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National Academy of Agricultural Science (NAAS) Rating : 3. 03

Promising Post-emergence Herbicides for Effective Weed Management in Direct Seeded Rice

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ABSTRACT: *An experiment was conducted in Kole lands of Thrissur, Kerala, India, during October 2011 to February 2012 to study the effect of various post emergent herbicides on weed flora and density in wet seeded rice. The results showed that grasses were the dominant weed flora followed by broad leaved weeds and sedges. Among the herbicidal treatments, maximum weed control efficiency was obtained in bispyribac sodium. The treatments cyhalofop-butyl with a follow up spray of metsulfuron methyl + chlorimuron ethyl (Almix), fenoxaprop p-ethyl with a follow up spray of metsulfuron methyl + chlorimuron ethyl and bispyribac sodium were the effective treatments with lower weed dry matter production. The highest grain yield on par with the hand weeded plot, was obtained in cyhalofop-butyl with a follow up spray of metsulfuron methyl + chlorimuron ethyl and fenoxaprop with a follow up spray of metsulfuron methyl + chlorimuron ethyl (5.8 t/ha).*

Key words: *Post emergent herbicides, weed spectrum, wet seeded rice, weed management*

INTRODUCTION

Rice (*Oryza sativa* L.) is a major food crop in Asia and many other tropical and sub-tropical countries of the world. Crop-weed competition is one of the prime yield limiting biotic constraints in rice. Direct seeded rice reduces labour cost and gives yield similar to that of transplanting, making it more economical. But weed problems are more critical in wet- seeding (Moorthy and Saha, 2002 [5]) contributing to a yield loss of 40 to 100 percent (Rao *et al*., 2007[7]). Though there are various weed control measures, use of herbicides is the most common practice as it is easier, time and labour saving, and economical compared to hand weeding (Rekha *et al*., 2003 [8]). For controlling mixed flora of weeds emerging simultaneously with wet-seeded rice, a viable recommendation would be a single application of a broad spectrum herbicide or a herbicide combination. Continuous use of same herbicide may lead to herbicide resistance in weeds and so the rotational use of different herbicides are essential for effective weed control. So the present study was conducted to evaluate the efficacy of new post emergence herbicides and herbicide combinations for weed control in wet-seeded rice, to find out the most effective herbicide or herbicide combination for cost effective weed control and to assess the response of rice and its major weeds to new herbicides.

METHODOLOGY

A field experiment was conducted during *mundakan* season (October 2011 to February 2012) in a farmer's field at Alappad in the *Kole* lands (10^0 31′ N latitude and $76^0$13′ E longitude and 1m below Mean Sea Level) of Thrissur district using the rice variety Jyothi. The soil was clayey with pH 5.5, organic C 2.1%, available P and K 26 and 281 kg/ha respectively. The experiment comprised of 13 treatments, viz., post emergent spray of metamifop (125 g/ha), metamifop (125 g/ha) with a follow up spray (fs) of carfentrazone ethyl (20 g/ha), metamifop (125 g/ha) with a follow up spray of metsulfuron methyl + chlorimuron ethyl (4 g/ha), cyhalofop-butyl (100 g/ha), cyhalofop-butyl (100 g/ha) with a follow up spray of metsulfuron methyl + chlorimuron ethyl (4 g/ha), fenoxaprop-p-ethyl (60 g/ha), fenoxaprop-p-ethyl (60 g/ha) with a follow up spray of metsulfuron methyl + chlorimuron ethyl (4 g/ha), fenoxaprop-p-ethyl (60 g/ha) with a follow up spray of ethoxysulfuron (15 g/ha), bispyribac sodium (30 g/ha), penoxsulam (25 g/ha),

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azimsulfuron (35 g/ha), unweeded control and hand weeded control. The trial was laid out in Randomized Block Design with three replications.

All herbicides were sprayed at 20 days after sowing (DAS) with follow up spray on next day using knapsack sprayer. Data on weed count, weed biomass and N, P and K content of weeds (at 30 DAS, 60 DAS and harvest), biometric observations, yield attributes, weed control efficiency (Gill and Vijayakumar, 1969 [2]), weed index (WI) and economics of production were also recorded. Data on weed biomass, which showed wide variation, was subjected to square root transformation "(x+0.5) to make the analysis of variance valid (Gomez and Gomez, 1984 [3]). Multiple comparisons among treatment means, where the F test was significant (at 5% level), were done with Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

A critical analysis of relative proportion of grasses, sedges and broad leaved weeds to total weed population in unweeded control revealed that during the crop growth period, the population of grasses was higher than that of sedges and broad leaved weeds (Fig. 1) and the major grasses found in the experimental area were *Echinochloa colona, Echinochloa crusgalli, Echinochloa stagnina* and *Leptochloa chinensis*. The higher proportion of grasses compared to sedges and broad leaved weeds in rice in *Kole* lands was also reported by Joy *et al*. (1993 [4]) and Sindhu (2008 [9]). Sedges like *Fimbristylis miliacea, Cyperus difformis* and *Cyperus iria* were present, among which the population of *Fimbristylis miliacea* was higher than that of *Cyperus* spp. In general, the population of broad leaved weeds was very low and in hand weeded plot, mainly *Lindernia crustacea* was present (8/m^2) (Table 1). Weeds especially sedges and broad leaved weeds were present in treatments in which graminicides (metamifop, cyhalofop-butyl and fenoxaprop p-ethyl) alone were applied and in unweeded check. The application of graminicides followed by a herbicide selective against broad leaved weeds and sedges or a herbicide with broad spectrum action resulted in weed free condition in other treatments.

At 30 DAS, all treatments except unweeded control and graminicides alone applied plots were weed free. The population of *Echinochloa* was 32/m^2 in the unweeded control whereas, a low grass count of 3-5/m^2 was registered in cyhalofop-butyl, metamifop and fenoxaprop p-ethyl treated plots (at 60 DAS) which shows their effectiveness in suppressing grass weeds (Table 1). The weed population was the lowest in bispyribac sodium, cyhalofop-butyl f*s* metsulfuron methyl + chlorimuron ethyl and in fenoxaprop p-ethyl f*s* metsulfuron methyl + chlorimuron ethyl (at 60 DAS) because of their broad spectrum action. Bispyribac sodium is as effective as hand weeding twice in suppressing weed population indicating the lowest weed count of 8/m^2 at harvest.

Weed biomass production to the tune of 33-38 kg/ha was registered in plots sprayed with graminicides alone (fenoxaprop p-ethyl, metamifop and cyhalofop-butyl) at 30 DAS (Table 2). The highest weed dry weight of 350 kg/ha was recorded in unweeded control. By 60 DAS, weed dry weight quadrupled in unweeded control to 1300 kg/ha and the lowest accumulation of dry matter (43 kg/ha) was noticed in hand weeded plots followed by bispyribac sodium (129 kg/ha) (Table 2). At the time of harvest also, weed biomass was minimum (65.33 kg/ha) in hand weeded plots followed by 146 kg/ha in bispyribac sodium. There was an increase in dry weight from 1300 to 2280 kg/ha in unweeded plot. The treatments cyhalofop-butyl f*s* metsulfuron methyl + chlorimuron ethyl and fenoxaprop p-ethyl f*s* metsulfuron methyl + chlorimuron ethyl were the next best treatments with lower weed biomass production.

With respect to nutrient uptake by weeds, very low N, P and K uptake was noticed in bispyribac sodium sprayed plots at all stages of crop growth. Nitrogen uptake (at 60 DAS) in bispyribac sodium sprayed plots was only one-twelfth of the uptake registered in unweeded control (Table 2). Maximum uptake of 41 kg/ha was observed in unweeded control at the harvesting stage of the crop which was double the uptake at 60 DAS. The treatments fenoxaprop p-ethyl f*s* metsulfuron methyl + chlorimuron ethyl, cyhalofop-butyl f*s* metsulfuron methyl + chlorimuron ethyl and fenoxaprop p-ethyl registered next lower values. With respect to K uptake, the treatments fenoxaprop p-ethyl f*s* metsulfuron methyl + chlorimuron ethyl and bispyribac sodium were on par with 1.8 and 1.6 kg/ha respectively.

At 30 DAS, the highest number of tillers was in handweeded plot which was on par with penoxsulam, fenoxaprop p-ethyl f*s* metsulfuron methyl + chlorimuron ethyl, cyhalofop-butyl, fenoxaprop p-ethyl fs ethoxysulfuron and metamifop fs carfentrazone ethyl. However at 60 DAS, tiller count in hand weeded control (592/m^2) was significantly superior to all other treatments (Table 3). Maximum number of productive tillers was also recorded in hand weeded treatment (215/m^2) and minimum was noticed in unweeded control with 156/m². The treatments cyhalofop-butyl f*s* metsulfuron methyl + chlorimuron ethyl and fenoxaprop p-ethyl f*s* metsulfuron methyl + chlorimuron ethyl were the next best treatments and were statistically on par with each other. Maximum grains/panicle (112) was recorded in hand weeded treatment as well as in cyhalofop-butyl f*s* metsulfuron methyl + chlorimuron ethyl (Table 3). The panicles in unweeded control plot registered 91 grains/panicle where as it was 96 per panicle for fenoxaprop p-ethyl + ethoxysulfuron which were comparable statistically. There was no significant difference between treatments for 1000 grain weight (test weight). The highest grain yield of 6.13 t/ha was recorded in hand weeded plot which was on par with cyhalofop-butyl f*s* metsulfuron methyl + chlorimuron ethyl and fenoxaprop f*s* metsulfuron methyl + chlorimuron ethyl (5.8 t/ha) and lowest yield of 4.03 t/ha was obtained in unweeded control (Table 3). Abraham *et al*. (2012 [1]) also reported about the efficacy of fenoxaprop in direct seeded rice. In the case of straw, the highest yield was obtained in hand weeding with 5.83 t/ha and lowest in unweeded control with 4.37 t/ha.

Among different treatments, maximum B: C ratio of 1.8 was obtained in cyhalofop-butyl f*s* metsulfuron methyl + chlorimuron ethyl, fenoxaprop p-ethyl f*s* metsulfuron methyl + chlorimuron ethyl, bispyribac sodium and fenoxaprop p-ethyl alone (Table 4). Although hand weeding resulted in a net profit of Rs. 63,075/-/ha, due to high cost of cultivation (Rs. 45,825/-/ha) the B:C ratio was reduced to 1.4 and the least B:C ratio of 1.2 was noted in unweeded control. The treatments cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl and fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl showed the lowest weed index of 5.2 followed by bispyribac sodium (6.1). Maximum weed control efficiency of 97.1 percent was obtained in hand weeded plots followed by bispyribac sodium (93.6%) and fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl (90%). Ramachandiran and Balasubramanian (2012 [6]) also reported about the higher weed control efficiency of fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl in aerobic rice.

From this study it can be concluded that, cyhalofop-butyl f*s* metsulfuron methyl + chlorimuron ethyl or fenoxaprop p-ethyl f*s* metsulfuron methyl + chlorimuron ethyl or bispyribac sodium alone can be recommended for effective post emergence weed control and higher yield in wet seeded rice. If grasses are the predominant weeds, cyhalofop-butyl or fenoxaprop p-ethyl alone without follow up spray of metsulfuron methyl + chlorimuron ethyl, can also be recommended.

Table 1
Effect of the treatments on count of grasses, sedges and broad leaved weeds (No./m²)

Treatments	*30DAS*			*60DAS*			*At harvest*		
	G	*S*	*B*	*G*	*S*	*B*	*G*	*S*	*B*
Metamifop	*2.1^{bc}(4)	3.3^{ab}(11)	3.9^{a}(15)	2.4^{bc}(5)	3.7^{a}(14)	2.7^{bc}(7)	2.4^{c}(5)	3.9^{ab}(15)	3.8^{ab}(14)
Metamifop fs carfentrazone ethyl	0.71^{d}(0)	0.71^{c}(0)	0.71^{c}(0)	2.3^{bcd}(5)	1.3^{cd}(2)	2.6^{bc}(7)	2.3^{c}(5)	2.6^{cde}(7)	2.9^{bcd}(8)
Metamifop f*s* metsulfuron methyl + chlorimuron ethyl	0.71^{d}(0)	0.71^{c}(0)	0.71^{c}(0)	1.5^{de}(2)	2.1^{bc}(4)	2.6^{bc}(7)	2.8^{bc}(7)	3.1^{bcd}(9)	2.5^{cd}(6)
Cyhalofop-butyl	1.9^{bc}(3)	3.3^{ab}(11)	2.7^{b}(7)	1.8^{cde}(3)	2.4^{bc}(5)	3.0^{ab}(9)	2.8^{bc}(7)	3.2^{bc}(10)	2.5^{cd}(6)
Cyhalofop-butyl f*s* metsulfuron methyl + chlorimuron ethyl	0.71^{d}(0)	0.71^{c}(0)	0.71^{c}(0)	1.8^{cde}(3)	1.9^{bc}(3)	1.3^{d}(1)	2.6^{bc}(7)	3.5^{b}(12)	2.2^{d}(5)
Fenoxaprop p-ethyl	2.2^{b}(5)	3.1^{b}(9)	2.9^{b}(8)	2.1^{bcd}(4)	2.7^{b}(7)	3.6^{a}(13)	2.5^{c}(6)	3.6^{b}(13)	3.7^{ab}(13)
Fenoxaprop-p-ethyl f*s* metsulfuron methyl + chlorimuron ethyl	0.71^{d}(0)	0.71^{c}(0)	0.71^{c}(0)	1.9^{bcd}(3)	0.7^{d}(0)	2.8^{abc}(7)	2.5^{c}(6)	2.4^{de}(5)	3.2^{abc}(10)
Fenoxaprop-p-ethyl fs ethoxysulfuron	0.71^{d}(0)	0.71^{c}(0)	0.71^{c}(0)	1.9^{bcd}(3)	2.4^{bc}(5)	2.3^{bc}(5)	3.3^{b}(10)	2.6^{cde}(7)	3.2^{abc}(10)
Bispyribac sodium	0.71^{d}(0)	0.71^{c}(0)	0.71^{c}(0)	0.9^{ef}(1)	0.7^{d}(0)	2.7^{bc}(7)	0.7^{d}(0)	0.7^{f}(0)	2.9^{bcd}(8)
Penoxsulam	0.71^{d}(0)	0.71^{c}(0)	0.71^{c}(0)	2.6^{ab}(7)	1.4^{cd}(3)	2.5^{bc}(6)	2.9^{bc}(8)	2.3^{de}(5)	2.7^{cd}(7)
Azimsulfuron	0.71^{d}(0)	0.71^{c}(0)	0.71^{c}(0)	2.1^{bcd}(4)	2.7^{b}(7)	3.2^{ab}(10)	3.0^{bc}(9)	2.3^{e}(5)	2.5^{cd}(6)
Unweeded control	4.7^{a}(22)	3.8^{a}(15)	2.9^{b}(8)	5.7^{a}(32)	3.7^{a}(14)	2.7^{bc}(7)	5.1^{a}(26)	4.5^{a}(20)	4.1^{a}(17)
Handweeded control	0.71^{d}(0)	0.71^{c}(0)	0.71^{c}(0)	0.7^{f}(0)	0.7^{d}(0)	2.9^{ab}(8)	0.7^{d}(0)	0.7^{f}(0)	2.9^{bcd}(8)

*$\sqrt{x+0.5}$ transformed values, Original values in parentheses. In a column, means followed by common letters do not differ significantly at 5% level by DMRT. G- Grasses, S- sedges, B- broad leaved weeds.

Table 2
Effect of post emergence herbicides on weed biomass and nutrient uptake by weeds

Treatments	*Weed biomass (kg/ha)*			*N uptake (kg/ha)*			*P uptake (kg/ha)*			*K uptake (kg/ha)*		
	30 DAS	*60 DAS*	*Harvest*	*30DAS*	*60DAS*	*Harvest*	*30DAS*	*60DAS*	*Harvest*	*30DAS*	*60DAS*	*Harvest*
Metamifop	*6.09^{b} (36.67)	17.94^{d} (321.33)	18.22^{d} (332.00)	*1.19^{bc} (0.93)	2.02^{d} (3.59)	2.21^{fg} (4.43)	*0.76^{c} (0.09)	1.20^{b} (0.96)	1.22^{e} (1.0)	*1.30^{b} (1.19)	2.28^{de} (4.71)	2.19^{g} (4.30)
Metamifop *fs* carfentrazone ethyl	0.71^{c} (0)	18.35^{cd} (336.33)	21.44^{c} (459.33)	0.71^{d} (0)	2.17^{bc} (4.24)	2.57^{cd} (6.15)	0.71^{c} (0)	1.14^{d} (0.80)	1.35^{c} (1.33)	0.71^{c} (0)	2.42^{bc} (5.37)	2.79^{de} (7.30)
Metamifop fs metsulfuron methyl+ chlorimuron ethyl	0.71^{c} (0)	18.59^{c} (345.00)	21.11^{c} (445.33)	0.71^{d} (0)	1.93^{e} (3.23)	2.67^{bc} (6.68)	0.71^{c} (0)	1.08^{f} (0.67)	1.35^{c} (1.33)	0.71^{c} (0)	2.22^{e} (4.45)	2.67^{e} (6.67)
Cyhalofop-butyl	6.25^{b} (38.67)	18.59^{c} (345.00)	19.24^{d} (370.00)	1.21^{b} (0.97)	2.16^{c} (4.17)	2.35^{cf} (5.05)	0.92^{b} (0.38)	1.10^{e} (0.72)	1.27^{d} (1.13)	1.32^{b} (1.23)	2.45^{b} (5.51)	2.67^{e} (6.64)
Cyhalofop-butyl fs metsulfuron methyl+ chlorimuron ethyl	0.71^{c} (0)	13.24^{f} (175.00)	16.5^{e} (272.00)	0.71^{d} (0)	1.76^{f} (2.62)	1.98^{h} (3.45)	0.71^{c} (0)	0.85^{j} (0.22)	1.14^{f} (0.81)	0.71^{c} (0)	1.61^{g} (2.09)	2.50^{f} (5.77)
Fenoxaprop p-ethyl	5.81^{b} (33.33)	15.38^{e} (236.00)	18.22^{d} (332.00)	1.11^{c} (0.74)	1.75^{f} (2.58)	2.12^{gh} (4.0)	0.77^{c} (0.10)	0.98^{g} (0.47)	1.21^{e} (0.93)	1.27^{b} (1.12)	1.85^{f} (2.93)	2.46^{f} (5.60)
Fenoxaprop p-ethyl fs metsulfuron methyl+ chlorimuron ethyl	0.71^{c} (0)	12.46^{g} (155.00)	15.08^{f} (227.33)	0.71^{d} (0)	1.58^{g} (2.0)	1.94^{h} (3.27)	0.71^{c} (0)	0.90^{h} (0.31)	1.07^{g} (0.65)	0.71^{c} (0)	1.51^{h} (1.81)	2.28^{g} (4.73)
Fenoxaprop-p-ethyl *fs*ethoxysulfuron	0.71^{c} (0)	19.56^{b} (382.00)	21.73^{c} (472.00)	0.71^{d} (0)	2.25^{b} (4.58)	2.48^{de} (5.66)	0.71^{c} (0)	1.17^{c} (0.87)	1.39^{c} (1.43)	0.71^{c} (0)	2.41^{bc} (5.33)	2.91^{cd} (8.0)
Bispyribac sodium	0.71^{c} (0)	11.39^{h} (129.33)	12.07^{g} (146.00)	0.71^{d} (0)	1.40^{h} (1.48)	1.46^{i} (1.66)	0.71^{c} (0)	0.87^{i} (0.26)	0.94^{h} (0.40)	0.71^{c} (0)	1.45^{h} (1.63)	1.53^{h} (1.86)
Penoxsulam	0.71^{c} (0)	19.56^{b} (382.00)	23.23^{b} (539.33)	0.71^{d} (0)	2.25^{b} (4.58)	2.74^{bc} (7.03)	0.71^{c} (0)	1.12^{e} (0.76)	1.44^{b} (1.60)	0.71^{c} (0)	2.24^{e} (4.55)	2.93^{c} (8.10)
Azimsulfuron	0.71^{c} (0)	18.31^{cd} (335.00)	23.35^{b} (544.67)	0.71^{d} (0)	2.20^{bc} (4.37)	2.84^{b} (7.60)	0.71^{c} (0)	1.15^{d} (0.83)	1.46^{b} (1.63)	0.71^{c} (0)	2.34^{cd} (5.01)	3.11^{b} (9.23)
Unweeded control	18.71^{a} (350.00)	36.06^{a} (1300.00)	47.75^{a} (2280.00)	2.99^{a} (8.50)	4.32^{a} (18.20)	6.44^{a} (41.04)	1.09^{a} (0.70)	1.93^{a} (3.25)	2.70^{a} (6.84)	2.96^{a} (8.23)	4.17^{a} (16.90)	6.62^{a} (43.33)
Handweeded control	0.71^{c} (0)	6.59^{i} (43.00)	8.11^{h} (65.33)	0.71^{d} (0)	0.98^{i} (0.47)	1.05^{j} (0.61)	0.71^{c} (0)	0.76^{k} (0.08)	0.78^{i} (0.11)	0.71^{c} (0)	1.00^{i} (0.51)	1.08^{i} (0.68)

*$\sqrt{x+0.5}$ transformed values, Original values in the parentheses. In a column, means followed by common letters do not differ significantly at 5% level in DMRT. DAS – Days after sowing. *fs* - follow up spray

Table 3
Effect of treatments on tiller count, yield attributes, yield, weed index (WI) and weed control efficiency (WCE)

Treatments	*Tiller count 30DAS (No./m^2)*	*Tiller count 60DAS (No./m^2)*	*Panicles (No./m^2)*	*Filled grains/ panicle (No.)*	*1000 grain weight (g)*	*Grain Yield (t/ha)*	*Straw Yield (t/ha)*	*WI*	*WCE (%)*
Metamifop	230.0^{d}	530.0^{de}	187.00^{de}	102.00^{abc}	29.67	5.13^{ef}	5.60^{abcd}	16.3^{bc}	85.4^{e}
Metamifop *fs*carfentrazone ethyl	252.0^{ab}	541.7^{cd}	187.33^{de}	109.00^{ab}	29.33	5.20^{def}	5.37^{def}	15^{bcd}	79.8^{f}
Metamifop fs metsulfuron methyl + chlorimuron ethyl	244.3^{bc}	554.0^{bc}	189.00^{d}	102.00^{abc}	29.33	5.50^{bcd}	5.20^{ef}	9.9^{def}	80.5^{f}
Cyhalofop-butyl	255.0^{ab}	524.7^{de}	191.33^{cd}	101.67^{bc}	29.33	5.37^{cde}	5.47^{cde}	12.3^{cde}	83.8^{e}
Cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl	232.0^{d}	556.0^{bc}	196.33^{bc}	112.00^{a}	28.33	5.80^{ab}	5.67^{abc}	5.2^{fg}	88^{d}
Fenoxaprop p-ethyl	244.3^{bc}	527.0^{de}	191.00^{cd}	105.00^{abc}	29.67	5.60^{bc}	5.17^{f}	8.4^{ef}	85.4^{e}
Fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl	258.7^{a}	554.7^{bc}	198.33^{b}	110.00^{ab}	30.67	5.80^{ab}	5.10^{f}	5.2^{fg}	90^{c}
Fenoxaprop-p-ethyl *fs* ethoxysulfuron	254.0^{ab}	509.7^{e}	182.33^{e}	96.00^{cd}	29.33	5.10^{ef}	5.80^{ab}	16.6^{bc}	79.3^{f}
Bispyribac sodium	235.3^{cd}	564.3^{b}	191.00^{cd}	105.67^{abc}	29.33	5.73^{b}	5.37^{def}	6.1^{f}	93.6^{b}
Penoxsulam	257.33^{a}	554.3^{bc}	190.67^{cd}	100.00^{bcd}	28.67	5.33^{cde}	5.50^{cd}	12.9^{cde}	76.3^{g}
Azimsulfuron	229.0^{d}	517.3^{e}	175.33^{f}	100.33^{bcd}	29.33	4.90^{f}	5.53^{bcd}	19.9^{b}	76.1^{g}
Unweeded control	230.7^{d}	394.0^{f}	156.67^{g}	91.00^{d}	29.33	4.03^{g}	4.37^{g}	33.8^{a}	-
Handweeded control	260.7^{a}	592.0^{a}	215.00^{a}	112.00^{a}	29.00	6.13^{a}	5.83^{a}	-	97.1^{a}

In a column, means followed by common letters do not differ significantly at 5% level in DMRT. *fs* - follow up spray

Table 4
Economics of cultivation as affected by post emergence herbicides

Treatments	*Total cost (Rs./ha)*	*Total income (Rs./ha)*	*Net profit (Rs./ha)*	*B:C ratio*
Metamifop	36,150/-	93,300/-	57,150/-	1.6
Metamifop *fs*carfentrazone ethyl	37,894/-	94,200/-	56,306/-	1.5
Metamifop fs metsulfuron methyl + chlorimuron ethyl	37,475/-	98,100/-	60,625/-	1.6
Cyhalofop-butyl	35,685/-	97,500/-	61,815/-	1.7
Cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl	37,010/-	1,04,100/-	67,090/-	1.8
Fenoxaprop p-ethyl	35,349/-	99,600/-	64,251/-	1.8
Fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl	36,674/-	1,02,300/-	65,626/-	1.8
Fenoxaprop-p-ethyl *fs* ethoxysulfuron	36,909/-	93,900/-	56,991/-	1.5
Bispyribac sodium	36,143/-	1,01,700/-	65,557/-	1.8
Penoxsulam	36,129/-	96,000/-	59,871/-	1.7
Azimsulfuron	36,280/-	90,000/-	53,720/-	1.5
Unweeded control	32,825/-	73,200/-	40,375/-	1.2
Handweeded control	45,825/-	1,08,900/-	63,075/-	1.4

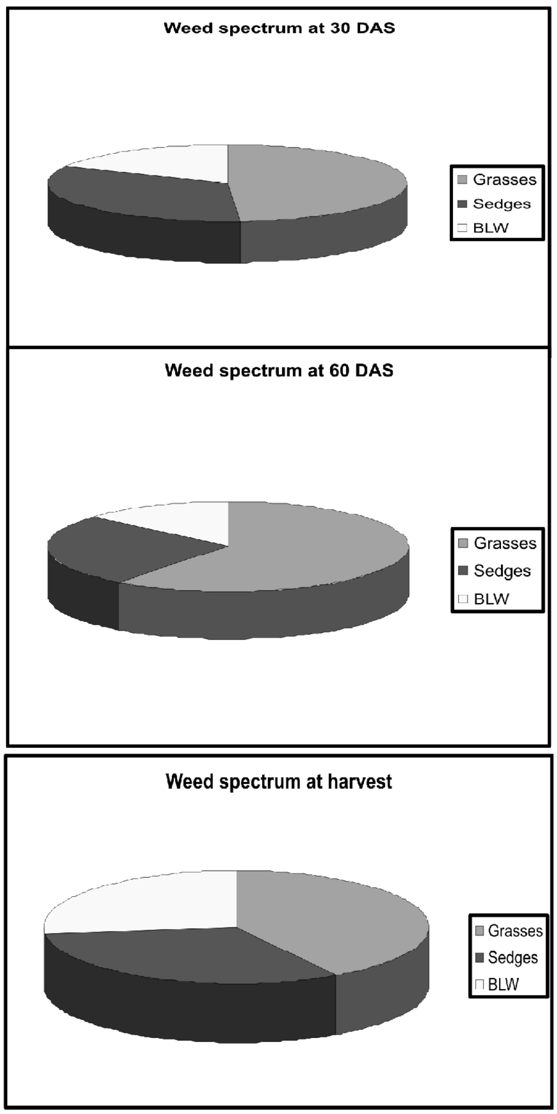

Figure 1: Dynamics of weed spectrum in the experimental plot at various stages of the crop in unweeded control

REFERENCES

Abraham CT, Prameela P and Laxmi MP. (2012), Bioefficacy testing of fenoxaprop- p- ethyl against weeds in direct seeded rice. *Indian Journal of Weed Science* **44** (2): 92-94.

Gill HS and Vijayakumar. (1969), Weed index- a new method for reporting weed control trial. *Indian Journal of Agronomy* **14** (1): 96-98.

Gomez AK and Gomez AA. (1984), *Statistical Procedures for Agricultural Research* (2nd edition). John Wiley and Sons, New York, 657p.

Joy, P.P., Syriac, E.K., Ittyaverah, P.J. and Joseph, C.A. (1993), Herbicidal technology for weed control in low land rice of Kerala. In: *Proceedings of the 5th Kerala Science Congress,* January 1993, Kottayam. Kerala State Council for Science, Technology and Environment, pp.135-137.

Moorthy BTS and Saha S (2002), Bio-efficacy of certain new herbicide formulations in puddle-seeded rice. *Indian Journal of Weed Science.* **34:** 46-49.

Ramachandiran K and Balasubramanian R. (2012), Efficacy of herbicides for weed control in aerobic rice. *Indian Journal of Weed Science* **44** (2): 118-121.

Rao AN, Johnson DE, Sivaprasad B, Ladha JK and Mortimer AM. (2007), Weed management in direct-seeded rice. *Advances in Agronomy* 93:153–255.

Rekha BK, Raju MS and Reddy MD. (2003), Effect of herbicides on weed growth, grain yield and nutrient uptake in rainfed lowland rice. *Indian Journal of Weed Science.* **35**: 121-122.

Sindhu, P.V. (2008), Eco friendly management of weeds in rice. Ph D thesis, Kerala agricultural University, Thrissur, Kerala, India. 274p.