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Study on economic feasibility of Some Promising Weedicides on Shallow land Transplanted Rice (*Oryza Sativa* L.) Under Rainfed Conditions

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ABSTRACT

The study on the economic feasibility of some promising weedicides reveals that among the different herbicides tested T_7 {2,4-D Ethyl Ester 30 per cent EC (Champion)} was found better during earlier growth stages up to 60 DAT, producing taller plants but at later stages T_4 (Fenoxoprop-P-ethyl 6.7 % w/w EC (Rice star)) was found to be the most effective to control weed in terms of total weed biomass production (18.76 g m^2 fresh weight and 8.67 g m^2 dry weight), weed control efficiency (71.81%) and herbicide use efficiency (56.10 %). The application of weedicides T_8 {Metsulfuron Methyl 10% + Chlorimum Ethyl 10% (Almix)} helped to acieve the highest grain yield (68.98 q ha^{-1} which was an increase of 20.29% over control. Treatment T8 was found to be economically feasible with the highest net return of Rs. 83121per hectare, and benefit: cost ratio of 2.21, while for control, the corresponding values were accounted to be Rs.45, 599 per hectare and 1.22 respectively. This was closely followed by the application of Pyrazo Sulfuron 50% EC (Saathi) @50g a.i. ha^{-1} as early Post-emergence in terms of grain yield and economic parameters.

Keywords : Economic, Efficiency, Rice, Weedicide, Weed, Yield

One of the major reasons of low productivity of rice in the Manipur state is the severe weed infestation. Moreover, the salubrious climatic condition of Manipur results in quick growth of many weeds in the cultivated fields causing strong competition with field crops. Hand weeding is effective and most common method to control weeds in this crop. However, scarcity and high wages of labour, particularly during peak period and early crop–weed competition make this operation uneconomical and unaffordable to the poor farmers. Removal of the weeds at the critical period by mechanical means is also not possible due to the unfavourable weather conditions. In such cases, different herbicides were used for better control of weeds. Various weedicides are used to eliminate weed species in rice fields. However, their efficiency seemed to be different from place to place depending upon the varied agro–climatic conditions and available weed flora. Moreover in the recent past so many new generation weedicides are coming up, which are cost effective, less toxic to the environment but needs to be tested under Manipur situation. Different herbicides were recorded effective by different researchers in India. Highest yield and increase in weed-control efficiency were recorded by using Butachlor. Pre-emergence application of mixture of almix + 2, 4-DEE 15 + 500 g ha^{-1} recorded the minimum weed density and their biomass (Dhiman and Singh, 2005). Treatment of Pretilachlor 0.75 kg ha^{-1} (pre-emergence) + paddy weeder, resulted in the highest grain yield, maximum weed-control efficiency (88%) and monetary returns (Rs 8,300 per hectare). Oxadiargyl 75g ha^{-1} + hand weeding at 40 days after transplanting (DAT) recorded the highest values of all the yield attributes, yield and economic returns and dry weight over the control (Subramanyam *et al.*, 2007). Keeping in view, study was conducted to study the effects of the weedicides, yield and economics of the different treatments in transplanted rice.

MATERIALS AND METHODS

The study was conducted at Research Farm of College of Agriculture, Central Agricultural University, Imphal during *Kharif* season of 2011-12. The details of the treatments tested are given in table 1. The design of experiment was laid out in Randomised Block Design (RBD) with 3 replications (11 plots in each replication) having plot size measuring 5 × 4 m^2 and inter plot and inter block spacing 0.3 and 0.5 m respectively. The net experimental area was 660 m^2.

The growth parameters were recorded at 30, 60, 90 days after transplanting while yield attribute (q ha^{-1}) were taken at the time of harvesting when the grain attained 14 per cent moisture. Straw yield from each net plot was sun dried for 3 days and weighted (q ha^{-1}). For fresh and dry weight of weeds, the collected weeds from each plot were taken and weighted (fresh) in g or kg after sun drying for 7 days or at oven for 24 hours at 70°C and recorded in gram (g) for dry weight.

Harvest index was calculated as formulated by Donald (1962). It is the ratio of economic yield (grain yield) to the biological yield (grain + straw yield).

$$\text{Harvest Index (HI)} = \frac{\text{Economic yield (q ha}^{-1})}{\text{Biological yield (q ha}^{-1})}$$

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Table 1 : Details of the treatments tested

Treatment notation	Weedicides	Trade name	Recommended dose in a.i. ha^{-1}	Mode of application
T_1	Paraquat Dichloride	Swat	500 g	Pre-emergence
T_2	Ethoxysulfuron	Sunrice	15 g	Pre-emergence
T_3	Oxadiargyl	Topstar	72 g	Early Post-emergence
T_4	Fenoxoprop-P-ethyl	Rice star	100 ml	Early Post-emergence
T_5	Pretilachlor	Sofit	450 g	Pre-emergence
T_6	Fenoxoprop-P-ethyl	Whipsuper	56.25 g	Early Post-emergence
T_7	2,4 – D Ethyl Ester	Champion	2.5 kg	Post-emergence
T_8	Metsulfuron Methyl + Chlorimum Ethyl	Almix	4 g	Early Post-emergence
T_9	Pyrazo Sulfuron	Saathi	50 g	Early Post-emergence
T_{10}	Pretilachlor	Rifit	450 g	Pre-emergence
T_{11}	Control			

Weed control efficiency is a measure to determine how best weeds are controlled by a weed control treatment and was calculated as formulated by Kondap and Upadhyay (1985).

$$\text{Weed control efficiency} = \frac{x-y}{x} \times 100$$

Where, x = Dry matter production of weeds in the unweeded plot; and

y = Dry matter production of weeds in the treated plot

Herbicide use efficiency is a measure for determining the efficiency of yield increase due to weed control measure *i.e.* herbicide and it can be calculated as below:

$$\text{Herbicides use efficiency} = \frac{x-y}{x} \times 100$$

Where, x = Grain yield of treatment plot; and

y = Grain yield of control plot

In computing the economics, different variable cost items were considered. The cost includes expenditure on ploughing, seed, chemical fertilizers, plant protection chemicals and labour charges at the prevailing market prices during 2011-12. Utility of adopting different practices was compared by using the following economic parameters.

Gross return = Total value of the produce (both grain and straw).

i.e., Gross return = Grain yield X Price + Straw yield X Price

Net return = Gross return – Total cost of cultivation.

Benefit Cost Ratio (B: C) = The benefit cost ratio was worked out by using the following formula.

$$\text{B: C Ratio} = \frac{\text{Total return (Rs.ha}^{-1})}{\text{Cost of cultivation (Rs.ha}^{-1})}$$

The experimental data obtained were subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984) at 5 per cent level.

RESULTS AND DISCUSSION

Effects of herbicides on yield of rice

Among the weed control treatments, Metsulfuron Methyl 10% + Chlorimum Ethyl 10% (Almix) resulted in maximum grain and straw yield (Table 2) and it proved statistically superior to all other treatments except Pyrazo Sulfuron 50 per cent EC (Saathi), Pretilachlor 50 per cent EC (Rifit) and 2,4–D Ethyl Ester 30 per cent EC (Champion). The increase in crop yield was due to increase in productive tillers and number of grains/ear owing to decrease in crop weed competition in these treatments. Slight variation was observed in the trend of straw yield, which resulted in differences in harvest indexes. But still the harvest index of Metsulfuron Methyl + Chlorimum Ethyl, 2,4–D Ethyl Ester, Pyrazo Sulfuron were maintained high in between 46 to 48, while Oxadiargyl could not produce higher grain yield but due to low straw yield its harvest index value was high. The sequential application of butachlor and anilophos fb 2, 4-D Sodium salt and Bispyribac Sodium and one hand weeding at 25 DAS resulted higher grain yield and profitable rice production (Pandey and Singh (1994) whereas, Mallikarjun *et al*., 2014).

Table 2 : Effect of different weedicides on yield attributes of rice, straw and grain yield transplanted of rice and harvest index

Treatments	Weed weight (in gm m^2)						Yield (q ha^{-1})		Increase/decrease on yield over control (%)		Harvest Index
	30 DAT		60 DAT		90 DAT		Straw	Grain	Straw yield	Grain yield	(%)
T_1	13.25 (179.96)	6.02 (36.23)	27.33 (746.45)	11.36 (129.52)	19.25 (371.93)	10.89 (107.58)	63.55	49.52	-0.42	7.20	43.79
T_2	8.26 (67.86)	4.90 (23.55)	19.99 (410.83)	8.44 (72.89)	12.16 (149.41)	7.99 (63.56)	74.92	61.28	17.39	32.67	44.99
T_3	10.92 (157.00)	5.52 (30.21)	25.89 (676.13)	12.08 (149.04)	13.95 (194.28)	9.11 (85.41)	68.80	58.64	7.80	26.95	46.01
T_4	4.78 (22.39)	2.06 (3.75)	8.91 (79.60)	4.23 (17.45)	20.12 (405.48)	11.19 (125.77)	66.47	52.97	4.15	14.68	44.35
T_5	8.35 (70.12)	3.67 (14.38)	12.76 (164.36)	5.42 (30.84)	14.25 (226.84)	7.52 (59.46)	70.08	55.03	9.81	19.13	43.98
T_6	4.89 (23.62)	2.03 (3.64)	15.41 (237.15)	7.03 (48.97)	20.45 (418.08)	10.31 (106.00)	66.12	48.81	3.60	5.67	42.47
T_7	4.71 (23.78)	2.04 (3.78)	13.97 (200.81)	7.13 (50.43)	10.07 (101.11)	6.14 (37.40)	74.15	65.12	16.19	40.98	46.76
T_8	5.38 (28.50)	2.12 (4.23)	8.61 (75.16)	3.72 (13.78)	4.77 (26.60)	2.32 (9.24)	76.77	68.98	20.29	49.34	47.16
T_9	4.12 (16.49)	2.02 (3.62)	10.67 (113.37)	5.23 (26.82)	7.02 (48.83)	3.85 (14.33)	77.66	67.58	21.68	46.31	46.53
T_{10}	9.15 (83.30)	4.91 (23.63)	20.15 (413.72)	8.20 (67.03)	18.95 (372.13)	9.27 (85.51)	72.34	61.29	13.35	32.69	45.87
T_{11}	15.29 (233.54)	7.36 (53.93)	29.26 (888.02)	12.21 (151.28)	20.79 (431.86)	12.64 (159.40)	63.82	46.19			41.99
SE(d) ±	**2.7469**	**0.9512**	**3.9816**	**2.0638**	**4.7655**	**1.8482**	**4.140**	**3.196**			**0.5862**
LSD(0.05)	**5.74**	**1.99**	**8.32**	**4.31**	**9.94**	**3.86**	**8.83**	**6.68**			**1.23**

***value within the parenthesis is transformation value*

Note: T_1 - Paraquat Dichloride @ 500g a.i. ha^{-1} (Pre-emergence), T_2 – Ethoxysulfuron *@ 15g a.i. ha^{-1} (Pre-emergence), T_3* – Oxadiargyl *@ 72g a.i. ha^{-1} (*Early Post-emergence*), T_4* " Fenoxoprop-P-ethyl *@ 100ml a.i. ha^{-1} (Pre-emergence), T_5 " Pretilachlor(sofit)@ 450g a.i. ha^{-1} (Pre-emergence), T_6* " Fenoxoprop-P-ethyl *@ 56.25g a.i. ha^{-1} (Early post-emergence), T_7* " 2,4 – D Ethyl Ester *@ 2.5kg a.i. ha^{-1} (Post-emergence), T_8* " Metsulfuron Methyl + Chlorimum Ethyl *@ 4g a.i. ha^{-1} (Pre-emergence), T_9* " Pyrazo Sulfuron *@ 50g a.i. ha^{-1} (Early Post-emergence), T_{10} " Pretilachlor(rifit)@ 450g a.i. ha^{-1} (Pre-emergence), T_{11} - Control*

Table 3: Effect of different herbicides on weed control efficiency and herbicides used efficiency

Treatments	Weed control efficiency (%)			Weed control efficiency	Herbicides use efficiency
	30 DAT	60 DAT	90 DAT	(%)	(%)
T_1	18.21	6.96	13.84	8.09	12.06
T_2	33.42	30.88	36.79	30.66	38.67
T_3	25.00	1.06	27.93	13.17	32.70
T_4	72.01	65.36	11.47	40.25	19.87
T_5	50.13	55.61	40.51	46.00	24.53
T_6	72.42	42.42	18.43	37.06	10.45
T_7	72.28	41.60	51.42	50.26	47.36
T_8	71.19	69.53	81.64	71.81	56.10
T_9	72.55	57.17	69.54	63.69	52.93
T_{10}	33.29	32.84	26.66	27.73	38.70
T_{11}	0	0	0	0	0
SE(d) ±	**1.594**	**2.209**	**2.775**	**0.538**	**0.6276**
LSD(0.05)	**3.33**	**4.62**	**5.80**	**1.13**	**1.31**

Note: T_1 - Paraquat Dichloride @ 500g a.i. ha^{-1} (Pre-emergence), T_2 – Ethoxysulfuron *@ 15g a.i. ha^{-1} (Pre-emergence), T_3* – Oxadiargyl *@ 72g a.i. ha^{-1} (*Early Post-emergence*), T_4* – Fenoxoprop-P-ethyl *@ 100ml a.i. ha^{-1} (Pre-emergence), T_5 – Pretilachlor(sofit)@ 450g a.i. ha^{-1} (Pre-emergence), T_6* – Fenoxoprop-P-ethyl *@ 56.25g a.i. ha^{-1} (Early post-emergence), T_7* – 2,4 – D Ethyl Ester *@ 2.5kg a.i. ha^{-1} (Post-emergence), T_8* – Metsulfuron Methyl + Chlorimum Ethyl *@ 4g a.i. ha^{-1} (Pre-emergence), T_9* – Pyrazo Sulfuron *@ 50g a.i. ha^{-1} (Early Post-emergence), T_{10} – Pretilachlor(rifit)@ 450g a.i. ha^{-1} (Pre-emergence), T_{11} - Control*

Table 4 : Economics of different herbicides on cost of cultivation, Gross return, Net return and Benifit: Cost Ratio and effects of different weedicides on weed dynamics.

Treatments	Cost of cultivation (Rs)	Gross return(Rs)	Net return(Rs)	Benifit: cost ratio
T_1	38222.4	88129	49907	1.31
T_2	38093.4	98262.9	60169	1.58
T_3	38105.4	103456	65351	1.71
T_4	39771.4	94057.8	54286	1.36
T_5	39803.4	97852.2	58049	1.46
T_6	38434.4	87352.8	48918	1.27
T_7	40365.4	114573	74208	1.8
T_8	37615.9	121115.8	83121	2.21
T_9	37883.4	119000.4	81117	2.14
T_{10}	37911.4	108191.6	70280	1.85
T_{11}	37289.4	82838.8	45,549	1.22

Note: T_1 - Paraquat Dichloride @ 500g a.i. ha^{-1} (Pre-emergence), T_2 – Ethoxysulfuron *@ 15g a.i. ha^{-1}(Pre-emergence), T_3* – Oxadiargyl *@ 72g a.i. ha^{-1} (*Early Post-emergence*), T_4* – Fenoxoprop-P-ethyl *@ 100ml a.i. ha^{-1} (Pre-emergence), T_5 – Pretilachlor(sofit)@ 450g a.i. ha^{-1} (Pre-emergence), T_6* – Fenoxoprop-P-ethyl *@ 56.25g a.i. ha^{-1} (Early post-emergence), T_7* – 2,4 – D Ethyl Ester *@ 2.5kg a.i. ha^{-1} (Post-emergence), T_8* – Metsulfuron Methyl + Chlorimum Ethyl *@ 4g a.i. ha^{-1} (Pre-emergence), T_9* – Pyrazo Sulfuron *@ 50g a.i. ha^{-1} (Early Post-emergence), T_{10} – Pretilachlor(rifit)@ 450g a.i. ha^{-1} (Pre-emergence), T_{11} - Control*

At all the stages of growth, weed density and dry matter significantly reduced under weed control treatment (Table 2). Application of almost all the weedicides *i.e*. Oxadiargyl 80 % WP (Topstar), Fenoxoprop-P-ethyl 6.7% w/w EC (Rice star), Pretilachlor 30.7% w/w EC (Sofit), Fenoxoprop-P-ethyl 9.3% w/w (Whipsuper), 2,4-D Ethyl Ester 30% EC (Champion), Metsulfuron Methyl 10% + Chlorimum Ethyl 10% (Almix), Pyrazo Sulfuron 50% EC (Saathi), Pretilachlor 50 per cent EC (Rifit) (60 DAT) could significantly decrease weed biomass compared to control, Paraquat Dichloride 24 per cent SL (Swat) and Ethoxysulfuron 15 per cent WDG (Sunrice). However, at 90 DAT all the treatments reduced weed population as well as dry matter production of weeds compared with control except Fenoxoprop-P-ethyl 6.7 per cent w/w EC (Rice star) (Table 4). The lower dry matter under these treatments may be attributed to checking of growth of both broad leaved and narrow-leaved weeds ultimately reduced the fresh and dry matter accumulation of weeds compared with control. Due to variation in the ability of killing effect of the weeds by the different weedicides, there was variation in this biomass accumulation of weeds in the different treatments and the lowest accumulation in Metsulfuron Methyl 10% + Chlorimum Ethyl 10 per cent might be due to this effect. Similar findings of reduction of biomass accumulation of weeds due to application of different weedicides were reported by Alam *et al*, (1995).

Effects of weedicides on economics of rice production

Various weed control methods had various cause which are presented in table 3. A perusal of table 4, revealed that, there was an overall increase in net income in weedicide treated plots over the control. Among the different weed control treatments, the highest paddy yield was obtained from T_8 [Metsulfuron Methyl 10% + Chlorimum Ethyl 10 per cent (Almix)] which gave the highest net return of Rs. 83121/ha. This was closely followed by T9 (Pyrazo Sulfuron), and T_7 (2, 4–D Ethyl Ester 30% EC) with their respective values of Rs. 81117/ ha and Rs. 74208/ha, while that of control, it was Rs. 45,549/ha only. This was due to more than proportionate increase in gross return compared to cost of cultivation of the crop. The highest benefit cost ratio 2.21 was also associated with T8 (Metsulfuron Methyl 10% + Chlorimum Ethyl 10%), followed by the treatments as observed in case of net return. Similar observation of higher net return and benefit cost ratio while using effective weedicides in rice cultivation was reported by Madhu *et al*. (1996), Mukherjee and Singh, (2005) and Rajkhowa *et al*. (2007).

Thus it can be concluded that, Metsulfuron Methyl 10% + Chlorimum Ethyl 10% (Almix) @4g a.i./ha as Early Post-emergence is the best herbicide mixture to control weeds in transplanted rice under rainfed conditions of Manipur as the plot treated with this weedicide could produce the highest grain yield with the lowest weed biomass. The treatment was also found economically feasible with the maximum net return (Rs. 83121/ha) and benefit: cost ratio (2.21) with more grain yield. This was closely followed by the application of Pyrazo Sulfuron 50% EC (Saathi) @50g a.i. /ha as early Post-emergence in grain yield and economic parameters.

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