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PROFITABILITY OF POST EMERGENCE HERBICIDES UNDER TRANSPLANTED RICE IN *VERTISOLS*

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Abstract

A field experiment was conducted at the Instructional cum Research Farm, I.G.K.V., Raipur (C.G.), India; during *Kharif* season of 2011. The experiment was laid out in randomized block design with three replications. The treatments consisted of ten different weed management treatments. Results reveals that two hand weeding at 20 and 40 DAT (T_9) recorderd significantly highest leaf area, leaf area index and yield but Bispyribac Na @ 20 g a.i. ha^{-1} (T_7) and Chlorimuron ethyl + Metsulfuron methyl @ 4 g a.i. ha^{-1} (T_8) were also better performing treatments in terms of yield. Though the net return was maximum under two hand weeding at 20 and 40 DAT (T_9) followed by Bispyribac Na @ 20 g a.i. ha^{-1} (T_7) and Chlorimuron ethyl + Metsulfuron methyl @ 4 g a.i. ha^{-1} (T_8) but benefit : cost ratio was higher under Bispyribac Na @ 20 g a.i. ha^{-1} (T_7) and this was narrowly followed by Chlorimuron ethyl + Metsulfuron methyl @ 4 g a.i. ha^{-1} (T_8). Energy use efficiency and energy output : input ratio was maximum under two hand weeding (T_9) and this was followed by Chlorimuron ethyl + Metsulfuron methyl @ 4 g a.i. ha^{-1} (T_8) and Bispyribac Na @ 20 g a.i. ha^{-1} (T_7).

Key words : LAI, yield, economics, energetics, hand weeding.

Introduction

Rice (*Oryza sativa* L.) is the most consumed cereal grain in the world, constituting the dietary staple food for more than half of the planet's human population. In world, rice is the second most widely consumed cereal next to wheat and it has occupied an area of 163.00 m ha, with a total production of 730.20 m t. Eighty per cent of the world rice production mainly comes from Asian countries and Brazil (FAO, 2013). Hence, there is a need to increase the productivity of rice. Rice is the backbone of the Indian agriculture being the main source of livelihood for more than 150 million rural households. In India, total rice crop area is 43.95 m ha, production is 106.19 m t and average productivity is 2.42 t ha^{-1}. It occupies about 23.30 per cent of the food grain production and 55 per cent of cereal production. The rice plays a very vital role in the national food security (Anonymous, 2014a). Chhattisgarh state is popularly known as "Rice Bowl of India" because maximum area is covered under rice during *kharif* and contribute major share in national rice production. It has geographical area of 13.51 m ha of which 5.90 m ha area is under cultivation. Rice occupies an area of 3.67 m ha with the production of 11.20 m t and productivity of 2.04 t ha^{-1}. In Chhattisgarh, rice is mainly grown under rainfed ecosystem, which covers about 74, 97 and 95 per cent cropped area of Chhattisgarh plain, Bastar plateau and Northern hill zones, respectively. Chhattisgarh State contributes 5.26 per cent of the total rice production of the country. However, the production and productivity of rice per unit area is very low (Anonymous, 2014b).

One major problem in rice cultivation for productivity is weed management. The various crop stand establishment practices and land type influence the intensity and nature of weed problem. Yield reduction in transplanted rice due to unchecked weed growth is 47 per cent (Mukharjee and Singh, 2005). Weed not only cause quantitative, but also quality of produce due to competition for nutrients, moisture, light and to some extent for space. They harbor many insects, pests and pathogens resulting in poor crop growth. Normally the loss in rice yield ranges between 15-20 per cent yet in severe cases the yield losses can be more than 50 per cent depending upon the species and intensity of weeds (BRRI, 2006). Hand weeding is the most effective method, however, high labour wages and non-availability of labour during peak periods of agricultural operations, timely

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weeding is not possible. On the other hand, herbicides offer economic and efficient weed control if applied at proper dose and stage (Kumar and Sharma, 2005). Use of low dose high efficiency herbicides, which will not only reduce the total volume of herbicide per unit area, but also application becomes easier and economical to the farmer (Kiran *et al.*, 2010).

Materials and Methods

Field experiment was conducted at the Instructional cum Research Farm, I.G.K.V., Raipur during *kharif* season of 2011. The soil was sandy loam in texture having low organic carbon (0.44%) and available N, P, K content in the soil was 211.4, 18.4 and 325 kg ha^{-1}, respectively, slightly alkaline in reaction (pH 7.3) and EC (0.43 dSm^{-2}). The treatments consisted of ten different weed management treatments *viz*, $\mathbf{T_1}$- Bentazone 48% SL W/V @ 720 ml a.i. ha^{-1}, $\mathbf{T_2}$- Bentazone 48% SL W/V @ 960 ml a.i. ha^{-1}, $\mathbf{T_3}$- Bentazone 48% SL W/V @ 1200 ml a.i. ha^{-1}, $\mathbf{T_4}$- Ethoxysulfuron 15% WDG @ 15 g a.i. ha^{-1}, $\mathbf{T_5}$-Oxadiargyl 80% WP @ 80 g a.i. ha^{-1}, $\mathbf{T_6}$- Pretilachlor 50% EC @ 500 g a.i. ha^{-1}, $\mathbf{T_7}$ – Bispyribac Na 10% SC @ 20 g a.i. ha^{-1}, $\mathbf{T_8}$- CME + MSM 20% WP @ 4 g a.i. ha^{-1}, $\mathbf{T_9}$- Two Hand Weeding, $\mathbf{T_{10}}$-Control. Rice cv. MTU-1010 was transplanted on July 14, 2011 with a spacing of 20 cm × 10 cm and harvesting was done on November 1st, 2011. Seedlings with 30 days age were used for transplanting. Recommended dose of nutrient was 100 kg N + 60 kg P_2O5 + 40 kg K_2O ha^{-1}, which was applied through urea, Di-ammonium phosphate and muriate of potash, respectively. The whole quantity of P and K was applied as basal dressing, while nitrogen was applied in three splits *viz*. 50 kg N ha^{-1} as basal and remaining 50 kg N in two equal splits at active tillering and panicle initiation stages. The herbicides were applied by knapsack sprayer fitted with flat-fan nozzle using 500 litres water ha^{-1}. Harvesting was done when crop attained maturity. Harvesting was done by labourers by using sickle. Harvested produce was left on the plot itself for sun drying for three days. After sun drying the produce was weighed plot-wise. Threshing was done by manual labourers with the help of Paddy drum thresher. The material threshed from each plot was kept separately and grain was separated from the chaff and straw by winnowing with the help of *supa*, after this the clean grains were weighed. The data obtained on various observations were tabulated and subjected to their analysis by using analysis of variance (ANOVA) and the treatment was tested by F test (Gomez and Gomez, 1984).

Gross return (Rs. ha^{-1}) was obtained by converting the harvested produce into monetary terms at the prevailing market rate during the course of studies for every treatment. Net return was obtained by deducting cost of cultivation from the gross return. The benefit: cost ratio was calculated with the help of the following formula:

Benefit : cost ratio = Net return / Total cost of cultivation.

Energy inputs were calculated and estimated in Mega Joule (MJ) ha^{-1} with reference to the standard values prescribed by Mittal *et al*. (1985). The standard energy coefficient for seed and straw of rice was multiplied with their respective yields and summed up to obtain for rice was calculated by adding the respective values of rice crop. Energy use efficiency, energy output-input ratio were calculated as per the following formula :

Energy use efficiency (q $MJ^{-1} \times 10^{-3}$) = Total produce (q)/ Energy input (MJ × 10^{-3})

Energy Output – Input Ratio = Energy output/ Energy input.

Results and Discussion

Leaf area and leaf area index

Results revealed that the significantly maximum leaf area (table 1) was observed under the treatment two hand weeding ($\mathbf{T_9}$), which was significantly superior over others, however, at 40, 60, 80 DAT and at harvest, treatments Bentazone 48% SL W/V @ 1200 ml ha^{-1} ($\mathbf{T_3}$), Bispyribac Na 10% SC @ 20 g a.i. ha^{-1} ($\mathbf{T_7}$), Chlorimuron ethyl + Metsulfuron methyl 20% WP @ 4 g a.i. ha^{-1} ($\mathbf{T_8}$) and in addition to Ethoxysulfuron 15 % WDG @ 15 g a.i. ha^{-1} ($\mathbf{T_4}$) at 60, 80 DAT and at harvest and Oxadiargyl 80% WP @ 80 g a.i. ha^{-1} ($\mathbf{T_5}$) at 80 DAT also registered at par leaf area to treatment two hand weeding at 20 and 40 DAT ($\mathbf{T_9}$). At all the intervals of observations, maximum leaf area index was observed under the treatment two hand weeding ($\mathbf{T_9}$), which was significantly superior over others, however, at 40, 60, 80 DAT and at harvest, treatments Bentazone 48% SL W/V @ ml ha^{-1} ($\mathbf{T_3}$), Bispyribac Na 10% SC @ 20 g a.i. ha^{-1} ($\mathbf{T_7}$), Chlorimuron ethyl + Metsulfuron methyl 20% WP @ 4 g a.i. ha^{-1} ($\mathbf{T_8}$) and in addition to it Ethoxysulfuron 15% WDG @ 15 g a.i. ha^{-1} ($\mathbf{T_4}$) at 60, 80 DAT and at harvest and Oxadiargyl 80% WP @ 80 g a.i. ha^{-1} ($\mathbf{T_5}$) at 80 DAT also registered at par leaf area index to treatment two hand weeding at 20 and 40 DAT ($\mathbf{T_9}$). The increase in LAI under above mentioned treatments might be due to production of higher number of leaves, which increased total photosynthetic surfaces with increase in leaf area and secondly due to increased availability of nitrogen, which resulted in larger leaves. In addition water

Table 1 : Effect of post emergence herbicides on leaf area and leaf area index at different duration of transplanted rice.

Treatment		Dose ha^{-1}	Time of application DAT	Leaf area (cm^2)			Leaf area index			
				40DAT	60DAT	80DAT	At harvest	40DAT	60DAT	80DAT	At harvest
T_1	Bentazone 48% SL W/V	720 ml	15	734.12	834.12	1024.18	900.78	3.67	4.17	5.12	4.50
T_2	Bentazone 48% SL W/V	960 ml	15	746.48	846.48	1033.38	913.15	3.73	4.23	5.17	4.57
T_3	Bentazone 48% SL W/V	1200 ml	15	777.42	864.09	1063.96	930.76	3.89	4.32	5.32	4.65
T_4	Ethoxysulfuron 15% WDG	15 g	15	758.08	858.08	1058.10	924.75	3.79	4.29	5.29	4.62
T_5	Oxadiargyl 80% WP	80 g	3	751.88	851.88	1052.00	918.55	3.76	4.26	5.26	4.59
T_6	Pretilachlor 50% EC	500 g	3	724.40	817.73	994.33	884.40	3.62	4.09	4.97	4.42
T_7	Bispyribac Na 10% SC	20 g	20	791.06	891.06	1090.99	957.72	3.96	4.46	5.45	4.79
T_8	CME + MSM 20% WP	4 g	20	785.03	878.37	1079.36	945.03	3.93	4.39	5.40	4.73
T_9	Two hand weeding	-	20 & 40	823.28	919.95	1117.28	986.62	4.12	4.60	5.59	4.93
T_{10}	Control	-	-	664.45	701.12	901.12	767.78	3.32	3.51	4.51	3.84
S.Em. ±				**17.89**	**21.04**	**23.76**	**22.66**	**0.09**	**0.10**	**0.12**	**0.11**
CD (P = 0.05)				**53.17**	**62.51**	**69.28**	**67.34**	**0.27**	**0.31**	**0.35**	**0.34**

availability enhances cell development and cell growth and this probably resulted in higher leaf area index and higher plant height. Also increasing water availability might be contributed to high yield (Yadav *et al*., 2009 and Halder and Patra, 2007).

Weed flora composition (%)

At 20 DAT, the percentage composition (table 2) of others weed species (20.61%) was recorded highest followed by *Spilanthes acmella* (18.14%). At later time intervals of observations *i.e.* 40, 60, 80 DAT and at harvest, the percentage composition of *Ischaemum rugosum* (24.52%, 27.42%, 27.80% and 29.11%, respectively) was recorded highest followed by *Echinochloa colona* (21.47%, 22.95%, 22.60% and 20.16%, respectively).

Other weed species like *Fimbristylis miliacaea, Cynodon dactylon* etc. were also observed in the experiment field in negligible quantum.

Grain and straw yield

The perusal of data (table 3) reveal that treatment two hand weeding (T_9) registered significantly highest grain yield (5.54 t ha^{-1}), however, it was found at par with the application of Bentazone 48% SL W/V @1200 ml ha^{-1} (T_3) (4.81 t ha^{-1}), Bispyribac Na 10% SC @ 20 g a.i. ha^{-1} (T_7) (5.25 t ha^{-1}) and Chlorimuron ethyl + Metsulfuron-methyl 20% WP @ 4 g a.i. ha^{-1} (T_8) (4.95 t ha^{-1}). The minimum seed yield was observed under control (T_{10}) (2.44 t ha^{-1}). Similar results was also reported by Halder and Patra (2007); Yadav *et al.* (2009); Gnanavel and Anbhazhagan (2010) and Murali *et al.* (2012). The straw yield was significantly influenced by different treatments. Two hand weeding (T_9) (6.74 t ha^{-1}) produced the highest straw yield and it was significantly superior to others but, it was at par to application of Bentazone 48% SL W/V @ 1200 ml ha^{-1} (T_3) (6.07 t ha^{-1}), Ethoxysulfuron 15% WDG @ 15 g a.i. ha^{-1} (T_4) (5.85 t ha^{-1}), Bispyribac Na 10% SC @ 20 g a.i. ha^{-1} (T_7) (6.53 t ha^{-1}) and Chlorimuron ethyl + Metsulfuron-methyl 20% WP @ 20 g a.i. ha^{-1} (T_8) (6.27 t ha^{-1}). The minimum straw yield (4.33 t ha^{-1}) was noted under control (T_{10}). Similar results were observed by Rawat *et al.* (2012). It can be inferred that treatments T_7, T_8 and T_9 checked the weeds in comparison to other treatments leading to higher grain yield and straw yield. While, in control (T_{10}) reverse trend was observed and therefore, the lowest straw yield was noted under this treatment. Similar findings were also reported by Ashraf *et al.* (2006).

Economics

The highest gross return (table 3) was obtained under treatment two hand weeding at 20 and 40 DAT (T_9)

Table 2 : Weed flora composition (%) at different duration of transplanted rice

Weed species	Weed flora composition (%)				
	20 DAT	40 DAT	60 DAT	80 DAT	At harvest
1. *Echinochloa colona*	8.83	21.47	22.95	22.60	20.16
2. *Ischaemum rugosum*	16.24	24.52	27.42	27.80	29.11
3. *Alternanthera triandra*	12.62	12.3	11.41	13.69	13.51
4. *Spilanthes acmella*	18.14	14.22	12.55	13.02	13.16
5. *Ludwigia octovalis*	8.52	6.19	5.02	5.96	6.62
6. *Cyperus rotundus*	15.14	9.96	10.24	10.25	8.74
7. Others	20.61	11.38	10.41	10.58	10.30

followed by Bispyribac Na 10% SC @ 20 g a.i. ha^{-1} (T_7) and Chlorimuron ethyl + Metsulfuron methyl @ 4 g a.i. ha^{-1} (T_8) and lowest gross return was noted under control (T_{10}). The highest net return was noted under Bispyribac Na 10% SC @ 20 g a.i. ha^{-1} (T_7) followed by two hand weeding at 20 and 40 DAT (T_9) and Chlorimuron ethyl + Metsulfuron methyl @ 4 g ha^{-1} (T_8). The benefit cost ratio was recorded highest under treatment application of Chlorimuron ethyl + Metsulfuron methyl 20% WP @ 4 g a.i. ha^{-1} (T_8), followed by Bispyribac Na 10% SC @ 20 g a.i. ha^{-1} (T_7), Bentazone 48% SL @ 1200 ml ha^{-1} (T_3) and two hand weeding at 20 and 40 DAT (T_9). Similar results were reported by Kiran *et al.* (2010). Bispyribac-sodium could be a suitable and economical herbicidal weed management for transplanted rice and

Table 3 : Effect of post emergence herbicides on yield and economics of transplanted rice

Treatment		Dose ha^{-1}	Time of application DAT	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C Ratio
T_1	Bentazone 48% SL W/V	720 ml	15	3.51	5.39	44448.33	23421.33	1.11
T_2	Bentazone 48% SL W/V	960 ml	15	3.79	5.43	47616.67	26389.67	1.24
T_3	Bentazone 48% SL W/V	1200 ml	15	4.81	6.07	59865.00	38438.00	1.79
T_4	Ethoxysulfuron 15% WDG	15 g	15	4.50	5.85	56173.33	35186.33	1.68
T_5	Oxadiargyl 80% WP 80 g	3	4.24	5.58	52945.00	32018.00	1.53	
T_6	Pretilachlor 50% EC 500 g	3	3.33	5.30	42308.33	21361.33	1.02	
T_7	Bispyribac Na 10% SC	20 g	20	5.25	6.53	65231.67	43404.67	1.99
T_8	CME +MSM 20 % WP	4 g	20	4.95	6.27	61586.67	40809.67	1.96
T_9	Two hand weeding	-	20 & 40	5.54	6.74	68803.33	44426.33	1.82
T_{10}	Control	-	-	2.44	4.33	31348.33	11079.33	0.55
SEm.±				**0.29**	**0.33**	-	-	-
CD (P=0.05)				**0.85**	**0.98**	-	-	-

Where, 1 q of grain costs: Rs. 1150/- 1 q of straw costs: Rs. 75/-.

Table 4 : Energetics of transplanted rice as influenced by weed management practices

Treatment		Dose ha^{-1}	Energy input (MJx10^{-3} ha^{-1})	Energy output (MJx10^{-3} ha^{-1})	Net energy output (MJx10^{-3} ha^{-1})	Energy use efficiency (q MJx10^{-3} ha^{-1})	Energy output input ratio
T_1	Bentazone 48% SL W/V	720 ml	11.63	119.06	107.44	7.49	9.07
T_2	Bentazone 48% SL W/V	960 ml	11.65	123.50	111.84	7.78	9.47
T_3	Bentazone 48% SL W/V	1200 ml	11.68	146.54	134.86	8.81	10.87
T_4	Ethoxysulfuron 15% WDG	15 g	11.54	139.28	127.74	8.48	10.43
T_5	Oxadiargyl 80% WP	80 g	11.55	132.08	120.53	8.24	10.10
T_6	Pretilachlor 50% EC	500 g	11.60	115.25	103.65	7.51	9.06
T_7	Bispyribac Na 10% SL	20 g	11.54	158.71	147.17	9.15	11.34
T_8	CME + MSM	4 g	11.54	151.05	139.51	9.95	12.42
T_9	Two hand weeding	20 & 40	11.93	165.74	153.81	10.30	12.91
T_{10}	Control	-	-	-	-	-	-

higher productivity (Viraputhiran and Balasubramanian, 2013).

Energetics

As regards to weed management treatments, the highest energy input (table 4) was registered under two hand weeding (T_9) followed by Bispyribac Na 10% SC @ 20 g a.i. ha^{-1} (T_7) and Chlorimuron ethyl + Metsulfuron methyl @ 4 g ha^{-1} (T_8). The highest energy output was observed under Bispyribac Na 10% SC @ 20 g a.i. ha^{-1} (T_7) followed by Bentazone 48% SL @ 1200 ml ha^{-1} (T_3) and Bentazone 48% SL @ 960 ml ha^{-1} (T_2). The maximum energy use efficiency and energy output: input ratio was recorded under two hand weeding (T_9) followed by Bispyribac Na 10% SC @ 20 g a.i. ha^{-1} (T_7) and Chlorimuron ethyl + Metsulfuron methyl @ 4 g a.i. ha^{-1} (T_8).

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