Original Research Article

Effect of organic mulching and early post emergence herbicides on weed dynamics and growth of unpuddled transplanted rice

ABSTRACT

Field studies were carried out in 2017 and 2018 at Agricultural Research Farm, Banaras Hindu University Varanasi, Uttar Pradesh, India, to evaluate the effect of natural mulching and herbicides on weed dynamics and growth of rice. The experiment was laid out in a split plot design with three mulching treatments *viz*. no mulching, cover crop of *Sesbania* followed by green mulch and rice residue mulch (5 t/ ha) in main plots and five weed management treatments, *viz*. weedy, two hand weeding, post-emergence application of bispyribac Na 25 g/ ha, penoxsulam 30 g/ ha and tank mix bispyribac Na 25 g/ ha + pyrazosulfuron 20 g/ ha at 18 DAT in sub plots. Combination of main plot treatments and sub plot treatment allocated randomly and all the treatment combination were replicated thrice. The study revealed that mulching with *Sesbania* provided effective control of weeds, recorded significantly higher growth attributes and biological yield as compared to no mulching in both the years. Among weed management treatments two hand weeding resulted significant reduction in density and dry matter of weeds and increased yield which was at par with post-emergence application of penoxsulam 30 g/ha in both the years Treatment combination of surface mulching of *Sesbania* with two hand weeding recorded significantly higher number of tillers, as compared to other treatment combinations, it was at par with combination of surface mulching with *Sesbania* and post-emergence application of penoxsulam 30 g/ha and rice straw mulching and post-emergence application of penoxsulam 30 g/ha.

Keywords: Herbicides, mulching, rice residue, *Sesbania*, weed management

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the principal source of food for more than half of the world's population. It is the main staple food crop of India. Rice is cultivated mainly through transplanting in puddled field, which results in formation of a hard pan and damages soil structure, though it helps in retention of more water and effective in weed control, but this needs more time, labour and energy. With the development of resource conserving technologies, unpuddled transplanting is being emerged as a viable alternative to puddled transplanted rice. Weeds are among the major biological constraints for broader adoption of unpuddled transplanted rice and therefore, the cultivation of unpuddled transplanted rice warrants intensive use of herbicides for weed control. Rice crop suffers more from weed competition unlike other cereal crops. Actual yield losses due to pests have been estimated ~ 40%, Weeds caused the highest loss (32%), worldwide (Rao *et al*., 2007). Weeds compete with crop plants for moisture, nutrients, light, space and other growth factors and in the absence of an effective control measures, remove considerable quantity of applied nutrients resulting in significant yield losses. Weed infestation is one of the major biotic constraints in rice production. About 350 species have been reported as weeds of rice, of which grasses are ranked as first posing serious problem followed by sedges and broad-leaf weeds causing major losses to rice production worldwide (Singh *et al*., 2016). Chemical methods of weed control are therefore the most practical and cost-efficient. Several pre-emergence (pendimethalin, oxadiazon, oxdiargyl, and pyrazosulfuron) and post-emergence herbicides (bispyribac-sodium, azimsulfuron, penoxsulam, fenoxaprop, ethoxysulfuron, and 2, 4-D) have been reported to provide effective weed control. Where rice is widely adopted, herbicide use is increased steadily, resulting in the appearance of resistance in weeds against certain herbicides (Farooq *et al.*, 2011; Kumar and Ladha, 2011).

A single weed control approach may not be able to keep weeds below the threshold level of economic damage. Therefore, adoption of integrated weed management (IWM) is essential for weed management. As one of the main natural organic source of weed control and nutrient management is crop residue in spite of this other sources are live mulches and cover crops. Maintenance of crop residues improves the soil properties by improving the moisture retention, restoring soil physical properties (Nawaz *et al*., 2016), and enhancing the nutrient cycling and activity of microbes (Adugna & Abegaz, 2016). Devasinghe *et al.* (2011) observed that the application of rice straw mulch at the rate of 4t/ha was effective in weed management under DWSR (Direct wet seeded rice) method. Moreover, incorporation of cover crop into the soil may add allelochemicals to the soil to prevent germination and establishment of weeds (Buhler, 2002).

In order to devise a sustainable weed management strategy for rice, studies need to be done on the natural mulches in combination with herbicides. Since not much work have been done in this field, this research is designed to address the problem of making unpuddled transplanted rice popular among farmers with the objective of evaluating the interaction effect of Sesbania green residue mulch, rice straw mulch and weed management in controlling weeds, enhancing rice productivity and sustaining soil quality.

2. MATERIALS AND METHODS

The field experiment was conducted in *kharif* 2017 and 2018 at Agriculture Research Farm, Institute of Agricultural Sciences, BHU, Varanasi. The site of the experimental field remained same during both the years of investigation. The experimental field was homogeneous in fertility with even topography and typically a mid-land, suitable for rice crop cultivation during *kharif* season, uniform textural make up having assured irrigation. The experiment was laid out in a split plot design with three mulching treatments *viz*. no mulching, cover crop of *Sesbania* followed by green mulch and rice residue mulch (5 t/ ha) in main plots and five weed management treatments, *viz*. weedy, two hand weeding, post-emergence application of bispyribac Na 25 g/ ha, penoxsulam 30 g/ ha and tank mix bispyribac Na 25 g/ ha + pyrazosulfuron 20 g/ ha at 18 DAT in sub plots. Combination of main plot treatments and sub plot treatment allocated randomly and all the treatment combination were replicated thrice. *Sesbania* was sown as a cover crop, 35 days before the transplanting with the row spacing of 25 cm at seed rate of 25 kg/ha and incorporated manually at the time of transplanting and rice straw mulching was done after transplanting as per treatment. The experimental field was under a rice-wheat system. Rice variety "Arize-6444" seed was sown as per respective treatments. A seed rate of 18 kg/ha was used for nursery raising of the crop. Nursery raising of seedlings were done by dry bed method. Well pulverized raised nursery beds were prepared. The pre-soaked seeds were sown in the raised nursery bed by *kudal* manually at a 25 cm row to row spacing. After one pass strip tillage followed by inundation of the land up to 3-5 cm of standing water for 48 hours to make the land sufficiently soft for transplanting (Haque *et al*. 2016), finally transplanting of seedlings were carried out. Eighteen days old seedlings were transplanted in the field at 2 seedlings per hill at spacing of 20 cm ×15 cm.

Uniform dose of nitrogen at the rate of 140 kg/ ha was applied through Urea (46% N), in three equal splits, at One-third dose of nitrogen, was applied as basal, remaining nitrogen was applied in two equal splits during active tillering (30 DAP) and panicle initiation stage (65 DAP) respectively. Entire dose of P_2O_5 (60 kg/ ha) in the form of Single Super Phosphate and K_2O (60 kg/ha) through Muriate of Potash along with 62.5 kg $ZnSO_4$ /ha (Zinc sulphate heptahydrate 21 per cent) were applied at the time of field preparation as basal dose. Sowing of *Sesbania* was done at 35 days before transplanting at the rate of 25 kg/ha with 25 cm row spacing. Residue of *Sesbania* was used as surface mulch between the rows of transplanted rice. Rice straw mulching was done after transplanting between the rows @ 5 t/ha. Weed control treatments were applied in the plots as per the treatments. Two weeding in the hand weeded plots were done manually at 20 and 40 days after transplanting. Weedy plots remained infested with native weed population till harvest of the crop. Herbicides were applied as aqueous medium at the rate of 500 liters water/ha with help of knapsack with flat fan nozzle. The amount of herbicides and water required was computed on the basis of gross plot size to be treated. Bispyribac-Na (25 g/ha), penoxsulam (30 g/ha) and bispyribac-Na (25 g/ha) + Pyrazosulfuron ethyl (20 g/ha) were applied at 18 days after transplanting (as post-emergence) as per the treatments.

The square quadrat measuring 1 m×1 m was thrown randomly at two spots in the plot and number of weed was counted. The weed biomass was recorded from the total biomass scraped in quadrat (1 m ×1m) from two randomly selected spots in each plot. The samples were first sun dried and then dried in oven at 60 ^{0}C samples obtained constant weight. The weed data were recorded as weed density (number/m^2) and weed biomass (g/m^2). Weed density and weed biomass data was subjected to square root transformation ($\sqrt{x+1}$) before statistical analysis. The crop was harvested manually in second fortnight of October 2017 and 2018 when panicles were nearly ripe and straw had turned yellow. The data on plant height, number of tillers/m^2 and dry matter accumulation / m^2 was recorded from randomly selected ten plants in the plot. The harvested crop was threshed manually. Collected data were statistically analyzed as per standard (Gomez and Gomez, 1984) procedure to draw a valid conclusion.

3. RESULT AND DISCUSSION

3.1 Effect on weed density and weed biomass

Data on density of grasses, sedges and broadleaf weeds as influenced by mulching and weed management at harvest, presented in Table1. Among mulching treatments, significantly lesser density of grasses, sedges and broad leaved weeds were found in cover crop of *Sesbania aculeata* followed by green residue mulch as compared to no mulching. It was on par with rice residue mulch, except density of grasses in 2017, whereas, no mulching recorded significantly maximum density of grasses, sedges and BLWs in both the years. This might be due to mulching smother the weed growth at early stage of crop growth. During summer fallows it covered the soil and it inhibited weeds growth and green residues inhibited weed seed emergence by physically impeding the progress of seedling from accessing light (Teasdale and Mohler 2000). Among weed management treatments, penoxsulam 30 g/ha recorded significantly lesser density of grasses, sedges and BLWs as compared to weedy during both the years. It was on par with two hand weeding during both the years except density of sedges in 2017, broadleaf weeds in 2018. Weedy recorded significantly maximum density of grasses, sedges amongst all the weed management treatments during both the years. Similar findings were also reported by Singh *et al*. (2009).

Data on biomass of grasses, sedges and broadleaf weeds as influenced by mulching and weed management at harvest are presented in Table 1. Cover crop of *Sesbania aculeata* followed by green residue mulch induced significantly lesser biomass of grasses, sedges and BLWs as compared to no mulching. In addition, it was on par with rice residue mulch during both the years except grasses and sedges biomass in 2018. No mulching recorded significantly maximum biomass of grasses, sedges and BLWs in both the years. Chung *et al*. (2003) also found that rice straw was the most effective method for controlling the most problematic weeds in rice (barnyard-grass, *E. crussgalli*). Similar findings were reported by Peigne *et al*., (2007). Among weed management, penoxsulam 30 g/ha recorded significantly lesser biomass of grasses, sedges and BLWs as compared bispyribac Na 25 g/ha and weedy during both the years. It was on par with tank mix bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha during both the years. Weedy recorded significantly maximum biomass of grasses, sedges and BLWs amongst all the weed management treatments during both the years.

3.2 Effect on growth attributes and yield

Mulching did not affect the plant height during both the years at 30 DAT. Penoxsulam 30 g/ha recorded significantly increase in plant height as compared to weedy during both the years. It was on par with two hand weeding. Further, bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha and bispyribac Na 25 g/ha alone had at par plant height. Weedy recorded significantly minimum plant height amongst all the weed management treatment during both the years of experimentation. Cover crop of *Sesbania aculeata* followed by green residue mulch recorded significantly higher number of tillers/m^2, dry matter accumulation/ m^2 and biological yield as compared to rice residue mulch and no mulching during both the years. Hemalatha e*t al.* (2000) also reported that in-situ incorporation of dhaincha recorded increase in plant height, number of tillers per hill. Among weed management practices, penoxsulam 30 g/ha recorded significantly higher number of tillers/m^2, dry matter accumulation/ m^2 and biological yield as compared to tank mix bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha, bispyribac Na 25 g/ha alone and weedy during both the years. It was at par with two hand weeding. Weedy recorded significantly minimum number of tillers/m^2, dry matter accumulation/ m^2 and biological yield amongst all the weed management treatment during both the years. These observation might be due to effective broad spectrum control of weeds due to early post emergence application of penoxsulam 30 g/ ha (Table 1) resulting in better performance of growth and yield.

3.3 Interaction effect of natural mulching and herbicide on number of tillers

At 30 DAT (Table 3), cover crop of *Sesbania aculeata* followed by green residue mulch + two hand weeding recorded significantly maximum number of tillers/m^2 than the rest of the treatment combinations and it was on par with cover crop of *Sesbania aculeata* followed by green residue mulch + penoxsulam 30 g/ha in first year and rice residue mulch + penoxsulam 30 g/ha, rice residue mulch + two hand weeding, cover crop of *Sesbania aculeata* followed by green residue mulch + penoxsulam 30 g/ha treatment combinations in second year. Further analysis of data in Table 3 revealed that among all treatments combinations, no mulching + weedy recorded significantly minimum number of tillers/m^2 during both the years. This might be due to weed competition and intra-plant competition for resources as compared to other treatment combinations which lead to better crop growth, resulting in increased tillering ability of plants.

4. CONCLUSION

On the basis of two years of experimentation, cover crop of *Sesbania aculeata* followed by green residue mulch with penoxsulam 30 g/ha recorded lesser weed density and biomass higher growth attributes and yield under agro-climatic condition of Varanasi region. These results conclude that if surface mulching is done in transplanted rice there is no need of pre- emergence herbicides for controlling early stage weeds in rice.

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Table 1. Effect of mulching and weed management treatments on weed growth in unpuddled transplanted hybrid rice

Treatment	Weed density (No./m²)						Weed biomass (g/m²)					
	Grasses		Sedges		BLW		Grasses		Sedges		BLW	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Mulching												
No mulching	7.54 (62)	8.01 (71)	6.82 (50)	7.13 (49)	4.23 (18)	5.03 (27)	10.68 (127)	10.97 (130)	8.28 (73)	8.31 (74)	5.79 (36)	7.41 (56)
Cover crop of *Sesbania* followed by surface mulch with same residue	5.07 (32)	5.31 (34)	5.29 (32)	5.36 (30)	3.32 (11)	3.63 (14)	7.24 (67)	8.40 (84)	6.13 (44)	6.37 (48)	4.23 (19)	4.70 (24)
Rice residue mulch (5 t/ha)	5.89 (40)	6.65 (53)	5.58 (37)	6.51 (46)	3.57 (12)	4.10 (20)	8.84 (89)	10.33 (121)	6.82 (54)	7.88 (70)	4.76 (23)	6.14 (45)
SEm±	0.33	0.288	0.26	0.40	0.10	0.21	0.42	0.35	0.33	0.27	0.20	0.37
LSD (P=0.05)	1.29	1.13	1.01	1.55	0.40	0.83	1.64	1.36	1.29	1.06	0.78	1.44
Weed Management												
Weedy	10.59 (113)	11.06 (128)	10.15 (103)	10.71 (96)	5.37 (28)	6.82 (47)	15.55 (245)	16.40 (270)	12.12 (147)	12.43 (155)	7.35 (56)	9.19 (86)
Two hand weeding at 20 and 40 DAT	3.97 (16)	3.93 (15)	3.97 (16)	4.34 (19)	2.89 (8)	2.43 (5)	5.41 (31)	6.27 (39)	4.87 (24)	4.75 (22)	3.91 (15)	3.94 (16)
Bispyribac (25 g/ha) at 18 DAT	6.46 (43)	7.25 (54)	5.50 (30)	6.28 (40)	3.71 (13)	4.63 (21)	8.98 (84)	10.30 (108)	6.53 (43)	7.80 (66)	4.78 (22)	6.89 (48)
Penoxsulam (30 g/ha) at 18 DAT	4.45 (22)	5.02 (29)	4.60 (21)	4.93 (25)	3.19 (9)	3.63 (14)	7.15 (53)	7.67 (61)	5.63 (32)	5.90 (36)	4.14 (16)	4.84 (26)
Bispyribac (25 g/ha) + pyrazosulfuron (20 g/ha) at 18 DAT	5.36 (29)	6.01 (37)	5.25 (28)	5.40 (29)	3.36 (11)	3.76 (14)	7.53 (59)	8.85 (81)	6.24 (40)	6.71 (46)	4.45 (19)	5.56 (33)
SEm±	0.38	0.39	0.20	0.42	0.14	0.30	0.52	0.46	0.23	0.36	0.23	0.30
LSD (P=0.05)	1.12	1.15	0.57	1.24	0.42	0.88	1.51	1.35	0.67	1.05	0.68	0.88

Data were square root transformed before analysis; however, back-transformed actual mean values are presented based on the interpretation from the transformed data.

Table 2. Effect of mulching and weed management treatments on growth and yield in unpuddled transplanted hybrid rice

Treatment	Growth attributes (30 DAT)						Total biological yield (q/ha)	
	Plant height (cm)		No. of tilers/m^2		Dry matter accumulation (g/m^2)			
	2017	2018	2017	2018	2017	2018	2017	2018
Mulching								
No mulching	34.89	30.89	158.27	155.23	202.55	198.66	98.56	95.38
Cover crop of *Sesbania* followed by surface mulch with same residue	38.12	36.04	227.63	216.04	287.40	271.14	132.41	130.17
Rice residue mulch (5 t/ha)	36.17	34.37	205.14	183.39	265.31	243.90	118.43	110.03
SEm±	1.100	1.052	5.34	5.39	9.554	8.444	5.058	4.711
LSD (P=0.05)	NS	NS	20.97	21.18	37.51	33.16	19.86	18.50
Weed Management								
Weedy	29.22	27.06	110.21	73.74	141.91	95.51	42.08	144.21
Two hand weeding at 20 and 40 DAT	40.70	38.49	248.91	235.39	326.17	307.42	150.30	42.02
Bispyribac (25 g/ha) at 18 DAT	36.22	33.57	176.49	177.47	211.40	224.90	109.42	104.78
Penoxsulam (30 g/ha) at 18 DAT	38.06	35.20	237.71	231.30	314.09	291.93	149.22	139.44
Bispyribac (25 g/ha) + pyrazosulfuron (20 g/ha) at 18 DAT	37.76	34.51	211.74	206.51	265.20	269.74	131.33	128.87
SEm±	1.271	1.081	4.99	5.76	9.136	7.694	4.227	3.900
LSD (P=0.05)	3.71	3.16	14.55	16.82	26.67	22.46	12.34	11.38

Table 3 Interaction effect of mulching and weed management treatments on number of tillers/m^2 at 30 DAT in unpuddled transplanted hybrid rice

Weed Management	Mulching					
	2017			2018		
	No mulching	Cover crop of *Sesbania* followed by surface mulch with same residue	Rice residue mulch (5 t/ha)	No mulching	Cover crop of *Sesbania* followed by surface mulch with same residue	Rice residue mulch (5 t/ha)
Weedy	77.25	146.33	107.03	61.86	115.82	43.55
Two hand weeding at 20 and 40 DAT	194.12	300.85	251.75	201.82	266.55	237.80
Bispyribac (25 g/ha) at 18 DAT	168.15	182.08	179.23	130.65	212.40	189.36
Penoxsulam (30 g/ha) at 18 DAT	177.97	271.38	263.78	191.19	263.35	239.37
Bispyribac (25 g/ha) + pyrazosulfuron (20 g/ha) at 18 DAT	173.85	237.50	223.88	190.62	222.06	206.86
	SEm±	**LSD (P=0.05)**		**SEm±**	**LSD (P=0.05)**	
Weed management at same levels of Mulching	8.636	25.21		9.983	29.14	
Mulching at same or different levels of Weed management	9.391	30.43		10.43	33.21	