# Research Paper

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# 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

### ■ DEVENDRA KUMAR DEWANGAN, ANU SHRI SINGH<sup>1</sup>, ESHU SAHU<sup>1</sup> AND A.R.TOPPO

**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-pethyl 60 g ha<sup>-1</sup> + ethoxysulfuron 15 g ha<sup>-1</sup> 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-pethyl 60 g ha<sup>-1</sup> + ethoxysulfuron 15 g ha<sup>-1</sup> 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-pethyl 60 g ha<sup>-1</sup> + ethoxysulfuron 15 g ha<sup>-1</sup> at 20 and 35 DAT followed by hand weeding and lowest from unweeded control.

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

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ice (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<sup>-1</sup> (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.

# **R**ESEARCH **P**ROCEDURE

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

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Author for correspondence : DEVENDRA KUMAR DEWANGAN Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, RAIPUR (C.G.) INDIA (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<sup>-1</sup> + chlorimuron-ethyl + metsulfuron-methyl 20 WP @ 4 g ha<sup>-1</sup> at 20 DAT, post-emergence application of fenoxaprop-p-ethyl 9 EC @ 60 g ha<sup>-1</sup> + ethoxysulfuron 15 WG @ 15 g ha<sup>-1</sup> at 20 DAT, post-emergence application of fenoxapropp-ethyl 9.3 EC@ 60 g ha<sup>-1</sup> + chlorimuron-ethyl + metsulfuronmethyl 20 WP @ 4g ha<sup>-1</sup> at 20 DAT + mechanical weeding (one way) at 35 DAT, post-emergence application of fenoxaprop-pethyl 9.3 EC @ 60 g ha<sup>-1</sup> + ethoxysulfuron 15 WG @ 15 g ha<sup>-1</sup> at 20 DAT + mechanical weeding (one way) at 35 DAT, post-emergence application of fenoxaprop-p-ethyl 9.3 EC @ 60 g ha<sup>-1</sup> + ethoxysulfuron 15 WG @ 15 g ha-1 at 20 DAT + mechanical weeding (two way) at 35 DAT, post-emergence application of fenoxapropp-ethyl 9.3 EC @ 60 g ha<sup>-1</sup> + chlorimuron -ethyl + metsulfuronmethyl 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<sup>-1</sup> 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.

# **R**ESEARCH ANALYSISAND 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<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup>) 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. EDITED WARD HANGENEIN DI ACHTES DI SECH JICH, FORM WELL MELL MELL MELLIMINIANDI, MELLURICHES MIN PERIODI MELLING MIN PERIODI MELLING MIN	cummanum, week		A and penetite cost a		NIC.
Treatments	nents	Seed yield (q ha <sup>4</sup> )	Total weed density(m <sup>2</sup> )	Total weed dry matter accurnulation (m <sup>-2</sup> )	WCE	B:C ratio
$T_1$	Fenoxaprop-p-ethyl @ 60 g ha' <sup>1</sup> +CME+MSM @ 4 g ha'' at 20 DAT	41.16	19.30	132.85	52.05	1.34
$\mathbf{T}_2$	Fenoxaprop p ethyl @ 60 g ha'l + ethoxysulturon @ 15 g ha'l at 20 DAT	13.30	15.65	116.05	58.11	1.12
Ţ,	Fenoxaprop-p-ethyl @ 60 g ha'l+ CME+MSM 4 g h $\epsilon$ 'l at 20 DAT + MW (one way) at 35 DAT	4 <mark>5.3</mark> 2	14.95	113.35	59.09	1.43
$T_4$	$\label{eq:constraint} Fenoxaprop-p-cthyl @ 60~gha^{1+} cthoxysulfaron @ 15~g~ha^{-1}~at 20~DAT + MW ~(sne~way)~at 35~DAT + MW ~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sne~way)~(sn$	45.73	13.39	111.36	5981	1.43
$\mathbf{T}_{s}$	Fenoxaprop-p-ethyl 60 g ha' <sup>1</sup> + ethoxysulfuron 15 g ha' <sup>1</sup> + MW (Two way) at 20 and 35 DAT	48.30	8.67	80.07	70.93	1.52
${\rm T}_6$	Fenoxaprop-p-cthyl 60 g ha'l+ CME+MSM 4 g ha'l 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	4637	1.08
$T_8$	Mechanical weeding (two way) -12, 25, 35 DAT	48.11	9.15	92.20	6672	1.34
${\rm T}_{\rm g}$	PoE followed by PdE fenoxaprop- p-ethyl + CME+MSM $@4$ g ha <sup>-1</sup> at 2) and 35 DAT	45.77	12.23	105.48	6193	1.45
${\rm T}_{\rm ID}$	PoE followed by PuE fenoxaprop-pethyl + ethoxysulfaron 15 g ha <sup>-1</sup> at $20$ and $35$ DAT	51.85	6.87	16.69	7477	1.72
$\mathrm{T}_{\mathrm{II}}$	Hand weeding – 20, 40 DAT	50.50	7.91	77.39	72.07	1.58
${\rm T}_{\rm I2}$	Unweeded control.	21.12	33.1	277.05	٠	0.33
	S.E. ±	0.83	0.86	4.17	·	1
	C.D. at 5%	2.02	2.32	12.24	×	×
CMF	CWE + MSM = Chlorimuron ethyl +Metsulfuron methyl: DAT =Days after transplanting: PoE =Post emergence; MW = Mechanical weeding	: MW = Mechani	cal weeding			

Tab)	Table 2 : Species wise weed density as influenced by integra	ted weed man	ntegrated weed management practices at 30 and 60 DAT in SRIV	ctices at 30 an	nd 60 DAT in	SRIV		09	40 DAT		
Ireatments		Echinochloa colona	Alternanthera triandra	Cyperus iria	Fimbristylis miliacea	Uther weeds	Échinochloa colona	ou Alternanthera triendra	Cyperus iria	Fimbristylis miliacea	Other weeds
${\rm T_{l}}$	Fenoxaprop-p-ethyl @ 60 g ha'l+CME+MSM @ 4 g	1.30	1.20	1.18	1.30	1.37	2.82	2.75	2.26	1.90	2.65
	ha <sup>-1</sup> at 20 DAT										
$\mathrm{T}_2$	Fenoxaprop-p-ethyl @ 60 g ha -l $+$ ethoxysulfuron @	1.32	1.14	1.08	1.25	1.34	2.00	2.05	1.90	1.70	2.70
	15g ha <sup>-1</sup> at 20 DAT										
$T_3$	Fenoxaprop-p-ethyl @ 60 g ha <sup>-1+</sup> CME+MSM 4 g	1.15	1.23	0.98	1.20	1.28	1.35	1.85	1.49	1.40	1.90
	$ha^{\text{-}I}$ at 20 DAT + MW (one way) at 35 DAT										
$T_4$	Fenoxaprop-p-ethyl @ 60 g ha' + ethoxy sulfuron @	1.10	1.10	0.97	1.22	1.21	1.30	1.35	1.24	1.35	1.82
	15 g ha <sup>-1</sup> at 20 DAT + MW (one way) at 35 DAT										
$\mathbf{T}_{\mathbf{S}}$	Fenoxaprop-p-ethyl 60 g ha <sup>1</sup> + ethoxysulfuron 15 g	1.35	1.16	1.05	1.15	1.27	0.69	0.90	0.83	0.75	0.95
	$ha^{\rm -l}+MW$ (Two way) at 20 and 35 DAT										
$T_6$	Fenoxaprop-p-ethyl 60 g ha <sup>-1</sup> + CME+MSM 4 g ha <sup>-1</sup>	1.18	1.30	1.10	1.08	1.30	0.77	1.09	0.89	1.08	1.25
	at $20 \text{ DAT} + MW$ (two way) at 35 DAT										
$T_7$	Mechanical weeding (one way) -12, 25, 35 DAT	0.55	0.70	0.50	09.0	0.76	2.95	2.81	2.30	1.96	2.80
$T_{s}$	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,	PoE followed by PoE fenoxaprop- p-ethyl +	1.20	1.25	1.13	1.15	1.35	1.25	1.21	1.20	1.13	1.39
	CME+MSM @ 4 g ha <sup>-1</sup> at 20 and 35 DAT										
${\rm T}_{\rm 10}$	PoE followed by PoE fenoxaprop-p-ethyl +	1.23	1.06	1.16	1.19	1.33	0.40	0.81	0.75	0.64	0.83
	ethoxysulfuron 15 g ha <sup>-1</sup> at 20 and 35 DAT										
$T_{11}$	Hand weeding – 20, 40 DAT	1.08	0.73	09.0	0.68	0.78	0.45	0.85	0.80	0.69	06.0
$T_{12}$	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
CM	CME + MSM = Chlorimuron ethyl + Metsulfuron methyl: DAT = Days after transplanting: PoE = Post emergence: MW = Mechanical weeding	=Days after tr	ansplanting: Pol	E =Post eme	rgence: MW	= Mechai	nical weeding				

EFFECT OF INTEGRATED WEED MANAGEMENT ON WEED FLORA DISTRIBUTION & PERFORMANCE OF RICE

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Atternanth wiondra 3.5 3.5 3.5 3.5 5.66 5.66 2.4 2.4 1.91 1.91 1.63 0.18 0.18	Ta	Table 3 : Species wise weed dry matter accumulation	as influenced by weed management practices at 30 and 60 DAT in SKI 30 DAT	by weed mana	gement prate 30 DAT	NUE OC 12 SOUTH	00.1244	SKI	60	60 DAT		
Encompopedity(@ 66 gh1 <sup>4+</sup> CME+MSM@)         0.73         (54         0.64         0.61         4.30         4.45         3.45         3.45         3.45 $4$ g m <sup>3</sup> a 20 DAT         Encompopedity(@ 66 gh1 <sup>4+</sup> CME+MSM@)         0.77         (64         0.6         0.53         3.32         3.35         2.35         2.11           Fine appropedity(@ 66 gh1 <sup>4+</sup> CME+MSM@)         0.77         (64         0.6         0.53         0.53         3.36         3.36         2.35         2.13         2.11           Fine appropedity(@ 66 gh1 <sup>4+</sup> CME+MSM@)         0.70         0.65         0.55         0.55         0.53         0.56         3.30         3.36         2.30         1.31           Fine appropedity(@ 66 gh1 <sup>4+</sup> CME+MSM@)         0.66         0.55         0.55         0.56         0.56         0.56         1.30         3.36         1.36         1.31 $61 \circ gh1^4 = dmay af NAT          0.51         0.55         0.56         0.56         0.56         0.56         1.36         1.36         1.37           61 \circ gh1^4 = dmay af NAT          0.51         0.56         0.56         0.56         2.36         2.36         2.36         2.36         1.37           61 \circ gh1^4 = dmay af NAT $	Irea	ttments	Echinochloa colona	Alternanthera triandra	Cyperus iria	r'imoristylis miliacea	Other weeds	Echinochlea colona	Alternanthera wiandra	Cyperus iria	Fimbristylis miliocea	Other weeds
4 g h <sup>-1</sup> d 2 0 D MT Ferezapenp-pethyl 6 0 g h <sup>+1</sup> +thoxysulfuma (17) (16) (16) (16) (16) (16) (16) (16) (16	$\mathrm{T}_{\mathrm{l}}$		0.75	0.54	0.68	0.64	0.61	4.30	4.45	3.45	2.45	3.61
Ferosaporp-ediy()@ 0.0 µu <sup>4</sup> - edioysultum         0.7         0.64         0.6         0.53         3.32         3.35         2.35         2.11           @ 17 g hu <sup>4</sup> at 30 DAT         (3.7)         0.57         0.54         0.48         3.30         3.56         2.30         1.98           Ferocaporp-ediy() @ 0.0 hu <sup>4</sup> - CME+MSM4         0.70         0.65         0.57         0.54         0.48         3.30         3.56         2.30         1.98           Ferocaporp-ediy() @ 0.0 hu <sup>4</sup> - Edoxyaulturon 15         0.65         0.55         0.55         0.56         0.40         3.10         3.76         2.30         1.98           Ferocaporp-ediy() @ 0.0 hu <sup>4</sup> - Edoxyaulturon 15         0.73         0.55         0.55         0.56         0.40         3.10         3.76         2.30         1.98           Ferocaporp-ediy() @ 0.0 hu <sup>4</sup> - Edoxyaulturon 15         0.73         0.55         0.56         0.50         0.56         0.50         1.98         1.47           Ferocaporp-ediy() @ 0.0 hu <sup>4</sup> - Edoxyaulturon 15         0.73         0.55         0.56         0.50         2.30         1.50         1.59         1.50         1.50         1.50         1.50         1.50         1.50         1.50         1.50         1.50         1.50		4 g ha <sup>-1</sup> at 20 DAT										
(6) 16 g hr <sup>1</sup> at 201DrT       (5) 16 g hr <sup>1</sup> at 201DrT       (6) 16 g hr <sup>1</sup> at 201DrT       (6) 16 g hr <sup>1</sup> at 201DrT       (7) 12 g hr <sup>2</sup>	H.		0.77	0.64	9.0	0.6	0.53	3.32	3.82	2.35	2.11	3.08
Ferrosaprop-petity ( $@$ 60 m/s <sup>+</sup> + CME+MSM         0.70         0.65         0.57         0.54         0.48         3.30         3.76         2.0         1.98           g m <sup>4</sup> at 20 IAT + WW (row way) at 31 DAT         0.61         0.52         0.55         0.56         0.40         3.10         3.35         2.16         1.81           Ferrosaprop-ethyl ( $0.60$ m <sup>4</sup> + choxyaulfaron         0.61         0.52         0.35         0.56         0.40         3.10         3.35         2.16         1.81           ( $0.7$ mov avy) at 31 and 35 DAT         0.73         0.59         0.55         0.50         2.20         2.05         1.81 $0.7$ mov avy) at 21 and 35 DAT         1         1         1         1         1         1         1 $0.7$ mov avy) at 21 and 35 DAT         1         1         1         1         1         1         1         1 $0.7$ mov avy) at 21 and 35 DAT         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1		@ 15 g ha <sup>-1</sup> at 20 DAT										
	Д		0.70	0.65	0.57	0.54	0.48	3.30	3.76	2.20	1.98	2.76
Encompropediaty ( $\frac{600}{0}$ bla <sup>++</sup> eboxyatifizon         0.61         0.52         0.55         0.40         3.10         3.5         2.16         181 $\frac{61}{0}$ bla <sup>+</sup> a <sup>+</sup> 20 DAT+MW (ore way) at \$5DAT         0.78         0.59         0.59         0.50         2.20         2.15         1.29         1.20 $\frac{61}{0}$ bla <sup>+</sup> + boxyatifizon 15         0.78         0.59         0.59         0.50         2.20         2.15         1.29         1.20 $\frac{61}{0}$ a <sup>+</sup> + MW (row way) at \$1 DAT         0.64         0.61         0.64         0.64         0.64         0.51         2.00         2.20         2.55         1.59         1.53 $\frac{61}{1}$ a <sup>+</sup> DDAT + MW (row way) at \$1 DAT         1         1         1         1         1         1         1         1         1         1 $\frac{61}{1}$ a <sup>+</sup> DDAT + MW (row way) at \$1 DAT         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1		g ha <sup>4</sup> at 20 EAT + MW (one way) at 35 DAT										
(3) T5g ha <sup>1</sup> at 20 DAT+MW (me way) at 3Tb AT         Fenexaprop-echyl (60 gia <sup>1+</sup> choxyalfinor) I5       0.78       0.59       0.59       0.5       0.50       2.06       1.29       120         g ha <sup>1+</sup> MW (Two way) at 3G hard 35 DAT        0.64       0.61       0.64       0.64       0.51       2.60       2.05       1.85       1.47         Fenexaprop-echyl (60 gha <sup>1+</sup> choxyalfinor) 12, 25, 35 DAT       0.64       0.64       0.64       0.24       0.34       2.46       1.55       1.30         Mechanical vecding (new way) -12, 25, 35 DAT       0.17       0.39       0.26       0.23       2.35       2.47       1.65       1.30         Mechanical vecding (new way) -12, 25, 35 DAT       0.17       0.39       0.26       0.23       2.35       2.49       1.55       1.30         Mechanical vecding (new way) -12, 25, 35 DAT       0.17       0.39       0.26       0.55       2.89       3.24       1.95       1.30         Mechanical vecding (new way) -12, 25, 35 DAT       0.17       0.39       0.26       0.55       2.89       3.24       1.75       1.30         Mechanical vecding (new way) -12, 25, 35 DAT       0.16       0.56       0.55       2.89       3.24       1.75       1.30	$T_4$		0.63	0.52	0.55	0.56	0.40	3.10	3.5	2.16	1.81	2.16
Feroexprop-ethyl (0 g ha <sup>1</sup> + koxysulfiron 15         0.73         0.59         0.5         0.50         2.20         2.05         1.29         1.20 $g ha^{1} + MW (Two wy) at 20 and 35 DAT          6.61         0.64         0.64         0.64         0.51         2.60         2.05         1.87         1.47           ha^{1} at 20 DAT T + MW (wo way) at 35 DAT          0.64         0.61         0.54         0.46         0.51         2.60         2.25         1.85         1.47           ha^{1} at 20 DAT T + MW (wo way) - 12, 25, 35 DAT          0.21         0.34         0.34         4.45         5.66         3.58         1.47           ha^{1} at 20 DAT T + MW (wo way) - 12, 25, 35 DAT          0.21         0.33         2.35         2.34         1.45         5.66         3.58         1.35           ha^{1} at 20 DAT T + MW (wo way) - 12, 25, 35 DAT          0.73         0.23         2.35         2.44         1.75         1.39           ha^{1} at 20 DAT T + MW (wo way) - 12, 25, 35 DAT           0.33         2.35         2.49         1.75         1.39           ha^{1} at 20 DAT V + MW (wo way) - 12, 25, 35 DAT           0.55         2.89         3.32$		@15g ha'l at 20 DAT+MW (one way) at 35DAT										
	T,		0.78	0.59	0.59	0.5	0.50	2.20	2.05	1.29	1.20	1.40
Fenoraprop-ethyl (0 jna <sup>1-</sup> CME+MSM 4g         0.64         0.61         0.54         0.64         0.51         2.60         2.92         1.85         1.47 $ha^1 u_t$ 70 $ha^1 t$ A0 $ha^1 t$ AW (two vay) at 35 $hAT$ 0.21         0.43         0.28         0.24         0.31         2.60         2.55         3.58         1.47           Mechanical vecding (one way) -12, 25, 35 $hAT$ 0.17         0.39         0.26         0.21         0.33         2.35         2.4         1.75         1.39           Mechanical vecding (one way) -12, 25, 35 $hAT$ 0.17         0.39         0.26         0.21         0.33         2.35         2.4         1.75         1.39           Mechanical vecding (one way) -12, 25, 35 $hAT$ 0.64         0.56         0.57         0.55         0.55         2.89         3.56         3.58         1.53           Mechanical vecding (one way) -12, 25, 35 $hAT$ 0.64         0.56         0.55         0.55         2.89         3.22         1.98         1.53           Mechanical vecding (wo way) -12, 25, 35 $hAT$ 0.64         0.56         0.55         0.56         2.89         3.22         1.98         1.53           Mechanical vecding (wo way) -12, 25, 30 $hAT$ 0.66         0.55		g ha <sup>4</sup> + MW (Two way) at 20 and 35 DAT										
$ha^{4}a^{4}$ 70 DAT + MW (two way) at STDAT $ha^{4}a^{4}$ 70 DAT + MW (two way) at STDAT $0.21$ $0.43$ $0.28$ $0.24$ $0.34$ $4.45$ $5.66$ $3.58$ $2.53$ Mechanical vecding (now way) - 12, 25, 35 DAT $0.17$ $0.39$ $0.26$ $0.21$ $0.33$ $2.33$ $2.4$ $1.75$ $1.39$ Mechanical vecding (two way) - 12, 25, 35 DAT $0.17$ $0.39$ $0.26$ $0.21$ $0.33$ $2.35$ $2.4$ $1.75$ $1.39$ Mechanical vecding (two way) - 12, 25, 35 DAT $0.17$ $0.39$ $0.26$ $0.21$ $0.33$ $2.35$ $2.4$ $1.75$ $1.39$ PoE followed by PeE finovaprop-pethyl + $0.65$ $0.65$ $0.55$ $0.55$ $1.65$ $1.53$ $1.56$ $1.53$ $1.53$ PoE followed by PeE finovaprop-pethyl + $0.66$ $0.55$ $0.53$ $1.65$ $1.53$ $1.98$ $1.53$ $1.53$ $1.98$ $1.53$ $1.53$ $1.94$ $1.53$ $1.94$ $1.55$ $1.39$ $1.53$ $1.94$ $1.95$ $1.94$ $1.95$ $1.95$ $1.94$ $1.95$	$T_6$		0.64	0.61	0.64	0.46	0.51	2.60	2.92	1.85	1.47	1.98
Mechanical vecding (one way) -12, 25, 35 DAT $0.21$ $0.43$ $0.24$ $0.34$ $4.45$ $5.66$ $3.58$ $2.53$ Mechanical vecding (two way) -12, 25, 35 DAT $0.17$ $0.39$ $0.26$ $0.21$ $0.33$ $2.35$ $2.4$ $1.75$ $1.39$ Mechanical vecding (two way) -12, 25, 35 DAT $0.17$ $0.39$ $0.26$ $0.21$ $0.33$ $2.35$ $2.4$ $1.75$ $1.39$ PoE followed by PoE finovaprop- $-ethyl +$ $0.63$ $0.64$ $0.56$ $0.52$ $0.57$ $2.89$ $3.22$ $1.98$ $1.53$ CME+MSM@ 4 g ha <sup>1</sup> at 20 and 35 DAT $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ $1$ <th></th> <td><math>ha^{-1}</math> at 20 DAT + MW (two way) at 35 DAT</td> <td></td>		$ha^{-1}$ at 20 DAT + MW (two way) at 35 DAT										
Mechanical vecding (two way) - 12, 25, 35 DAT $0.17$ $0.39$ $0.26$ $0.21$ $0.33$ $2.35$ $2.4$ $1.75$ $1.39$ PoE followed by PoE finoxaprop- p-ethyl+ $0.65$ $0.64$ $0.66$ $0.52$ $0.55$ $2.89$ $3.22$ $1.98$ $1.53$ CME+MSM( $\overline{w}$ 4 g ha <sup>1</sup> at 20 and 35 DAT $1.65$ $0.66$ $0.55$ $0.67$ $0.53$ $0.53$ $1.65$ $1.83$ $1.05$ $(9.1)$ PoE followed by PoE finoxaprop-p-ethyl+ $0.66$ $0.55$ $0.53$ $0.53$ $1.65$ $1.83$ $1.05$ $(9.1)$ PoE followed by PoE finoxaprop-p-ethyl+ $0.66$ $0.55$ $0.53$ $0.53$ $1.65$ $1.83$ $1.05$ $(9.1)$ PoE followed by PoE finoxaprop-p-ethyl+ $0.66$ $0.55$ $0.53$ $0.53$ $1.65$ $1.65$ $1.05$ $(9.1)$ And weeding-20, 40 DAT $0.40$ $0.46$ $0.32$ $0.39$ $2.00$ $1.91$ $1.22$ $1.05$ Hand weeding-20, 40 DAT $0.40$ $0.25$ $0.39$ $0.06$ $0.10$ $0.12$ $0.16$ <th><math>\mathbf{T}_{\mathbf{J}}</math></th> <td></td> <td>0.2</td> <td>0.43</td> <td>0.28</td> <td>0.24</td> <td>0.34</td> <td>4.45</td> <td>5.66</td> <td>3.58</td> <td>2.53</td> <td>3.85</td>	$\mathbf{T}_{\mathbf{J}}$		0.2	0.43	0.28	0.24	0.34	4.45	5.66	3.58	2.53	3.85
Def followed by Def finoxaprop- $p-efhyl+$ 0.65       0.64       0.66       0.52       0.55       2.89       3.22       1.98       1.53         CME+MSM@ 4 g ha <sup>1</sup> at 20 and 35 DAT       Emergence       0.66       0.55       0.67       0.52       0.53       1.65       1.83       1.05       (.91         PoE followed by PoE finoxaprop-p-ethyl+       0.66       0.55       0.67       0.52       0.53       1.65       1.83       1.05       (.91         PoE followed by PoE finoxaprop-p-ethyl+       0.66       0.55       0.67       0.52       0.53       1.65       1.83       1.05       (.91         PoE followed by PoE finoxaprop-p-ethyl+       0.66       0.55       0.57       0.53       1.65       1.53       1.05       (.91         Hand weeding $-20, 40$ DAT       0.40       0.35       0.28       0.39       2.00       1.91       1.22       1.06         Unweeded control.       1.22       3.12       1.37       1.2       1.21       1.21       1.22       1.06       3.25       (.39       (.10         S.E. $\pm$ 0.06       0.02       0.01       0.02       0.03       0.03       0.10       0.57       0.39       0.30	$T_8$	Mechanical weeding (two wa/) -12, 25, 35 DAT	0.17	0.39	0.26	0.21	0.33	2.35	2.4	1.75	1.39	1.89
CME+MSM @ 4 g ha <sup>1</sup> al 20 and 35 DAT $O.66 \ 0.55 \ 0.67 \ 0.52 \ 0.53 \ 1.65 \ 1.83 \ 1.05 \ 1.83 \ 1.05 \ 0.91$ $O.61 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ 0.91 \ $	$T_{g}$		0.65	0.64	0.66	0.52	0.55	2.89	3.22	1.98	1.53	2.15
$ \begin{array}{llllllllllllllllllllllllllllllllllll$		CME+MSM ( $\textcircled{W}$ 4 g ha <sup>1</sup> at 20 and 35 DAT										
choxysulfuron 15 g ha " at 20 and 35 DATHand weeding $-20$ , $40$ DAT $0.40$ $0.46$ $0.35$ $0.28$ $0.39$ $2.00$ $1.91$ $1.22$ $1.06$ Unweeded control. $1.22$ $3.12$ $1.37$ $1.2$ $1.21$ $11.8$ $10.63$ $8.25$ $6.39$ S.E. $\pm$ $0.06$ $0.02$ $0.05$ $0.03$ $0.04$ $0.19$ $0.18$ $0.13$ $0.10$ C.D. at 5% $0.18$ $0.07$ $0.14$ $0.08$ $0.10$ $0.57$ $0.54$ $0.30$ $0.30$	$T_{\rm l0}$		0.66	0.55	0.67	0.52	0.53	1.65	1.83	1.05	0.91	1.05
Hand weeding $-20, 40$ DAT0.400.460.350.280.392.001.911.221.06Unweeded control.1.223.121.371.21.2111.810.638.256.39S.E. $\pm$ 0.060.020.050.030.040.190.180.13(.1010C.D. at 5%0.180.070.140.080.100.570.54(.39(.30		ehoxysulfuron 15 g ha <sup><math>1</math></sup> at 20 and 35 DAT										
Unvecded control. 1.22 3.12 1.37 1.2 1.21 11.8 10.63 8.25 6.39 S.E.± 0.06 0.02 0.05 0.03 0.04 0.19 0.18 0.13 0.10 C.D.at 5% 0.18 0.07 0.14 0.08 0.10 0.57 0.54 0.39 0.30	${\rm T}_{\rm ll}$		0.40	0.46	0.35	0.28	0.39	2.00	1.91	1.22	1.06	135
0.18 0.13 0.10 0.54 0.39 0.30	$T_{\rm D}$		1.22	3.12	1.37	1.2	1.21	11.8	10.63	8.25	629	9.72
0.54 0.39 0.30		S.E.±	90.0	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

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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-pethyl 60 g ha<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup>) 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<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup> + MW (two ways), mechanical weeding performed on two ways and fenoxaprop-p-ethyl 60 g ha<sup>-1</sup>+ (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-pethyl 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 <sup>1</sup> @ 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<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup>) followed by hand weeding twice and fenoxaprop-p-ethyl 60 g ha<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup> + 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<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup> 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 160 g ha<sup>-1</sup> + ethoxysulfuron 15 g ha-1) followed by hand weeding twice and fenoxaprop-p-ethyl 60 g ha<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup> 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 broadleaved 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<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup>) 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<sup>-1</sup>) 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<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup>) closely followed by hand weeding and fenoxaprop-p-ethyl 60 g ha<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup> 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<sup>-1</sup>+ ethoxysulfuron 15 g ha<sup>-1</sup>) (1.72) followed by hand weeding and fenoxaprop-p-ethyl 60 g ha<sup>-1</sup> + ethoxysulfuron 15 g ha<sup>-1</sup> +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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