Research Paper

ADVANCE RESEARCH JOURNAL OF
CROP IMPROVEMENT
Volume 4 | Issue 1 | June, 2013 | 79-84

Effect of integrated weed management on weed flora distribution, weed dynamics and performance of rice (*Oryza sativa* L.) under system of rice intensification (SRI) in Chhattisgarh

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ABSTRACT : A field experiment conducted at Research cum-Instructional Farm, Department of Agronomy, IGKV, Raipur (C.G.) during *Kharif* season of 2009 in Randomized Block Design (RBD) with three replications. The dominated weed flora of the rice field comprised of *Alternanthera triendra, Echinocloa colona, Fimbristylis miliacea* and *Cyperus iria* throughout the crop season. Other weeds *were Ischaemum rugosum, Boreria sirida, Commelina benghalensis, Cynotis axillaris, Aescheynomene indica* etc. observed in the experiment field. Results revealed that post-emergence combined application of fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1} at 20 and 35 DAT was statistically at par with hand weeding (twice) at 20 and 40 DAT for controlling weeds effectively in system of rice intensification method of rice. The maximum grain yield and straw yield was recorded under fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1} at 20 and 35 DAT followed by hand weeding. All the treatments gave significantly higher seed yield than unweeded control. The highest gross return and B:C ratio was obtained from fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1} at 20 and 35 DAT followed by hand weeding and lowest from unweeded control.

Key Words : Rice, Weed flora, Weed dynamics, Integrated weed management

How to cite this paper : Dewangan, Devendra Kumar, Singh, Anu Shri, Sahu, Eshu and Toppo, A.R. (2013). Effect of integrated weed management on weed flora distribution, weed dynamics and performance of rice (*Oryza sativa* L.) under system of rice intensification (SRI) in Chhattisgarh, *Adv. Res. J. Crop Improv.*, **4** (1) : 79-84.

Paper History : Received : 29.04.2013; **Revised :** 07.05.2013; **Accepted :** 29.05.2013

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Rice *(Oryza sativa* L.*)* is on of the most important and extensively grown premium food crop of the world and important staple food of more than 60 per cent of the world's population. Chhattisgarh is known as rice bowl of central India. The area and productivity of rice in Chhattisgarh is 3.61 million ha and 1.5 t ha^{-1} (Anonymous, 2009), which is quite low as compared to many states as well as country. Weeds are the major constraints in production of rice which often pose serious problem. Weeds compete with crop plants for moisture, light, nutrients and space. The extent of yield reduction of rice due to weeds is estimated from 15-95 per cent (Gogoi *et al*., 1996). Weed competition depends upon method of rice cultivation, weed species and their time of emergence etc. Weed problems are generally of lower magnitude in traditional method because of puddling, transplanting and continuous submergence of water but in SRI fields, weeds infestation is higher as compared to traditional transplanting system due to wetting and drying of field. The untimely and poor weed management adversely affects proper growth and yield of rice. Herbicide used in isolation, however, unable to obtain complete weed control because of their selective killing. Their use can be made more effective if apply in combination and/or supplemented with other weed management practices such as hand weeding or mechanical weeding etc which are available for weed control in rice. Keeping these points in view, integrated approach of weed management was evaluated for more feasible and practicable control of mixed weed flora in SRI.

RESEARCH PROCEDURE

The experiment was carried out at research cum-instructional-Farm, IGKV, Raipur (C.G.) during *Kharif* season

(July to November) of 2009. The experiment was conducted in Randomized Block Design (RBD). There were three replication and twelve treatments of various combinations of different herbicides (*viz.*, post-emergence application of fenoxaprop-p-ethyl 9.3EC @ 60 g ha^{-1} + chlorimuron-ethyl + metsulfuron-methyl 20 WP @ 4 g ha^{-1} at 20 DAT, post-emergence application of fenoxaprop-p-ethyl 9 EC @ 60 g ha^{-1} + ethoxysulfuron 15 WG @ 15 g ha^{-1} at 20 DAT, post-emergence application of fenoxaprop-p-ethyl 9.3 EC@ 60 g ha^{-1} + chlorimuron-ethyl + metsulfuron-methyl 20 WP @ 4g ha^{-1} at 20 DAT + mechanical weeding (one way) at 35 DAT, post-emergence application of fenoxaprop-p-ethyl 9.3 EC @ 60 g ha^{-1} + ethoxysulfuron 15 WG @ 15 g ha^{-1} at 20 DAT + mechanical weeding (one way) at 35 DAT, post-emergence application of fenoxaprop-p-ethyl 9.3 EC @ 60 g ha^{-1} + ethoxysulfuron 15 WG @ 15 g ha^{-1} at 20 DAT + mechanical weeding (two way) at 35 DAT, post-emergence application of fenoxaprop-p-ethyl 9.3 EC @ 60 g ha^{-1} + chlorimuron -ethyl + metsulfuron-methyl 20 WP @ 4 g ha^{-1} at 20 DAT + mechanical weeding (two way) at 35 DAT, two purely of mechanical type (mechanical weeding performed one way and two ways), one hand weeding at 20 and 40 DAT and one unweeded control . Rice variety MTU-1010 was grown as a test crop. Rice seedlings of 14 days old were transplanted with a spacing of 20 x 20 cm. The crop was fertilized with 90, 60 and 40 kg N, P and K ha^{-1} applied through urea, single super phosphate and muriate of potash, respectively. The whole amount of P and K was applied as basal dressing, while nitrogen was applied in three splits *viz.*, 30 kg N/ha as basal and remaining 60 kg/N in two equal splits at maximum tillering and panicle initiation stage. Organic manures as green manuring crop was grown and incorporated in soil at flowering stage. Rice was harvested in the second week of November, 2009.

RESEARCH ANALYSIS AND REASONING

The results of the present study as well as relevant discussions have been presented under following sub heads:

Weed flora :

The experiment field was infested throughout the crop season with different weeds. The dominant weed species were *Alternanthera triendra, Echinocloa colona, Fimbristylis miliacea and Cyperus iria* throughout the crop season. Other weeds were *Ischaemum rugosum, Boreria sirida, Commelina benghalensis, Cynotis axillaris, Aescheynomene indica* etc.

Total and species wise weed density :

The total weed density was observed lower in the treatment PoE followed by PoE (Fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1}) followed by hand weeding twice at harvest. Infestation of weeds increased with time under unweeded check up to harvest. The maximum weed density was observed in unweeded control plot throughout the crop growth period because no control measure was adopted in this plot.

Table 1 : Effect of weed management practices on seed yield, total weed density, total weed dry matter accumulation, weed control efficiency and benefit: cost ratio of rice in SRI

	Treatments	Seed yield (q ha^{-1})	Total weed density(m^{-2})	Total weed dry matter accumulation (m^{-2})	WCE	B:C ratio
T_1	Fenoxaprop-p-ethyl @ 60 g ha^{-1}+CME+MSM @4 g ha^{-1} at 20 DAT	41.16	19.30	132.85	52.05	1.34
T_2	Fenoxaprop-p-ethyl @ 60 g ha^{-1} + ethoxysulfuron @ 15 g ha^{-1} at 20 DAT	43.30	15.65	116.05	58.11	1.42
T_3	Fenoxaprop-p-ethyl @ 60 g ha^{-1}+ CME+MSM 4 g ha^{-1} at 20 DAT + MW (one way) at 35 DAT	45.32	14.95	113.35	59.09	1.43
T_4	Fenoxaprop-p-ethyl @ 60 g ha^{-1}+ ethoxysulfuron @ 15 g ha^{-1} at 20 DAT + MW (one way) at 35 DAT	45.73	13.39	111.36	59.81	1.43
T_5	Fenoxaprop-p-ethyl 60 g ha^{-1} + ethoxysulfuron 15 g ha^{-1} + MW (Two way) at 20 and 35 DAT	48.30	8.67	80.07	70.93	1.52
T_6	Fenoxaprop-p-ethyl 60 g ha^{-1}+ CME+MSM 4 g ha^{-1} at 20 DAT – MW (two way) at 35 DAT	46.90	11.08	99.83	63.97	1.47
T_7	Mechanical weeding (one way) -12, 25, 35 DAT	40.93	22.84	148.59	46.37	1.08
T_8	Mechanical weeding (two way) -12, 25, 35 DAT	48.11	9.15	92.20	66.72	1.34
T_9	PoE followed by PoE fenoxaprop- p –ethyl + CME+MSM @ 4 g ha^{-1} at 20 and 35 DAT	45.77	12.23	105.48	61.93	1.45
T_{10}	PoE followed by PoE fenoxaprop-p-ethyl + ethoxysulfuron 15 g ha^{-1} at 20 and 35 DAT	51.85	6.87	69.91	74.77	1.72
T_{11}	Hand weeding – 20, 40 DAT	50.50	7.91	77.39	72.07	1.58
T_{12}	Unweeded control.	21.12	33.1	277.05	-	0.33
	S.E. ±	0.83	0.86	4.17	-	-
	C.D. at 5%	2.02	2.52	12.24	-	-

CME + MSM = Chlorimuron ethyl +Metsulfuron methyl; DAT =Days after transplanting; PoE =Post emergence; MW = Mechanical weeding

Table 2 : Species wise weed density as influenced by integrated weed management practices at 30 and 60 DAT in SRI

Treatments		30 DAT					60 DAT				
		Echinochloa colona	*Alternanthera triandra*	*Cyperus iria*	*Fimbristylis miliacea*	Other weeds	*Echinochloa colona*	*Alternanthera triandra*	*Cyperus iria*	*Fimbristylis miliacea*	Other weeds
T_1	Fenoxaprop-p-ethyl @ 60 g ha^{-1}+CME+MSM @ 4 g ha^{-1} at 20 DAT	1.30	1.20	1.18	1.30	1.37	2.82	2.75	2.26	1.90	2.65
T_2	Fenoxaprop-p-ethyl @ 60 g ha^{-1} + ethoxysulfuron @ 15 g ha^{-1} at 20 DAT	1.32	1.14	1.08	1.25	1.34	2.00	2.05	1.90	1.70	2.70
T_3	Fenoxaprop-p-ethyl @ 60 g ha^{-1}+ CME+MSM 4 g ha^{-1} at 20 DAT + MW (one way) at 35 DAT	1.15	1.23	0.98	1.20	1.28	1.35	1.85	1.49	1.40	1.90
T_4	Fenoxaprop-p-ethyl @ 60 g ha^{-1}+ ethoxysulfuron @ 15 g ha^{-1} at 20 DAT + MW (one way) at 35 DAT	1.10	1.10	0.97	1.22	1.21	1.30	1.35	1.24	1.35	1.82
T_5:	Fenoxaprop-p-ethyl 60 g ha^{-1} + ethoxysulfuron 15 g ha^{-1} + MW (Two way) at 20 and 35 DAT	1.35	1.16	1.05	1.15	1.27	0.69	0.90	0.83	0.75	0.95
T_6	Fenoxaprop-p-ethyl 60 g ha^{-1}+ CME+MSM 4 g ha^{-1} at 20 DAT + MW (two way) at 35 DAT	1.18	1.30	1.10	1.08	1.30	0.77	1.09	0.89	1.08	1.25
T_7	Mechanical weeding (one way) -12, 25, 35 DAT	0.55	0.70	0.50	0.60	0.76	2.95	2.81	2.30	1.96	2.80
T_8	Mechanical weeding (two way) -12, 25, 35 DAT	0.50	0.68	0.46	0.58	0.74	0.70	0.98	0.86	0.81	1.02
T_9	PoE followed by PoE fenoxaprop- p –ethyl + CME+MSM @ 4 g ha^{-1} at 20 and 35 DAT	1.20	1.25	1.13	1.15	1.35	1.25	1.21	1.20	1.13	1.39
T_{10}	PoE followed by PoE fenoxaprop-p-ethyl + ethoxysulfuron 15 g ha^{-1} at 20 and 35 DAT	1.23	1.06	1.16	1.19	1.33	0.40	0.81	0.75	0.64	0.83
T_{11}	Hand weeding – 20, 40 DAT	1.08	0.73	0.60	0.68	0.78	0.45	0.85	0.80	0.69	0.90
T_{12}	Unweeded control.	3.10	2.91	2.75	2.9	2.80	4.16	4.50	4.66	4.67	4.05
	S.E. ±	0.17	0.11	0.12	0.13	0.12	0.17	0.13	0.11	0.11	0.16
	C.D. at 5%	0.51	0.32	0.36	0.39	0.34	0.51	0.38	0.33	0.31	0.47

CME + MSM = Chlorimuron ethyl +Metsulfuron methyl: DAT =Days after transplanting: PoE =Post emergence: MW = Mechanical weeding

Table 3 : Species wise weed dry matter accumulation as influenced by weed management practices at 30 and 60 DAT in SRI

	Treatments	30 DAT					60 DAT				
		Echinochloa colona	*Alternanthera triandra*	*Cyperus iria*	*Fimbristylis miliacea*	Other weeds	*Echinochloa colona*	*Alternanthera triandra*	*Cyperus iria*	*Fimbristylis miliacea*	Other weeds
T_1	Fenoxaprop-p-ethyl @ 60 g ha^{-1}+CME+MSM @ 4 g ha^{-1} at 20 DAT	0.75	0.54	0.68	0.64	0.61	4.30	4.45	3.45	2.45	3.61
T_2	Fenoxaprop-p-ethyl @ 60 g ha^{-1} +ehoxysulfuron @ 15 g ha^{-1} at 20 DAT	0.77	0.64	0.6	0.6	0.53	3.32	3.82	2.35	2.11	3.08
T_3	Fenoxaprop-p-ethyl @ 60 g ha^{-1}+ CME+MSM 4 g ha^{-1} at 20 DAT + MW (one way) at 35 DAT	0.70	0.65	0.57	0.54	0.48	3.30	3.76	2.20	1.98	2.76
T_4	Fenoxaprop-p-ethyl @60g ha^{-1}+ehoxysulfuron @15g ha^{-1} at 20 DAT+MW (one way) at 35DAT	0.63	0.52	0.55	0.56	0.40	3.10	3.5	2.16	1.81	2.16
T_5	Fenoxaprop-p-ethyl 60 g ha^{-1} + ehoxysulfuron 15 g ha^{-1} + MW (Two way) at 20 and 35 DAT	0.78	0.59	0.59	0.5	0.50	2.20	2.05	1.29	1.20	1.40
T_6	Fenoxaprop-p-ethyl 60 g ha^{-1}+ CME+MSM 4 g ha^{-1} at 20 DAT + MW (two way) at 35 DAT	0.64	0.61	0.64	0.46	0.51	2.60	2.92	1.85	1.47	1.98
T_7	Mechanical weeding (one way) -12, 25, 35 DAT	0.21	0.43	0.28	0.24	0.34	4.45	5.66	3.58	2.53	3.85
T_8	Mechanical weeding (two way) -12, 25, 35 DAT	0.17	0.39	0.26	0.21	0.33	2.35	2.4	1.75	1.39	1.89
T_9	PoE followed by PoE fnoxaprop- p –ethyl + CME+MSM @ 4 g ha^{-1} at 20 and 35 DAT	0.65	0.64	0.66	0.52	0.55	2.89	3.22	1.98	1.53	2.15
T_{10}	PoE followed by PoE fnoxaprop-p-ethyl + ehoxysulfuron 15 g ha^{-1} at 20 and 35 DAT	0.66	0.55	0.67	0.52	0.53	1.65	1.83	1.05	0.91	1.05
T_{11}	Hand weeding – 20, 40 DAT	0.40	0.46	0.35	0.28	0.39	2.00	1.91	1.22	1.06	1.35
T_{12}	Unweeded control.	1.22	3.12	1.37	1.2	1.21	11.8	10.63	8.25	6.39	9.72
	S.E. ±	0.06	0.02	0.05	0.03	0.04	0.19	0.18	0.13	0.10	0.13
	C.D. at 5%	0.18	0.07	0.14	0.08	0.10	0.57	0.54	0.39	0.30	0.37

CME + MSM = Chlorimuron ethyl +Metsulfuron methyl: DAT =Days after transplanting: PoE =Post emergence: MW = Mechanical weeding

The species wise weed density at different dates revealed that *Alternanthera triendra, Echinocloa colona, Fimbristylis miliacea and Cyperus iria* and other weeds were effectively controlled by different weed management practices. At 30 DAT, the lowest weed density of *Echinochloa colon, Fimbristylis miliacea and Cyperus iria* was observed minimum under the treatment where two ways mechanical weeding was performed followed by one way mechanical weeding performed and remained significantly lower than rest of the treatments. However, it was comparable to each other. All treatments showed significantly lower weed density than unweeded control.

At 60 DAT, all the weed species *viz.*, *Alternanthera triendra, Echinocloa colona, Fimbristylis miliacea and Cyperus iria* significantly reduced under PoE followed by PoE (fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1}) followed by hand weeding twice. In case of other weeds, lower weed density was observed in treatment PoE followed by PoE (fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1}) whereas hand weeding twice, fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1} + MW (two ways), mechanical weeding performed on two ways and fenoxaprop-p-ethyl 60 g ha^{-1}+ (CME + MSM) + MW (two ways) remained next in order. It was further observed that count of *Echinochloa colona* in all the treatments of herbicides was found to be equally reduced due to effective control by fenoxaprop-p-ethyl applied at 20 DAT. Dwivedi *et al.* (2003) observed that weed density of *Echinochloa colona* was significantly reduced by the application of fenoxaprop-p-ethyl. Bhattacharya *et al.* (2001) reported that the application of fenoxaprop-p-ethyl at 1000 ml ha^{-1} @ 15 DAT recorded the lowest weed density and weed dry matter accumulation. Similar results were also noted by Singh *et al.* (2003). The highest weed density was recorded under unweeded control which was significantly higher than rest of treatments because no control measure was adopted in this plot. Similar results were noted by Sharma *et al.* (2003).

Total and species wise dry matter accumulation :

Table 3 reveals that different weed management practices showed significant effect on total dry matter accumulation of weeds. In general, the increased density of weeds enhanced dry matter accumulation of weeds per unit area. At harvest, the total dry matter accumulation by weed was observed lowest in treatment PoE followed by PoE (fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1}) followed by hand weeding twice and fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1} + MW (two ways). Similar results were also noted by Pal *et al.* (2002). Unweeded control treatment allowed significantly higher dry biomass accumulation at 30 and 60 DAT.

The dry matter accumulation of different weed spp. were recorded at 30 and 60 DAT. At 30 DAT, the lowest dry matter accumulation of all the weed species *viz.*, *Echinochloa colona, Alternanthera triandra, Cyperus iria, fimbristylis miliacea* and other weeds were observed under two ways mechanical weeding followed by one way mechanical weeding. Both the treatments were significantly lower than the rest of the treatments including the unweeded control. However, it was comparable to each other. Hand weeding twice,fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1} at 20 DAT + MW (two ways) were next in order. These results are in accordance with these of Nair (2002).

Whereas, at 60 DAT, the lower dry matter accumulation of *Echinochloa colona,Alternanthera triandra,Cyperus iria, fimbristylis miliacea* and other weeds were observed in treatment PoE followed by PoE (fenoxaprop-p-ethy l60 g ha^{-1} + ethoxysulfuron 15 g ha^{-1}) followed by hand weeding twice and fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1} at 20 DAT+MW (two ways).Treatment unweeded control produced maximum dry matter of all the weed species at 60 DAT (Table 3). The minimum dry matter accumulation under these treatments might be due to better efficacy of fenoxaprop-p-ethyl against grassy weeds like *Echinochloa colona* etc. and ethoxysulfuron against broad leaved weeds like *Alternanthera triandra* etc. Singh *et al.* (2003) found that the dry weight of weed deceased by the application of fenoxaprop-p-ethyl. Singh *et al.* (2004) also found that of fenoxaprop-p-ethyl reduced growth and dry matter of narrow leaves of weeds. These results also confirmed with the findings of Saini and Angiras (2002). The lowest dry matter accumulation of *Alternanthera triandra* found under the treatments of ethoxysulfuron was might have been due to the better killing capacity of ethoxysulfuron as compared to CME +MSM against broad leaf weed.They also observed ethoxysulfuron resulted in significantly lower density of broad-leaved weeds and sedges and hence, lower total weed dry weight. Sharifi (2003) found application of ethoxysulfuron has good effect on broadleaves and sedges (*Cyperus* spp.) of paddy fields. Unweeded control yielded the highest dry matter accumulation till harvest.

Further, mechanical weeding produced the minimum weed dry matter accumulation at early growth stages but increased in later growth stages (at 60 DAT and after) might be due to increased occurrence of weeds in the inter plant spaces where weeder could not reach. Hiromi *et al.* (2001) noted that mechanical weeding become difficult due to increased occurrence of weeds at interhilll spaces in later stages of rice. Similar difficulty with cono-weeder was also reported by Rajendran *et al.* (2007).

Effect on grain yield :

The highest grain yield (51.85) was observed under PoE followed by PoE (fenoxaprop-p-ethyl 60gha^{-1}+ ethoxysulfuron 15 g ha^{-1}) narrowly followed by hand weeding (Table 1). However, both the treatments were comparable to each other. This was owing to low crop-weed competition and longer weed free period under these treatments which leads to high growth and yield of rice. Fischer *et al.* (1993) found that longer weed free period favoured significantly increase in yield of rice. (Kolhe, 1999) observed that post emergence application of fenoxaprop-p-ethyl+ ethoxysulfuron was as effective as hand weeding twice. He also reported that lower yield reduction (5.3 to 12.8%) was obtained with combined application of these chemicals. The cono weeder was found to increase the grain yield. This might be due to the fact that cono weeding incorporated the weeds in thesoil and minimized the weeds besides increasing the soil aeration and root pruning (Uphoff, 1999). Rajendran *et al.* (2007) reported that mechanical weeding plus soil stirring by cono weeder significantly increased the grain yield. The minimum grain yield was obtained from unweeded control (21.12 q ha^{-1}) due to no control measure was adopted in this plot.

Weed control efficiency :

The maximum weed control efficiency was observed with PoE followed by PoE (fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1}) closely followed by hand weeding and fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1} at 20 DAT + MW (two ways). It was also noted that application of herbicides enhanced weed control efficiency due to restricted weed growth, resulted lower production of dry matter of weeds lead to high weed control efficiency. This is in accordance with the finding of Kolhe (1999).

Economics :

Data from Table 1 revealed that the maximum benefit: cost ratio was obtained from the treatment PoE followed by PoE (fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1}) (1.72) followed by hand weeding and fenoxaprop-p-ethyl 60 g ha^{-1}+ ethoxysulfuron 15 g ha^{-1} +MW (two ways) (1.52). The lowest benefit: cost ratio was obtained from unweeded control. This was due to the lowest grain yield obtained in control. No doubt, the results of hand weeding were also better but are time consuming, expensive and laborious hence, cannot be recommended at large scale.

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