Indian Journal of Weed Science **52**(2): 183–186, 2020

Print ISSN 0253-8040 Online ISSN 0974-8164

Effect of live mulches and herbicides on weeds and yield of direct-seeded rice under irrigated conditions

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Article information

DOI: 10.5958/0974-8164.2020.00033.7

Type of article: Research note

Received : 1 March 2020
Revised : 2 June 2020
Accepted : 4 June 2020

Key words
Direct-seeded rice
Herbicides
Live mulch
Nutrient uptake
Sesbania

ABSTRACT

A field experiment was conducted at Mata Gujri College, Fatehgarh Sahib, Punjab during rainy season of 2017 to study the effect of live mulches and herbicides in direct-seeded rice under irrigated condition. The experiment was laid out in a split-plot design with three replications. The live mulch include *Sesbania rostrata*, *Vigna unguiculata* and *Sesamum indicum* while weed management treatments were pendimethalin 1.0 kg/ha (PE) *fb* bispyribac-Na 25 g/ha (PoE), bispyribac-Na 25 g/ha + carfentrazone 20 g/ha (PoE), bispyribac-Na 25 g/ha + ethoxysulfuron 18 g/ha (PoE) and pendimethalin 1.0 kg/ha (PE) along with weed free and weedy checks. Results indicated that higher yield attributes and yield were recorded under live mulch with *Sesbania rostrata*, which was statistically at par with live mulch with *Vigna unguiculata* and significantly superior over live mulch with *Sesamum indicum*. Among herbicides, application of bispyribac-Na 25 g/ha + carfentrazone 20 g/ha being at par with bispyribac-Na 25 g/ha + ethoxysulfuron 18 g/ha was significantly superior over other treatments.

Rice (*Oryza sativa* L.) is the principle source of food for more than half of the world population. Puddling and transplanting, the most common methods of rice establishment, require large amount of water (on an average 2500 litres) to produce 1.0 kg of rice (Bouman 2009), and amounts for about 30-40% of the total cost of cultivation (Chaudhary and Varshney 2003). Under this situation, direct-seeding of rice (DSR) seems a viable alternative in rescuing farmers (Farooq *et al*. 2011). The direct-seeding involves sowing of pre-germinated/soaked/dry seeds in wet (saturated) puddle/dry soils. Weed competition in DSR is, however a major problem that reduces the grain yield by 50-60% (Maity and Mukherjee 2008). Therefore, appropriate weed management strategies are required for the success of DSR. Brown manuring/live mulch helps smothering weeds, conserving moisture and adding about 15 kg N/ha without adding much on cost of production (Singh *et al.* 2007). Intercropping of green manuring crops with rice followed by killing them with post-emergence herbicides at 30 DAS reduces weed densities by about 40-50% (Gaire *et al*. 2013). It is a sustainable practice in suppressing weed growth and supplying nitrogen for soil fertility (Oyeogbe *et al.* 2017). The use of on-farm perennial leguminous species as mulching material can improve agricultural sustainability by limiting inputs (Mulvaney *et al*. 2017). Herbicides offer the most effective, economical and practical way of weed management. Pre-emergence herbicides in combination with post-emergence herbicides are needed to control weeds in DSR because of diverse weed flora. Application of pendimethalin 1.0 kg/ha *fb* bispyribac + carfentrazone (25 + 20 g/ha) was at par with pendimethalin 1.0 kg/ha *fb* bispyribac + ethoxysulfuron (25 + 18 g/ha) which was significantly superior over other treatments in respect to minimizing weed density and weed dry weight, weed index and maximizing weed control (Kumar and Singh 2018).

A field experiment was conducted at Mata Gujri College, Fatehgarh Sahib (Punjab), during *Kharif* season of 2017. The soil was alluvial having clay loam in texture with normal soil reaction (7.9), medium organic carbon (0.62%), medium available N (280.15 kg/ha), and medium in available P_2O_5 (30.84 kg/ha) and low available K_2O (130.84 kg/ha). The experiment was laid out in a split-plot design with 18 treatment combinations (3 live mulch and 6 weed management practices and three replications. The live mulch was subjected to main plots, *viz*. live mulch with *Sesbania rostrata*, *Vigna unguiculata* and

Sesamum indicum and weed management was kept in sub-plots, *viz*. weedy free, weed check, pendimethalin 1.0 kg/ha (PE) *fb* bispyribac-Na 25 g/ha (PoE), bispyribac-Na 25 g/ha + carfentrazone 20 g/ha (PoE), bispyribac-Na 25 g/ha + ethoxysulfuron 18 g/ha (PoE) and pendimethalin 1.0 kg/ha (PE). Recommended dose of N, P_2O_5 and K_2O were applied at 120, 60 and 40 kg/ha, respectively. Half of total nitrogen and full dose of phosphorus, and potassium were applied to rice crop as basal before sowing. Remaining half dose of nitrogen in the form of urea was top dressed in two equal splits, at active tillering and panicle initiation stages. Sowing was done manually with the help of spade at a row spacing of 20 cm. Rice variety '*PR 126*' was seeded directly in soil using 30 kg seed/ha on 12th June 2017. Direct-seeding was done by sowing pre-germinating seed in prepared seedbed. *S. rostrata*, *V. unguiculata* and *S. indicum were* sown on 14 June 2017 in the row spacing of rice using 50 kg/ha, 40 kg/ha and 4 kg/ha, respectively. The plot was kept moist for two weeks for establishment of seedlings by through irrigation and thereafter three irrigations were required applied. Pendimethalin was sprayed in the evening on the day of sowing while bispyribac-Na applied as mix tank with carfentrazone and ethoxysulfuron sprayed 25 days after sowing. The herbicides were sprayed with a knapsack sprayer fitted with flat-fan nozzle using spray volume of 500 L/ha. Weed density and weed dry weight data were collected at 30, 60, 90 DAS and at harvest stage. Weed density (no./m^2) was counted randomly from plot. Weed samples were sun dried for two days and kept in an oven drying at 70 ± 2 ^{0}C for 48 hours till their weight become constant. The data on weeds were subjected to square root transformation ($\sqrt{x+0.5}$) to normalize their distribution. Grain yield and its attributes were also recorded during the course of investigation at crop maturity.

Effect on density and dry matter of weeds

The major annual grasses in DSR were *Echinochloa crus-galli, Echinochloa colona* and *Leptochloa chinensis*, perennial sedge *Cyperus rotundus* and *C. iria* and broad-leaved weeds such as *Commelina diffusa* and *Caesulia axillaris*. The live mulch had no significant influences on the total density of different group of weeds (grasses, sedge and broad-leaved weed) at 30 DAS while it influenced significantly at 60, 90 DAS and at harvest stage. However, the total weed density, and their dry weight influenced significantly due to application of different live mulch treatments (**Table 1**). The data revealed that the minimum weed density and total weed dry matter were recorded under live mulch with *Sesbania rostrata* which was found at par with *V. unguiculata* and significantly inferior with *S. indicum*. This can be attributed to low vigorous growth of weeds due to smothering effect of *S. rostrata* and *V. unguiculata*. These mulches also fix atmospheric nitrogen into soil for better crop growth. Higher density and dry weight of weeds were recorded under live mulch with *S. indicum,* which might have been due to the fact that the treatment is not cover crop or leguminous crop. At initial stage of crop, it is unable to suppress the density and their dry weight of weeds. Poor establishment of crop due to higher density and their dry weight of weeds in these treatments was the some as reported earlier (Kumar and Singh 2016, Mulvaney *et al.* (2017).

Among herbicides, bispyribac-Na 25 g/ha + carfentrazone 20 g/ha was at par with bispyribac-Na 25 g/ha+ ethoxysulfuron 18 g/ha and it was significantly superior over others treatments in respect of minimizing weed density and their dry weight at different stages. This might be attributed to more bio-efficiency of bispyribac- Na which effectively controled the diversified weeds as was reported by Yadav *et al.* (2011).

Interaction effect of live mulch and weed management practices was found significant for total weed density and dry weight at 60 days after sowing (**Table 2**). Irrespective of weed control methods, minimum weed density and weed dry weight was recorded under mulching with *S. rostrata*. The minimum weed density and dry weight of weeds was recorded with application of bispyribac-Na 25 g/ha + carfentrazone 20 g/ha. Application of bispyribac-Na 25 g/ha + carfentrazone 20 g/ha combined with *S. rostrata* mulch was most effective in reducing the weed density and weed dry weight and found at par with bispyribac-Na 25 g/ha *fb* ethoxysulfuron 18 g/ha, but significantly superior over other treatments. These results were also in conformity with earlier findings (Singh *et al.* 2013, Kumar *et al.* 2015).

Weed control efficiency and weed index

The data clearly indicated that live mulch with *S. rostrata* (59.51%) recorded the highest WCE and closely to as similar to live mulch with *V. unguiculata* (56.67%). However, the minimum WCE was recorded in live mulch with *S. indicum* (54.81%) at 60 DAS (**Table 1**). Probably, *S. rostrata* was found most effective to suppress weed growth in term of density and their dry matter at all stages of crop growth over the *V. unguiculata* and *S. indicum*. Behera and Das (2019) also reported similar results. The weed control efficiency under bispyribac-Na 25

Table1. Effect of live mulch and weed management on total weed density, total weed dry weight, WCE and WI in direct-seeded rice

Treatment	Total weed density (no./m^2)				Dry matter of weeds (g/m^2) at DAS				WCE (%) at 60 DAS	WI (%)
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest		
Live mulche										
Live mulch with *Sesbania rostrata*	10.2(120)	10.4(122)	9.5(110)	10.2(127)	5.3(33)	9.5(112)	9.6(120)	9.9(123)	59.51	20.14
Live mulch with *Vigna unguiculata*	10.3(124)	10.8(12)	9.9(118)	11.0(134	5.3(33)	9.7(120)	9.7(125)	10.3(131)	56.67	20.20
Live mulch with *Sesamum indicum*	10.4(126)	11.1(130)	10.3(129)	11.4(136)	5.4(35)	10.5(129)	10.3(130)	10.9(147)	55.81	20.27
LSD (p=0.05)	NS	0.43	0.55	0.61	NS	0.41	0.48	0.58	-	-
Weed management practice										
Pendimethalin 1.0 kg/ha *fb* bispyribac-Na 25 g/ha	9.57(91)	12.6160)	11.8(139)	13.0(149)	5.1(25)	11.5(128)	11.5(131)	12.4(155)	56.02	25.03
Bispyribac-Na 25 g/ha+ carfentrazone 20 g/ha	12.5(156)	9.4(90)	8.8(76)	9.9(88)	6.6(43)	8.2(77)	8.1(78)	9.6(92)	75.55	7.45
Bispyribac-Na 25 g/ha + ethoxysulfuron 18 g/ha	12.9(165)	9.5(92)	9.3(85)	9.7(103)	6.7(44)	8.4(78)	8.4(80)	9.6(93)	76.01	7.75
Pendimethalin 1.0 kg/ha	9.59(93)	14.3(210)	13.2(173)	14.6(195)	5.0(25)	12.4(167)	12.9(170)	13.6(184)	44.40	28.15
Weed free	0.71(0)	0.7(0)	0.7(0)	0.7(0)	0.71(0)	0.71(0)	0.7(0)	0.7(0)	100	0
Weed check	16.5(278)	18.0(320)	15.4 239)	17.5(257)	8.0(64)	17.7(259)	16.7(266)	17.3(298)	0	53.19
LSD (p=0.05)	0.76	0.52	0.44	0.50	0.31	0.71	0.74	0.79	-	-

Figures in parentheses are the original values, which were subjected to square root transformation before statistical analysis

Table 2. Interaction effect of live mulch and weed management on total weed density and total dry weight in direct-seeded rice

Treatment	Total weed density at 60 DAS (no./m^2)			Total weed dry matter at 60 DAS (g/m^2)		
	Live mulch with *Sesbania rostrata*	Live mulch with *Vigna unguiculata*	Live mulch with *Sesamum indicum*	Live mulch with *Sesbania rostrata*	Live mulch with *Vigna unguiculata*	Live mulch with *Sesamum indicum*
Pendimethalin 1.0 kg/ha *fb* bispyribac-Na 25 g/ha	12.17 (150)	12.60 (160)	13.13 (171)	11.09(122)	11.11 (124)	12.25 (150)
Bispyribac-Na 25 g/ha + carfentrazone 20 g/ha	8.81(76)	9.79(96)	9.74(94)	7.48 (55)	8.57 (73)	8.62 (74)
Bispyribac- Na 25g/ha + ethoxysulfuron 18g/ha	8.56(75)	9.81(96)	9.96(97)	8.14 (65)	8.50 (71)	8.65 (73)
Pendimethalin 1.0 kg/ha	13.57 (181)	14.39 (206)	14.85 (220)	12.41(155)	12.90 (166)	13.30 (76)
Weed free	0.71(0)	0.71(0)	0.71(0)	0.71(0)	0.71(0)	0.71(0)
Weed check	18.47(350)	17.47 (310)	17.99 (320)	17.08(291)	16.49 (270)	19.53 (380)
Weed management at same level of live mulch		0.31			0.22	
LSD (p=0.05)		1.10			1.42	
Live mulch at different level of weed management		0.30			0.40	
LSD (p=0.05)		0.99			1.15	

Figures in parentheses are the original values, which were square root transformed before analysis

g/ha + ethoxysulfuron 18 g/ha (76.01%) and bispyribac-Na 25 g/ha + carfentrazone 20 g/ha (75.55%) was at par. Similar results were also reported earlier by Gill and Walia (2014). Among weed management treatments, minimum weed index was recorded under bispyribac-Na 25 g/ha + carfentrazone 20 g/ha (7.45%) closely followed by bispyribac-Na 25 g/ha + ethoxysulfuron 18g/ha (7.75%).

Effect on yield attributes and yield

The live mulch and herbicides had significant effect on yield attributes but live mulch did not significantly influence the test weight and harvest index (**Table 3**). The data indicated that the maximum grain yield (4.77 t/ha) and yield attributes, *i.e.* effective tiller/m^2 (207.67), no. of grains/panicle (131.39), panicle length (30.10 cm), weight of panicle (3.30 g) and test weight (24.14 g) recorded under live mulch with *S. rostrata* was at par with *V. unguiculata,* but significantly higher than *S. indicum*. This could be due to lower total weed infestation and dry matter accumulation as a result these treatments consequently improved the crop growth (Thakur *et al.* 2011, Sarangi *et al*. 2016).

The maximum yield attributes and yield were recorded in weed free plots (**Table 3**). Among the weed management treatments, the maximum grain yield and yield attributes were recorded with application of bispyribac-Na 25 g/ha + carfentrazone 20 g/ha, which was at par with bispyribac- Na 25 g/ha+ ethoxysulfuron 18 g/ha but significantly superior over other herbicidal treatments. This might be due to higher weed control efficiency and the lowest weed index in these treatments. The similar results were recorded by Walia *et al*. (2012). Thus, the application of live mulch of *Sesbania rostrata* with bispyribac-Na 25 g/ha *fb* carfentrazone 20 g/ha may be recommended for weed management and higher yield in rice under irrigated condition of central Punjab.

Table 3. Effect of live mulch and weed management on yield attributes and yields of crop in direct-seeded rice

Treatment	No. of effective tillers/m^2	Panicle weight (g)	No. of grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Test weight (g)
Live mulche								
Live mulch with *Sesbania rostrata*	207.67	3.30	131.39	4.77	6.71	11.42	40.86	24.14
Live mulch with *Vigna unguiculata*	196.94	3.17	126.78	4.64	6.48	11.04	40.82	22.33
Live mulch with *Sesamum indicum*	190.33	3.06	117.33	4.42	6.18	10.47	40.53	21.55
LSD (p=0.05)	12.34	0.18	7.64	0.26	0.37	0.67	0.54	1.62
Weed management practice								
Pendimethalin 1.0 kg/ha *fb* bispyribac-Na 25 g/ha	204.00	3.25	126.33	4.32	6.26	10.49	40.33	22.54
Bispyribac-Na 25 g/ha + carfentrazone 20 g/ha	218.33	3.45	136.44	5.47	7.18	12.57	42.66	24.04
Bispyribac-Na 25 g/ha + ethoxysulfuron 18 g/ha	213.56	3.43	133.44	5.30	7.08	12.42	42.89	24.10
Pendimethalin 1.0 kg/ha	194.44	3.00	124.11	4.11	6.04	10.16	40.49	20.82
Weed free	227.89	3.65	139.44	5.80	7.37	12.76	42.20	25.10
Weed check	131.67	2.29	91.22	2.68	4.80	7.48	35.85	19.44
LSD (p=0.05)	10.89	0.17	6.09	0.44	0.36	0.73	NS	1.13

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