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## Studies on mulching and weed management in unpuddled transplanted rice (*Oryza sativa* L.)

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### Abstract

A field experiment was conducted during *kharif* season of 2017 and 2018 at Institute of Agricultural Sciences, BHU, Varanasi. 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 replicated thrice. The results revealed that cover crop of *Sesbania* followed by surface mulch followed by green mulch and rice straw mulch recorded significantly higher growth attributes, yield attributes and production efficiency as compared to no mulching. Among weed management treatments post-emergence application of penoxsulam 30 g/ha resulted in significantly higher growth and yield attributes as compared to weedy and increased production efficiency followed by spraying of bispyribac 25 g/ha+ pyrazosulfuron 20 g/ha and post-emergence spraying of bispyribac 25 g/ha.

**Keywords:** Cover crop, mulching, post-emergence, rice straw, unpuddled transplanting

### Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops in the world and is consumed by more than 3 billion people (Fageria, 2007) [3]. In India, rice (*Oryza sativa* L.) is one of the most important cereal crop of *kharif* season and the staple food of 2.7 million people of the eastern and southern parts of the country. It is estimated that, by the year 2025, it will be necessary to produce about 60% more rice than currently produced to meet food needs (Fageria, 2007 GRISP, 2013) [3, 5]. Transplanting in puddled soil is the most dominant and traditional method of establishment in rice. Puddling of soil before transplanting rice (*Oryza sativa*) helps to suppress weeds during crop establishment but this practice is tedious, costly, time and energy consuming (Gill *et al.*, 2014) [4]. On the other hand, non-puddled transplanting is an emerging option to overcome these problems (Haque *et al.*, 2016) [6] and also reduce cost of rice cultivation (Islam *et al.*, 2014) [8]. With the development of resource conserving technologies, unpuddled transplanting is being emerged as a viable alternative to puddled transplanted rice. Crop under unpuddled transplanting faces severe weed infestation due to less tillage and lack of submergence at the time of transplanting. Rice straw is a good organic mulch material for weed management it remains on soil surface, undecomposed for longer period of time (due to presence of ligno-cellulosic materials). Moreover, incorporation of cover crop into the soil may add allelochemicals to the soil to prevent germination and establishment of weeds (Buhler, 2002) [2]. Use of appropriate one shot early post-emergence herbicides in could provide good control on weeds in unpuddled transplanted system and helps achieve high yield with higher net benefit over weed free plots (Rahman, 2016) [11]. In order to devise a sustainable weed management strategy for unpuddled transplanted rice, studies need to be done on the mulching in combination with herbicides. Since not much work has been done in this field, this research is designed to address the problem of making unpuddled transplanted rice popular among farmers.

### Materials and Methods

The field experiment was conducted in *kharif* 2017 and 2018 at Agriculture Research Farm, Institute of Agricultural Sciences, BHU, Varanasi. Geographically farm is located at an

altitude of 75.7 m above the mean sea level in the Northern Gangetic alluvial plains, 25°18'N latitude, 88°03'E latitude. 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 *khari* season, uniform textural make up having assured irrigation. The experiment was laid out in a split plot design with three mulching treatments *viz.*, without mulching, cover crop of *Sesbania* followed by surface mulch with same residue and rice straw mulch (5 t/ha) in main plots and five weed management treatments, *viz.*, weedy, hand weeding at 20 and 40 DAT, post-emergence application of bispyribac 25 g/ha at 18 DAT, post-emergence application of penoxsulam 30 g/ha at 18 DAT and post-emergence application of bispyribac 25 g/ha and pyrazosulfuron 20 g/ha at 18 DAT in sub plots. *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 (5t/ha) was done after transplanting as per treatment. The experimental field was under a rice-wheat system. All crop residues were removed at ground level at the time of harvest. 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) [6], 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. Flexible wire rope and colored cloth strips were used at specific interval as per the desirable spacing for maintaining the distance between plant and rows during transplanting operation.

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<sub>2</sub>O<sub>5</sub> (60 kg/ha) in the form of Single Super Phosphate and K<sub>2</sub>O (60 kg/ha) through Muriate of Potash along with 62.5 kg ZnSO<sub>4</sub>/ha (Zinc sulphate heptahydrate 21 per cent) were applied at the time of field preparation as basal dose. Sowing of *Sesbania* was done at 45 days before transplanting at the rate of 25 kg/ha with 25 cm row spacing and incorporated manually at the time of transplanting. 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 crop was harvested manually in second fortnight of October 2017 and 2018 when panicles were nearly ripe and straw had turned yellow. After manual threshing, grain yield was recorded after separating from the straw by winnowing. The data on plant height, number of tillers/m<sup>2</sup>, panicle length, test weight, was recorded from randomly selected ten plants in the plot. The harvested crop was threshed manually. Production efficiency in terms of kg/ha/day was determined by dividing the yield to the number of days to maturity of each treatment separately.

The sample of rice grain, straw and weeds were collected at harvest, dried in sun and then oven dried. The samples were ground and sieved through 0.5 mm sieve. The required quantity of samples was weighed out accurately and was subjected to acid extraction to determine N, P and K content. The required quantity of samples was weighed out accurately and was subjected to acid extraction and N, P and K content was determined. Nitrogen content in digested plant material was determined by micro kjeldhal method as described by AOAC (1995) [1]. Phosphorus and potassium content was determined by Vanadomolybdo phosphoric yellow colour method described by Koenig and Johnson (1942) and flame photometric method suggested by Jackson (1973).

Data were analyzed using analysis of variance (ANOVA) to evaluate the differences among treatments while the means were separated using the least significant difference (LSD) test at the 5% level of significance.

## Results and Discussion

### Effect on weeds

Cover crop of *Sesbania aculeata* followed by green residue mulch recorded lesser weed density and weed biomass as compared to no mulching. However, it was on par with rice residue mulch in 2017. No mulching recorded significantly maximum density and biomass of weeds during both the years. Among weed management practices, penoxsulam 30 g/ha recorded significantly lesser density of weeds and weed biomass as compared to bispyribac Na 25 g/ha alone and weedy during both the years. However, it was on par with two hand weeding during both the years. It was evident from the table 1 bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha and bispyribac Na 25 g/ha were comparable with each other. Weedy recorded significantly maximum density and biomass of weeds amongst all the weed management treatments. This might be due to cover crop might have reduced weed seed germination and later stages of crop weed growth might have been suppressed at early stages of crop growth. Yadav *et al.* (2010) [14] also observed that penoxsulam at 25 g/ha as pre-emergence (3 DAT) and 22.5 g/ha as post-emergence (10-12 DAT) application provided satisfactory control of all types of weeds.

Perusal of data revealed that mulching caused significant variations in nitrogen, phosphorous and potassium content in weeds. Significantly lowest nitrogen, phosphorous and potassium content in weed was found in cover crop of *Sesbania aculeata* followed by green residue mulch as compared to no mulching and it was statistically on par with rice residue mulch, whereas, no mulching recorded highest nitrogen content in weed during both the years (Table 2). It is evident from table 2 penoxsulam 30 g/ha recorded significantly lesser nitrogen, phosphorous and potassium content in weed as compared to weedy and during both the years. However, it was on par with two hand weeding during both the years and also it was statistically comparable with bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha in 2017.

Weedy recorded significantly highest nitrogen, phosphorous and potassium content in weed amongst all the weed management treatment during both the years of experimentation.

### Effect on crop

Mulching did not affect the plant height during both the years. Penoxsulam 30 g/ha recorded significantly higher plant height as compared to weedy during both the years. However, it was on par with two hand weeding at all the stages of observation. Further, bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha and bispyribac Na 25 g/ha alone had at par plant height at harvest. Weedy recorded significantly minimum plant height amongst all the weed management treatment at all the stages of observation during both the years of experimentation.

Critical analysis of data in table 2 revealed that, significantly higher no. of tillers/m<sup>2</sup> was recorded with cover crop of *Sesbania* followed by green residue mulch as compared to rice residue mulch and no mulching treatment during both the years. This might be due to vigorous growth of *Sesbania* and availability of green residue mulch on the field. Joseph (1998) reported that incorporation of *Sesbania aculeata* in rice on 35 DAS uniformly increased the productive tillers/ m<sup>2</sup> and 1000 grain weight. Penoxsulam 30 g/ha recorded higher value of number of tillers/m<sup>2</sup> as compared to tank mix bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha, bispyribac Na 25 g/ha alone and weedy at all the stages of observation during both the years (Table 1). This might be attributed to broad spectrum and complete killing of weeds due to penoxsulam leading to a higher weed control. Singh (2002) [13] reported that the weed density in weed control treatments was lower thus offer less competition to rice plants which in turn benefitted the number of shoots and panicles/ m<sup>2</sup>. Similar findings were reported by Sansa *et al.*, (2016) [12].

Yield attributes of the plant is the resultant of the vegetative growth of the plant which collectively determines yield. Appraisal of data in table 2 revealed that, cover crop of *Sesbania aculeata* followed by green residue mulch recorded significantly higher panicle length as compared to no mulching during both the years. However, it was on par with rice residue mulch during both the years of study. Weed management treatments also caused significant variations in panicle length. Penoxsulam 30 g/ha recorded longer panicle as compared to bispyribac Na 25 g/ha alone and weedy during both the years. However, it was on par with two hand weeding and bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha. Further analysis of data in table evidenced that bispyribac Na 25 g/ha alone and tank mix bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha were at par with each other in 2018,

whereas, weedy recorded significantly shortest panicle during both the years of study. Test weight did not differed significantly due to mulching as well as weed management treatments. The highest panicle length might be due to better growth of plant with the availability of efficient utilization of nutrient and available resources with less weed competition in cover crop of *Sesbania aculeata* followed by green residue mulch which increased number of tillers (Table 2) which ultimately leads to highest panicle length.

Cover crop of *Sesbania aculeata* followed by green residue mulch recorded significantly maximum production efficiency as compared to no mulching and it was on par with rice residue mulch during both the years of study. Further analysis of data revealed that penoxsulam 30 g/ha recorded significantly higher production efficiency as compared to bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha, bispyribac Na 25 g/ha alone and weedy during both the years, however, it was on par with two hand weeding. Tank mix bispyribac Na 25 g/ha + pyrazosulfuron 20 g/ha recorded significantly higher production efficiency as compared to bispyribac Na 25 g/ha alone and weedy. Weedy recorded significantly minimum production efficiency amongst all the weed management treatment during both the years of experimentation. Higher production efficiency recorded under these treatment might be due to lower weed competition and higher grain yield.

Nitrogen, phosphorous and potassium content by crop as influenced by mulching and weed management treatments (Table 2). Data revealed that tested mulching as well as weed management treatments failed to cause any significant variations in total nitrogen, phosphorous and potassium content during both the years of study. Weed management treatments had significant variation in nitrogen, phosphorous and potassium content. All the weed management practices were on par with each other with respect to nitrogen content except bispyribac Na 25 g/ha alone and weedy in 2017 and 2018 which was significantly inferior to other weed management treatments. This might be due to less weed competition in herbicide treated plots in comparison to weedy plots and more nitrogen utilization by crop which would increase nitrogen content. Lower values of N, P and K content in weedy as compared to weed control treatments were also reported by Tala and Jena (2014). Increased nutrient content (Table 2) under these treatments was obviously owing to effective weed control both during initial and later stages of crop growth, leading to lesser competition for nutrients. Weed management treatments failed to cause any significant variations in phosphorus and potassium content during both the years of study.

**Table 1:** Effect of mulches and weed management treatments on weed density, weed biomass and nutrient content in weed in unpuddled transplanted hybrid rice

Treatment	Weed density (No./m <sup>2</sup> ) at 40 DAS		Weed biomass (g/m <sup>2</sup> ) at 40 DAS		Nitrogen content in weeds (%)		Phosphorous content in weeds (%)		Potassium content in weeds (%)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
<b>Mulching</b>										
No mulching	10.86b (140)	12.59c (171)	13.92b (213)	14.89b (261)	1.70b	1.77b	0.28c	0.33b	0.51b	0.55b
Cover crop of <i>Sesbania</i> followed by surface mulch with same residue	7.69a (71)	7.72a (74)	9.61a (110)	9.94a (118)	1.20a	1.30a	0.25a	0.26a	0.37a	0.39a
Rice residue mulch(5 t/ha)	8.34a (81)	9.68b (110)	10.53a (128)	11.49a (159)	1.39a	1.59ab	0.27b	0.29ab	0.42ab	0.44a
SEM±	0.29	0.49	0.48	0.50	0.06	0.08	0.009	0.01	0.03	0.02
LSD (P=0.05)	1.14	1.93	1.90	1.98	0.23	0.30	0.04	0.05	0.10	0.08
<b>Weed management</b>										

Weedy	16.06c (261)	17.84c (318)	19.48c (384)	22.19c (508)	1.91c	1.99c	0.30c	0.35d	0.59c	0.62d
Two hand weeding at 20 and 40 DAT	6.55a (41)	6.98a (51)	8.43a (73)	8.27a (71)	1.12a	1.22a	0.23a	0.22a	0.33a	0.35a
Bispyribac (25 g/ha) at 18 DAT	8.29b (71)	9.78b (99)	10.96b (125)	11.37b (133)	1.59b	1.75b	0.28b	0.32c	0.48b	0.52c
Penoxsulam (30 g/ha) at 18 DAT	6.48a (44)	7.15a (75)	8.28a (74)	8.80a (82)	1.16ab	1.28a	0.26ab	0.26b	0.35a	0.37a
Bispyribac (25 g/ha) + pyrazosulfuron (20 g/ha) at 18 DAT	7.43ab (56)	8.21ab (55)	9.61ab (96)	9.91ab (102)	1.38b	1.52b	0.27b	0.30c	0.41b	0.45b
SEm±	0.33	0.61	0.47	0.64	0.08	0.07	0.010	0.01	0.02	0.02
LSD (P=0.05)	0.97	1.79	1.38	1.88	0.25	0.19	0.03	0.02	0.07	0.06

**Table 2:** Effect of mulches and weed management treatments on growth attributes, yield attributes and nutrient content in crop in unpuddled transplanted hybrid rice

Treatment	Plant height at harvest (cm)		No. of tillers at harvest (/m <sup>2</sup> )		Panicle Length (cm)		Test weight		Production efficiency (kg/ha/day)		Nitrogen content in crop (%)		Phosphorous content in crop (%)		Potassium content in crop (%)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
<b>Mulching</b>																
No mulching	100.56	94.71	255.52b	246.26b	21.77b	20.90b	23.40	21.87	30.85b	29.31b	0.61	0.55	0.10	0.11	1.16	1.02
Cover crop of <i>Sesbania</i> followed by surface mulch with same residue	108.80	105.65	321.63a	312.46a	25.59a	24.56a	23.76	22.20	41.66a	40.92a	0.62	0.62	0.12	0.13	1.19	1.22
Rice residue mulch (5 t/ha)	104.95	99.53	284.72ab	265.24b	25.35a	24.00a	24.01	22.44	38.00a	35.09a	0.65	0.62	0.11	0.12	1.17	1.09
SEm±	2.04	2.25	11.60	7.39	0.70	0.68	0.33	0.30	1.44	1.27	0.011	0.03	0.01	0.01	0.04	0.05
LSD (P=0.05)	NS	NS	45.57	29.03	2.76	2.67	NS	NS	5.66	4.98	NS	NS	NS	NS	NS	NS
<b>Weed management</b>																
Weedy	95.69c	88.54c	158.71d	109.04d	87.09	100.52	23.19	21.69	12.96d	12.5d	0.56c	0.50b	0.10	0.12b	1.12	1.02
Two hand weeding at 20 and 40 DAT	109.91a	108.34a	350.23a	351.16a	8.49	10.06	24.30	22.70	47.13a	45.6a	0.65a	0.64a	0.12	0.11a	1.17	1.17
Bispyribac (25 g/ha) at 18 DAT	102.91b	98.23b	263.05c	261.72c	25.74	36.26	23.33	21.80	34.33c	32.7c	0.60b	0.61a	0.10	0.11a	1.17	1.02
Penoxsulam (30 g/ha) at 18 DAT	108.15a	103.92a	344.46b	345.30a	13.15	17.23	23.97	22.40	46.85a	44.3a	0.64a	0.63a	0.12	0.12a	1.17	1.19
Bispyribac (25 g/ha) + pyrazosulfuron (20 g/ha) at 18 DAT	107.18ab	100.79b	319.98b	306.04b	17.69	25.23	23.83	22.25	42.90b	40.4b	0.66a	0.61a	0.11	0.12a	1.24	1.16
SEm±	2.352	2.384	10.68	8.38	4.27	3.36	0.33	0.31	1.31	1.10	0.015	0.03	0.01	0.01	0.05	0.06
LSD (P=0.05)	6.87	6.96	31.19	24.46	12.46	9.81	NS	NS	3.83	3.20	0.04	0.07	NS	NS	NS	NS

## 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, yield attributes, production efficiency and nutrient content by crop under agro-climatic condition of Varanasi region.

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