Mysore J. Agric. Sci., 52 (2) : 271-277, 2018

Efficacy of Pre and Post-emergence Herbicides on Weed Flora, Yield and Weed Index in Dry Direct-Seeded Rice (*Oryza sativa* L.)

P. NAGARJUN AND G. N. DHANAPAL
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560065
E-mail: nagarjunp009@gmail.com

ABSTRACT

A field experiment was conducted at Main Research Station, Hebbal, Bangalore during *kharif*, 2016 to study the effect of different herbicide combinations and weed management methods on major weed flora, yield and weed index in dry direct seeded rice. The experiment consisted 12 treatments and replicated thrice in RCBD design. Among various weed management treatments, hand weeding at 20, 40 and 60 DAS recorded significantly lowest total weed density and dry weight (18m^{-2} and 5.23 g m^{-2}) whereas, among herbicide combinations bensulfuron-methyl + pretilachlor (60 g + 600 g ha^{-1}) as pre-emergence *fb* bispyribac sodium (25 g ha^{-1}) at 25 DAS recorded significantly lowest total weed density and dry weight (20.3m^{-2} and 5.57 g m^{-2}) and was found on par with bensulfuron methyl + pretilachlor (60 g + 600 g ha^{-1}) as pre-emergence fb triafamone + ethoxysulfurn (60 g ha^{-1} 25 DAS) (25.3m^{-2} and 6.21g m^{-2}). Significantly higher paddy grain and straw yield was recorded in hand weeding at 20, 40 and 60 DAS (5.17 and 7.13 t ha^{-1}, respectively) and found on par with application of bensulfuron-methyl + pretilachlor (60 g + 600 g ha^{-1}) as pre-emergence *fb* bispyribac sodium (25 g ha^{-1}) at 25 DAS (5.04 t ha^{-1} and 7.04 t ha^{-1}, respectively).

Keywords: Dry direct-seeded rice, rice herbicides, weed density, weed dry weight

RICE (*Oryza sativa* L.) is the most important and widely cultivated crop in the world. Asia is the home of rice as more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. About 90 per cent of total rice is grown and consumed in Asia (Seema *et al*., 2014). In India, rice produces 106.54 million tonnes (Anon., 2015) and provides 29.9 per cent of the total calories to rice consuming population (Timmer and Peter, 2010). Of the four ecologies of rice culture in India, irrigated ecology spreading over 26.54 million ha *i.e.*, 58.7 per cent of total acreage (FAI, 2011), which contributes over 75 per cent of total production. Recently, however there is trend towards direct seeded rice because of labour and water scarcity (Mallikarjun *et al*., 2014). To overcome these twin problems especially that of human labours involved in nursery preparation and transplanting operations, researchers as well as farmers are looking at mechanical transplanting and direct seeding options that were developed and adopted widely in South-East Asian countries.

The establishment of rice crop through dry direct seeding technique is not only simple to use but also has been found effective in sustaining the production of rice. Direct seeding of rice offers the advantages of eliminating the nursery raising and transplanting operations, faster and easier planting, reduces labour requirement (only 1-2 labour ha^{-1}), hastens crop maturity and increase water use efficiency, thus 25 per cent (250-300 man hours) of total human labour involved in rice cultivation were reduced making rice cultivation more profitable (Kachro and Bazaya, 2011). Rice crop sown through direct seeding technique is associated with the problem of profuse growth of weeds and infestation of heterogeneous weed flora is the biggest biological constraint. The success of direct seeding entirely depends on efficient weed management practices because uncontrolled weeds in direct wet seeded rice can reduce yields to the tune of 53 per cent and losses were reported even up to 90 per cent (Bhat *et al*., 2011). The weed flora of direct seeded rice crop is entirely different from that of transplanted crop due to maintenance of saturation moisture at sowing and shallow depths of

water up to 3 weeks after sowing. As weeds emerge almost at the same time as that of the crop in wet seeded rice and weed competition with rice crop is greater, hence weed management by herbicide is more crucial (Singh and Singh, 2010).

Keeping the above facts in view, an experiment was conducted to study the "Effect of different herbicide combinations on major weed flora, yield and weed index of dry direct-seeded rice (*Oryza sativa* L.)".

Material and Methods

The field experiment was conducted during *kharif*, 2016 to study the effect of combination of herbicides against complex weed flora, and their effect on growth and yield of dry direct seeded rice (upland condition). The field study was conducted at the Main Research Station, Hebbal, Bangalore. The soil type was sandy loam with a pH of 6.8, with organic carbon of 0.55 per cent. The treatment combinations tested were as follows :

	Treatments	Dose (g ha^{-1})	Time of application (DAS)
T_1	Bensulfuron methyl + pretilachlor *fb* triafamone + ethoxysulfurn (RM)	60 + 600 /60	0-3 *fb* 25
T_2	Oxadiargyl *fb* triafamone + ethoxysulfuron (RM)	100/60	0-3 *fb* 25
T_3	Pendimetalin *fb* triafamone + ethoxysulfuron (RM)	1000/60	0-3 *fb* 25
T_4	Pyrazosulfuron ethyl *fb* triafamone+ethoxysulfuron (RM)	20/60	0-3 *fb* 25
T_5	Bensulfuron-methyl+pretilachlor *fb* bispyribac sodium	60 +600 /25	0-3 *fb 25*
T_6	Oxadiargyl *fb* bispyribac sodium	100/25	0-3*fb* 25
T_7	Pendimethalin* *fb* bispyribac sodium	1000 /25	0-2 *fb* 25
T_8	Pyrazosulfuron ethyl *fb* bispyribac sodium	20/ 25	0-3 *fb* 25
T_9	Pendimethalin* *fb* penoxsulam + cyhalofop butyl (RM)	1000 /135	0-3 *fb* 25
T_{10}	Three mechanical weedings	-	20,40,60 DAS
T_{11}	Hand weedings	-	20,40,60 DAS
T_{12}	Weedy check	-	-

*Pendimethalin (Stomp extra 38.7% CS), RM: Ready Mix, fb: Followed by, DAS: Days After Sowing. Spray volume: 750 L ha^{-1} for pre-emergence and 500 L ha^{-1} for post-emergence herbicides.

Rice variety MAS-946 was sown at a spacing of 30 cm between rows and seeds are placed closely between plants and fertilizer level of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} was applied. These treatment combinations were replicated thrice in RCBD. The pre-emergence and post-emergence herbicides were applied using spray volume of 750 liters ha^{-1} and 500 liters ha^{-1} with Knapsack sprayer having WFN nozzle. The data on species wise weed count in a quadrant of 50 cm x 50 cm were collected on 60 days after sowing (DAS). Data was averaged over three replications and two spots per replication. From this, density of major weed species m^{-2} and the density of weeds' category - sedge, grass and broad leaf weeds on 60 DAS were worked out. In addition, dry weight of weeds' category – sedges, grass and broad leaf weeds (g m^{-2}) was also collected at 60 DAP. The data on weeds' density and dry weight were analyzed using transformation of square root of (x + 1) and log (X + 2), depending on the variability and weed index was calculated by using the formula suggested by Gill & Vijayakumar (1966). Paddy grain and straw yield were recorded at harvest. The data collected on different traits was statistically analyzed using the standard procedure and the results were tested at five per cent level of significance as given by Gomez and Gomez (1984). The critical difference was used to compare treatment means.

Results and Discussion

The effect of different herbicide combinations on major weed flora, weed density, dry weight, yield and weed index are presented under the following headings.

Weedflora

Major weed flora observed in the experimental plots was *Cyperusrotundus* (sedge), *Cynoadon dactylon, Chloris barbata, Digitaria marginata, Echinolchloa colona* (among grasses). Whereas, among broad leaf weeds, major weeds were *Commelina benghalensis, Acanthospermum hispida, Lagascea mollis, Euphorbia geniculata, Borreria hispida, Tridax procumbens* and *Ageratum conyzoides*. Among the weed species, the densities of *C. rotundus, D. marginata, A. conyzoides, C. benghalensis, C. dactylon* and *L. mollis* were more than other weed species, indicating their dominance and competitiveness with the dry direct seeded rice (Table I).

TABLE I

Major weed species' density (No.m^{-2}) observed in dry direct seeded rice at 60 days after sowing as influence by different herbicides combinations

Treatments	Sedges		Grasses						Broad leaf Weed									Total Weeds
	Cr	Total	Cd	Da	Dm	Ec	Clb	Total	Ac	Bh	Lm	Cb	Ah	Eg	Tp	Es	Eh	Total	
Bensulfuron methyl + pretilachlor (60+600) *fb* triafamone + ethoxysulfurn (60) (RM)	4.7	4.7	2.0	1.3	3.7	1.0	2.0	10.0	2.3	1.3	2.7	1.3	1.7	0.0	0.0	1.3	0.0	10.7	25.3
Oxadiargyl (100) *fb* triafamone + ethoxysulfuron (60) (RM)	7.7	7.7	4.3	0.7	3.7	2.0	2.3	13.0	0.7	2.0	2.3	2.0	1.3	0.7	1.7	0.0	4.7	16.7	37.3
Pendimetalin *fb* triafamone (1000) + ethoxysulfuron (60) (RM)	9.0	9.0	2.7	2.0	4.3	1.0	1.3	11.3	0.0	1.3	2.3	1.3	2.0	2.0	2.7	2.0	2.0	19.3	39.7
Pyrazosulfuron ethyl (20) *fb* triafamone + ethoxysulfuron (60) (RM)	7.3	7.3	3.0	2.3	5.3	0.3	1.0	12.0	1.3	2.0	2.7	2.0	0.0	2.0	2.0	3.3	1.0	20.0	39.3
Bensulfuron-methyl + pretilachlor (60 + 600) *fb* bispyribac sodium (25)	3.3	3.3	2.7	2.7	1.0	0.3	1.0	7.7	1.7	1.0	0.7	0.3	0.3	0.0	0.0	0.7	1.0	9.3	20.3
Oxadiargyl (100) *fb* bispyribac sodium (25)	6.7	6.7	3.3	3.0	1.3	1.7	1.7	11.0	1.0	0.3	4.3	2.3	1.7	0.7	1.0	2.7	2.0	17.7	35.3
Pendimethalin* (1000) *fb* bispyribac sodium (25)	9.3	9.3	2.0	2.0	3.3	3.3	2.0	12.7	0.3	1.0	4.0	3.7	1.3	1.3	1.7	1.0	0.7	18.7	40.7
Pyrazosulfuron ethyl (20) *fb* bispyribac sodium (25)	8.3	8.3	6.0	4.0	0.7	1.3	0.0	12.0	2.7	0.3	4.3	1.3	2.0	0.3	1.3	0.7	1.0	19.3	40.3
Pendimethalin* (1000) *fb* penoxsulam + cyhalofop butyl (135) (RM)	16.0	16.0	3.3	4.3	2.0	4.0	2.0	15.7	0.3	0.7	6.3	2.3	2.0	1.7	2.7	0.3	2.0	25.7	57.3
Three mechanical weedings (20, 40, 60 DAS)	7.0	7.0	2.7	2.0	1.3	2.0	2.7	10.7	0.7	1.0	1.3	1.0	1.7	2.3	0.7	2.0	1.0	13.0	30.7
Hand weedings (20,40, 60 DAS)	2.0	2.0	1.7	1.3	2.7	1.3	0.0	7.0	0.3	0.7	0.7	1.3	2.0	1.3	0.7	0.0	0.7	9.0	18.0
Weedy check	22.0	22.0	5.3	11.3	5.3	2.0	2.0	26.0	2.7	2.0	8.0	15.3	8.0	2.0	2.0	2.0	2.7	51.7	99.6

Data averaged over three replications and two spots per replication

Sedge: Cr- *Cyperus rotundus,* Grasses: Cd-*Cynoadon dactylon*, Dm - *Digitaria marginata,* Ec - *Echinochloa colona,* Clb-*Chloris barbata;* Broad leaf weeds: Ah-*Acanthospermum hispida,* Bh- *Borreria hispida*, Cb-*Commelina benghalensis*, Es-*Emilia sanchifolium*, Lm-*Lagasca mollis*, Eg - *Euphorbia geniculata,* Eh-*Euphorbia hirta,* Ac -*Ageratum conyzoids,* Tp-*Tridax procumbens.*

*The total of grasses and broad leaf weeds includes values of other minor weeds also which are not mentioned in total

TABLE II

Weeds' density and dry weight – category wise (sedge, grasses and broad leaf weeds) at 60 days after sowing in dry direct seeded rice as influenced by different herbicide combinations

	Treatments	Weeds' density (No. m^{-2})				Weeds' dry weight (g m^{-2})			
		Sedges#	Grasses#	Broad leaf #	Total #	Sedges#	Grasses#	Broad leaf #	Total #
T_1	Bensulfuron methyl + pretilachlor (60+600) *fb* triafamone + ethoxysulfurn (60) (RM)	0.82 (4.7)	1.08(10.0)	1.07(10.7)	1.42(25.3)	2.03(1.03)	3.24(2.24)	0.58 (2.94)	0.84 (6.21)
T_2	Oxadiargyl (100) *fb* triafamone + ethoxysulfuron	0.96 (7.7)	1.15(13.0)	1.27(16.7)	1.59(37.3)	3.27 (2.27)	5.06(4.07)	0.76 (4.81)	1.08 (11.15)
T_3	Pendimetalin *fb* triafamone (1000) + ethoxysulfuron (60) (RM)	1.04 (9.0)	1.12 (11.3)	1.33(19.3)	1.62(39.6)	4.63(3.63)	5.07(4.07)	0.84 (5.94)	1.17 (13.64)
T_4	Pyrazosulfuron ethyl (20) *fb* triafamone + ethoxysulfuron (60) (RM)	0.96 (7.3)	1.11(12.0)	1.34(20.0)	1.61(39.3)	3.83(2.83)	5.27(4.27)	0.91 (7.17)	1.18 (14.27)
T_5	Bensulfuron-methyl + pretilachlor (60 + 600) *fb* bispyribac sodium (25)	0.73 (3.3)	0.98 (7.7)	1.02 (9.3)	1.34(20.3)	1.90(0.90)	3.17(2.17)	0.54 (2.50)	0.82 (5.57)
T_6	Oxadiargyl (100) *fb* bispyribac sodium (25)	0.93 (6.7)	1.11 (11.0)	1.27(17.7)	1.56(35.3)	2.83(1.83)	4.97(3.97)	0.73 (4.38)	1.04 (10.19)
T_7	Pendimethalin* (1000) *fb* bispyribac sodium (25)	1.05 (9.3)	1.16(12.7)	1.28(18.7)	1.62(40.6)	4.07(3.07)	5.34(4.34)	0.83 (5.95)	1.15 (13.35)
T_8	Pyrazosulfuron ethyl (20) *fb* bispyribac sodium (25)	1.01 (8.3)	1.13(12.0)	1.32(19.3)	1.62(39.6)	4.47(3.47)	5.20(4.20)	0.88 (6.57)	1.18 (14.23)
T_9	Pendimethalin* (1000) *fb* penoxsulam + cyhalofop butyl (135) (RM)	1.25(16.0)	1.23(15.7)	1.44(25.7)	1.77(57.3)	5.33(4.33)	11.46(10.4)	0.85 (6.13)	1.34 (20.93)
T_{10}	Three mechanical weedings (20, 40, 60 DAS)	0.94 (7.0)	1.09(10.7)	1.17(13.0)	1.51(30.6)	3.02(2.02)	4.84(3.84)	0.70 (4.00)	1.04 (9.86)
T_{11}	Hand weedings (20,40, 60 DAS)	0.59 (2.0)	0.92 (7.0)	1.00 (9.0)	1.30(18.0)	1.56(0.56)	3.11 (2.11)	0.53 (2.55)	0.79 (5.23)
T_{12}	Weedy check	1.37(22.0)	1.45(26.0)	1.72(51.7)	2.01(99.6)	7.80(6.80)	19.46(18.4)	1.39(23.67)	1.70 (48.93)
	S.Em±	0.05	0.08	0.09	0.05	0.46	0.58	0.05	0.04
	CD(P=0.05)	0.15	0.22	0.25	0.15	1.34	1.70	0.14	0.12

Data within the parentheses are original values; Transformed values - # = log (X+2), + = square root of (X+1).

*Pendimethalin (Stomp extra 38.7% CS) , RM: Ready Mix, fb: Followed by Spray volume: 750 L ha^{-1} for pre-emergence and 500 L ha^{-1} for post-emergence herbicides.

TABLE III

Grain, straw yield and weed index in dry direct seeded rice as influenced by different herbicide combinations.

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Weed Index (%)
T_1 Bensulfuron methyl + pretilachlor (60+600) *fb* triafamone + ethoxysulfurn (60) (RM)	4.95	6.86	4.20
T_2 Oxadiargyl (100) *fb* triafamone + ethoxysulfuron (60) (RM)	4.11	6.06	20.36
T_3 Pendimetalin *fb* triafamone (1000) + ethoxy sulfuron (60) (RM)	3.89	6.01	24.73
T_4 Pyrazosulfuron ethyl (20) *fb* triafamone + ethoxy sulfuron (60) (RM)	4.04	6.08	21.74
T_5 Bensulfuron-methyl + pretilachlor (60 + 600) *fb* bispyribac sodium (25)	5.04	7.07	2.45
T_6 Oxadiargyl (100) *fb* bispyribac sodium (25)	4.15	6.04	19.71
T_7 Pendimethalin* (1000) *fb* bispyribac sodium (25)	4.16	6.04	19.50
T_8 Pyrazosulfuron ethyl (20) *fb* bispyribac sodium (25)	4.21	6.13	18.57
T_9 Pendimethalin* (1000) *fb* penoxsulam + cyhalofop butyl (135) (RM)	3.90	6.06	24.49
T_{10} Three mechanical weedings (20, 40, 60 DAS)	4.11	6.11	20.43
T_{11} Hand weedings (20,40, 60 DAS)	5.17	7.13	0.00
T_{12} Weedy check	1.31	2.29	74.55
SEm±	0.20	0.33	
LSD(P=0.05)	0.59	0.96	NA

*Pendimethalin (Stomp extra 38.7% CS), RM: Ready Mix, fb: Followed by Spray volume: 750 L ha^{-1} for pre-emergence and 500 L/ha for post-emergence herbicides

Weed density (number m^{-2}) and dry weight (g m^{-2})

Among different category of weeds, in unweeded control the density and dry weight of broad leaf weeds (51.7 m^{-2} and 23.67 g m^{-2}) was higher followed by grasses (26.0 m^{-2} and 18.4 g m^{-2}) and sedges (22.0 m^{-2} and 6.80 g m^{-2}, respectively) at 60 DAS (Table II). Effective control of weeds was noticed at 60 DAS with application of bensulfuron-methyl + pretilachlor (60 + 600 g ha^{-1}) as pre-emergence *fb* bispyribac sodium (25 g ha^{-1}) at 25 DAS followed by bensulfuron methyl + pretilachlor (60 + 600 g ha^{-1}) as pre-emergence *fb* triafamone + ethoxysulfurn (60 g ha^{-1}at 25 DAS) as evident from the reduced weed density and dry weight due broader spectrum of effective on major weed flora. All these herbicide mixtures were superior to unweeded control in reducing the weeds' density and dry weight. The results are in conformity with the results obtained by Kumaran *et al.,* 2015.

Paddy grain yield and weed index

Significantly higher paddy grain and straw yield was recorded in hand weeding at 20, 40 and 60 DAS (5.17 and 7.13 t ha^{-1}) because of complete removal of weeds that resulted in the reduced weed competition and improved growth and yield parameters. Similar results are reported by Madukumar (2011), which was found on par with application of bensulfuron-methyl + pretilachlor (60 + 600 g ha^{-1}) as pre-emergence *fb*

TABLE IV
Economics of dry direct seeded rice as influenced by different herbicides combinations.

	Treatments	Cost of Cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C Ratio
T_1	Bensulfuron methyl + pretilachlor (60+600) *fb* triafamone + ethoxysulfurn (60) (RM)	31,325	84,931	53,607	2.71
T_2	Oxadiargyl (100) *fb* triafamone + ethoxysulfuron (60) (RM)	30,155	71,681	41,526	2.38
T_3	Pendimetalin *fb* triafamone (1000) + ethoxysulfuron (60) (RM)	30,055	68,587	38,532	2.28
T_4	Pyrazosulfuron ethyl (20) *fb* triafamone + ethoxysulfuron (60) (RM)	30,590	70,798	40,208	2.31
T_5	Bensulfuron-methyl + pretilachlor (25) (60 + 600) *fb* bispyribac sodium	31,458	86,743	55,285	2.76
T_6	Oxadiargyl (100) *fb* bispyribac sodium (25)	31,155	72,037	40,882	2.31
T_7	Pendimethalin* (1000) *fb* bispyribac sodium (25)	31,243	72,181	40,938	2.31
T_8	Pyrazosulfuron ethyl (20) *fb* bispyribac sodium (25)	30,133	73,081	42,948	2.43
T_9	Pendimethalin* (1000) *fb* penoxsulam + cyhalofop butyl (135) (RM)	31,265	68,882	37,617	2.20
T_{10}	Three mechanical weedings (20, 40, 60 DAS)	32,515	71,777	39,262	2.21
T_{11}	Hand weedings (20,40, 60 DAS)	35,585	88,555	52,970	2.49
T_{12}	Weedy check	27,358	23,962	-3,395	0.88

*Pendimethalin (Stomp extra 38.7% CS), RM: Ready Mix, fb: Followed by Spray volume: 750 L ha^{-1} for pre-emergence and 500 L/ha for post-emergence herbicides
Men Labour: Rs. 250 per day; Women Labour: Rs. 200 per day, Herbicide application cost: Rs. 600 ha^{-1}; Selling price of produce: Paddy grain: Rs. 13000 t^{-1}, Straw: Rs. 3000 t^{-1}.

bispyribac sodium (25 g ha^{-1}) at 25 DAS (5.04 t ha^{-1}) and (7.04 t ha^{-1}), respectively, followed by bensulfuron methyl + pretilachlor (60 + 600 g ha^{-1}) as pre-emergence *fb* triafamone + ethoxysulfurn (60 g ha^{-1}) at 25 DAS (4.95t ha^{-1}) and (6.86 t ha^{-1}), respectively. These herbicides are highly effective in suppressing the major weed flora with lower weed density and weed dry weight. Thus, reduced the competition for light, water and nutrients between crop and weeds. Similar results were obtained by Vijay Singh *et al.*, 2016. Unweeded control gave the lowest paddy grain yield (1.31t ha^{-1}), due to severe competition from all types of weeds. Lower weed index was observed in pre-emergence application bensulfuron-methyl + pretilachlor (60 + 600 g ha^{-1}) *fb* bispyribac sodium (25 g ha^{-1}) at 25 DAS (2.45 %) followed by bensulfuron methyl + pretilachlor (60 + 600 g ha^{-1}) as pre-emergence *fb* triafamone + ethoxysulfurn (60 g ha^{-1}) at 25 DAS (4.20 %) (Table III).

Economics

Economics is the ultimate criteria for acceptance and wider adoption of any technology. Among different indicators of economics, efficiency in any production system, net returns and B:C ratio have greater impact on the practical utility and acceptance of the technology by the farmers. In the present study, comparative economics of different weed management practices are indicated in Table IV. Herbicide mixtures were cheaper than hand weeding.

The higher net returns and B:C ratio was obtained in application of bensulfuron-methyl + pretilachlor (60 + 600 g ha^{-1}) as pre-emergence *fb* bispyribac sodium (25 g ha^{-1}) at 25 DAS (` 55,285 $ha^{-1}$ and 2.76) followed by bensulfuron methyl + pretilachlor (60 + 600 g $ha^{-1}$) as pre-emergence *fb* triafamone + ethoxysulfurn (60 g $ha^{-1}$) at 25 DAS (` 53,607 and 2.71) due to improved yield and reduced cost of weed management. Whereas, it was only ` 52,970 ha^{-1} and 2.49 in hand weeding plots. The lowest B:C ratio (0.88) was obtained in the weedy check plots. Similar findings have been reported by Prameela *et al*., 2014.

Among herbicide combinations, application of bensulfuron-methyl + pretilachlor (60 + 600 g ha^{-1}) as pre-emergence *fb* bispyribac sodium (25 g ha^{-1}) at 25 DAS and bensulfuron methyl + pretilachlor (60 + 600 g ha^{-1}) as pre-emergence *fb* triafamone + ethoxysulfurn (60 g ha^{-1}) at 25 DAS were found better in controlling weeds along with obtaining higher paddy grain yield and economic returns.

References

Anonymous, 2015, Fourth advance estimates of production of food grains for 2013-14 Agricultural Statistics Division, Directorate of Economics and Statistics, Department of Agriculture and Cooperation.

Bhat, I. A., Dileep, K. and Bazaya, B. R., 2011, Studies on the effect of weed management practices on drum seeded wet rice (*Oryza sativa* L.). *J. Res.*, **10** (2) : 71-77.

Fai, 2011, Fertilizer statistics. Indian Agriculture and Allied Fibres. Part 2. *The Fertilizer Association of India*, New Delhi.

Gomez, K. A. and Gomez, A. A., 1984, Statistical procedure for agricultural research. *An. Int. Rice Res. Inst. book*, a willey – inter Science, John wiley and sons Inc. New York, United states of America.

Gill, H. S. and Vijayakumar,1969, Weed index- a new method for reporting weed control trials. *Indian J. Agron.*,**14** (1) : 96-98.

Kachro, D. and Bazaya, B. R., 2011, Efficacy of different herbicide on growth and yield of direct wet seeded rice sown through drum seeder. *Indian J. Weed Sci.*, **43** (1&2): 67-69.

Kumaran, S. T., Kathiseran, P., Muraliarthanari, C., Chinnusamy and Sanjivkumar, V., 2015, Efficacy of new herbicide (bispyribac sodium 10% SC) against different weed flora, nutrient uptake in rice and their residual effects on succeeding crop of green gram under zero tillage. *J. Appl. and Nat. Sci*., **7** (1) : 279 – 285.

Madukumar, V., 2011, Evaluation of pre and post emergent herbicides in aerobic rice. *M. Sc. (Agri.) Thesis*., Univ. Agric. Sci., Bangalore.

Mallikarjun, Channabasavanna, A. S., Sudheendra, S. and Shrinivas, C. S., 2014, Effect of herbicides on weed control and yield of wet seeded rice (*Oryza sativa* L.). *The Bioscan*, **9**(2) : 581-583.

Prameela, P., Syama Menon, S. and Meera Menon, V., 2014, Effect of post emergence herbicides on weed dynamics in wet seeded rice. *J. Tropical Agri.*,**52**(1) : 94-100.

Seema, Krishna, M. and Devi, M. T. T., 2014, Effect of nitrogen and weed management on nutrient uptake by weeds under direct seeded aerobic rice. *The Bioscan*, **9**(2) : 535-537.

Singh, M. and Singh, R. P., 2010, Influence of crop establishment methods and weed management practices on yield and economics of direct-seeded rice (*Oryza sativa* L.). *Indian J. Agron.*, **55**(3) : 224- 229.

Timmer and Peter, C., 2010, The changing role of rice in asia's food security. ADB Sustainable Development Working Paper Series. *Asian Develop. Bank*. **15** : 18.

Vijay Singh, Mangi Jat, L., Zaoor Ganie, A., Bhagirath, S., Chauhan and Raj Gupta, K., 2016, Herbicide options for effective weed management in dry direct seeded rice under scented rice-wheat rotation of western Indo-Gangetic plains. *Crop Protec*., **81**(5) : 168-176.

(*Received :* May, 2018 *Accepted :* June, 2018**)**