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Research article

EVALUATION OF LOW DOSE HERBICIDES IN TRANSPLANTED RICE (*Oryza Sativa* L.)

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ABSTRACT: A field experiment was conducted during *kharif* 2011 at College of Agriculture, Rajendranagar. The experiment consisted of 12 treatments laid out in randomized block design with three replications consisting of two pre-emergence herbicides integrated with post emergence herbicides and one hand weeding at 40DAT and two post emergence herbicide, hand weeding twice at 20 and 40 days after transplanting, compared with weed free and unweeded check. The predominant weed flora observed in the experimental field were *Echinochloa crusgalli, Panicum repens, Cynodon dactylon, Cyperus rotundus, Cyperus difformis, Eclipta alba and Ammania baccifera*. The results revealed that pre-emergence application of Bensulfuron methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1}+ Hand weeding at 40 DAT (5455 kg ha^{-1} and 6345 kg ha^{-1}) and Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} + Bispyribac sodium @ 25 g a.i ha^{-1} recorded significantly higher grain and straw yield (5365 and 6265kg ha^{-1}, respectively) which remained at par with two hand weedings at 20 and 40 DAT (5580 and 6464 kg ha^{-1}). In terms of economics, highest net returns (Rs. 33,189 ha^{-1}) and B:C ratio (1.40) were also high with the pre-emergence application of Bensulfuron-methyl 0.6%+ Pretilachlor 6% @ 10 kg granules ha^{-1}+ Bispyribac sodium @ 25 g a.i. ha^{-1} at 20DAT (1.40) compared to that of two hand weedingds (Rs. 31,952 ha^{-1}) and benefit cost ratio (1.17) .
Key Words: Weed Density, Weed control Efficiency, Weed Index, Grain Yield, Straw yield, Benefit: Cost Ratio

INTRODUCTION

Weeds are unwanted plants playing a very important role in different eco-systems and many of them cause enormous direct and indirect losses. The losses include interference with cultivation of crops, loss of bio-diversity, loss of potentially productive lands, loss of grazing areas and livestock production, erosion following fires in heavily invaded areas, choking of navigational and irrigation canals and reduction of available water in water bodies. As the weed cause nearly 45 % of the total loss, every attempt has to be made to contain the weed menace and uphold the production. Weed management takes away nearly one third of total cost of production of field crops. In India, the manual method of weed control is quite popular and effective. Of late, labour has become non-availability and costly, due to intensification, diversification of agriculture and urbanization. The usage of herbicides in India and elsewhere in the world is increasing due to possible benefits to farmers and continuous use of the same group of herbicides over a period of time on a same piece of land leads to ecological imbalance in terms of weed shift and environmental pollution. The complexity of these situations has resulted in a need to develop a wholistic sustainable eco-friendly weed management programme throughout the farming period. Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Sustainable weed management is the use of weed control methods that are socially acceptable, environmentally benign and cost-effective. An attempt has been made to review the different approaches used in sustainable weed control options, in this paper. Rice is the premiere food crop of india and its total area in the country has been stabilized around 44 M ha with a production of 99.18 M.t and productivity of 2.17 t ha^{-1}. To meet the projected target of 140 M.t of rice by 2025 AD its productivity should be enhanced to 3.2 t ha^{-1}.

There are many reasons for low productivity of rice and weed infestation has been recognized as one of the major constraints. Unlike other arable crops, the problem of weeds in rice is conspicuous as it is grown under environmental conditions favourable for profuse growth and reproduction of semi aquatic weeds. In transplanted rice, yield reduction has been reported to be 28-45% due to uncontrolled weeds. (Singh *et al*., 2003).

The current global population of 6.4 billion is expected to reach 7.5 billion by 2020 and 9.0 billion by 2050 and most of this population increase will occur in developing countries of Asia and Africa where rice is the staple food. Globally rice is cultivated in 154 M ha with an annual production of around 600MT and average productivity of 3.9 t ha^{-1}. In India rice is cultivated round the year, in one or the other part of the country, in diverse ecologies spread over 448 M ha with production of 99.1 MT and productivity of 2.2 t ha^{-1}. It is estimated that by 2020 atleast 170 to 180 MT (115 to 120 MT milled rice) of rice has to be produced in India (4.03 t ha^{-1}) to maintain the present level of self sufficiency (Mishra *et al.*, 2006), which means, the productivity should go up by another one tonne from current productivity level.

In the recent past, due to hike in labour wages and their non-availability during crucial agricultural operations, manual weeding has become an uneconomical preposition and subsequently farmers are compelled to take up chemical weed control. Many promising herbicides that are selective to rice have been identified and became popular recent times. The use of pre-emergence herbicides made it possible to control weed growth during initial stage of crop and offer scope to the crop for better utilization of resources. However one hand weeding is essential at 30-40 DAT for getting higher yields in rice. Recent trend of herbicide usage is to find out effective weed control methods using low dose high efficiency herbicides including post emergence selective herbicides which make the application easier and economical to the farmer with wide spectrum weed control in transplanted rice. Sulfonyl urea herbicides includes Bensulfuron-methyl, Metsulfuron-methyl, Chlorimuron-ethyl, Pyrazosulfuron-ethyl, Bispyribac sodium etc. As these herbicides are highly effective at very low rate of application, they are known as low dose high efficiency herbicides (LDHE herbicides**)**. In cognizance of the above, the present study was undertaken to test the relative efficacy of sulfonyl urea group herbicides on weed growth and yield of transplanted rice.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* 2011 at College Farm, College of Agriculture, Rajendranagar, Hyderabad. The soil was sandy clay loam in texture having pH 7.8, EC 0.23 ds m^{-1}, OC 0.42%, available N, P_2O_5 and K_2O 233, 28.5 and 129 kg ha^{-1} respectively. The treatments comprised of pre-emergence application of Pyrazosulfuron-ethyl @ 25 g a.i. ha^{-1} fb HW at 40 DAT (T_1), Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} fb HW at 40 DAT (T_2), Bispyribac sodium @ 25 g a.i. ha^{-1} at 20 DAT (T_3), Almix (Metsulfuron-methyl 10% + Chlorimuron ethyl 10%) @ 4 g a.i. ha^{-1} at 20 DAT (T_4) and sequential application of pre and post emergence herbicides Pyrazosulfuron ethyl @ 25 g a.i. ha^{-1} as PE + Bispyribac sodium 25 g a.i. ha^{-1} at 20 DAT (T_5), Pyrazosulfuron ethyl @ 25 g a.i. ha^{-1} as PE + Almix 4 g a.i. ha^{-1} at 20 DAT (T_6), Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} as PE+ Bispyribac sodium @ 25 g a.i. ha^{-1} at 20 DAT (T_7), Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} as PE + Almix @ 4 g a.i. ha^{-1} at 20 DAT (T_8), Butachlor (50% Granules) @ 1.5 kg a.i. ha^{-1} as PE + HW at 40 DAT (T_9), Two hand weedings at 20 and 40 DAT (T_{10}), Two mechanical weedings at 20 and 40 DAT (T_{11}) and Weedy check (T_{12}). The experiment was conducted in RBD with three replications. All the herbicides were applied by manually operated knapsack sprayer fitted with flat fan nozzle using spray volume of 500 l ha^{-1}. The granular herbicides were applied by mixing with sand @ 50 kg ha^{-1}. The density and biomass of weeds were recorded at 20, 40, 60DAT and at harvest. 25 days old seedlings of rice variety “MTU 1010” were transplanted at 20 cm× 10cm spacing on August 19, 2011. The crop was fertilized with 120 kg N, 60 kg phosphorus and 40 kg potassium per hectare. The total annual rainfall received during the crop season was 376 mm distributed over 25 rainy days. Pre-emergent application of herbicides was done at three days after transplanting. Post emergence herbicides bispyribac sodium and Almix were sprayed on 20 DAT. Since the data on weed count and weed dry weight showed high variation, the data were subjected to square root transformation using the formula $\sqrt{x+0.5}$ and the statistical analysis was done Weed index and weed control efficiency were calculated as per the standard formulae. Weed samples were also collected at 40DAT and at harvest to determine the N, P and K removal by weeds. Plant DMP (Dry matter production) and nutrient uptake of rice were recorded at active tillering, panicle initiation and at harvest to evaluate the effect of weed control practices on crop growth. Nitrogen content was estimated by Micro Kjeldhal digestion method as suggested by Humphries (1956).The Phosphorus and Potassium contents were estimated by Triple acid digestion method as suggested by Jackson (1973). The uptake of nutrients (N, P and K) was worked out by multiplying the per cent nutrient content with dry matter production and expressed in kg ha^{-1}. The yield and yield parameters were recorded at harvest.

Effect of weed control treatments on weed density, weed dry matter and weed control efficiency

Persual of data revealed that application of Bensulfuron-methyl 0.6%+ Pretilachlor 6% @ 10kg granules ha^{-1} as PE was found effective in limiting weed growth by recoding lower weed density values (5.41, 5.68 and 5.84) compared to that of weedy check plot (9.32) at 20 DAT. At 40 DAT, lowest weed density of 5.24 was observed with two hand weedings (20 and 40DAT) treatment. Performance of combination of pre and post emergence herbicides was found equally effective as that of hand weeding at 20 DAT, showing that hand weeding can be substituted by these herbicides if labour availability is a problem. Pre-emergence application of Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules per ha^{-1} was found effective even at 40DAT and recorded significantly lower weed density compared to that of weedy check. The application of post emergence herbicides (Bispyribac sodium @ 25 g a.i. ha^{-1} and/or Almix @ 4 g a.i. ha^{-1}) at 20DAT recorded higher weed density values compared to that of combination of pre and post emergence herbicides. Nevertheless, pre-emergence application of Bensulfuron-methyl 0.6% + Pretilachlor 6% @10kg granules per ha^{-1} was found effective even at 40DAT and recorded significantly lower weed density (7.10) compared to that of weedy check (12.02). At crop harvest also two hand weedings treatment resulted in lower weed density (5.75) which remained on par with Bensulfuron-methyl 0.6%+ Pretilachlor 6% @ 10k granules per ha^{-1} + hand weeding at 40 DAT (6.02) and Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} + Bispyribac Sodium @ 25 g a.i. ha^{-1} (6.16). Application of Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules per ha^{-1} alone could not control weeds effectively at later stages there by indicating that one hand weeding is essential around 40DAT for effective weed control or can be substituted by application of post emerence herbicide Bispyribac Sodium @ 25 a.i. ha^{-1} which showed efficient control of weeds in the present study by recording lower weed density values. This could be due to high bio-efficacy of these herbicides in controlling a wide range of weed species (grasses, sedges and broad leaved weeds). Similar results were reported by Saha *et al*. (2010) and Saha *et al*., (2009). Weed Dry matter has got direct effect on weed biomass production. Bensulfuron–methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} as pre-emergence application in different treatments recorded lower weed dry matter values (178, 194, 187 kg ha^{-1}) and weed control efficiency (74.03, 71.70 and 72.69) compared to that of weedy check plot (686 kg ha^{-1}) at 20 DAT. At 40 DAT and 60DAT all weed control treatments recorded significantly lower weed dry matter and weed control efficiency over weedy check. Superiority of two hand weedings treatment continued even at crop harvest and resulted in lower weed dry weight (196 kg ha^{-1}) and weed control efficiency (82.35%). This was followed by application of Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} + Bispyribac sodium @ 25 g a.i. ha^{-1} (244 kg ha^{-1} and 78.01%). This findings of present study are in accordance with that of Jadhav *et al*. (2008), Yadav *et al*., (2009).

Nutrient uptake by weeds (kg ha^{-1})

The data pertaining to the influence of different herbicide treatments on nutrient uptake (N, P and K) by weeds at 40 DAT and at harvest is presented in Table 2. The nutrient uptake by weeds was significantly influenced by different weed control treatments.

Nitrogen

Maximum N uptake (kg ha^{-1}) by weeds was observed in weedy check at 40 DAT and at harvest followed by 2 Mechanical weedings at 20 and 40 DAT. Where as minimum N uptake by weeds was recorded by hand weeding at 20 and 40 DAT followed by Bensulfuron methyl 0.6% + Pretilachlor 6% @ 10 kg G ha^{-1} fb Bispyribac sodium @ 25 g a.i ha^{-1} at 20DAT and Bensulfuron methyl 0.6% + Pretilachlor 6% @ 10 kg G ha^{-1} as PE fb HW at 40 DAT.

Phosphorous

Phosphorous uptake by weeds differed significantly due to various treatments. The highest P uptake by weeds was observed in weedy check at 40 and at harvest followed by 2 mechanical weedings at 20 and 40 DAT. Among herbicidal treatments, the P uptake by weeds was significantly lower with application of Bensulfuron methy 0.6% + Pretilachlor 6% + Bispyribac sodium @ 25 g a.i. ha^{-1} and it is on par with hand weeding twice at 20 and 40 DAT followed by Bensulfuron methyl @ 06% + Pretilachlor 6% + hand weeding at 40 DAT.

Potassium

As regards to K uptake highest uptake by weeds was observed in weedy check at 40 and at harvest followed by 2 mechanical weedings at 20 and 40 DAT. Among herbicidal treatments, the P uptake by weeds was significantly lower with application of Bensulfuron methyl @ 0.6%+ Pretilachlor 6% + Bispyribac sodium @ 25 g a.i ha^{-1} and it is on par with hand weeding twice at 20 and 40 DAT followed by Bensulfuron methyl 0.6% + Pretilachlor 6% + hand weeding at 40 DAT. Pursual of data further indicated that maximum N,P and K uptake by crop and minimum depletion of nutrients by weeds were observed in hand weeding treatment.

This was mainly due to more drymatter production and minimum nutrient depletion by weeds subsequently more availability of these nutrients to crop, while minimum uptake of these nutrients was observed in unweeded check due to minimum shoot dry matter production by the crop and maximum depletion of nutrients by weeds. Further, it was observed that the total uptake of nutrients by crop and weeds together in unweeded check was less than the nutrient uptake by crop alone in case of hand weeding and other herbicidal treatments. But there was a marked reduction in growth, yield attributes, yield and nutrient uptake of rice in weedy check despite adequate availability of nutrients. Hence, it appears that crop weed competition under high weed intensity exerts some adverse effect on the uptake and utilization of nutrients by the crop and weed on the expected level. Then, when there was a competition between weeds and crop for nutrients, both crop and weeds could not utilize this to the maximum extent. This showed the importance of keeping the field from weeds to enable the crop to absorb more nutrients from the soil.

Yield attributes

Plant height and dry matter production of crop was highest with two hand weedings at 20 and 40DAT. Among herbicidal treatments, Bensulfuron - methyl 0.6% + Pretilachlor 6% @ 10k granules per ha^{-1} + hand weeding at 40 DAT and Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} + Bispyribac Sodium @ 25 g a.i. ha^{-1} recorded taller plants and higher crop dry matter production and remained at par with two hand weeding at 20 and 40 DAT treatments. The yield attributes of transplanted rice viz., number of panicles per m2, Grains per panicle, number of filled grains per panicle and 1000 grain weight were significantly higher with two hand weedings treatment and this has ultimately resulted in highest grain yield(5580 kg ha-1) followed by Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1}+ Hand weeding at 40 DAT (5455 kg ha^{-1}) and Bensulfuron - methyl 0.6% + Pretilchlor 6% @ 10 kg granules ha^{-1} + Bispyribac sodium @ 25 g a.i. ha^{-1} (5365 kg ha^{-1}). Weedy check recorded lowest grin yield of 2542 kg ha^{-1}.

Table: 1 Effect of weed control treatments on Weed Density, Weed Dry Matter and Weed Control Efficiency at 20 DAT and Harvest

Treat ments	20DAT				HARVEST				WDM (Kg ha^{-1})		WCE (%)	
	Grasses	Sedges	BLW	Total	Grasses	Sedges	BLW	Total	20DAT	HARVEST	20DAT	HARVEST
T_1	19.6 (4.48)	10.8 (3.36)	12.8 (3.65)	43.2 (6.61)	23.4 (4.89)	13.8 (3.78)	13 (3.67)	50.2 (7.12)	348.35	388.05	49.24	71.03
T_2	12.2 (3.56)	9 (3.08)	10.4 (3.30)	31.6 (5.68)	15.3 (3.97)	8.8 (3.05)	11.4 (3.45)	35.5 (6.00)	187.43	221.34	72.69	80.02
T_3	40.8 (6.43)	22.4 (4.79)	17 (4.18)	80.2 (8.98)	26 (5.15)	15.8 (404)	18.2 (4.32)	60 (7.78)	682.54	440.34	0.54	60.26
T_4	41.4 (6.47)	24.2 (4.97)	17.8 (4.28)	83.4 (9.16)	28.8 (5.41)	17.8 (4.28)	21.6 (4.70)	68.2 (8.29)	681.15	512.40	0.74	53.75
T_5	18.2 (4.32)	10.4 (3.30)	13.4 (3.73)	42 (6.52)	20.5 (4.58)	14.4 (3.86)	12.2 (3.56)	47.1 (6.90)	321.00	419.11	53.22	62.17
T_6	19.2 (4.44)	10.4 (3.30)	13.4 (3.73)	43 (6.60)	22.5 (4.80)	15.5 (4.00)	13.8 (3.78)	51.83 (7.23)	332.00	507.25	51.62	54.22
T_7	11.6 (3.48)	7.8 (2.88)	9.2 (3.11)	28.6 (5.41)	15.9 (4.05)	9.8 (321)	11.8 (3.51)	37.5 (6.16)	178.23	243.69	74.03	78.01
T_8	14.6 (3.89)	8 (2.92)	9.4 (3.15)	32 (5.70)	17.8 (4.28)	11.7 (3.49)	14.8 (3.91)	44.3 (6.69)	194.23	323.44	71.70	70.81
T_9	12.2 (3.56)	9.4 (3.15)	12 (3.54)	33.6 (5.84)	20.3 (4.56)	13 (3.67)	13.3 (3.71)	46.6 (6.86)	237.54	293.66	65.38	73.50
T_{10}	40.6 (6.41)	22.6 (4.81)	17.4 (4.23)	80.6 (9.01)	14.2 (3.83)	9.2 (3.11)	8.8 (3.05)	32.2 (5.72)	674.23	195.58	1.75	82.35
T_{11}	41 (6.44)	23 (4.85)	18.8 (4.39)	82.8 (9.13)	23.1 (4.86)	14.4 (3.86)	21 (4.64)	58.5 (7.68)	682.12	562.00	0.60	49.28
T_{12}	42.4 (6.55)	24.5 (5.00)	19.2 (4.44)	86.1 (9.31)	77.7 (8.84)	52.1 (7.25)	50.4 (7.13)	180.2 (13.44)	686.23	1108.00	--	--
SEm	0.06	0.05	0.07	0.10	0.10	0.09	0.06	0.10	4	12		--
Cd	0.18	0.16	0.21	0.29	0.30	0.28	0.20	0.30	12	35		---

Effect of weed control treatments on nutrient uptake by weeds at 40 DAT and Harvest						
Treatments	40 DAT			Harvest		
	N	P	K	N	P	K
Pyrazosulfuron-ethyl @ 25 g a.i. ha^{-1} fb HW at 40 DAT (T_1)	4.90	2.54	5.87	453	1.24	4.38
Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} fb HW at 40 DAT (T_2)	3.61	1.84	3.81	2.60	0.71	2.51
Bispyribac sodium @ 25 g a.i. ha^{-1} at 20 DAT (T_3)	3.29	2.07	4.11	5.73	1.44	4.85
Almix (Metsulfuron-methyl 10% + Chlorimuron ethyl 10%) @ 4 g a.i. ha^{-1} at 20 DAT (T_4)	4.60	2.63	5.24	6.34	1.73	5.97
Pyrazosulfuron ethyl @ 25 g a.i. ha^{-1} as PE + Bispyribac sodium 25 g a.i. ha^{-1} at 20 DAT (T_5)	3.05	1.74	3.53	4.64	1.33	4.55
Pyrazosulfuron ethyl @ 25 g a.i. ha^{-1} as PE + Almix 4 g a.i. ha^{-1} at 20 DAT (T_6)	3.93	2.01	4.43	5.13	1.68	5.57
Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} as PE+ Bispyribac sodium @ 25 g a.i. ha^{-1} at 20 DAT (T_7)	2.23	1.12	2.23	2.51	0.77	2.64
Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} as PE + Almix @ 4 g a.i. ha^{-1} at 20 DAT (T_8)	2.94	1.54	3.48	3.24	1.10	3.54
Butachlor (50% Granules) @ 1.5 kg a.i. ha^{-1} as PE + HW at 40 DAT (T_9)	4.92	2.37	4.61	3.29	0.99	3.24
Two hand weedings at 20 and 40 DAT (T_{10})	2.06	1.31	2.65	1.96	0.60	2.15
Two mechanical weedings at 20 and 40 DAT (T_{11})	5.28	3.21	5.18	6.31	1.92	6.38
Weedy check (T_{12}).	12.31	6.75	14.72	12.81	3.62	11.77
SEm$\pm$	0.1	0.2	0.2	0.3	0.07	0.2
CD(P=0.05)	0.3	0.5	0.6	0.8	0.2	0.5

CONCLUSION

Present study revealed that sequential application of Bensulfuron-methyl 0.6% + Pretilachlor 6% @ 10 kg granules ha^{-1} + Bispyribac Sodium @ 25 g a.i. ha^{-1} as post emergence at 20 DAT or the same pre-emergence herbicide + one hand weeding at 40 DAT may be suggested for better weed control and higher economic returns in transplanted rice.

Effect of weed control treatments on yield attributes in transplanted rice									
Treatments	Plant Height	No of tillers m^{-2}	Dry matter (kg ha^{-1})	Panicles m^{-2}	Gains per panicle	Filled Grains per panicle	Grain yield	Straw Yield	Harvest Index
T1	73.2	474	6440	437	124	117	4835	5843	45.28
T2	76.05	518	6980	497	133	127	5455	6345	46.23
T3	70.34	449	5676	396	103	95	4220	5358	44.14
T4	66.45	407	5443	350	98	93	3904	5021	43.74
T5	73.23	452	6310	416	117	110	4563	5629	44.90
T6	69.02	414	6120	380	106	98	4280	5460	43.94
T7	76.56	512	6950	491	137	131	5365	6265	46.13
T8	70	448	6470	414	119	111	4563	5629	44.77
T9	72.87	487	6710	460	127	120	5115	6000	46.02
T10	80.12	524	7120	506	142	137	5580	6464	46.33
T11	67.1	393	5197	358	93	84	3844	4893	44.00
T12	57.34	332	4812	296	80	69	2542	3342	43.20
SEm$\pm$	1.3	4.5	62	5.4	2.5	3.8	75	87	-
CD	3.9	14	182	16	7.3	11	220	254	-

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