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Integrated weed management for control of complex weed flora in direct-seeded upland rice under Southern transition zone of Karnataka

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ABSTRACT

A field experiment was conducted during summer 2014 and 2015 at Agriculture and Horticultural Research Station, Kathalagere Davanagere district (Zone-7, Southern Transition Zone, Karnataka), to study the effect of various weed management practices on weed density, weed dry weight, yield and economics of direct seeded rice. The experiment consists of ten treatments replicated thrice in a randomized complete block design. Among the various treatments, three hand weeding (20,40 and 60 DAS) recorded significantly higher rice grain (4.04 t/ha and 3.64 t/ha) and straw (6.3 t/ha and 6.52 t/ha) yields in 2014 and 2015, respectively and it was found at par with pendimethalin 1.0 kg/ha at 2 DAS *fb* bispyribac sodium 25 g/ha *fb* manual weeding (3.87 t/ha, 6.0 t/ha in 2014 and 3.5 t/ha and 6.4 t/ha in 2015, respectively). Higher net returns and benefit: cost ratio of ` 28965 and 2.0 and ` 41402 and 2.4 in 2014 and 2015, respectively were obtained with pendimethalin 1.0 kg/ha *fb* bispyribac sodium 25 g/ha as post-emergence with manual weeding.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important food crops of the world and it is the staple food of about half the world’s population. India is the second largest rice producing country in the world with an area of 43.4 Mha and produced 104.3 Mt of rice with a productivity of 2404 kg/ha (Anonoymus 2016) It is one of the most important food crops of India which is evident from the fact that 29.9% of the total calories comes from this crop (Timmer 2010). Of the four ecologies of rice culture in India, irrigated ecology spreading over 26.54 million ha *i.e.* 58.7% of total acreage (FAI, 2011) contributes to over 75% of production. Rice yield growth has slowed considerably in recent years and has failed to keep up with population growth, leading to shortages and higher prices that have adversely affected the poor. This was demonstrated by the food crisis and the rice price spike experienced in 2008. Clearly, food security remains somewhat tenuous despite the rapid economic growth experienced in many parts of the world (Sushil *et al.* 2010).

Transplanted rice cultivation has become uneconomical due to escalating labour costs and non availability of timely labour. To overcome these problems especially that of human labour involved in transplanting, 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. In direct-seeded rice, seeds are sown manually in rows on well prepared field requires only 1-2 labour/ha. It eliminates the nursery raising, puddling and transplanting operations and thus 25% (250-300 man hours) of total human labour involved in rice cultivation were reduced making rice cultivation more profitable, with no major problems with respect to water management. Success of dry seeding entirely depends on efficient weed management. The yield loss in DSR is as high as 50-60% due to simultaneous germination of both crop and weeds seeds (Pinjari *et al*. 2016). Weed management in direct-seeded rice can be accomplished by mechanical, cultural and chemical methods. Mechanical method of weed control consisting of repeated weeding and hoeing by use of hand hoe is effective, but labour intensive and reduces the benefit: cost ratio. Hence, for direct-seeded rice, the chemical method of weed management is a good option (Sahu and Singh 2011). Weeds in direct-seeded rice emerge almost at the same time as that of the crop and start competing with crop from very beginning, Hence weed management by herbicide is more critical. Therefore, an experiment was conducted with an objective to find the best herbicide combinations to manage weeds effectively in direct seeded rice.

MATERIALS AND METHODS

A field experiment was conducted during summer 2014 and 2015 to know the bio-efficiency of combination of herbicides against complex weed flora, and their effect on growth and yield of direct seeded rice under upland condition. The field study was conducted at the Agricultural Research Station, Kathalagere, Davanagere District (Zone-7, Southern Transition Zone, Karnataka), under the jurisdiction of the University of Agricultural Sciences, Bengaluru. The soil type was sandy clay loam. The treatment combinations tested were bispyribac-sodium 25 g/ha at 20 DAS, pendimethlain 1000 g/ha (2 DAS) *fb* bispyribac-sodium 25 g/ha at 25 DAS, oxadiargyl 100 g/ha at 2 DAS *fb* bispyribac-sodium 25 g/ha at 25 DAS, pyrazosulfuron-ethyl 20 g/ha at 3 DAS *fb* bispyribac-sodium 25 g/ha at 25 DAS, pendimethlain 38.7 CS, 1000 g/ha (2 DAS) *fb* bispyribac 25 g/ha at 25 DAS *fb* manual weeding at 45 DAS, pendimethlain 1000 g/ha (2 DAS) *fb* manual weeding at 30 DAS, at bispyribac-sodium 25 g/ha + chlorimuron-ethyl + metsulfuron-methyl 4 g/ha at 20 DAS, mechanical weeding (conoweeding at 20, 40 and 60 DAS) hand weeding (20, 40 and 60 DAS), unweeded control. These treatment combinations were replicated thrice in randomized complete block design.

Rice variety '*JGL-1798*' was sown at a common spacing of 20 x 10 cm and fertilizer level of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha. The gross and net plot sizes were 3.6 x 3.0 m and 3.0 x 2.6 m, respectively. The herbicides were applied using spray volume of 500 L/ha and 375 L/ha with knapsack sprayer having flood jet nozzle. The data on species wise weed count in a quadrate of 50 x 50 cm were collected on 30, 60 and 90 DAS (days after sowing). From this, density of major weed species/m^2 (sedges, grass and broad-leaf weeds) was worked. In addition, dry weight of weeds' category – sedges, grass and broad-leaf weeds (g/m^2) was also collected at 30, 60 DAS and at harvest. The data on weeds' density and dry weight were analyzed using transformation of square root of $(\sqrt{x+1})$ and log $(\sqrt{x+2})$, depending on the variability. At harvest, the data on rice yield, straw yield and number of panicles/m^2 were collected. In addition, the economics of weed management practices were also calculated based on the prevalent market prices of the inputs used. 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).

RESULTS AND DISCUSSION

Weed flora

Major weed flora observed in the experimental plots were *Cyperus rotundus* (sedge), *Digitaria marginata, Echinolchloa colona* (among grasses); whereas among broad-leaf weeds, *Borreria articularis, Spilanthes acmella, Commelina benghalensis, Ageratum conyzoides, Euphorbia geniculata* and *Euphorbia hirta* were dominant. Among the weed species, the densities of *Cyperus rotundus, Digitaria marginata, Echinolchloa colona, Spilanthes acmella, Euphorbia geniculata* and *Ageratum conyzoides* were more than other weed species indicating their dominance and competitiveness with the direct-seeded rice in both the years.

Weed density and dry weight

Among different category of weeds, density and dry weight of broad-leaf weeds was higher plots in weedy followed by grasses and sedges at 60 after DAS in weedy (**Table 1**). At 60 DAS, hand weeding at 20, 40 and 60 DAS recorded significantly lowest total weed density in both the years and it was found at par with pre-emergence application of pendimethalin 1000 g/ha *fb* bispyribac-sodium 25 g/ha (20 DAS) *fb* manual weeding (45 DAS) as effectively reduced the density and dry-weight of weeds comparable to other treatments. Oxadiargyl 100 g/ha (3 DAS) *fb* bispyribac-sodium 25 g/ha (20 DAS) and perndimethlain 1.0/ha at 2 DAS *fb* manual weeding (30 DAS) also reduced the weed density and dry weight compared to application of bispyribac-sodium 25 g/ha + chlorimuron-ethyl + metsulfuron-methyl 4 g/ha (20 DAS) and bispyribac-sodium 25 g/ha alone since the latter treatments consisted of post-emergence herbicides. However, all these herbicide treatments significantly lowered the weed density as compared to weedy. Effective control of weeds with combination of pendimethalin 1000 g/ha at 3 DAP *fb* bispyribac-sodium 25 g/ha (20 DAS) *fb* manual weeding (45 DAS) and pyrazosulfuron-ethyl 20 g/ha *fb* bispyribac-sodium 25 g/ha (20 DAS) was noticed at 60 DAS as evident from the reduced weed density and dry weight. These findings were in conformity to Sangeetha (2006) and Brar and Bhullar (2012).

Phytotoxicity

None of the herbicides caused phytotoxicity to rice in terms of yellowing, curling, epinasty, hyponasty, and wilting symptoms in both the years.

Table 1. Weeds density (no./m²) and weeds dry weight (g/m²) as influenced by weed management practices in direct-seeded rice at 60 DAS during 2014 and 2015

Treatment	Weed density				Weed dry matter			
	Grasses	Sedges	Broad-leaf	Total	Grasses	Sedges	Broad-leaf	Total
2014								
Bispyribac-sodium	3.88(14.3)	2.21(12.9)	1.51(35.9)	1.79(63.1)	2.66(6.2)	2.72(6.5)	1.29(20.9)	1.53(33.5)
Pendimethalin *fb* bispyribac-Na	2.60(6.3)	1.89(19.6)	1.19(13.5)	1.62(39.4)	1.66(1.9)	2.91(7.7)	0.96(7.2)	1.27(16.8)
Oxadiargyl *fb* bispyribac-Na	2.85(7.3)	1.96(14.6)	1.22(15.9)	1.59(37.8)	1.98(3.0)	2.79(6.9)	1.12(12.0)	1.36(21.9)
Pyrazosulfuron *fb* bispyribac-Na	3.50(12.0)	2.11(10.6)	1.18(16.0)	1.58(38.6)	2.13(3.7)	2.24(4.1)	1.00(9.6)	1.25(17.4)
Pendimethalin *fb* bispyribac-Na *fb* manual weeding	2.29(4.3)	1.81(7.0)	1.21(14.9)	1.45(26.2)	1.42(1.0)	1.86(2.5)	0.96(7.5)	1.11(11.1)
Pendimethalin *fb* manual weeding	2.75(6.7)	1.94(13.0)	1.45(27.8)	1.68(47.5)	1.94(2.8)	2.60(6.2)	1.17(13.6)	1.38(22.6)
Bispyribac + (chlorimuron + metsulfuron)	3.55(12.3)	2.12(16.9)	1.36(21.5)	1.71(50.7)	2.36(4.8)	2.97(8.0)	1.24(15.6)	1.47(28.4)
Three cono weeding	2.05(4.0)	1.73(7.0)	1.09(10.5)	1.35(21.5)	1.38(1.0)	1.85(2.5)	0.87(5.5)	1.03(9.0)
Three hand weeding	1.95(3.0)	1.71(5.9)	1.01(9.9)	1.29(18.8)	1.28(0.7)	1.73(2.0)	0.79(4.7)	0.95(7.4)
Weedy	5.11(27.3)	2.45(42.6)	1.77(57.2)	2.11(127)	4.07(16.9)	5.29(27.3)	1.68(47.0)	1.97(91.3)
LSD (p=0.05)	1.66	0.38	0.36	0.25	1.06	0.82	0.33	0.25
2015								
Bispyribac-sodium	3.87(14.3)	2.20(35.7)	1.63(40.7)	1.96(90.6)	2.90(7.6)	4.71(21.8)	5.73(32.5)	1.80(61.9)
Pendimethalin *fb* bispyribac-Na	2.85(7.3)	1.96(17.7)	1.55(34.0)	1.78(59.0)	1.95(2.9)	2.91(7.6)	4.78(22.1)	1.53(32.6)
Oxadiargyl *fb* bispyribac-Na	2.55(5.7)	1.88(16.3)	1.52(32.3)	1.74(54.3)	1.75(2.1)	2.66(6.7)	4.52(20.4)	1.47(29.2)
Pyrazosulfuron *fb* bispyribac-Na	3.03(8.3)	2.00(17.7)	1.60(39.0)	1.83(65.0)	2.09(3.4)	2.98(8.1)	5.14(26.5)	1.59(38.1)
Pendimethalin *fb* bispyribac-Na *fb* manual weeding	2.10(3.7)	1.75(12.0)	1.47(29.3)	1.66(45.0)	1.49(1.3)	2.31(4.4)	4.08(16.1)	1.36(21.9)
Pendimethalin *fb* manual weeding	3.21(9.7)	2.05(20.0)	1.62(41.0)	1.85(70.7)	2.24(4.2)	3.24(9.6)	5.36(28.3)	1.63(42.0)
Bispyribac-Na + (chlorimuron + metsulfuron)	3.44(11.3)	2.10(24.3)	1.68(47.7)	1.91(83.3)	2.58(5.9)	3.76(13.4)	6.01(37.2)	1.73(56.5)
Three cono weeding	2.84(7.7)	1.95(21.3)	1.68(48.3)	1.89(77.3)	2.05(3.5)	3.45(11.1)	5.72(33.8)	1.68(48.4)
Three hand weeding	2.06(3.3)	1.75(9.7)	1.39(23.3)	1.58(36.3)	1.43(1.1)	2.09(3.4)	3.53(12.1)	1.24(16.6)
Weedy	5.41(29.3)	2.52(43.7)	1.95(88.3)	2.21(161)	4.41(19.1)	5.67(31.4)	9.25(86.6)	2.14(137.1)
LSD (p=0.05)	1.27	0.30	0.21	0.10	0.86	0.80	2.07	0.21

Data within the parentheses are original values; Transformed values - - # log $=\sqrt{x+2}$, + = square root of ($\sqrt{x+1}$); DAS = Days after sowing

Table 2. Number of panicles/m² at harvest, rice yield, straw yield (t/ha), weed index and economics of direct-seeded rice as influenced by weed management practices during 2014 and 2015

Treatment	No. of panicles/m²		Rice grain yield t/h		Straw yield t/ha		Weed index (%)		Net returns (x10³ `/ha)		B:C Ratio	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Bispyribac-sodium	197	142	2.83	2.07	4.51	3.73	30.1	43.1	16.86	28.63	1.6	2.1
Pendimethalin *fb* bispyribac-Na	240	209	3.33	3.40	5.22	6.15	17.6	6.5	22.33	42.56	1.8	2.5
Oxadiargyl *fb* bispyribac-Na	228	215	3.22	3.42	5.13	6.21	20.3	6.0	21.42	14.65	1.8	1.5
Pyrazosulfuron *fb* bispyribac-Na	250	207	3.55	3.39	5.59	6.05	12.1	6.8	26.71	31.96	2.0	2.2
Pendimethalin *fb* bispyribac-Na *fb* manual weeding	272	224	3.87	3.55	5.99	6.44	4.4	2.4	28.96	41.40	2.0	2.4
Pendimethalin *fb* manual weeding	206	205	3.00	3.13	4.74	6.04	25.7	14.0	19.62	26.28	1.7	2.0
Bispyribac-Na + (chlorimuron + metsulfuron)	219	183	3.12	2.92	4.97	5.46	22.7	19.7	20.44	31.84	1.7	2.2
Three cono weeding	265	196	3.76	3.10	5.89	5.64	6.9	14.8	27.44	26.89	1.9	1.9
Three hand weeding	289	231	4.04	3.64	6.37	6.52	0.0	0.0	28.70	39.20	1.9	2.2
Weedy	51	60	0.44	0.58	0.75	1.45	89.2	84.0	-17.38	-13.42	0.3	0.4
LSD (p=0.05)	34.72	34.7	0.57	0.55	0.82	0.94	-	-	-	-	-	-

NA: Not analysed; Cost of herbicides: Pendimethalin 38.7 EC - ` 450/700 ml; oxadiargyl 80 WP- ` 248/35 g; chlorimuron-ethyl + metsulfuron-methyl 20 WP (almix 20 WP) - ` 350/20 g; pyrazosulfuron-ethyl 10 WP – ` 250/80 g; bispyribac-sodium 10% SC – ` 560/ 80 ml; herbicide application cost, ` 500/ha

Grain and straw yield

The data pertaining to number of panicles/m^2, rice grain yield, straw yield and weed index were presented (**Table 2**). Three hand weeding (20,40 and 60 DAS) recorded significantly higher rice grain 4.04 t/ha and 3.64 t/ha and straw yield 6.3 t/ha and 6.52 t/ha in 2014 and 2015, respectively as compared to all other treatments, and it was found at par with pendimethalin 1.0 kg/ha at 2 DAS *fb* bispyribac-sodium 25 g/ha at 20 DAS with manual weeding at 45 DAS (3.87 t/ha, 6.0 t/ha in 2014 and 3.5 t/ha and 6.4 t/ha in 2015) and cono weeding at 20, 40 and 60 DAS (3.76 t/ha, 5.9 t/ha and 3.10 t/ha and 5.64 t/ha) resulted in the lowest rice grain and straw yields (0.44 t/ha, 0.76 t/ha and 0.58 t/ha, 1.45 t/ha) during 2014 and 2015, respectively The increase in rice grain yield over weedy check due to different treatments was attributed to the reduced density and biomass of weeds at all stages of crop growth, which resulted in increased dry matter of rice, number of panicles/m^2 .These results were in accordance with Sangeetha (2006) and Singh and Pairka (2014).

Economics

Among different weed management practices, higher net returns of ` 28965/ha and ` 41402/ha was recorded in the pendimethalin 1.0 kg/ha *fb* bispyribac-sodium 25 g/ha with one manual weeding, during 2014 and 2015, respectively, along with higher benefit: cost ratio of 2.0 and 2.4 in summer 2014 and 2015 (**Table 2**). This result was obtained due to effective weed management at critical stages by integration of effective pre- and post-emergence herbicides along with manual weeding, which resulted in higher grain with reduced cost of cultivation. Similar findings have been also reported by Prameela *et al.* 2015.

It was concluded that integrated weed management consisting of pre-emergence application of pendimethalin 1.0 kg/ha *fb* post-emergence application of bispyribac-sodium 25 g/ha with one manual weeding at 45 DAS in direct-seeded rice was found most remunerative under Southern transition zone of Karnataka.

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