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Research Paper

Effect of weed-management practices on system of rice (*Oryza sativa*) intensification under southern dry zone of Karnataka

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ABSTRACT

A field experiment was conducted during the rainy season (*kharif*) of 2014 and 2015 at Zonal Agricultural Research Station, V.C. Farm, Mandya, Karnataka, to know the effect of weed-management practices on system of rice intensification (SRI) method of rice (*Oryza sativa* L.) cultivation under southern dry zone of Karnataka. The experiment consisted of 8 treatments, replicated thrice in a randomized complete block design. Among the various treatments, weed-free check recorded significantly higher grain yield (6.04 t/ha) and it was found at par with herbicide treatment, viz. pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR (Londax Power) @ 10 kg/ha *fb* post-emergence application of bispyribac sodium (Nominee Gold) @ 25 g/ha at 20 days after sowing (DAS) (5.53 t/ha). Among the weed the management practices, pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR (Londax Power) @ 10 kg/ha *fb* post-emergence application of bispyribac sodium (Nominee Gold) @ 25 g/ha at 20 days after sowing (DAS) found effective in control of all types of weeds and registered higher net monetary returns (₹53,270/ha) and benefit : cost ratio (2.80). Uncontrolled weed growth caused 49.5% reduction in grain yield.

Key words: Butachlor, Bispyribac-sodium, Economics, Sequential application, Weeds, Yield

Rice is the most important staple food crop of India. In India, rice is contributing 45% to the total foodgrain production and is grown in an area of 44.1 million ha with a production of 106.64 million tonnes and productivity of 2.42 t/ha. To sustain present food self sufficiency and to meet future food demands, India has to increase its rice productivity by 3% per annum. In India, manual method of transplanting is the most dominant and traditional method of crop establishment in irrigated lowland rice, which not only consumes more water but also causes wastage of water resulting in degradation of land. Water-resource limitations make traditional transplanting of rice with inundation of 5 cm of water throughout the crop growing period is not possible now a days. To mitigate this problem, many methods of cultivation have been developed, one among them is system of rice intensification (SRI) (Ramachandra *et al.,* 2012). The system of rice intensification is a new and promising resource saving method of growing rice under irrigated or rainfed conditions. Studies in a number of countries have shown a significant increase in rice yield, with substantial savings of seeds (80–90%), water (25–50%) and cost (10–20%) compared to conventional methods. The SRI is not a technology, but a set of simple ideas and principles that help produce more productive and robust plants.

The main features of this system are transplanting of young seedlings (10–14 days old) singly in a square with wide spacing using manures and fertilizers. 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 alternate wetting and drying of field. Timely unavailability of labours made weed management more difficult and costlier. Chemical weed control by using pre-emergence herbicides being cost effective and less labour dependent is recommended to overcome this constraint under SRI. Broad spectrum of weed flora may not be controlled by spraying pre-emergence herbicides alone, as flushes of weeds come up at different growth stages. Hence, use of sequential application of pre- *fb* post-emergence herbicides or pre-emergence herbicides *fb* manual weeding could be more convenient in containing the weed menace. By keeping above information in view, present

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investigation was carried out to study effect of the weed-management practices on system of rice intensification (SRI) method of rice cultivation under southern dry zone of Karnataka.

MATERIALS AND METHODS

A field experiment was conducted during the rainy season (*kharif*) 2014 and 2015 to find out effect of the weed management practices on system of rice intensification (SRI) method of rice cultivation under southern dry zone of Karnataka. The field study was conducted at the Zonal Agricultural Research Station, University of Agricultural Sciences, V.C. Farm, Mandya (12° 34.3' N, 76° 49.8' E, 697 m above mean sea-level). The soil of the experimental site was red sandy loams classified as Alfisols with bulk density and particle density of 1.15 g/cc and 2.65 g/cc respectively. The soil *p*H was 6.5 (neutral in reaction), electrical conductivity was 0.358 dS/m and organic matter content of 0.385%. It was low in available nitrogen (225 kg/ha), phosphorus (28 kg/ha) and potassium (126 kg/ha). Eight treatments, viz. bensulfuron-methyl 0.6% + pretilachlor 6% GR @ 10 kg/ha (PRE) + passing of conoweeder (CW), butachlor @ 1 kg/ha (PRE) + passing of CW, bensulfuron-methyl 0.6% + pretilachlor 6% GR @ 10 kg/ha (PRE) *fb* bispyribac sodium @ 25 g/ha (POST), butachlor @ 1 kg/ha (PRE) *fb* bispyribac sodium @ 25 g/ha (POST), bispyribac sodium @ 25 g/ha (EARLY POST). These weed control treatments were compared with hand weeding thrice at 20, 40 and 60 DAS, weedy and weed-free check. These 8 treatments were laid out in complete randomized block design with 3 replications.

Medium-duration rice variety 'Tanu' was grown as a test crop. Under SRI method of rice cultivation, 12 days old seedlings raised from rice mat nursery were transplanted with a spacing of 25 cm × 25 cm in both the seasons with a seed rate of 5 kg/ha. The crop was fertilized with 100-50-50 kg N-P_2O_5-K_2O/ha and 50% nitrogen, entire dose of phosphorus and potassium were applied as basal in addition to zinc sulphate @ 25 kg/ha. The remaining 50% of the nitrogen was top-dressed at 2 equal splits– at tillering and panicle initiation stage. The gross plot size was 5.0 m × 3.0 m. Pre-emergence herbicides were mixed with sand @ 100 kg/ha and applied uniformly in the field on 5 days after transplanting (DAT). A thin film of water was maintained at the time of pre-emergence herbicide application. The post-emergence herbicides were sprayed at 3–4 leaf stage of weeds by using knapsack sprayer fitted with deflector nozzle mixed with water @ 750 L/ha. Hand weeding was carried out as per the treatment schedule. The cono weeder is generally used in SRI for intercultural operation. All other agronomic and plant-protection measures were adopted as per the recommended packages of the UAS, Bengaluru. Bensulfuron-methyl 0.6% + pretilachlor 6% GR is combination of 2 herbicides and is in granular form and found safe to rice and sold in the trade name of Londax Power.

$$\text{WCE (\%)} = \frac{\text{Dry matter production of weeds in unweeded plot} - \text{Dry matter production of weeds in treated plot}}{\text{Dry matter production of weeds in unweeded plot}} \times 100$$

$$\text{WI (\%)} = \frac{\text{Yield from weed free plot} - \text{Yield from treated plot}}{\text{Yield from weed-free plot}} \times 100$$

The data on weed density and weed dry weight (at 30 and 60 DAS) were recorded with the help of quadrate (0.5 m × 0.5 m). The normality of distribution was not seen in case of observation on weeds, hence, the values were subjected to square-root transformation ($\sqrt{x+0.5}$) prior to statistical analysis to normalize their distribution. Data on plant height (at harvesting) and yield attributes like number of productive tillers, grain weight/panicle, 100-seed weight and grain yield were recorded. The weed-control efficiency was worked out on the basis of weed dry matter production using the formula suggested by Mani *et al.* (1973) and weed index was calculated by using the formula suggested by Gill and Vijayakumar (1969). All the data obtained in the study were statistically analyzed using F-test, the procedure given by Gomez and Gomez (1984), Critical difference values at P=0.05 were used to determine the significance of differences between means.

RESULTS AND DISCUSSION

Weed flora

The predominant weed flora associated with dry direct-seeded rice in experimental field were (in association with the direct-seeded dry sown rice), viz. *Cynodon dactylon* (4.72%), *Echinochloa colonum* (18.87%), *Panicum repens* (7.55%) and *Leptochloa chinensis* (5.66%) among grasses; *Ludwigia parviflora* (16.98%), *Commelina benghalensis* (11.32%), *Oxalis corniculata (*9.43%) and *Marsilea quadrifolia* (3.77%) among broad leaf weeds (BLW); and *Cyperus rotundus* (12.26%) and *Cyperus iria* (9.43%) among sedges.

Weed density and dry weight

All the weed-control treatments significantly reduced the density and dry weight of grasses, BLW, sedges and total weeds as compared to unweeded check (Tables 1, 2). Among different category of weeds, density and dry weight of broad leaf weeds (41.51%) was higher followed by grasses (36.79%) and sedges (21.70%). Among the weed the control treatments, hand-weeding thrice at 20, 40 and 60 DAS recorded significantly lower weed density and weed dry matter production as compared to the other treat-

Table 1. Density of weeds (No./m^2) as influenced by weed-management practices in system of rice intensification method at 30 and 60 days after sowing (pooled data of 2 years)

Treatment	Grasses	BLW	Sedges	Total	Grasses	BLW	Sedges	Total
	30 DAS				60 DAS			
Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha + 1 CW at 40 DAS	3.54 (12.01)	3.85 (14.33)	1.73 (2.48)	5.41 (28.81)	3.94 (14.99)	4.56 (20.25)	1.77 (2.65)	6.19 (37.88)
Butachlor @ 1 kg a.i./ha (PRE) + 1 CW at 40 DAS	3.77 (13.73)	4.45 (19.33)	2.05 (3.73)	6.10 (36.79)	4.30 (18.02)	5.07 (25.18)	2.13 (4.03)	6.91 (47.21)
Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha (PRE) + Bispyribac sodium @ 25 g a.i./ha	1.03 (0.59)	1.08 (0.68)	0.91 (0.33)	1.44 (1.60)	0.99 (0.50)	1.00 (0.53)	0.88 (0.28)	1.33 (1.30)
Butachlor @ 1 kg a.i./ha (PRE) + Bispyribac sodium @ 25 g a.i./ha	3.21 (9.81)	3.99 (15.43)	1.96 (3.35)	5.40 (25.58)	4.07 (16.05)	4.40 (18.81)	1.73 (2.56)	6.16 (37.42)
Bispyribac sodium @ 25 g a.i./ha (EARLY POST)	4.63 (20.95)	5.60 (30.88)	2.58 (6.24)	7.66 (58.07)	4.98 (24.37)	6.15 (37.36)	2.38 (5.21)	8.20 (66.93)
Hand-weeding thrice at 20, 40 and 60 DAS	1.68 (2.38)	2.68 (6.69)	1.11 (0.72)	3.21 (9.79)	2.68 (6.69)	3.45 (11.37)	1.26 (1.09)	4.43 (19.15)
Weed-free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy check	5.76 (32.74)	7.96 (63.18)	2.84 (7.70)	10.20 (103.6)	6.55 (42.58)	8.48 (71.37)	2.75 (7.07)	11.02 (121.0)
SEm±	0.13	0.18	0.11	0.13	0.15	0.12	0.10	0.14
CD (*P*=0.05)	0.38	0.54	0.33	0.38	0.45	0.36	0.30	0.41

*Square root (X+0.5) transformed values; CW, cono-weeder; BLW, broad leaf weed, DAS, days after sowing; values in the parentheses are original values.

Table 2. Dry weight of weeds (No. /m^2) as influenced by weed management practices in system of rice intensification method at 30 and 60 days after sowing (pooled data of 2 years)

Treatment	Grasses	BLW	Sedges	Total	Grasses	BLW	Sedges	Total
	30 DAS				60 DAS			
Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha + 1 CW at 40 DAS	1.66 (2.24)	1.29 (1.17)	1.31 (1.21)	2.26 (4.61)	1.80 (2.76)	2.01 (3.52)	1.67 (2.28)	3.01 (8.56)
Butachlor @ 1 kg a.i./ha (PRE) + 1 CW at 40 DAS	1.81 (2.75)	1.72 (2.45)	1.46 (1.65)	2.71 (6.85)	2.04 (3.65)	2.23 (4.46)	1.78 (2.67)	3.36 (10.77)
Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha (PRE) + Bispyribac sodium @ 25 g a.i./ha	0.86 (0.23)	0.86 (0.24)	0.81 (0.17)	1.06 (0.63)	0.85 (0.22)	0.89 (0.30)	0.86 (0.24)	1.12 (0.75)
Butachlor @ 1 kg a.i./ha (PRE) + Bispyribac sodium @ 25 g *a.i.*/ha	1.70 (2.40)	1.43 (1.58)	0.91 (0.33)	2.19 (4.31)	1.99 (3.47)	2.12 (4.01)	0.94 (0.39)	2.89 (7.86)
Bispyribac sodium @ 25 g a.i./ha (EARLY POST)	2.37 (5.10)	1.87 (2.98)	1.88 (3.02)	3.41 (11.10)	2.40 (5.29)	3.17 (9.73)	2.19 (4.30)	4.44 (19.32)
Hand-weeding thrice at 20, 40 and 60 DAS	1.26 (1.08)	0.89 (0.29)	1.03 (0.57)	1.56 (1.93)	1.49 (1.72)	1.39 (1.44)	1.56 (1.94)	2.37 (5.10)
Weed-free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy check	2.69 (6.74)	2.67 (6.64)	2.13 (4.02)	4.23 (17.39)	3.26 (10.09)	3.76 (13.63)	2.93 (8.16)	5.69 (31.88)
SEm±	0.07	0.08	0.05	0.05	0.07	0.13	0.08	0.11
CD (*P*=0.05)	0.19	0.23	0.16	0.16	0.20	0.38	0.25	0.33

*Square root (x+0.5) transformed values; CW, cono-weeder; BLW, broad leaf weed, DAS, days after sowing, values in the parentheses are original values.

ments. However, it was at par with pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha *fb* post-emergence application of bispyribac sodium 25 g/ha. However, the lowest weed density and dry weight of weeds were observed in weed-free check and the highest were recorded in weedy check. These results are in conformity with the findings of Sanodiya and Singh (2017), who reported that sequential application of bispyribac sodium after pre-emergence herbicide found effective in control of weeds in direct-seeded rice. The crop yield is directly proportional to weed-control efficiency. The weed- control efficiency at 60 DAS was maximum in pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha *fb* post-emergence application of bispyribac sodium 25 g/ha with a WCE of 97.60%. These results confirm findings of Sanodiya and Singh, 2017.

Growth, yield and yield-attributing characters

The data pertaining to plant height at harvesting (cm), no. of tillers at harvesting, grain weight/panicle (g), 100-seed weight (g), per cent choppiness, grain yield (t/ha) and weed index (%) varied significantly among the weed-management practices. All the weed-control treatments resulted in significantly higher grain yield than weedy check. Unweeded check registered 49.5% reduction in grain yield as compared to weed-free check due to sever competition offered by uncontrolled weeds for nutrients, soil moisture, space and light. Among the weed-control treatments, significantly higher grain yield (6.04 t/ha) was obtained with season-long weed-free check as compared to weedy check (3.05 t/ha) (Table 4). However, it was on par with pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR @ 10 kg/ha *fb* post-emergence application of bispyribac sodium @ 25 g/ha (5.53 t/ha) and hand-weeding thrice at 20, 40 and 60 DAS (5.80 t/ha). The superior performance of these treatments were mainly attributed to enhanced yield parameters, viz. number of tillers/plant, grain weight/panicle and 100-seed weight (Table 3). The increase in rice grain yield over weedy check owing 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 confirm the findings of Singh and Pairka (2014) and Sen *et al*. (2018). Pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR @ 10 kg/ha or butachlor *fb* 1 cono weeder failed to enhance the paddy grain yield significantly due to severe weed competition.

Economics

Among different weed-management practices, the

Table 3. Growth and yield parameters in system of rice intensification method as influenced by weed-management practices (pooled data of 2 years)

Treatment	Plant height at harvesting (cm)	No. of tillers at harvesting	Grain weight/ panicle (g)	100-seed weight (g)	Per cent choppiness	WCE (%)	
						30 DAS	60 DAS
Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha + 1 CW at 40 DAS	72.39	13.67	2.88	1.93	14.45	73.45	73.00
Butachlor @ 1 kg a.i./ha (PRE) + 1 CW at 40 DAS	72.58	12.65	2.47	1.74	19.55	60.65	65.85
Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha (PRE) + Bispyribac sodium @ 25 g *a.i.*/ha	80.99	15.14	3.18	2.13	12.35	96.40	97.60
Butachlor @ 1 kg a.i./ha (PRE) + Bispyribac sodium @ 25 g *a.i.* /ha	72.91	12.31	2.49	1.75	16.05	75.15	75.15
Bispyribac sodium @ 25 g a.i./ha (EARLY POST)	65.46	11.74	1.95	1.37	25.35	36.05	39.55
Hand-weeding thrice at 20, 40 and 60 DAS	84.14	16.78	3.35	2.22	9.35	88.90	83.85
Weed-free check	83.57	15.97	3.00	2.07	9.15	100.00	100.00
Weedy check	57.57	9.12	2.01	1.35	45.70	0.00	0.00
SEm±	3.66	0.75	0.12	0.07	1.10	-	-
CD (P=0.05)	11.10	2.26	0.36	0.20	3.30	-	-

CW, Cono-weeder; DAS, days after sowing; WCE, weed-control efficiency.

Table 4. Yield and economics of system of rice intensification method as influenced by weed-management practices (pooled data of 2 years)

Treatment	Grain yield (t/ha)	Weed index (%)	Net returns (× 10^3₹/ha)	Benefit: cost ratio
Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha + 1 CW at 40 DAS	5.38	7.00	49.86	2.62
Butachlor @ 1 kg a.i /ha (PRE) + 1 CW at 40 DAS	4.85	15.95	43.69	2.50
Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 10 kg/ha (PRE) + Bispyribac sodium @ 25 g a.i./ha	5.53	4.15	53.27	2.80
Butachlor @ 1 kg a.i./ha (PRE) + Bispyribac sodium @ 25 g a.i./ha	4.93	14.95	44.67	2.53
Bispyribac sodium @ 25 g a.i./ha (EARLY POST)	3.93	31.85	32.10	2.20
Hand-weeding thrice at 20, 40 and 60 DAS	5.80	3.95	53.65	2.45
Weed-free check	6.04	0.00	44.06	2.02
Weedy check	3.05	47.45	20.72	1.83
SEm±	0.19	-	-	-
CD (*P*=0.05)	0.57	-	-	-

CW, Cono-weeder; DAS, days after sowing.

higher net returns (₹53,270/ha) and B:C ratio (2.80) were recorded in pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR @ 10 kg/ha *fb* post-emergence application of bispyribac sodium @ 25 g/ha, while the lowest net returns (₹20,720/ha) and B:C ratio (1.83) in unweeded check (Table 4). The increased monetary benefits in these treatments were mainly attributed to higher grain yield and reduced labour cost. This result was obtained owing 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 yield with reduced cost of cultivation. Similar findings have also been reported by Prameela *et al*. (2014) and Dhanapal *et al.* (2018). Similar results of higher net returns and B:C ratio in SRI method owing to increased grain and straw yields, which clearly showed the influence of weed-free environment for crop growth and development were also reported by Rathika and Ramesh (2018).

On the basis of 2 years data, it was concluded that pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR @ 10 kg/ha *fb* post-emergence application of bispyribac sodium @ 25 g/ha was found most effective and economical in controlling the weeds in SRI method of rice cultivation in Cauvery Command area of Karnataka.

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