**	**100**	**100**

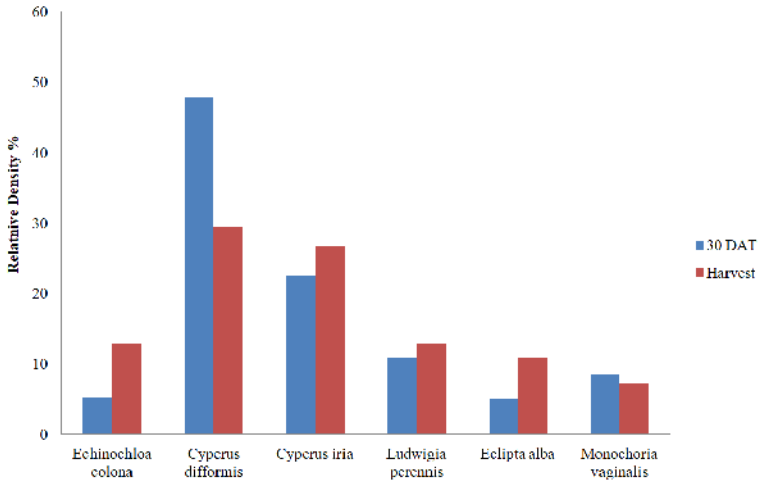

Fig. 1. Relative density (%) of weeds in control plots at 30 DAT & at harvest.

Out of mixed weed species weed *Cyperus difformis* followed by weed *Cyperus iria* were more rampant (47.83 and 22.43 % at 30 DAT and 29.50 and 26.65 at harvest) due to their continuous reemergence with rice crop. Similar trend of weed flora presence in rice also reported by Mahajan *et al*. (2003); Punia *et al*., (2016).

The population of all weeds differed significantly at 30 DAT and harvest stage which was due to different weed control measures (Table 2 and Fig. 2). Before emergence of weeds the mixed application of bensulfuron methyl 72 g ha^{-1} and pretilachlor 720) g ha^{-1} suppressed the population of weeds like *Ecinochloa colona* (2.50 and 2.13 m^{-2}), *Cyperus difformis* (13.00 and 3.19 m^{-2}), *Cyperusiria* (7.32 and 5.25m^{-2}), *Ludwigia perennis* (2.10 and 2.61 m^{-2}) *Eclipta alba* (1.66 and 5.25 m^{-2}), *Monochoria vaginalis* (1.07 and 1.30 m^{-2}) and in some weeds it was at par with lower dose of bensulfuron methyl 60 g ha^{-1} and Pretilachlor 600 g ha^{-1} but it was also noted that hand weeding twice (20 and 40 DAT) at both stages was proven highly effective against all weeds present as lowest density was observed. Similar findings were also found by Kumar *et al*., (2013): Kumar *et al*. (2014); Kaur and Singh (2015). It was noticed that all weeds of weedy check plots at both the growth intervals fetched maximum dry weight. This was attributed to non adoption of weed control measure in the weedy check plots. When field were applied herbicide application and hand weeding, the dry weights of weeds were reduced (Table 3 and Fig. 3). The reduction in the dry weight of all the weeds was marginal with the application of lower doses of bensulfuron methyl 48 g a.i. ha^{-1} with pretilachlor 480 g a.i. ha^{-1} as pre-emergence and check herbicides, butachlor at 1500 ml ha^{-1} and pendimethalin 1300 ml ha^{-1}.

Table 2: Weed density as affected by different treatments (No. m^{-2}).

Treatments	Details	*Echinochloa colona*		*Cyperus difformis*		*Cyperus iria*		*Ludwigia perennis*		*Eclipta alba*		*Monochoria vaginalis*	
		30DAT	At Harvest	30DAT	At Harvest	30DAT	At Harvest	30DAT	At Harvest	30DAT	At Harvest	30DAT	At Harvest
T_1	Weedy check (Control)	3.47 (11.57)	4.81 (22.64)	10.34 (106.50)	7.23 (51.76)	7.10 (49.93)	6.87 (46.75)	4.98 (24.28)	4.80 (22.54)	3.44 (11.35)	4.43 (19.10)	4.42 (19.01)	3.63 (12.65)
T_2	Bensulfuron methyl + Pretilachlor (48+480) g ha^{-1}	2.43 (5.38)	2.74 (7.00)	5.90 (34.26)	3.04 (8.77)	4.04 (15.84)	3.19 (9.68)	3.00 (8.51)	2.59 (6.23)	2.09 (3.85)	3.41 (11.10)	2.69 (6.75)	2.10 (3.91)
T_3	Bensulfuron methyl + Pretilachlor (60+600) g ha^{-1}	2.24 (4.50)	2.35 (5.00)	3.82 (14.10)	2.40 (5.26)	2.94 (8.12)	2.59 (6.18)	1.70 (2.39)	2.06 (3.75)	1.60 (2.06)	2.83 (7.51)	1.72 (2.46)	1.49 (1.73)
T_4	Bensulfuron methyl + Pretilachlor (72+720) g ha^{-1}	1.73 (2.50)	1.62 (2.13)	3.67 (13.00)	1.92 (3.19)	2.80 (7.32)	2.40 (5.25)	1.61 (2.10)	1.76 (2.61)	1.47 (1.66)	2.40 (5.25)	1.25 (1.07)	1.34 (1.31)
T_5	Pendimethalin 1300 g ha^{-1}	2.69 (6.75)	3.67 (12.95)	5.70 (31.97)	3.55 (12.14)	4.37 (18.59)	4.39 (18.74)	3.16 (9.48)	2.84 (7.58)	2.73 (6.97)	(3.81 14.04)	3.04 (8.75)	2.27 (4.63)
T_6	Butachlor 1500 g ha^{-1}	2.92 (8.00)	2.69 (6.71)	7.17 (50.97)	3.19 (9.71)	5.11 (25.58)	3.78 (13.75)	3.41 (11.12	2.78 (7.25	2.41 (5.31)	2.95 (8.18)	2.65 (6.50)	2.81 (7.38)
T_7	Handweeding20 40DAT	1.57 (1.95)	1.58 (2.00)	2.63 (6.43)	1.72 (2.47)	2.24 (4.50)	2.35 (5.00)	1.20 (0.95)	(1.59 2.02)	1.21 (0.97)	1.97 (3.39)	0.71 0.00	1.11 (0.73)
SEm±		0.25	0.37	0.49	0.32	0.24	0.42	0.33	0.44	0.35	0.41	0.59	0.23
CD(P=0.05)		0.77	1.10	1.45	0.96	0.73	1.25	1.01	1.33	1.04	1.24	1.78	0.70

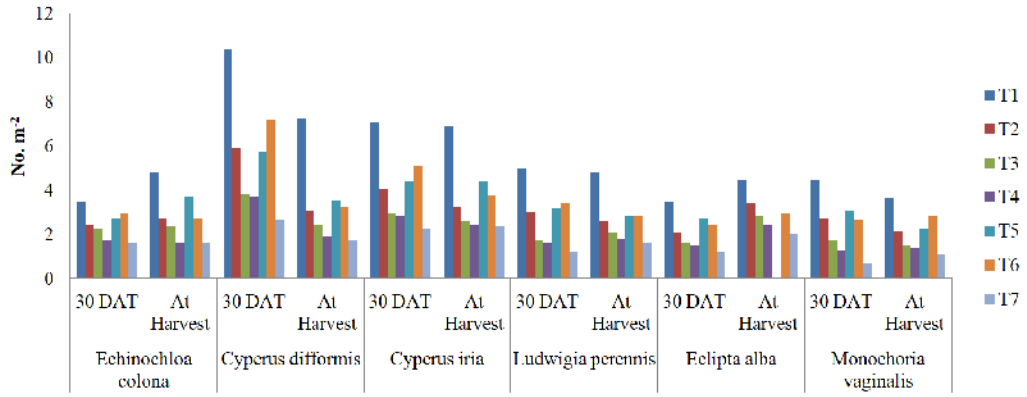

Fig. 2. Effect of different treatments on density (No. m^{-2}) of weeds in rice.

Table 3: Dry weight (g m^{-2}) of weeds in rice as affected by different treatments.

Treatments	Details	*Echinochloa colona*		*Cyperus difformis*		*Cyperusiria*		*Ludwigia perennis*		*Eclipta alba*		*Monochoria vaginalis*	
		30 DAT	At Harvest	30 DAT	At Harvest	30 DAT	At Harvest	30 DAT	At Harvest	30 DAT	At Harvest	30 DAT	At Harvest
T_1	Weedy check (Control)	2.17 (4.20)	7.95 (62.75)	2.59 (6.19)	9.26 (85.30)	3.31 (10.43)	11.17 (124.38)	1.14 (0.81)	3.32 (10.50)	2.19 (4.28)	5.69 (31.83)	1.95 (3.30)	2.54 (5.96)
T_2	Bensulfuron methyl + Pretilachlor (48+480) g ha^{-1}	1.63 (2.15)	3.94 (15.00)	1.59 (2.04)	3.75 (13.54)	1.92 (3.18)	5.20 (26.50)	0.91 (0.33)	1.88 (3.05)	1.40 (1.45)	3.92 (14.85)	1.37 (1.39)	1.83 (2.87)
T_3	Bensulfuron methyl + Pretilachlor (60+600) g ha^{-1}	1.35 (1.31)	3.12 (9.25)	1.25 (1.08)	2.66 (6.58)	1.62 (2.13)	4.10 (16.28)	0.79 (0.13)	1.38 (1.40)	1.21 (0.98)	3.39 (10.98)	0.92 (0.34)	1.06 (0.63)
T_4	Bensulfuron methyl + Pretilachlor (72+720) g ha^{-1}	1.26 (1.09)	1.92 (3.20)	1.06 (0.62)	2.16 (4.17)	1.38 (1.40)	3.87 (14.50)	0.78 (0.10)	1.29 (1.17)	0.85 (0.23)	2.92 (8.02)	0.73 (0.04)	0.96 (0.43)
T_5	Pendimethalin 1300 g ha^{-1}	1.63 (2.16)	(4.80 22.50)	2.07 (3.80)	(4.12 16.45)	2.07 (3.80)	7.45 (55.00)	0.98 (0.47)	1.81 (2.79)	1.66 (2.25)	(4.48 19.58)	1.45 (1.59)	1.90 (3.10)
T_6	Butachlor 1500 g ha^{-1}	1.93 (3.24)	(4.03 15.78)	2.17 (4.23)	(3.65 12.86)	2.74 (7.00	5.92 (34.50)	0.99 (0.48)	1.81 (2.78)	1.63 (2.17)	3.00 (8.50)	1.45 (1.60)	1.89 (3.08)
T_7	Handweeding20and40DAT	1.01 (0.53)	1.62 (2.13)	0.84 (0.20)	1.82 (2.80)	1.08 (0.68)	3.60 (12.43)	0.77 (0.09)	0.99 (0.48)	0.84 (0.20)	2.54 (5.97)	0.71 0.00	0.89 (0.29)
SEm±		0.11	0.279	0.694	0.359	0.13	0.427	0.025	0.101	0.084	0.181	0.024	0.054
CD(P=0.05)		0.34	0.835	2.077	1.074	0.39	1.279	0.074	0.303	0.251	0.543	0.072	0.162

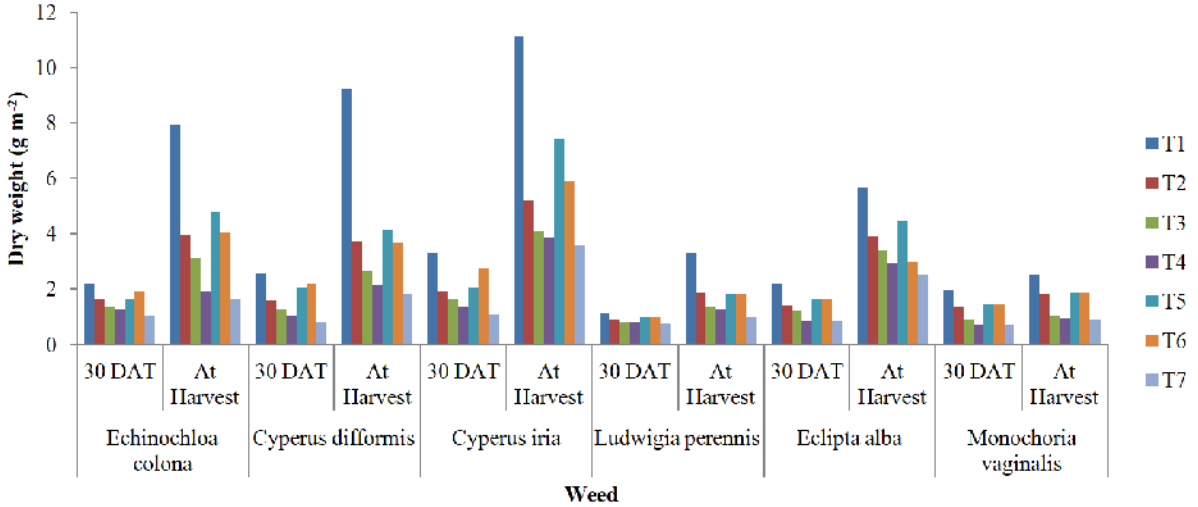

Fig. 3. Effect of different treatments on dry weight (g m^{-2}) weeds in rice.

All these weeds were showed positive response of chemicals applied effectively with the application of bensulfuron methyl 72 g a.i. ha^{-1} with pretilachlor as pre-emergence 720 g a.i. ha^{-1}, *Ecinochloa colona* (1.09 and 3.20 gm^{-2}), *Cyperus difformis* (0.62 and 4.17gm^{-2}), *Cyperus iria* (1.40 and 14.50 gm^{-2}), *Ludwigia perennis* (0.10 and 1.17 gm^{-2}) *Eclipta alba* (0.23 and 8.02 gm^{-2}), *Monochoria vaginalis* (0.04 and 0.43 gm^{-2}). The data on yield attributing parameters (Table 4 and Fig. 4) showed that yield parameters were on gainful side on, effective tillers (no.m^{-2}), panicle length (cm) total grains panicle^{-1} sound grains, panicle^{-1}, sterility % and test weight test weight (g) under hand weeding twice, however next best treatments were mixed application of bensulfuron methyl 60 g a.i. ha^{-1} with pretilachlor as pre-emergence 600 g a.i. ha^{-1} followed by mixed application of bensulfuron methyl 72 g a.i. ha^{-1} with pretilachlor 720 g a.i. ha^{-1}. The final results clearly indicated that weed free environment throughout the critical period ensure better growth and development of foliage and converted in more effective yield attributing parameters. These results are also similar to those of other researches Chandra and Solanki (2003); Chauhan *et al*., (2013).

Table 4: Yield attributing characters of rice as influenced by different treatments at harvest.

Treatments		Effective tillers (No. m^{-2})	Panicle length (cm)	Total Grains panicle^{-1}	Sound grains panicle^{-1}	Sterility %	Test weight (g)
T_1	Weedy check(Control)	144	26.45	163.75	115.75	41.47	26.91
T_2	Bensulfuronmethyl + Pretilachlor(48 + 480)gha^{-1}	217	27.30	186.50	146.75	27.09	27.01
T_3	Bensulfuronmethyl + Pretilachlor (60+600)gha	264	28.91	197.25	162.75	21.20	27.16
T_4	Bensulfuronmethyl + Pretilachlor (72+720) gha^{-1}	257	28.54	193.75	156.5	23.80	27.03
T_5	Pendimethalin1300 gha^{-1}	197	27.35	183.50	138	32.97	27.01
T_6	Butachlor 1500 gha^{-1}	184	27.25	180.25	135	33.52	27.05
T_7	Handweeding 20 and 40DAT	286	29.60	207.78	175.78	18.20	27.23
SEm±		5.01	0.24	0.99	0.73	0.48	0.15
CD(P=0.05)		15.00	0.72	2.96	2.20	1.44	NS

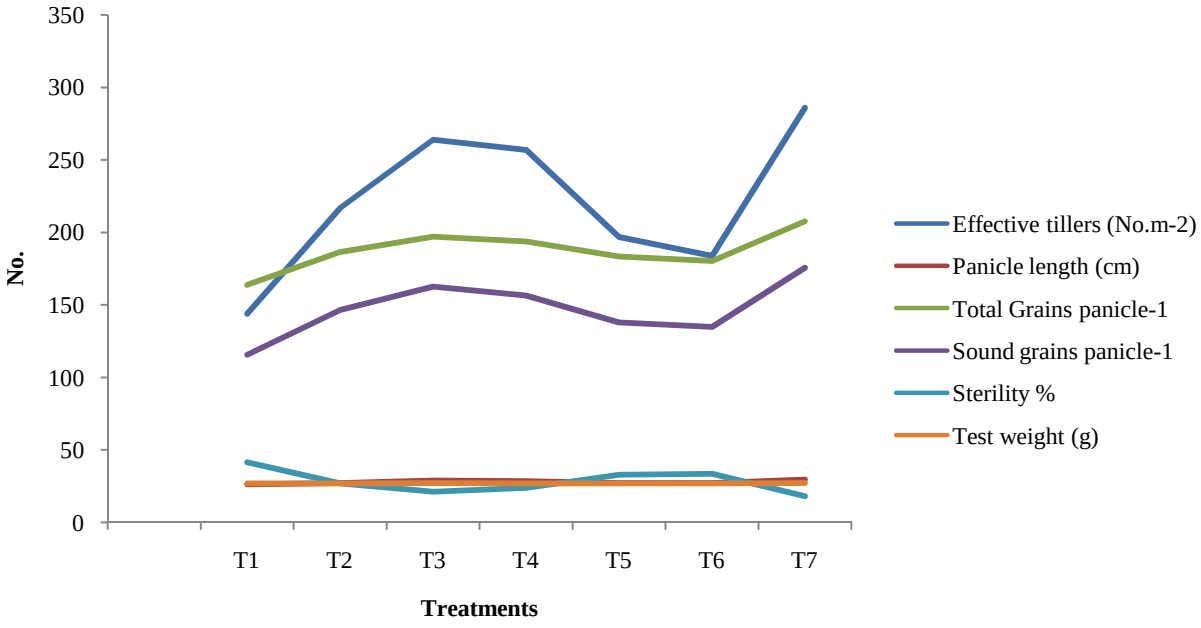

Fig. 4. Effective tillers m^{-2}, panicle length, total grains panicle-1, sound grains panicle-1, sterility % and test weight at harvest of rice as influenced by different treatments.

Table 5, figure 5 and 6 depicts that pre-emergence mixed application of Bensulfuron methyl 48 g a.i. ha^{-1} with Pretilachlor 480 g a.i. ha^{-1}, resulted in significantly higher grain yield (5153 kg ha^{-1}) over rest of the doses, although the grain yield was at higher side (5889 kg ha^{-1}) when provided hand weeding at two different growth

stages which was superior over all the weed control treatments. It is clear from the data that the weed control measures also caused significant variation on straw yield. The straw yield was minimum in weedy check plots (6254 kg ha^{-1}), where as valuable increase was observed when pre-emergence mixed application of bensulfuron methyl + pretilachlor was applied @ (48+480), (60+600) and (72+720) g ha^{-1}. The grain and straw yields were appreciably more (5889 and 9964 kg ha^{-1}) under hand weeding plots when given twice over all the treatments. The increased yields under these treatments was due to removal of weeds which increase the availability of nutrients, space, sunlight and water finally resulted in better growth and development of crop plants. Mukherjee and Maity (2011); Chauhan and Opena (2013); Kumar *et al*. (2014) also confirmed the above findings in their research programmes.

Weedy check plot gave minimum harvest index (31.51 %), which increased equally with the application with different dose of bensulfuron methyl + pretilachlor @ (48+480), (60+600) and (72+720) g a.i. ha^{-1} (35.31, 35.65, 35.58%) (Table 4). As usual hand weeding twice (20 and 40 DAT) gave highest harvest index (37.15%) and was significantly superior to other chemicals bensulfuronmethyl + pretilachlor including check herbicides pendimethalin (32.47 %) and butachlor (32.09 %).

The results presented in Table 5, Fig. 5 and 6 confirm that weed index was minimum (0.00%) with hand weeding twice which gradually increase with the application of bensulfuronmethyl + pretilachlor when applied (60+600) g a.i.ha^{-1}(12.50%), the index was maximum(51.15%) under weedy check. This increase was owing to higher coefficient of partitioning of photosynthatase in sink, Chandra and Solanki, (2003) found similar trends in their experiments.

Weed control efficiency had strongly reverse relationship with weed biomass. The weed control efficiency ranged from 41.33 to 92.56% (Table 4) over weed check plot. Maximum (92.56%) weed control efficiency was observed when hand weeding was done at two times. It was closely followed by bensulfuron methyl + pretilachlor @ (72+720) and (60+600) g a.i. ha^{-1} (90.27% and 86.06%).

Table 5: Effect of different weed control treatments on grain yield, straw yield, harvest index, weed index and Weed control efficiency.

Treatments		Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index (%)	Weed Index (%)	WCE (%)	
						30 DAT	Harvest
T_1	Weedy check(Control)	2877	6254	31.51	51.15	-	75.94
T_2	Bensulfuronmethyl + Pretilachlor(48+480) gha^{-1}	4340	7952	35.31	26.30	63.97	86.06
T_3	Bensulfuronmethyl + Pretilachlor(60+600) gha^{-1}	5153	9302	35.65	12.50	78.70	90.27
T_4	Bensulfuronmethyl + Pretilachlor(72+720) gha^{-1}	5010	9072	35.58	14.93	85.23	62.43
T_5	Pendimethalin1300 gha^{-1}	3606	7499	32.47	38.76	48.88	75.38
T_6	Butachlor1500 gha^{-1}	3571	7560	32.09	39.35	41.33	92.56
T_7	Handweeding 20 and 40DAT	5889	9964	37.15	0.00	90.43	75.94
SEm±		36.02	76.83	-	-	-	-
CD(P=0.05)		107.85	230.05	-	-	-	-

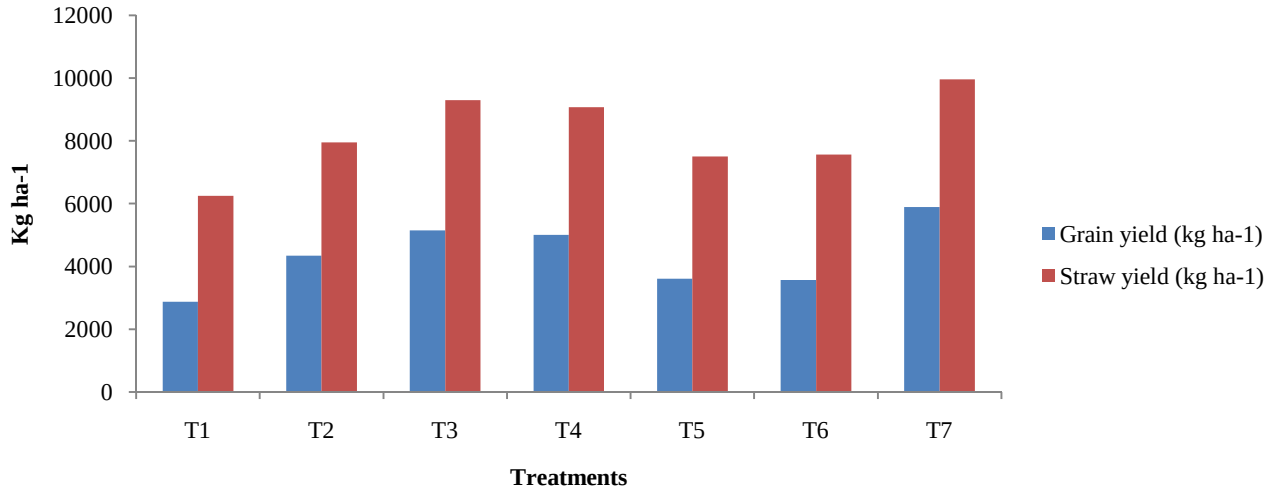

Fig. 5. Effect of different weed control treatments on grain yield, straw yield.

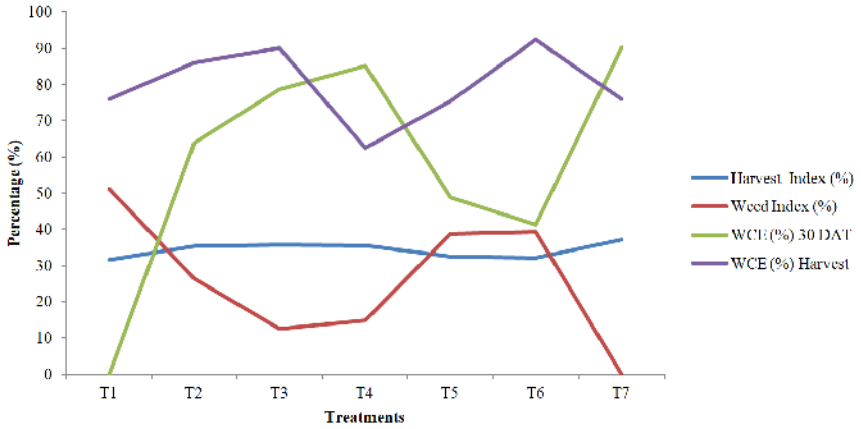

Fig. 6. Effect of different weed control treatments on harvest index, weed index and Weed control efficiency.

This was endorsed to create weeds free area which reduced the biomass production under these treatments. These results are in close conformity to the findings of other investigators Prakash *et al.*, (2013); Ramachandra *et al*., (2014).

The data presented in Table 6 and depicted in Fig. 7 and 8 represents cost of cultivation (Rs ha^{-1}), gross monetary returr (GMR, Rs ha^{-1}), net monetary return (NMR Rs ha^{-1}) and benefit cost ratio (B:C ratio) of the experiment on per hectare basis. As per data presented in Table 5 weedy check plots had the lowest cost of cultivation (Rs. 31262 ha^{-1}), which increased in the range of Rs. 32962 to Rs. 33662 ha^{-1} with the increase in dose of bensulfuron methyl + pretilachlor @ (48+480), (60+600) and (72+720) g a.i. ha^{-1} as pre-emergence. While, hand weeding at two different stages (20 and 40 DAT) fetched maximum cost of cultivation (Rs 39262 ha^{-1}).

Weedy check plot gave minimum gross monetary returns (Rs 63794 ha^{-1}) in and hand weeding twice gave maximum (Rs 127742 ha^{-1}). It was noticed that mixed application of Bensulfuron methyl 60 g a.i. ha^{-1} and Pretilachlor 600 g a.i. ha^{-1} could not compensate the GMR as obtained with hand weeding twice but the later treatment (i.e. hand weeding twice) had the higher investment. These variations were due to differences in economical yield (grain and straw) under the treatments

The net monetary returns (NMR) was also minimum (Rs 32532 ha^{-1}) in treatments without weed control treatments, which increased to the range of Rs 46526 to 79045 ha^{-1} when weeds were controlled by herbicides. The NMR under Bensulfuron methyl + Pretilachlor @ (60+600) g a.i. ha^{-1} was Rs. 79045 ha^{-1}, which was followed by Bensulfuron methyl + Pretilachlor @ (72+720) g a.i. ha^{-1} Rs 75609 ha^{-1}. Hand weeding fetched the highest GMR and the NMR (Rs 88480 ha^{-1}), because of higher grain yield. Reddy *et al*. (2012) also showed similar trends in their research programmes. Das *et al.*, (2017) also found that the post-emergence application of bispyribac sodium 25 g/ha at 25 DAT proved economical herbicide for transplanted rice as compared to hand weeding twice and also other herbicides and weedy check

Benefit cost ratio is the profitability or monetary gain under a particular treatment with each rupee of investment. Weedy check plots gave minimal B:C (2.04) and higher (3.37) when Bensulfuron methyl + Pretilachlor was applied at different concentrations due to proportionate increase in economical yield because of less numbers of weeds present in the field with main crop resulting in less competition. H and weeding twice gave less B:C ratio than mixed application of Bensulfuron methyl 60 g a.i. ha^{-1} with Pretilachlor 600 g a.i. ha^{-1} due to involvement of more labourers under hand weeding. These findings are similar to investigations done by Bali *et al*. (2006); Sunil *et al.*, (2010)

Table 6: Economics of different weed control treatments.

Treatments		Cost of cultivation (Rs ha^{-1})	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C Ratio
T_1	Weedy check(Control)	31262	63794	32532	2.04
T_2	Bensulfuronmethyl + Pretilachlor (48+480) gha^{-1}	32962	94758	61796	2.87
T_3	Bensulfuronmethyl + Pretilachlor (60+600) gha^{-1}	33312	112357	79045	3.37
T_4	Bensulfuronmethyl + Pretilachlor (72+720) gha^{-1}	33662	109271	75609	3.25
T_5	Pendimethalin 1300 gha^{-1}	33062	79622	46560	2.41
T_6	Butachlor 1500 gha^{-1}	32462	78988	46526	2.43
T_7	Handweeding 20 and 40DAT	39262	127742	88480	3.25

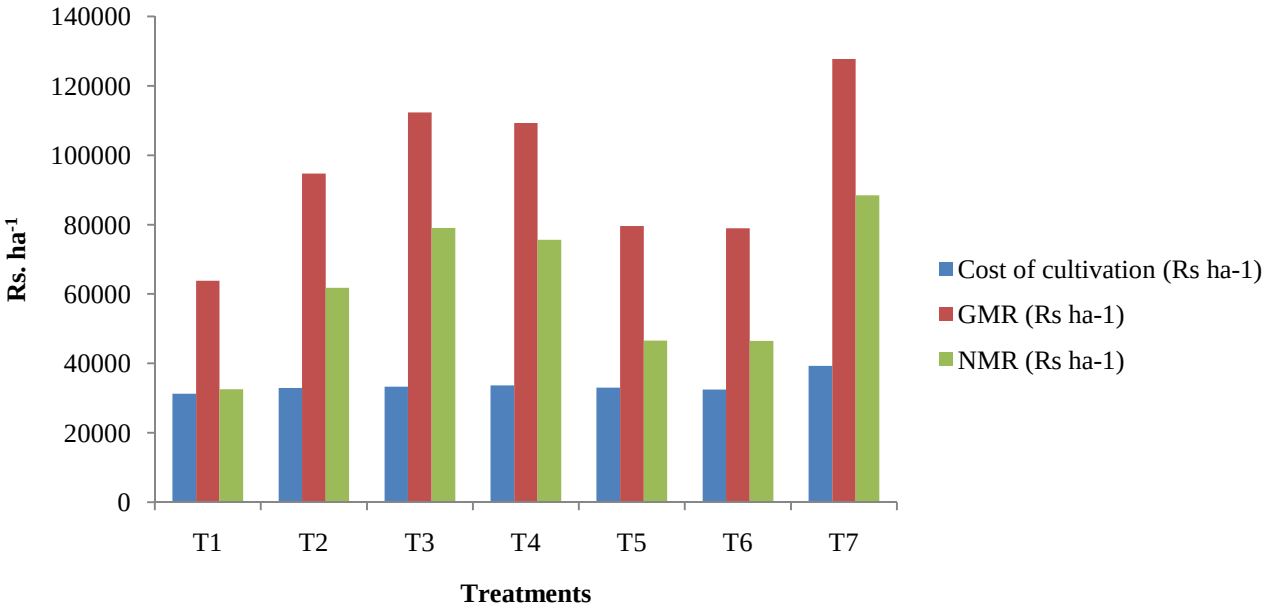

Fig. 7. Economic analysis of different weed control treatments.

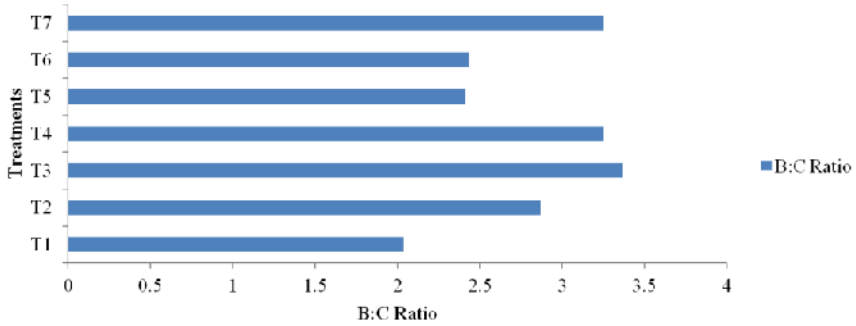

Fig. 8. B:C Ratio of different weed control treatments.

CONCLUSION

It was concluded that weeds will always be present in rice field and will try to predominate, hence it is essential to manage weeds and reduce their population by application of herbicidal combination to such an extent that no economic damage is caused due to weeds and non availability of resources like labourer etc. Therefore, the pre emergence mixed application of bensulfuron methyl 60) g ha^{-1} and pretilachlor 600 g ha^{-1} can be recommended for effective weed management in transplanted rice.

REFERENCES

Anonymous Agricultural statistics at a Glance (2015). Government of India, Ministry of Agriculture Department of Agriculture & Cooperation. Directorate of Economics & Statistics, New Delhi.

Arthanari, P. M., Gowthami, S., Chinnusamy, C., Sathyapriya, R., & Hariharasudhan, V. (2017). Effect of Low Dose Early Post Emergence Herbicide on Growth and Yield of transplanted Rice Crop. *Chem. Sci. Rev. Lett.*, *6*(21): 231-236.

Bali, S.A., Singh, M., Kachroo, D., Sharma, B. C., & Shivran, D. R. (2006). Efficacy of herbicides in transplanted, medium duration rice under sub-tropical condition of Jammu. *Indian Journal of Agronomy*, *51* (2): 128-130.

Chandra, S., & Solanki, O. S. (2003). Herbicidal effect on yield attributing characters of rice in direct seeded puddle rice. *Agricultural Science Digest*, *23*(1): 75-76.

Chauhan, B. S., & Opena, J. (2013). Weed management and grain yield of rice sown at low seeding rates in mechanized dry-seeded systems. *Journal of Field Crops Research*, *141*: 9–15.

Chauhan, P. S., Jha, A. K., & Soni, M. (2013). Efficacy of chlorimuron-ethyl against weeds in transplanted rice. *Indian Journal of Weed Science*, *45*(2): 135–136.

Das, R., Bera1, S., Pathak A., & Mandal M. K. (2017). Weed management in transplanted rice through bispyribacsodium 10% sc and its effect on soil microflora and succeeding crop blackgram.

International Journal of Current Microbiology and Applied Sciences, *4*(6): 681-688.

Ganie, A. H., Tali, B. A., Khuroo, A. A., Reshi, Z. A., & Wafai, B. A. (2015). Taxonomic diversity, distribution pattern and management implications of weed flora in rice fields of Kashmir Valley. *Indian Journal of Weed Science*, *47*(1): 11–15.

Kaur, S., & Singh S. (2015). Bio-efficacy of different herbicides for weed control in direct-seeded rice. *Indian Journal of Weed Science*, *47*(2): 106–109

Kumar, B., Kumar, R., Kalyani, S., & Haque, M. (2013). Effectiveness and economics of integrated weed management in transplanted rice (*Oryza sativa*). *Trends in Biosciences*, *6*(2): 212-215.

Kumar, R. S., Durairaj, S. N., Daisy, M., & Archana, H. A. (2014). Studies on weed management practices in transplanted rice. *Trends in Biosciences*, *7*(23): 3882-3885.

Mahajan, G., Boparai, B. S., Brar, L., S., & Sardana, V. (2003). Effect of Pretilachlor on weeds in direct-seeded puddle rice. *Indian Journal of Weed Science, 35*(1-2): 128-130.

Manhas, S. S., Singh, G., Singh, D., & Khajuria, V. (2012). Effect of tank-mixed herbicides on weeds and transplanted rice (*Oryza sativa* L.). Annals of Agricultural Research. *New Series*, *33*(1-2): 25-31.

Mukherjee, P. K., & Maity, S. K. (2011).Weed control in transplanted and wet-seeded rainy season rice. *Indian Journal of Agriculture Sciences*, *81*(2): 45-49.

Prakash,C, Shivran, R. K., Koli, N. R., & Sharma, J. C. (2013). Bio-efficacy of herbicide combination on weed control and yield performance of transplanted rice (*Oryza sativa* L.). *Trends In Biosciences*, *6*(1): 120-124.

Patil, P. S., Dusing, Y. A. Y., Aherrao, Aher, U. P., & Patil, D. A. (2010). Role of crop weeds in traditional medicines in Buldhana district (Maharastra). *Life Sci. Leaflets, 10*: 261-272.

Punia, S. S, Yadav D, Hooda, V. S., Duhan, A., & Amarjeet (2016). Prevalence of weed flora of transplanted rice in different regions of Haryana. *Agriculture Research Journal*, *53*(1): 41-45.

Rajkhowa, D. J ., Deka, N. C., Borah, N., & Barua, I. C. (2007). Effect of herbicides with or without paddy weeder on weeds in transplanted summer rice. *Indian Journal of Agronomy*, *52*(2): 107-110.

Ramachandra, C., Shivakumar, N., & Ningaraju,G. K. (2014). Effect of herbicides and their combination on weed dynamics in rice-based cropping system. *Indian Journal of Weed Science*, *46*(2): 123–125.

Ram, H., Singh, J. P. Bohra, J. S., Singh, R. K., & Sutaliya, J. M. (2014). Effect of seedlings age and plant spacing on growth, yield, nutrient uptake and economics of rice (*Oryza sativa*) genotypes under system of rice intensification. *Indian Journal of Agronomy*, *59*(2): 256-260.

Rani, V. D., Pinto, B., Kanu, M., & Srijani, M. (2021). Predominant Sedges & Broad-Leaved Weed Management by Herbicides and its Impact on Yield Parameters, Harvest Index and Grain Yield, Straw Yield of Kharif Direct Seeded Rice: *Biological Forum – An International Journal, 13*(2): 254-259.

Reddy, B. G. M., Ravishankar, G., Balganvi, S., Joshi, V. R., & Negalur, R. K. (2012). Efficacy of bensulfuron methyl plus pretilachlor for controlling weeds in transplanted rice. *Oryza*, *49*(1): 65-67.

Savary, S., Castilla, N. P., Elazegui, F. A., & Teng, P. S. (2005). Multiple effects of two drivers of agricultural change, labour shortage and water scarcity, on rice pest profiles in tropical Asia. *Field Crops Research*, *91*(2-3), 263-271.

Singh, V. P., Singh, G., & Singh, M. (2005). Effect of Bensulfuron-methyl (Londax 60 DF) on sedges and non-grassy weeds in transplanted rice. *Indian Journal of Weed Science*, *37*(1-2), 40-44.

Singh, P., Singh, R., & Singh, K. N. (2007). Efficacy of new herbicides in transplanted rice under temperate conditions of Kashmir. *Indian Journal of Weed Science*, *39*(3-4): 167-171.

Singh, S., Singh, G., Singh, V. P., & Singh, A. P. (2005). Effect of establishment methods and weed management practices on weeds and rice in rice-wheat cropping system. *Indian Journal of Weed Science*, *37*(1&2): 51-57.

Singh, V., Singh, G., & Singh, M. (2004). Effect of fenoxaprop-P-ethyl on transplanted rice and associated weeds. *Indian Journal of Weed Science*, *36*(1): 190-192.

Statista The statistics portal, 2017- https://www.statistia.com

Sunil, C. M., Shekara, B. G., Kalyanamurthy K. N., & Shankaralingappa, B. C. (2010). Growth and yield of aerobic rice as influenced by integrated weed management practices. *Indian Journal of Weed Science, 42*(3-4): 180-183.

Sureshkumar, R., Nalliah, Durairaj, S., Marimuthu S., & Muthukumar, M. (2016). Weed characters and indices of transplanted rice as influenced by different weed management practices. *International Journal of Agriculture Sciences*, *8*(51): 2221-2223.

How to cite this article: Rawat, A.K.; Lodhi, S.R., Tiwari, A.; and Nayak, S. (2021). Performance of Herbicides on Weeds and Productivity of Transplanted Rice in Central Part of India . *Biological Forum – An International Journal, 13*(4): 607-615.