Effect of different mulching materials on weed dynamics and yield of direct seeded rice in Chitwan, Nepal

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Abstract

An experiment was carried out at farmers' field to compare the effects of live mulches and herbicide on weed growth and dynamics, yield, and economic performance of direct seeded rice under humid sub-tropical condition at Phulbari, Chitwan in 2009. The experiment was conducted in Randomized Complete Block Design with eight treatments and three replications. The treatments consisted of i) control, ii) three hand weeding, iii) herbicide application (bispyribac sodium @ 80 ml/ha) + one hand weeding, iv) wheat straw mulch @ 5t/ha + one hand weeding, v) *Eupatorium* mulch @ 5t/ha + one hand weeding, vi) brown manuring with *Sesbania aculeata* @ 30 kg/ha, vii) brown manuring with *Sesamum indicum* @ 2kg/ha, and viii) brown manuring with *Crotolaria juncea* @ 30 kg/ha. Weed dry matter accumulation was significantly lower with herbicide application (1.15 g/m^2) than wheat straw mulch (6.75 g/m^2). The treatments with brown manuring and *Eupatorium* mulch were found to be equally effective in suppressing the weed growth by reducing both dry matter content and weed density. Application of *Eupatorium* mulch one day after sowing produced significantly higher grain yield (3.5 t/ha) than control (1.77 t/ha), *Sesamum* brown manuring (2.97 t/ha) and wheat straw mulch (2.83 t/ha). Yield attributes like effective tillers/m^2, panicle length and panicle weight were positively correlated with grain yield (r = 0.540, 0.705, 0.531 and 0.613 respectively). The net profit (Rs. 63.17 x 1000/ha) obtained from the treatment with *Eupatorium* mulch was higher than other tested treatments. *Eupatorium* mulch and herbicide application recorded equal benefit cost ratio of 2.4. Cultivation of direct seeded rice with the application of *Eupatorium* mulch or brown manuring (BM) of *Sesamum* was found effective for increasing yield and net returns in humid subtropical condition of Chitwan. Live mulching could be an eco-friendly weed control options in DSR. The BM option also provides crop residue for the addition of organic matter. This result suggests that BM is a potential alternative of herbicide application. Either mulching with *Eupatorium* and wheat straw or growing of *Sesbania* and *Crotolaria* as BM with rice up to 30 DAS are advisable to increase productivity with reduced cost of production at Chitwan and similar condition.

Key words : brown manuring, direct seeded rice, live mulch, weed dynamics

Introduction

Rice is grown by transplanting one-month old seedlings into the puddled soil for increasing fertilizer efficiency and minimizing weed population at the initial stage. But, this practice increases the cost of cultivation (Giri, 1996) with potential loss of farm income (Tripathi *et al.,* 2004). Moreover, it has been realized that continuous puddling degrades natural resources like soil and water (Hobbs, 2003). It is estimated that world's per capita availability of water, about 85% of which is used in agriculture, is decreasing over the years. Balasubramanian *et al*. (2000) reported that the water availability was declined by 60% from 1950 to 1990. Water scarcity threatens the sustainability of irrigated rice ecosystems. Due to water scarcity, it may no longer be feasible for farmers to undertake wet cultivation and flood fields to ensure good crop yield (Johnson and Mortimer, 2005). Similarly, the increasing cost of labor threatens the sustainability of transplanted rice within the rice–wheat system in the Indo-Gangetic plains. The labor requirement for transplanted rice (nursery and transplanting) is approximately 50 person days/ha in comparison to 3-7 person days/ha for drill or wet seeded rice (Mann *et al.,* 2007; FAO, 2010). In comparison to transplanted rice direct seeded rice also minimizes the emissions of methane gas. With the development of resource conserving technologies, direct seeding is being emerged as a viable alternative to transplanted rice (Tripathi *et al*., 2004). However, the main problem of direct seeded rice (DSR) is the weed infestation, which causes grain yield loss up to 90 percent (Rehman *et al*., 2007). Maity and Mukherjee (2008) reported that uncontrolled weeds reduce the grain yield by 96% in dry DSR, 61% in wet DSR and 40% in transplanted rice.

The longer weed-free periods, up to 70 days, after the emergence of seeds contributes increasing rice yield. The growth of weeds emerged thereafter is suppressed by the crop (Fischer *et al.*, 1993). The slow initial growth of DSR under moisture stress condition and favorable environment for the growth of wide spectrum of weeds is the main reason of reduced productivity of rain-fed crop. Therefore, effective weed management is essential for higher productivity of direct-seeded rice.

Hand weeding is the most popular method of removing weeds in Nepal and in the developing world. Besides hand weeding, a number of herbicides have been developed and tested for direct seeded rice around the world. The effects of herbicides, such as, butachlor, thiobencarb, pendimethalin, oxyfluoren, propanil, quinclorac, ioxynil, 2, 4-D, and Na bispyribac have been tested in direct seeded rice in the past. Mulching is another technique to reduce weed problems in direct seeded unpuddled rice. Mulching helps to maintain optimum surface soil moisture for germination and rooting of the crop, protects seeds from birds, and helps controlling weeds. Organic mulch, such as straw, hay, dry sugarcane leaves, FYM, rice hulls, saw dust and bark dust provides stronger mechanical barriers to all kinds of germinating weeds. Singh *et al.* (2007) reported that the density of grassy weeds was low in the rice field mulched at all stages of crop growth. Gurung (2006) reported that weed infestation was significantly higher in no mulch plot (56.95 g/m^2) than in the mulched plot (38.59 g/m^2). Brown manuring (BM) is another method of controlling weeds in DSR**.** Brown manuring is simply a no-till version of green manuring, in which selective herbicide 2,4-D @ 400-500 g/ha is applied to knockdown and desiccate the BM materials like *Sesbania* nearly at blooming (30-40 days) stage. Co-culturing *Sesbania* and rice is a common practice throughout the world, but co-culturing *Crotolaria, Sesamum,* etc. have not been tested so far.

Brown manuring helps smothering weeds, conserving moisture and adding about 15kg N/ha without adding much on cost of production. A lower broad-leaved weed density and dry weight were observed with *Sesbania* and other brown manuring species than the surface mulch. Intercropping of brown manuring crops with rice reduced weed densities by about 40-50 % (Rehman *et al.,* 2007). Singh *et al*. (2007) reported that application of wheat residue mulch at 4 t/ha and *Sesbania* intercropping for 30 days were equally effective in controlling weeds in dry-seeded rice . The facultative weed *Eupatorium* has been reported a good source of organic matter and weed suppressor for several upland crops including DSR in Himachal Pradesh (Acharya *et al.,* 1998). Since not much works have been done in this field, this research is designed to address the problem of making DSR popular among farmers with the objective of evaluating the effect of different live mulches and BM in controlling weeds and enhancing rice productivity.

Materials and methods

A farmer's field experiment was conducted to see the effects of live mulches and other weed management practices on weed dynamics, crop yield, and economic performance of direct seeded rice (Cv. Ram Dhan) under humid sub-tropical condition at Phulbari, Chitwan in 2009. The experiment was conducted on slightly acidic (pH 5.2) sandy loam soil. The soil was low in available N (0.18%), high in available phosphorus (59.1 kg/ha), and low in available potash (153 kg/ha).

The experiment was conducted in Randomized Complete Block Design (RCBD) with eight treatments and three replications. The treatments consisted of 1) control, 2) three hand weeding, 3) herbicide application (bispyribac sodium @ 80 ml/ha) + one hand weeding, 4) wheat straw mulch @ 5t/ha + one hand weeding, 5) *Eupatorium* mulch @ 5t/ha + one hand weeding, 6) Brown manuring (BM) with *Sesbania aculeata* @ 30 kg/ha, 7) Brown manuring with *Sesamum indicum* @ 2 kg/ha, and 8) Brown manuring with *Crotolaria juncea* @ 30 kg/ha. Rice was sown in line with Chinese power tiller keeping rows 15 cm apart. The seed rate was 25.0 kg/ha. Sowing of rice seeds was done in plots of 6.5 m x 5.5 m (37.75 m^2) size. Two plots were separated by a bund of 0.5 m width and replications were separated by a bund of one m width.

The area, where research site was located, received about 1485 mm rainfall during the entire crop growth period. The average relative humidity for that duration was 85.20%. The crop was fertilized with 120.80.60 kg NPK/ha through Urea, Di-ammonium phosphate (DAP) and Muriate of potash (MOP). Fifty percent of the N, and whole P and K was used as basal dose and the remaining 50 % of N was top dressed, half at maximum tillering stage (35 DAS) and another half at panicle initiation stage (60 DAS). Before sowing, rice seeds were soaked in cold water for 12 hours and treated with Bavistin @2 g/kg seed. These treated seeds were sown in the field with Chinese seed drill. From the experimental site, 10 m^2 area at the centre was taken as net plot rows for harvesting and remaining 4 rows each on both sides of the net plot were used for biometrical and phenological observations. Major weeds in the rice field were identified. Weed density and dry weight of these weeds were measured especially up to maximum vegetative stage. Effective tillers/m^2, number of grains/panicle, thousand seed weight, grain and straw yields were recorded during the experimentation. Statistical analysis of the data was carried out by MSTAT- C package, and correlation and regression analysis was done by using Minitab. Mean was separated by performing analysis of variance (ANOVA) at 5% significance level (Gomez and Gomez, 1984).

Results and discussion

Weed species, weed density, weed dry matter content, and their relations with rice yield

Main weed species found in the experimental sites were categorized into two groups. Broad leaved weeds, such as Gandhe *(Ageratum conyzoides),* Lunde *(Amaranthus* species*),* Kane (*Commelina diffusa),* Bhringraj (*Eclipta prostrate),* Jwane (F*imbristylis miliace)* were kept in the first group. Grasses and sedges, such as Dubo (*Cynodon dactylon),* Banso *(Digitaria adcendens),* Sawa (*Echinochloa colona)* Kade sawa (*Echinochloa crusgalli),* Madilo (*Ischaemum rugosum),* Godhe dubo *(Paspalum distichum),* and Sedges *(Cyperus iria, Cyperus difformis)* were kept in the second group. The result showed significant effect of weed management on weed count. Significantly higher positive correlation (r = 0.982) was observed between weed density and weed dry mater at 45 DAS (Table 1, and Fig 1).

Table 1. Correlation coefficient among yield attributing characters, weed dry matter accumulation at 45 DAS (g/m^2), and straw and grain yields in DSR at Phulbari VDC, Chitwan in 2009

Para-meter	WM 45 DAS	FPP	ET	PL	PW	GPP	TGW	SY
WM 45 DAS								
FPP	-0.584**							
ET	-0.666**	0.838**						
PL	-0.538**	0.455*	0.456*					
PW	-0.630**	0.324	0.407*	0.837**				
GPP	-0.420*	0.311	0.282	0.708**	0.723**			
TGW	0.106	0.272	0.033	0.013	-0.067	-0.041		
SY	-0.795**	0.618**	0.552**	0.286	0.386	0.318	0.28	
GY	-0.860**	0.540**	0.705**	0.531**	0.613**	0.354	-0.114	0.693**

Note. n = 24, df = 22, r at 0.05 = 0.404, r at 0.01= 0.515; *, ** = significant at 5% and 1%, respectively. FPP. final plant population/m^2; ET. effective tillers/m^2; PL. panicle length; PW. panicle weight; GPP. grains/ panicle; TGW. Thousand seed weight; SY. straw yield; GY. grain yield

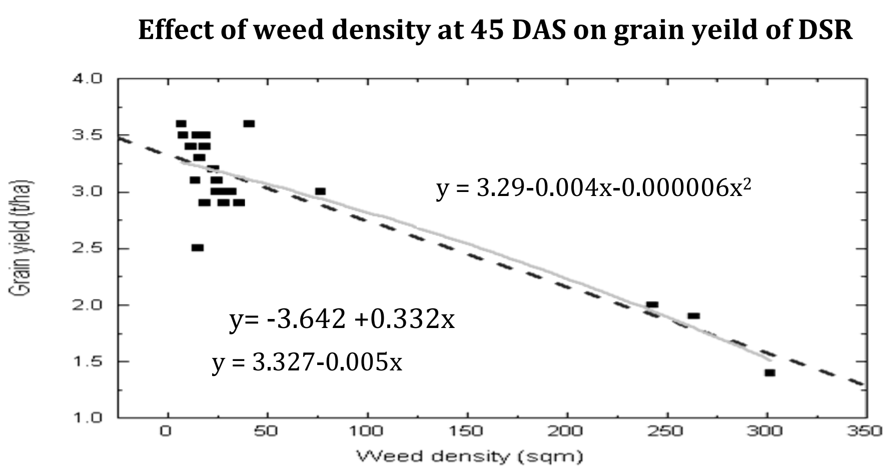

Figure 1. The relationship between weed density at 45 DAS and grain yield of DSR at Phulbari, Chitwan

Weed management practices adopted in all treatments significantly reduced the weed density and weed dry matter as compared to control (Table 2). Herbicide application was found most effective to suppress weed growth in terms of density and dry matter accumulation at all stages of crop growth. The weed density was found maximum at early growth stage of crop (15 DAS) in all treatments except control, but declined remarkably at 30 DAS and 45 DAS. The result showed that wheat straw mulch and *Eupatorium* mulch were found most effective, and BM was found least effective in controlling weed density at early stages (15 and 30 DAS) of crop growth.

Table 2. Effect of mulching materials on weed density (no. of weeds/m^2) and dry weight (g/m^2) in DSR at Gopalgunj, Phulbari VDC, Chitwan in 2009

Treatments	15 DAS	30 DAS	45 DAS
Control (T_1)	303.3^{ab} (16.2^{a})	199.0^{a} (86.7^{a})	269.7^{a} (88.2^{a})
3 hand weeding (T_2)	281.0^{ab} (12.5^{ab})	47.0^{c} (5.5^{e})	20.3^{b} (3.2^{bc})
Herbicide bispyribac application (T_3)	223.3^{ab} (15.6^{a})	41.3^{c} (25.9^{d})	11.7^{b} (1.2^{c})
Wheat straw mulch (T_4)	157.3^{b} (5.9^{c})	93.7^{bc} (41.4^{cd})	41.3^{b} (6.8^{b})
Eupatorium mulch (T_5)	246.7^{ab} (7.9^{bc})	146.7^{ab} (66.6^{b})	26.0^{b} (3.9^{bc})
BM *Sesbania* (T_6)	331.7^{a} (17.8^{a})	137.7^{ab} (27.9^{d})	23.3^{b} (4.0^{bc})
BM *Sesamum* (T_7)	263.3^{ab} (13.4^{ab})	99.7^{bc} (53.7^{bc})	23.0^{b} (4.2^{bc})
BM *Crotolaria* (T_8)	293.7^{ab} (14.8^{a})	151.7^{ab} (59.6^{b})	22.3^{b} (4.7^{bc})
LSD (= 0.05%)	144.3 (5.53)	73.61 (16.50)	29.38 (4.90)

Figures in parentheses indicate the weed dry matter (g/m^2). Means separated by DMRT and columns represented with same letters are not significant at 5% level of significance.

Yield and yield attributes of rice

A wide variation was observed between treatments in yield attributes, such as effective tillers/m^2 and grains/panicle, but statistically the results of the use of *Eupatorium* mulch, and brown manuring with *Crotolaria* are not significantly different. Similarly, significant difference was not observed in thousand seed weight, which ranged from 22.63 to 24.33 g, depending upon the weed management practices (Table 3). The observed result agreed with Hasanuzzaman *et al.* (2008) who reported that thousand seed weight remained statistically unchanged in different weed management practices.

Table 3. **Effect of mulching materials on yield attributing characters and grain and straw yields of DSR at Gopalgunj, Phulbari VDC, Chitwan in 2009**

Treatment	Effective tillers/m^2	Grains/ panicle	1000 seed weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Control (T_1)	96.67^b	186.3^b	23.82^a	1.77^c	3.17^d
3 hand weeding (T_2)	143.67^{ab}	217.3^{ab}	23.73^a	3.17^{ab}	4.43^{bc}
Herbicide bispyribac application (T_3)	181.67^a	216.0^{ab}	23.42^a	3.43^a	5.00^a
Wheat straw mulch (T_4)	142.33^{ab}	239.7^a	24.05^a	2.83^b	4.83^{ab}
Eupatorium mulch (T_5)	162.67^a	243.0^a	24.33^a	3.50^a	4.77^{ab}
BM *Sesbania* (T_6)	172.33^a	198.0^b	22.80^a	3.17^{ab}	4.83^{ab}
BM *Sesamum* (T_7)	171.00^a	197.7^b	23.05^a	2.97^b	4.17^c
BM *Crotolaria* (T_8)	188.00^a	245.3^a	22.63^a	3.23^{ab}	4.17^c
LSD	48.84	33.95	2.559	0.388	0.514

Means separated by DMRT and columns represented with same letters are not significant at 5% level of significance.

The average grain yield in this experiment was 3.01 t/ha, ranging from 1.77 t/ha to 3.5 t/ha (Table 3) in different treatments. All other treatments produced significantly higher grain yield than the control (1.67 t/ha). Significantly higher yields were observed in the treatments, in which *Eupatorium* mulch (3.5 t/ha) and Na bispyribac herbicide (3.43 t/ha) were used. Among the BM treatments, the use of *Crotolaria* produced relatively higher yield (3.23 t/ha) than others and was at par the use of Na bispyribac. Similarly, the average straw yield observed in the experiment was 4.42 t/ha ranging from 3.17 t/ha to 5.0 t/ha depending upon the weed management practices. The straw yield with herbicide application was significantly higher (5.0 t/ha) than three hand weeding (4.4 t/ha) and BM treatments except *Sesbania* BM. This result agrees with the findings of Hasanuzzaman *et al. (*2008), which stated that herbicide application produced higher straw yield than hand weeding. *Sesbania* BM produced significantly higher straw yield (4.8 t/ha) in comparison to *Crotolaria* BM (4.17 t/ha) and *Sesamum* BM (4.17 t/ha). The relationships between weed density and weed dry matter at 45 DAS and grain yield of DSR have shown the negative correlation (Table 1 and Fig 2).

Effect of Weed dry matter on grain yield in DSR

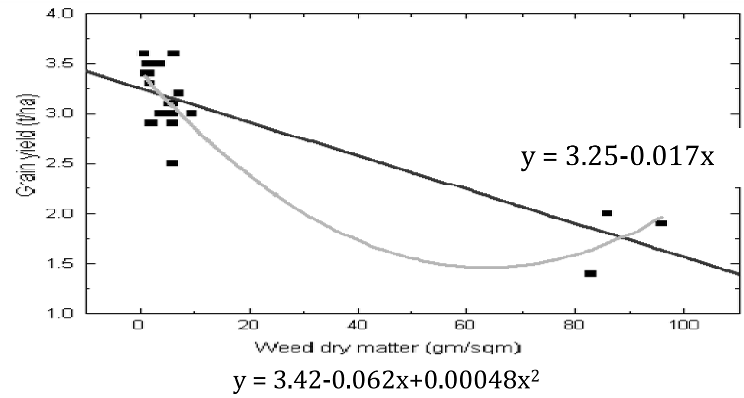

Fig 2. The relationship between weed dry matter at 45 DAS and grain yield of DSR at Phulbari, Chitwan

Economics of DSR

The economics of various weed management treatments are presented in Table 4. Direct-seeding has the potential to reduce cost. Cost of cultivation was found to vary from Rs. 34.60 x 1000/ha (control) to Rs. 50.35 x 1000 /ha (3 hand weeding). The gross returns of different treatments varied from Rs. 53.68 x 1000 /ha to 101.80 x 1000/ha depending upon different treatments. *Eupatorium* mulch gave highest gross returns (Rs. 101.80 x 1000/ha) as compared to all other treatments. Among the BM, *Sesbania* (Rs. 93.67 x 1000/ha) and *Crotolaria* (Rs. 93.33 x 1000/ha) produced more gross return than *Sesamum* (Rs. 86.68 x 1000/ha). The calculation of net return is another parameter of conducting economic analysis in this research. The net return varied from Rs. 19.07 x 1000 /ha (control) to Rs. 59.15 x 1000/ha

Table 4. **Economic analysis of different treatments as affected by live mulch at farmers' field in Phulbari VDC, Chitwan in 2009**

Treatments	Cost of cultivation (x 1000 Rs/ha)	Gross returns (x 1000 Rs/ha)	Net returns (x1000 Rs/ha)	Benefit. cost ratio
Control (T_1)	34.60	53.68	19.07	1.5
3 hand weeding (T_2)	50.35	92.47	42.12	1.8
Bispyribac application (T_3)	42.15	100.81	58.68	2.4
Wheat straw mulch (T_4)	45.90	85.32	39.42	1.9
Eupatorium mulch (T_5)	42.65	101.80	59.15	2.4
BM *Sesbania* (T_6)	41.65	93.67	52.02	2.3
BM *Sesamum* (T_7)	40.06	86.68	46.61	2.2
BM *Crotolaria* (T_8)	41.35	93.33	51.97	2.3

(*Eupatorium* mulch). All tested treatments were found superior to control in terms of net return. The B. C ratio also gave similar result. This ratio ranged from 1.5 to 2.4. The highest B. C ratio was obtained in *Eupatorium* mulch and herbicide application (2.4). A higher B.C ratio of BM was found than the wheat straw mulch. Singh *et al.* (2007) reported that *Sesbania* as brown manuring was as effective as the mulch in realizing higher economic returns. However, the result of this research suggested that the economic return of brown manuring is higher than wheat straw mulch.

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