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EFFECT OF WEED MANAGEMENT PRACTICES ON WEED PARAMETERS, YIELD AND NUTRIENT UPTAKE OF DIRECT SEEDED UPLAND RICE

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ABSTRACT

A field experiment was conducted during kharif season of 2011 at Bhubaneswar taking 12 weed management practices in randomized block design with three replications to study the effect of weed management practices on weed, yield and nutrient uptake by rice. Hand weeding showed lower weed density (4.2 per m^2) which was at par with Fenoxaprop + chlorimuron + metsulfuron and cyhalofop-butyl + chlorimuron + metsulfuron at 30 days after sowing. Hand weeding recorded significantly lower weed biomass of 1.9 g m^{-2} which was at par with fenoxaprop + chlorimuron + metsulfuron, cyhalofop-butyl + chlorimuron + metsulfuron, bispyribac sodium and fenoxaprop + ethoxysulfuronat 30 DAS. Hand weeding recorded significantly highest yield of 3490 kg ha^{-1}whereas weedy check recorded the lowest yield of 1490 $kgha^{-1}$. Among different chemical methods, higher yield of 3270 $kgha^{-1}$ was obtained with fenoxaprop + chlorimuron + metsulfuron, closely followed by cyhalofop-butyl + chlorimuron + metsulfuron. Fenoxaprop + chlorimuron + metsulfuron also recorded higher number of effective tillers per m^2 (330.3), grains per panicle (113.7) and test weight (23.5 g). Among different weed control practices, the treatment fenoxaprop + chlorimuron + metsulfuron recorded lowest weed index (6.30) % and highest with and hand weeding. Fenoxaprop + chlorimuron + metsulfuron recorded maximum uptake of N (62.6 kg), and P (13.2 kg ha^{-1}) and K uptake (85.3 kg ha^{-1}) highest in Cyhalofop butyl + chlorimuron + metsulfuron. Net returns were recorded highest infenoxaprop + chlorimuron + metsulfuron (`16120 $ha^{-1}$) followed by cyhalofop butyl +chlorimuron + metsulfuron (`16080 ha^{-1}) with highest benefit cost ratio 2.37.

Keywords: Upland rice, Weeds, Herbicides, Nutrients uptake.

INTRODUCTION

Rice (Oryza sativa. L.,) is the staple food of 66% of global production and the major source energy in human diets of entire Asia and in India it is one of the most important food crop in terms of both area, production and consumer preference. The productivity of rice has increased from 1984 kg per hectare in 2004-05 to 2372 kg ha^{-1} in 2011-12. To meet the demand for food from this increased population, the farmers have to produce 40 % more grains by 2020. As per an estimate, the upland rice area is around 5.5 million hectares which accounts 12.33 % of the total rice area of the country (Singh and Angiras, 2003).The productivity of upland rice is only 0.8 tonnes ha^{-1} which is far below the national average. In Odisha, upland rice is grown in about 1.0 million hectare with a very low productivity of 0.6 tonnes ha^{-1} (Singh *et al.* 2011). With the introduction of short statured high yielding rice varieties with erectophyle leaves, the weed menace is becoming more acute. Aerobic soil conditions and dry-tillage practices, besides alternate wetting and drying conditions, are conducive for germination and growth of highly competitive weeds, which cause grain yield losses of 50–91%. Singh *et al.*, (2005) reported good success with dry-seeded rice production technology in large-scale farmer participatory trials in the Terai of Uttaranchal, India, when the stale-seed bed technique was combined with the application of pre-emergence herbicide, pendimethalin within 2 days after seeding (DAS). Thus, timely weed control is crucial to increase rice productivity. Herbicides are considered to be an alternative supplement to hand weeding. Several pre-emergence herbicides including butachlor, thiobencarb, pendimethalin, oxadiazon, oxyfluorfen, and nitrofen alone or supplemented with hand weeding have been reported to provide a fair degree of weed control (Pellerin and Webster, 2004). Thus, this present investigation was planned to find out the best herbicide and its mixture on yield and economics of direct seeded rice.

MATERIALS AND METHODS

The field experiment was laid out on randomized block design during kharif season of 2011 at Central Research Station, OUAT, Bhubaneswar, with 12 weed management practices i.e. T_1 pyrazosulfuron, T_2 pretilachlor–S, T_3 cyhalofop-butyl, T_4 fenoxaprop, T_5 cyhalofop-butyl + chlorimuron + metsulfuron, T_6 fenoxaprop + chlorimuron + metsulfuron, T_7 azimsulfuron, T_8 bispyribac sodium, T_9 fenoxaprop + ethoxysulfuron, T_{10} oxyfluorfen + 2, 4-D, T_{11} 2 Hand Weeding, T_{12}

Weedywith 3 replications. The soil of the experimental site was sandy loam in texture with pH of 5.7. The available nitrogen, phosphorus and potassium were 168, 40 and 135 kg ha^{-1} respectively. The test variety "Lalat" was sown in line on dated 22 june, 2012. The weed management practices were imposed as per the treatments and recommended agronomic practices, plant protection measures and formulae were followed. Recommended dose of fertilizers of nitrogen, phosphorus and potash requirements were met from urea, single superphosphate and muriate of potash, respectively. Nitrogen @ 60 kg per ha was applied in two splits i.e. 50% as basal and rest 50% panicle initiation stage. Phosphorus and potassium were applied as basal at the time of sowing. The herbicides were applied as per treatment by foot sprayer using a flat fan nozzle so as to the fluid uniformly throughout the targeted area. The details of the treatments were T_1 Pyrazosulfuron @ 25 g ha^{-1} at 3-7 DAS, T_2 Pretilachlor –S @ 750 ml ha^{-1} at 0-5 DAS, T_3 Cyhalofop butyl @ 90 g ha^{-1} at 25 DAS, T_4 Fenoxaprop @ 60 ml ha^{-1} at 30 DAS, T_5 Cyhalofopbutyl + chlorimuron + metsulfuron @120 ml ha^{-1} at 25-30 DAS, T_6 Fenoxaprop + chlorimuron + metsulfuron @ 80 ml ha^{-1} at 25-30 DAS, T_7 Azimsulfuron @ 35 g ha^{-1} at 20 DAS, T_8 Bispyribac sodium @ 25 g ha^{-1} at 20 DAS, T_9 Fenoxaprop + Ethoxysulfuron 15 WG @75 g.ha^{-1} at 25-30 DAS, T_{10} Oxyfluorfen + 2,4-D @ 800 ml ha^{-1} at preemergence + 30 DAS, T_{11} Two hand weedings at 20 and 40 DAS. Total weed density by quadrate of size 0.50 m2 per plot was taken at periodical intervals. The weed samples brought in paper bags were air dried in shade initially followed by oven drying at 800C for 24 hours to determine its dry matter till constant weight and expressed in g m-2. Weed control efficiency (WCE) and weed index (WI) was calculated based on the weed dry matter and grain yield, respectively. Growth characters like plant drymatter and weed parameters like weed density and weed biomass, were recorded at various stages of growth. At harvest, the yield attributes and yield of rice were recorded. The grain and straw samples were oven dried, processed and analyzed fornitrogen, phosphorus and potassium by adopting standard procedures (Jackson, 1973).

RESULTS AND DISCUSSION

Weed density

About 24 different species of weeds belonging to 11 families (grasses-8, sedges-3 and broad leaves-13) were observed in the experimental site. Among the monocot weeds, Digitariaciliaris, Cyperusesculentus and Cyperusrotundus were the most dominant weeds followed by Sporobulusdiander, Eleusineindica, Cynodondactylon and Echinochloacolonaat different stages of crop growth. At the time of harvest, Digitariaciliaris was the most dominant weed and found to the tune of 25.3% of total weed density. Among the broad leaf weeds, Oldenlandiacorymbosa was the most prevalent weed in the experimental site followed by Ludwigiaparviflora and Ageratum conyzoides. During harvest, Ludwigiaparviflora was the most dominant broad leaf weed and found to the tune of 10.27 %. This occurrence of weeds might be due to their inherent ability of quick germination, early seeding vigour, rooting habit and speedy growth under the favorable climatic condition. This finding is in conformity with the result obtained by Reddy (1993).

Table 1: Effect of weed management treatments on weed density weed biomass per m^2

Treatment	Weed density			Weed biomass		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Pyrazosulfuron	15.8	27.5	47.8	8.3	23.5	32.5
Pretilachlor –S	20.5	30.8	55.3	9.3	24.7	33.7
Cyhalofop butyl	17.7	26.7	51.5	9.5	23.4	33.8
Fenoxaprop	12.8	23.5	34.5	6.8	18.5	26.5
Cyhalofopbutyl+chlorimuron + metsulfuron	6.5	12.5	16.7	3.2	7.8	12.3
Fenoxaprop +chlorimuron + metsulfuron	4.8	11.8	13.8	2.5	5.7	10.5
Azimsulfuron	11.3	21.7	26.8	4.8	16.5	25.7
Bispyribac sodium	7.7	15.5	18.8	3.0	9.8	16.7
Fenoxaprop + Ethoxysulfuron	9.5	18.3	22.5	3.2	12.7	20.5
Oxyfluorfen + 2,4-D	13.9	25.8	36.5	7.5	21.3	29.8
Hand weeding	4.2	3.6	2.8	1.9	4.5	4.8
Weedy	72.3	104.7	126.7	25.5	33.5	46.7
SE(m)±	1.04	1.58	1.94	1.12	0.93	0.88
C.D (0.05)	3.03	4.60	5.81	3.34	2.73	2.56

Population increased up to 60 DAS and thereafter decreased till harvest. Herbicides had remarkable effect on weed population throughout the growth stages. Post-emergence application of

fenoxaprop + chlorimuron + metsulfuron, the best treatment to controlled weeds efficiently. Weed density differed significantly due to herbicide application in all stages of crop growth. Weed density was at par in fenoxaprop + chlorimuron + metsulfuron 4.8 per m^2 and cyhalofop butyl + chlorimuron + metsulfuron application 6.5 per m^2 at 30 DAS. At all the stages, fenoxaprop + chlorimuron + metsulfuron recorded significantly lower weed density among different chemical methods of weed control employed. Hand weeding exhibited significant influence on weed population at different growth stages. Significantly the lowest weed density was observed with hand weeding at all stages of crop growth.This might be due to timely eradication of weeds by intercultural tools. The weeds were uprooted and killed. Similar findings were observed by Pandey *et al.*, (1996). The lower weed density with that treatment might be due to inherent ability of chemical to affect the cell division, cell growth and hampering the germination of weeds. Similar findings were reported by Ramachandran *et al., (*2012).

Weed biomass

There was an increasing trend in the dry weights of weeds with the increase of crop age up to 90 DAS irrespective of different treatments (Table 1). Herbicide application had a significant effect on dry matter accumulation of weeds. The weed biomass per m^2 was significantly lower with treatment receiving fenoxaprop + (chlorimuron + metsulfuron) which was at par with cyhalofop butyl + (chlorimuron + metsulfuron) treatment. Hand weeding twice recorded lowest weed biomass per m^2 at all growth stages of crop. At all the stages of crop, weedy check exhibited significantly highest weed biomass per m^2.The lowest weed biomass observed with those treatments was due to efficient control of dominant weed from the beginning of crop growth (Ramachandran *et al.*, 2012). It might be due to the use of mixture of herbicides which showed broad spectrum control of weeds. This is evident from earlier result that fenoxaprop ethyl at 50 g ha^{-1} could be used as post-emergence spray for the control of grassyweeds (Singh *et al.*, 2008).

Table 2: Effect of weed management treatments on weed control efficiency

Treatments	30 DAS	60 DAS	90 DAS
Pyrazosulfuron	67.45	29.85	30.40
Pretilachlor –S	63.5	26.26	27.83
Cyhalofop butyl	62.74	30.14	27.62
Fenoxaprop	73.34	44.78	43.25
Cyhalofop butyl + chlorimuron + metsulfuron	87.45	76.71	73.66
Fenoxaprop + chlorimuron + metsulfuron	90.19	82.98	77.51
Azimsulfuron	81.17	50.74	44.96
Bispyribac sodium	88.23	70.74	64.23
Fenoxaprop + Ethoxysulfuron	87.45	62.08	56.10
Oxyfluorfen + 2,4-D	70.58	36.41	36.18
Hand weeding	92.54	86.56	89.72
Weedy	-	-	-

Weed control efficiency (WCE): The data indicated that from 30 days onwards highest WCE was observed in treatment receiving fenoxaprop + chlorimuron + metsulfuron. It was closely followed by cyhalofop butyl + chlorimuron + metsulfuron treatment. This might be due to the reduction of weed biomass thus resulted in increase in weed control efficiency. The higher WCE was recorded with fenoxaprop + chlorimuron + metsulfuron.

Growth and yield attributes characters

Dry matter accumulation: Data (Table 3) indicated that dry matter accumulation by rice plants increased progressively with advancement of growth of crop. The peak rate of crop growth was observed between 40 and 60 DAS.

Table 3: Effect of weed management on dry matter accumulation (g per m^2) rice plants at different stages of growth

Treatments	20 DAS	40 DAS	60 DAS	80 DAS	Harvest
Pyrazosulfuron	30.1	293	709	827	919
Pretilachlor - S	29.3	345	754	968	1080
Cyhalofop butyl	33.7	324	821	924	1031
Fenoxaprop	31.7	319	780	1027	1183
Cyhalofop butyl + (chlorimuron + metsulfuron)	28.0	321	800	1108	1280
Fenoxaprop + (chlorimuron + metsulfuron)	32.2	358	818	1182	1318
Azimsulfuron	31.6	338	800	1010	1122
Bispyribac sodium	32.5	341	853	1021	1135
Fenoxaprop + Ethoxysulfuron	33.8	301	742	969	1020
Oxyfluorfen + 2,4-D	29.2	311	766	946	1028
Hand weeding	24.6	299	690	919	1055
Weedy	24.8	250	291	307	332

SE(m)±	1.48	15.5	28.0	41.4	47.8
C.D (0.05)	4.40	45.0	82.0	122	140

Dry matter accumulation by rice plants was influenced significantly by weed management treatments at all the stage of growth. Treatment receiving fenoxaprop + chlorimuron + metsulfuron produced highest quantity at all the growth stages of rice. It was closely followed by cyhalofop butyl + chlorimuron + metsulfuron treatment. The dry matter production with weedy plots were significantly lowest among all the treatments in all the stages of crop growth it may be due towhen multiple weed problems exist, it becomes advantageous to use a mixture of herbicides to control both broadleaf and grass weeds (Brommer *et al.,* 2000).

Yield attributing characters: The effective tillers per m^2significantly higher with hand weeding twice plots (338.2) which were at par with fenoxaprop+ chlorimuron+ metsulfuron (330.3) andcyhalofop butyl + chlorimuron+metsulfuron (325.2). Weedy check treatment recorded significantly lowest number of effective tillers per m^2 (200.3) among the treatments.The fenoxaprop + chlorimuron + metsulfuron and cyhalofop butyl + chlorimuron + metsulfuron treatment produced highest panicle length i.e.23.5 cm. All the chemical methods of weed control were at par with respect to length of panicle. The significantly lowest value of 19.7 cm was obtained from weedy treatment.Among the herbicide treatments, significantly higher number of grains per panicle was observed with fenoxaprop+ chlorimuron + metsulfuron (113.7) which was at par with bycyhalofopbutyl + chlorimuron + metsulfuron (110.5), azimsulfuron (107.3) and bispyribac sodium (109.7).The number of grains per panicle was lowestwith weedy plot (75.8). The reason due to the post-emergence mixture of fenoxaprop + ethoxysulfuron on rice was theappropriate weed management practice to control broad spectrum of weed species with minimum grass, sedge, broad-leaved weed and total weed density and their drymatter production and higher weed control efficiency to obtain higher productivity in rice (Singh *et al.,* 2006).

Table 4: Effect of different weed control measures on effective tillersm^{-2}, length of panicle (cm), number of grains panicle^{-1} and 1000 grain weight (g) in direct seeded upland rice

Treatments	Effective tillers/m^2	Length of panicle (cm)	Number of grains/ panicle	1000 grain weight (g)
Pyrazosulfuron	296.7	22.8	100.7	22
Pretilachlor –S	288.5	22.8	97.2	21.5
Cyhalofop butyl	290.5	22.5	97.5	21.8
Fenoxaprop	303.7	22.4	102.3	22.4
Cyhalofop butyl +chlorimuron + metsulfuron	325.2	23.5	110.5	23.3
Fenoxaprop + chlorimuron + metsulfuron	330.3	23.5	113.7	23.5
Azimsulfuron	305.7	23.2	107.3	22.5
Bispyribac sodium	321.5	23.3	109.7	23
Fenoxaprop + Ethoxysulfuron	315.6	23.4	107.3	22.9
Oxyfluorfen + 2,4-D	300.5	23.3	102	22.3
Hand weeding	338.2	23.6	117.3	24
Weedy	200.3	19.7	75.8	21.3
SE(m)±	4.95	0.61	4.88	0.39
C.D (0.05)	14.78	1.80	14.24	1.15

Among all the twelve treatments, the hand weeding recorded the highest number of grains per panicle (117.3).Higher test weight was observed with fenoxaprop+ chlorimuron+ metsulfuron (23.5g). Hand weeding recorded a better test weight (24g) over both the herbicide and no herbicide treatments, while the lowest in weedy treatment.The higher yield attributes might be due to reduced weed density, weed biomass and higher weed control efficiency as it controlled the weeds effectively starting from early stage of crop growth to the period of critical weed competition stage leading to better establishment of crop. The minimum yield component in unweeded check is the result of severe weed competition by uncontrolled weed growth (Gogoi *et al.* 2000).

Yield

Rice yields with all herbicide combinations tested were higher than that with the weedy check and lower than withthe weed-free treatmentwas presented in Table 6. The highest grain yield of 3270 kg ha^{-1} was produced with fenoxaprop + chlorimuron+ metsulfuron which was at par with cyhalofop butyl + chlorimuron +

metsulfuron (3230 kg ha^{-1}). Among the herbicides, pretilachlor-s recorded lowest grain yield (2460 kg ha^{-1}). The grain yields of azimsulfuron, bispyrbacsodium andfenoxaprop + ethoxysulfuron were at par.

Table 5: Effect of weed management practices on grain and straw yield, harvest index and weed index (%)

Treatments	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})	Harvest index (%)	Weed index (%)	Net returns	B: C ratio
Pyrazosulfuron	2.725	3.430	44.27	21.92	11528	1.96
Pretilachlor –S	2.460	3.150	43.85	29.51	9535	1.8
Cyhalofop butyl	2.640	3.290	44.51	24.35	10665	1.87
Fenoxaprop	2.920	3.565	45.02	16.33	13445	2.14
Cyhalofop butyl+(chlorimuron+metsulfuron)	3.230	4.090	44.12	7.45	16080	2.37
Fenoxaprop + (chlorimuron + metsulfuron)	3.270	3.970	45.16	6.30	16120	2.34
Azimsulfuron	3.000	3.770	44.31	14.04	14225	2.22
Bispyribac sodium	3075	3860	44.34	11.89	14763	2.26
Fenoxaprop + Ethoxysulfuron	3070	3890	44.10	12.03	14820	2.27
Oxyfluorfen + 2,4-D	2875	3615	44.29	17.62	12663	2.04
Hand weeding	3490	4260	45.03	-	14205	1.9
Weedy	1490	1810	45.15	57.30	1820	1.12
SE(m)±	47.41	69.16	-	-	-	-
C.D (0.05)	139.07	201.45	-	-	-	-

Hand weeding twice treatment recorded significantly highest grain yield of 3490 kg ha^{-1} among all the treatments, while significantly lower grain yield was obtained with weedy plot (1490 kg ha^{-1}). The treatment fenoxaprop + chlorimuron + metsulfuron and cyhalofopbutyl + chlorimuron + metsulfuron produced 119.5 and 116.8% higher yield over weedy check. With respect of straw yield was significant due to different treatments. The treatment cyhalofop butyl + chlorimuron + metsulfuron recorded significantly higher straw yield of 4090 kg ha^{-1} which was at par with fenoxaprop + chlorimuron+metsulfuronand fenoxaprop + ethoxysulfuron. Hand weeding twice treatment recorded significantly higher straw yield of 4260 kg ha^{-1} while lowest yield was observed with weedy treatment (1810 kg ha^{-1}). It is because of weedy check indicated the improvement in crop growth due to relative weed free environment as a result of implemented treatments. Improvement in yield contributing parameters including panicle bearing tillers, grains per panicle and test weight in the treated plots compared with the weedy check resulted in improved grain yield (Nadeem *et al.*, 2011).

Table 6: Effect of weed management treatments on NPK uptake (kgha^{-1}) by rice at harvest

Treatment	Nitrogen		Phosphorous		Potassium	
	Grain	Straw	Grain	Straw	Grain	Straw
Pyrazosulfuron	31.3	17.8	9.2	1.1	11.4	57.6
Pretilachlor - S	29.0	17.3	8.4	1.0	10.3	53.5
Cyhalofop butyl	31.6	17.7	9.2	1.1	11.2	54.3
Fenoxaprop	33.8	18.9	10.0	1.2	12.2	58.5
Cyhalofop butyl + (chlorimuron+metsulfuron)	38.7	23.7	11.5	1.5	13.7	71.6
Fenoxaprop + (chlorimuron + metsulfuron)	39.5	23.0	11.7	1.5	13.9	69.5
Azimsulfuron	35.1	19.9	10.2	1.2	12.6	59.9
Bispyribac sodium	35.9	20.8	10.5	1.3	12.9	62.1
Fenoxaprop + Ethoxysulfuron	35.6	21.4	10.5	1.3	12.8	62.6
Oxyfluorfen+ 2,4-D	33.9	18.8	9.9	1.2	12.1	57.1
Hand weeding	40.8	22.5	12.1	1.3	14.9	69.0
Weedy	15.6	7.0	3.9	0.4	4.8	19.2
SE (m)±	0.010	0.010	0.002	0.010	0.005	0.010
C.D (0.05)	0.033	0.03	0.006	0.032	0.015	0.031

Highest harvest index (HI) value of 45.16 was obtained with fenoxaprop + chlorimuron + metsulfuron followed by weedy check, hand weeding, fenoxaprop and cyhalofop butyl. The treatment fenoxaprop + chlorimuron + metsulfuronrecorded lowest weed index of 6.3% followed by cyhalofop butyl +chlorimuron+ metsulfuron 7.45%. The treatments azimsulfuron, bispyribac sodium and fenoxaprop + ethoxysulfuron produced more or less equal values of weed index. Weedy check treatment recorded maximum weed index value of 57.30%.

Economics: The treatment fenoxaprop + chlorimuron + metsulfuron exhibited maximum net return of `.16,120 $ha^{-1}$ followed by cyhalofop butyl +chlorimuron + metsulfuron (`.16080 ha^{-1}). The treatment cyhalofop butyl +chlorimuron + metsulfuron recorded highest B:C ratio of 2.37 which was closely followed by fenoxaprop + chlorimuron +

metsulfuron (2.34), fenoxaprop +ethoxysulfuron (2.27), bispyribac sodium (2.26) and azimsulfuron (2.22). The lowest B: C ratio was observed with weedy check treatment (1.12).

Nutrients uptake: The total nitrogen (63.4 kg ha^{-1}) and phosphorus (13.4 kg ha^{-1}) uptake (table.6) recorded highest in hand weeding twice treatment which had significant diffenrence with Fenoxaprop + chlorimuron + metsulfuroni.e 62.59 kg $ha^{-1,}$ 13.18 kg $ha^{-1}$and followed by Cyhalofop butyl + chlorimuron + metsulfuron, the value was 62.48 kg ha^{-1} and 13 kg ha^{-1} respectively. Lowest N and P uptake in grain and straw was found lowest in Pretilachlor –S i.e. 46.35 kg ha^{-1} and 9.45 kg ha^{-1} among herbicidal treatments.The total K uptake in grain and straw was highest in Cyhalofop butyl + chlorimuron + metsulfuron i.e. 85.30 kg ha^{-1} which was statistically at par withFenoxaprop + chlorimuron + metsulfuron, the value was 83.41 K ha^{-1} and the total K uptake in grain and straw was found lowest in Pretilachlor –S i.e.63.86 kg ha^{-1} among herbicidal treatments, herbicidal mixture of application resulted in significant increase in grain yield over control despite lower percentage inhibition in total weed density and dry weight over control compared with the other weed control treatments. This may be due to the enhanced nutrient availability (Nadeem *et al.,* 2011).

It may be concluded from the results that post emergence application of mixing two herbicide is better than single herbicide either pre or post emergence application. Post emergence application of fenoxaprop + chlorimuron+ metsulfuron is recommended for direct seeded upland rice as this treatment recorded highest grain yield, gross return and net return along with higher nutrient uptake by rice. The next best treatment in order was cyhalofop butyl + chlorimuron + metsulfuron. Although hand weeding twice gave highest yield, but the net return was less than herbicide treated plots. Further, availability and high rate of labour wage are the two great constraints to adopt hand weeding in rice field. Hence, it is always advised to go for herbicidal application for timely weed control with higher monetary benefit. However, for the conformity of the results the experiment needs repetition for two more seasons on multi-locations.

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