The Bioscan 10(1): 459-463, 2015 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EFFICACY OF SOME PROMISING WEEDICIDES ON SHALLOWLAND TRANSPLANTED RICE (*ORYZA SATIVA L.*) UNDER RAINFED CONDITIONS

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KEYWORDS
Efficiency
Rice
Weedicide
Weed
Yield

Received on :
10.12.2014

Accepted on :
18.02.2015

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ABSTRACT

An experiment was conducted at the Research Farm, College of Agriculture, Central Agricultural University,Imphal to study the efficacy of a 10 promising weedicides viz. Swat (Paraquat Dichloride 24% SL), Sunrice (Ethoxysulfuron 15% WDG), Topstar (Oxadiargyl 80% WP), Rice star (Fenoxoprop-P-ethyl 6.7% w/w EC), Sofit (Pretilachlor 30.7% w/w EC), Whipsuper (Fenoxoprop-P-ethyl 9.3% w/w), Champion (2,4-D Ethyl Ester 30% EC), Almix (Metsulfuron Methyl 10% + Chlorimum Ethyl 10%), Saathi (PyrazoSulfuron 50% EC) and Rifit (Pretilachlor 50% EC) under 11 treatments (including control treatment) in Randomized Block Design with 3 replications. Among the different herbicides tested T_7 {2,4-D Ethyl Ester 30% EC (Champion)} was found better, during earlier growth stages upto 60 DAT, producing taller plants but at later stages T_4 {Fenoxoprop-P-ethyl 6.7 % w/w EC (Rice star)} was found most effective to control weed least total weed biomass production (18.76g/m^2 fresh weight and 8.67g/m^2 dry weight), weed control efficiency (71.81%) and herbicide use efficiency (56.10 %). Different yield attributes viz. number of effective tillers per hill, number of spikelets, filled grains were recorded the highest with the application of {Metsulfuron Methyl 10% + Chlorimum Ethyl 10% (Almix)} weedicide T_8 resulting to the highest grain yield (68.98 q/ha) increasing 20.29 % over control.

INTRODUCTION

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 (Dhiman *et al.*, 1998). Pre-emergence application of mixture of almix + 2,4-DEE 15 + 500 g/ha recorded the minimum weed density and their biomass(Mukherjee and Singh, 2005). Treatment of pretilachlor 0.75 kg/ha (pre-emergence) + paddy weeder, resulted in the highest grain yield, maximum weed-control efficiency (88%) and monetary returns (Rs 8,300/ha). Herbicides alone were inferior to their use with paddy weeder (Rajkhowa *et al.*, 2007). Oxadiargyl 75g/ha + 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 know the effects of the weedicides on weed dynamics, 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. 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) plot size measuring 5 X 4 $m^2$with interplot and inter block spacing0.3 m and 0.5 m respectively. The net experimental area was 660 m^2.

Observations were recorded under different parameters to achieve the objectives of the experiment.From each plot, 5 hills were randomly selected and were tagged to be sample plants excluding the plant situated in the border rows to record the growth and yield attributes of rice. The growth parameters were recorded at 30, 60, 90 days after transplanting (DAT) while yield attribute (qha^{-1}) were taken at the time of harvesting when the grain attained 14% moisture. Straw yield from each net plot was sun dried for 3 days and weight (qha^{-1}).

Periodic (30 days interval) weed population was recorded from each experimental plot with the use of quadrate size of 1 m^2. The available weed species were then identified and broadly grouped as narrow leaved, broad leaved and sedges. For fresh and dry weight of weeds, the collected weeds from each plot were taken and weighted (fresh) in g or kg. These were then sundried for 7 days or dried at oven for 24 hours at 70^0 C and recorded in gram (g) for dry weight.

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

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

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

$$\text{Weed control efficiency} = \frac{X - Y}{X} \text{ X } 100$$

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:

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

Where, x = Grain yield of treatment plot; and

y = Grain yield of control plot

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). The level of significance used in 'F' test was given at 5 per cent. Critical difference (CD) values are given in the Table at 5 per cent level of significance, wherever the 'F' test was significant.

RESULTS AND DISCUSSION

Effects of herbicides on growth parameters and yield of rice

The differences in the plant height (Table 2) due to application of herbicides differ significantly with one another. Among the herbicides Fenoxoprop-P-ethyl 6.7% w/w EC (Rice star) as early Post-emergence (T_4) produced the tallest plant which was on par with 2,4-D Ethyl Ester 30% EC (Champion) (T_7) and Metsulfuron Methyl 10% + Chlorimum Ethyl 10% (Almix) as early post emergence (T_8) and PyrazoSulfuron 50% EC (Saathi) (T_9) but significantly taller than the control. This might be due to suppression of weed growth by these weedicides giving better inputs of growth to rice plant. The results are in close conformity with those reported by Yani*et al* (2010). On the contrary Paraquat dichloride 24% SL (Swat) had negative impact on rice height.

The different herbicides produced difference in the number of functional leaves (Table 2), the largest number of functional leaves were associated with application of Fenoxoprop-P-ethyl 6.7% w/w EC (Rice star) (T_6) in all the stages of crop growth but which was equally good with all the herbicide application treatments and significantly better than the control. This also might be due to the reason of giving better environment to rice plant by controlling weeds in herbicide treated plots. Similar findings were reported by Channappagoudar *et al.*, (2013) in turmeric by the application of pendimethalin (pre-emergence) 1.0 kg ha^{-1} recorded higher LAI, LAD, CGR and NAR.

Among the herbicide treated plots, the number of tillers per plant (Table 3) was almost on par statistically during earlier growth stages upto 60 DAT but at later growth i.e. 90 DAT, Metsulfuron Methyl 10% + Chlorimum Ethyl 10% (T_8) produced the highest tiller number (15.34), which was significantly better than all the treatments except T_1 (14.49), T_5 (14.40) and T_{10} (14.23). Through Paraquat dichloride 24% SL had negative impact on plant height, surprisingly, it could produce higher tiller number equivalent to the best treatment (T_8) and significantly better than control. This also might be due to supply of better growth input to rice by reducing

Table 1: Detailsof the treatments tested

Treatment notation	Weedicides	Trade name	Recommended dose in a.i./ha	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	PyrazoSulfuron	Saathi	50 g	Early Post-emergence
T_{10}	Pretilachlor	Rifit	450 g	Pre-emergence
T_{11}	Control			

Table 2: Effect of different weedicides on plant height and number of active leaves per hill of transplanted rice at different growth stages

Treatments	Plant height (in cm)			increase/decrease (%) of plant height over T_{11}	Number of leaves / hill			increase/decrease (%) of plant height over T_{11}
	30 DAT	60 DAT	90DAT		30 DAT	60 DAT	90DAT	
T_1	66.69	95.25	98.41	- 5.53	26.33	38.47	33.13	15.31
T_2	72.74	102.58	105.66	1.43	33.80	39.40	35.17	22.41
T_3	76.23	100.53	105.75	1.52	27.40	37.53	33.51	16.64
T_4	75.99	102.81	111.07	6.62	27.40	36.33	32.27	12.32
T_5	73.89	100.72	106.65	2.38	32.00	40.60	35.41	23.25
T_6	76.09	103.88	107.37	3.07	31.40	39.20	35.40	23.22
T_7	81.77	107.56	110.83	6.39	28.07	41.73	34.73	20.85
T_8	75.62	105.07	109.31	4.93	30.80	39.13	34.27	19.28
T_9	76.35	98.49	109.01	4.64	29.13	43.07	34.40	12.77
T_{10}	68.59	101.02	104.37	0.19	32.40	46.00	34.73	20.88
T_{11}	73.92	100.37	104.17		27.60	32.27	28.73	
SE(d)	2.3530	2.5463	2.0569		1.3478	1.5951	1.2051	
CD at 5%	4.91	5.32	4.30		2.81	3.33	2.52	

Table 3: Effect of different weedicides on number of tillers/hill of transplanted at different growth stages of rice:

Treatments	No. of tillers/hill			Increase/decrease (%) of plant height over T_{11}
	30 DAT	60 DAT	90DAT	
T_1	11.73	14.47	14.49	43.84
T_2	11.33	12.80	12.76	26.84
T_3	10.87	11.40	12.26	21.87
T_4	10.27	11.27	12.71	26.34
T_5	12.13	14.40	14.40	43.14
T_6	12.20	13.40	13.40	33.20
T_7	11.00	12.33	12.34	22.66
T_8	11.33	12.33	15.34	62.42
T_9	12.73	13.20	13.23	31.51
T_{10}	12.87	13.07	14.23	41.45
T_{11}	9.33	9.73	10.06	
SE(d)	0.8895	1.4587	0.0724	
CD at 5%	1.86	N.S.	0.15	

Table 4: Effect of different weedicides on yield attributes of rice, straw and grain yield transplanted of rice and harvest index

Treatments	No. of Effective tillers per hill	Panicle length (cm)	No. of spikelets per panicle	No.of filled grains per panicle	Test wt. (gm)		Yield (q / ha) % increase/decrease on yield over control			Harvest Index (%)
					Straw	Grain	Straw yield	Grain yield		
T_1	8.67	23.65	245.23	227.53	38.47	63.55	49.52	-0.42	7.20	43.79
T_2	8.87	23.86	258.47	237.97	39.42	74.92	61.28	17.39	32.67	44.99
T_3	8.67	22.87	260.03	235.57	38.63	68.80	58.64	7.80	26.95	46.01
T_4	9.04	23.13	254.93	228.40	38.47	66.47	52.97	4.15	14.68	44.35
T_5	9.13	23.40	242.87	230.33	39.84	70.08	55.03	9.81	19.13	43.98
T_6	8.60	22.68	258.33	242.97	38.51	66.12	48.81	3.60	5.67	42.47
T_7	9.60	23.48	245.93	240.84	38.57	74.15	65.12	16.19	40.98	46.76
T_8	9.60	23.93	264.53	244.77	39.13	76.77	68.98	20.29	49.34	47.16
T_9	9.61	23.38	263.10	243.23	38.72	77.66	67.58	21.68	46.31	46.53
T_{10}	9.61	23.24	254.07	239.07	38.59	72.34	61.29	13.35	32.69	45.87
T_{11}	7.73	22.63	229.97	214.53	39.35	63.82	46.19			41.99
SE(d)	0.444	0.383	7.261	6.668	0.495	4.140	3.196			0.5862
CD at5%	0.93	0.80	15.18	13.94	1.03	8.83	6.68			1.23

competition of weeds in these treatments. Similar finding was also reported by Sultan Ahmed et al (1986) and Pandey and Singh (1994).

All the weed control treatments caused marked increase in yield attributes of rice i.e. no. of effective tillers/hill, panicle length, number of filled grains/panicle and to weight over control. Again among the herbicides, Metsulfuron Methyl 10% + Chlorimum Ethyl 10% resulted overall better performance in all the yield attributes (Table 4) and more or less similar performances were attributed by PyrazoSulfuron 50% EC, Pretilachlor 50% EC and Fenoxoprop-P-ethyl 9.3% treatments. There might be due to better number of leaves/plant and tiller numbers in these treatments. Similar results were also reported earlier by Pandey and Singh (1994).

Table 5: Effect of different weedicides on weed population per m^2 andfresh and dry weight of weeds of transplanted rice

Treatments	Weed population per m^2			Total Population	increase/ decrease (%) of plt. ht. over T_{11}	Weed weight (in gm/m^2)					
	30 DAT	60 DAT	90DAT			30 DAT		60 DAT		90DAT	
						FreshWt.	Dry Wt.	FreshWt.	Dry Wt.	FreshWt.	Dry Wt.
T_1	8.11 (65.67)	9.53 (91.50)	6.34 (39.80)	23.98	- 17.99	13.25(179.96)	6.02 (36.23)	27.33(746.45)	11.36(129.52)	19.25(371.93)	10.89(107.58)
T_2	7.98 (63.33)	8.38 (71.33)	4.65 (21.17)	21.01	- 28.15	8.26(67.86)	4.90 (23.55)	19.99(410.83)	8.44(72.89)	12.16(149.41)	7.99(63.56)
T_3	6.48 (41.67)	7.65 (58.47)	4.42 (19.13)	18.55	- 36.56	10.92(157.00)	5.52(30.21)	25.89(676.13)	12.08(149.04)	13.95(194.28)	9.11(85.41)
T_4	3.23 (10.00)	4.33 (18.33)	6.34 (40.43)	13.90	- 52.46	4.78(22.39)	2.06(3.75)	8.91(79.60)	4.23(17.45)	20.12(405.48)	11.19(125.77)
T_5	6.18 (38.00)	7.47 (56.47)	4.50 (20.07)	18.15	- 37.93	8.35(70.12)	3.67(14.38)	12.76(164.36)	5.42(30.84)	14.25(226.84)	7.52(59.46)
T_6	3.71 (13.33)	6.72 (44.80)	5.92 (34.73)	16.35	- 44.08	4.89(23.62)	2.03(3.64)	15.41(237.15)	7.03(48.97)	20.45(418.08)	10.31(106.00)
T_7	3.61 (12.63)	4.92 (23.77)	3.13 (9.67)	11.66	- 60.12	4.71(23.78)	2.04(3.78)	13.97(200.81)	7.13(50.43)	10.07(101.11)	6.14(37.40)
T_8	4.07 (16.10)	4.24 (17.53)	1.67 (2.77)	9.98	- 65.87	5.38(28.50)	2.12(4.23)	8.61(75.16)	3.72(13.78)	4.77(26.60)	2.32(9.24)
T_9	4.45 (19.33)	5.71 (32.23)	3.34 (10.70)	10.50	- 64.09	4.12(16.49)	2.02(3.62)	10.67(113.37)	5.23(26.82)	7.02(48.83)	3.85(14.33)
T_{10}	8.21 (67.10)	6.71 (44.80)	6.69 (44.73)	21.61	- 26.09	9.15(83.30)	4.91(23.63)	20.15(413.72)	8.20(67.03)	18.95(372.13)	9.27(85.51)
T_{11}	11.30 (127.33)	10.62(113.10)	7.32 (53.33)	29.24		15.29(233.54)	7.36(53.93)	29.26(888.02)	12.21(151.28)	20.79(431.86)	12.64(159.40)
SE(d)	1.2659	1.1190	1.2577	3.6426		2.7469	0.9512	3.9816	2.0638	4.7655	1.8482
CD at 5%	2.64	2.34	2.63	7.61		5.74	1.99	8.32	4.31	9.94	3.86

*value within the parenthesis is transformation value

Among the weed control treatments, Metsulfuron Methyl 10% + Chlorimum Ethyl 10% (Almix) resulted in maximum grain and straw yield and it proved statistically superior to all other treatment except PyrazoSulfuron 50% EC (Saathi), Pretilachlor 50% EC (Rifit) and 2,4–D Ethyl Ester 30% EC (Champion). The increase in crop yield was due to increase in productive tillers, number of grains/ear and 1000-grain weight 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, PyrazoSulfuron 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 findings are in accordance with the findings of Pandey and Singh (1994). Mallikarjun *et al.,* (2014) observed that 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.

Effects of herbicides on weed population and biomass

During earlier growth stages of rice (upto60 DAT), Fenoxoprop-P-ethyl 6.7% w/w EC (T_4), Fenoxoprop-P-ethyl 9.3% w/w (T_6), 2,4-D Ethyl Ester 30% EC (T_7) and Metsulfuron Methyl 10% + Chlorimum Ethyl 10% (T_8) were found to be very effective in reducing weed population (Table 5) comparing to other weedicides and control but at later stage (90 DAT), T_8 still maintained the highest in reducing weed population, followed by T_7 and T_9 but Fenoxoprop-P-ethyl failed to reduce weed population. In total the highest weed population (29.24 / m^2) was recorded with control and the lowest (9.98 / m^2) in T_8.

At all the stages of growth, weed density and dry matter significantly reduced under weed control treatment (Table 6). 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% EC (Rifit) (60 DAT) could significantly decrease weed biomass compared to control, Paraquat Dichloride 24% SL (Swat) and Ethoxysulfuron 15% WDG (Sunrice). However, at 90 DAT all the treatment reduced weed population as well as dry matter

Table 6: Effects of different weedicides on weed dynamics

Treatment	Weed Dynamics		
	Grass	Sedges	Broad
T_1	5.58	6.96	6.36
T_2	4.52	3.29	4.59
T_3	5.58	2.51	4.70
T_4	3.32	7.01	6.25
T_5	3.23	3.71	5.11
T_6	3.58	7.03	7.29
T_7	5.18	1.83	2.77
T_8	4.27	0.71	2.30
T_9	4.53	1.00	2.60
T_{10}	5.09	2.38	4.26
T-$_{11}$	6.34	8.45	9.31
SE(d)	0.1227	0.6613	2.7054
CD at 5%	0.26	1.38	N.S.

Table 7: 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	90DAT		
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
CD at 5%	3.33	4.62	5.80	1.13	1.31

production of weeds compared with control except Fenoxoprop-P-ethyl 6.7% w/w EC (Rice star) (T_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% might be due to this effect. Similar findings of reduction of biomass accumulation of weeds due to application of different weedicides were reported by (Battacharya and Kolhe, 1985, Alam *et al.,* 1995 and Singh *et al.,* 1992).

Effects of herbicides on weed dynamics

Fifteen weed species belonging to seven families were found to infest the experimental plot. The most important weed species in the experimental plots throughout the growing period were *Monochoriavaginalis, Jussiaeasaffructicosa, Echinochloacrusgalli, Frimbristylismeliacea,* respectively. At 60 DAT two more new weed species emerged, but found to decline the previous weed species population. However, at 90 DAT one new weed species emerged and *Jussiaeasaf fruticosa* was found with the highest degree of weed infestation. The different weed control treatments have different effects on different weed species (Table 7). The weed control treatment with Metsulfuron Methyl 10% + Chlorimum Ethyl 10% (Almix) reduced the weed population of sedges and broad leaves and proved the most effective herbicide against broad leaves and sedges and more or less similar results were obtained with PyrazoSulfuron 50% EC, Pretilachlor 50% EC and 2,4–D Ethyl Ester 30% EC. But for controlling grasses Pretilachlor and Fenoxoprop-P-Ethyl were found more effective in controlling grassy weed recording lower weed population than Metsulfuron Methyl 10% + Chlorimum Ethyl 10% which retained insignificant population with other weedicides but lower than the control. The finding is in close conformity with that of Mukherjee Dhiman and Singh (2005).

ACKNOWLEDEGEMENT

The author would like to thank N. Iboton Singh, Dr. Edwin Luikham, N. Gopimohan Singh, Dr. Tombisana, Dr. Shashidhar K.S. and JoseptKoireng, College of Agriculture, CAU for their help and encouragement to conduct the research work.

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