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Effect of leaf mulches on soil moisture conservation, growth and yield of blackgram in upland soils of Tripura

B.K. Bhattacharya, M. Datta and S. Mitra

ICAR Research Complex, Tripura Centre, Lembucherra 799 210, India.

Abstract

A field experiment was conducted during 1995 with blackgram grown under three different leaf mulches in rainfed upland soils at ICAR Farm, Tripura. The leaf mulch of *Acacia auriculiformis* produced significantly higher average grain yield (7.03 q/ha) of blackgram and improved water use efficiency (0.55 kg/ha mm) followed by *Glyricidia maculata* leaf and chan grass. The average moisture depletion rate was higher (0.8 to 3.1 mm/day) in unmulched conditions than under leaf mulches (0.6 to 2.1 mm/day) due to higher evaporation from the exposed soil surface. Chan grass conserved more moisture in the surface soils. The higher rate of profile moisture depletion in the case of acacia mulching during flowering and pod formation stages of the crop as compared to glyricidia and chan, might have been due to higher absorption of moisture by the crop and subsequent transpiration loss. The mean maximum LAI of the crop was also highest in acacia mulching (2.3) followed by glyricidia (1.3) and chan (1.1) mulches. The above ground biomass accumulation at different phenophases of the crop was also significantly higher (74.7 to 456 g/m^2) under acacia mulching than the other two leaf mulches.

Additional keywords: Water-use-efficiency, moisture depletion.

Introduction

The application of mulches is of utmost importance in conserving soil moisture alongwith weed control. Some workers have used mulches in rabi season under irrigated potato crop (Jaiswal 1995), some have applied it in summer cotton or rainy season crops (Singh and Bhan 1993; Kumar *et al.* 1995). The yield increase and water economy were reported to be higher in summer and rabi season when severe moisture stress occurred. All of them used rice straw or synthetic materials (Polythene) as mulches which may not be cost-effective in remote area like Tripura. But, there is abundance of different natural vegetation in the uplands of Tripura such as *Glyricidia maculata, Acacia auriculiformis* and Chan grass (*Saccharum sp.*) with high regeneration ability after cutting. Moreover, the rabi season in Tripura with a low rainfall (130 mm) and high evaporation (240 mm) imposes severe moisture stress specially in the upland soils. Therefore the yield of rabi crops in the upland soils of Tripura was at or below marginal level.

Keeping these factors in view an experiment was undertaken to investigate the relative efficacy of three different leaf mulches in conserving soil moisture and improving growth and yield of rabi blackgram (*Phaseolus mungo*).

Materials and methods

A field experiment was conducted in rainfed upland soils at ICAR farm, Lembucherra, Tripura during rabi 1995 with blackgram (*Phaseolus mungo*). The soil was sandy clay loam in texture with sand, silt and clay varying from 49-56%, 14-20%, 26-36%, respectively in different layers of the 160 cm deep soil profile. the soil had a bulk density of 1.4 Mg/m^3, porosity of 16.6 per cent and maximum water retentive capacity of 35.94 per cent. The pH of the soil was 5.5, organic carbon 0.4 per cent, CEC 4.8 cmol (+) kg^{-1}, base saturation 29 per cent, available N 240 kg/ha, P 150 kg/ha and K 80 kg/ha.

The experiment was laid out in factorial RBD with three varieties of blackgram (V1, B-12-4-4; V2, B-3-8-8 and V3, T9) and four levels of leaf mulches such as no mulch (M0),

leaves of *Glyricidia maculata* (M1), leaves of *Acacia auriculiformis* (M2) and chan grass (M3). Leaves were applied @ 10 t/ha. The soil moisture estimation was done periodically at 10 days interval for the depths of 0-5 cm, 5-15 cm, 15-30 cm, 30-45 cm from sowing to harvest. Consumptive water use was calculated using effective rainfall method (Dastane 1974) and semi-empirical equation (Bhattacharyya *et al.* 1996). The observations on periodic above ground biomass, maximum rooting depth (by profile digging method), leaf area index (LAI) (calculated by graphical method) were also taken. Statistical analysis was done using MSTATC software package.

Results and discussion

Grain yield

The mean grain yield was significantly higher (Table 1) under leaf mulches than no-mulch (control) (3.50 q/ha) with a CV value of 11.9 per cent. Among the three mulches, the mean yield was significantly higher under acacia (7.03 q/ha) compared to glyricidia (5.23 q/ha) and chan (3.7 q/ha). Among the three cultivars, V2 and V3 recorded significantly higher yield than V1.

Water use and water use efficiency

The mean water use (Table 1) was found to be highest (137 mm) in the 0-45 cm soil profile in no-mulch (control) conditions compared to mulched conditions. This may be attributed to higher evaporation from the surface soil in no-mulch treatment compared to very little evaporation under mulches (Singh and Bhan 1993). Among the three leaf mulches, the water use was found to be higher under acacia leaf with a mean value of 128 mm followed by glyricidia leaf (115 mm) and chan grass (102 mm). The highest water use under acacia might have resulted in higher yield.

Table 1. Grain yield, water use and water use efficiency in blackgram under different leaf mulches

	Grain yield (q/ha)				Water use (mm)				Water use efficiency (kg/ha-mm)			
Mulches	Cultivars			Mean	Cultivars			Mean	Cultivars			Mean
	V1	V2	V3		V1	V2	V3		V1	V2	V3	
M0	2.6	3.8	4.0	3.50	162	107	142	137.0	0.16	0.36	0.28	0.27
M1	4.9	4.9	5.9	5.23	117	123	118	119.3	0.42	0.40	0.50	0.44
M2	7.2	7.9	6.0	7.03	114	132	138	128.0	0.63	0.60	0.43	0.55
M3	3.1	3.9	4.1	3.70	110	100	96	102.0	0.28	0.39	0.43	0.37
Mean	4.5	5.12	5.00		125.8	115.5	123.5		0.373	0.44	0.410	
CV (%)		11.9										
			CD (P=0.05)		SEm±							
Variety			0.08		0.019							
Mulch			0.07		0.022							
Variety x Mulch			0.09		0.037							

The mean water use efficiency was also found to be higher under leaf mulches (Kumar *et al.* 1995) compared to no-mulch conditions (0.27 kg/ha-mm). Acacia gave highest mean value (0.55 kg/ha-mm) followed by glyricidia leaf (0.44 kg/ha-mm) and chan grass (0.28 to 0.43 kg/ha-mm).

Table 2. Volumetric moisture content (mm) of surface (0-5 cm) and profile (0-60 cm) as effected by leaf mulches at different growth stages of rabi blackgram

Treatment	10 DAS		20 DAS		30 DAS		40 DAS		50 DAS		Maturity (70 DAS)	
	Surface	profile	Surface	profile	Surface	profile	Surface	profile	Surface	profile	Surface	profile
Cultivar												
V1	10.9	140 (1.7)	6.5	124	10.3	142 (1.9)	6.3	123 (0.8)	6.0	115 (0.9)	3.6	96
V2	11.2	137 (1.5)	5.2	122	11.8	148 (2.3)	7.1	125 (1.1)	6.3	114 (0.7)	3.0	99
V3	11.1	147 (2.7)	6.6	121	11.4	150 (2.1)	7.8	129 (1.2)	6.1	118 (1.0)	2.1	99
Leaf mulch												
M0	9.3	140 (2.2)	4.8	118	11.2	149 (3.1)	6.4	118 (0.8)	5.4	110 (1.4)	1.8	82
M1	11.2	143 (2.1)	5.1	122	11.1	149 (2.1)	5.8	128 (0.9)	5.3	119 (0.8)	1.0	103
M2	11.9	144 (2.1)	6.9	123	12.1	143 (1.8)	8.0	125 (1.7)	6.3	108 (0.7)	3.2	94
m3	12.0	140 (1.4)	7.7	126	10.2	145 (1.3)	8.0	132 (0.6)	7.4	126 (0.6)	5.5	113
CV (%)	10.2	5.6	24.2	4.3	16.7	4.3	18.9	25.1	16.2	7.7	69.6	16.9

* Data presented in the parentheses between two dates are depletion rate of profile moisture in mm/day for that particular period.
* DAS = Days after sowing

Among the three cultivars, the average water use was higher in V1 and V3 compared to V2, but V2 recording highest yield gave highest water use efficiency followed by V3 and V1.

Surface and profile moisture

The data presented in Table 2 showed that the average values of surface soil (0-5 cm) moisture at different stages of crop growth up to maturity (70 DAS) were higher under chan and acacia leaf (3.2 to 12.1 mm) compared to control (1 to 11.2 mm). Glyricidia leaf mulch was found to conserve higher surface moisture compared to no-mulch (control) up to 10 DAS, but at the later stages of growth, the values were almost equal or sometimes less or little higher compared to no-mulch. The gradual degradation of glyricidia leaf within 10 DAS seemed to leave soil sufficiently exposed for evaporation to take place at the later stages of crop growth as compared to initial stages. The chan grass with its compact linear orientation as mulches and acacia leaf with glossy surface and very little degradability due to high lignin content conserved higher surface moisture compared to quickly degradable glyricidia.

The average depletion rates of profile moisture were higher under acacia (0.7 to 2.1 mm/day) and glyricidia (0.8 to 2.1 mm/day) compared to chan (0.6 to 1.4 mm/day). The depletion rates were slightly higher in no-mulch conditions (0.8 to 3.1 mm/day) than under leaf mulches due to higher evporation from the exposed soil surface. The depletion rates under acacia mulching in most of the stages were comparable to that under glyricidia but became double between 30-40 DAS corresponding to flowering and pod formation stages which are sensitive to water availability.

It may be mentioned that no consistent difference in surface moisture and depletion rates of profile moisture was observed among the three cultivars.

Rooting depth, leaf area index (LAI) and harvest index

The highest mean maximum rooting depth (Table 3) was recorded under acacia (42 cm) followed by glyricidia (36 cm) and chan (31.3 cm). The straw-like dense and compact linear orientation of chan grass which was different from other two leaf mulches seemed to have inhibited aeration into the soil thereby rooting depth (Chaudhury and Prihar 1974).

Table 3. Rooting depth, LAI and harvest index in blackgram under different leaf mulches

Mulches	Max. root depth (cm)				Maximum (LAI)				Harvest index			
	Cultivars			Mean	Cultivars			Mean	Cultivars			Mean
	V1	V2	V3		V1	V2	V3		V1	V2	V3	
M0	33	37	35	35.0	1.2	1.1	1.0	1.1	0.14	0.21	0.26	0.203
M1	32	39	37	36.0	1.3	1.4	1.2	1.3	0.20	0.17	0.31	0.230
M2	40	45	41	42.0	2.2	2.7	1.9	2.3	0.22	0.16	0.28	0.220
M3	31	32	31	31.3	1.2	1.7	1.1	1.3	0.16	0.16	0.25	0.19
Mean	34.0	38.3	36.0		1.5	1.8	1.3		0.18	0.175	0.275	
CV (%)								8.05				7.7
						CD (P=0.05)		SEm±		CD (P=0.05)		SEm±
					Variety		0.207	0.048	Variety	0.010		0.027
					Mulch		0.180	0.057	Mulch	0009		0.016
					Variety x mulch		0.235	0.096	Variety x mulch	0.012		0.027

Acacia gave highest mean maximum LAI value of 2.3 followed by glyricidia (1.3), chan (1.3) and no-mulch (1.1) (Table 3). A significantly higher mean values of harvest index were recorded in leaf mulches (0.19 to 0.23) over control (0.203).

Among the three cultivars, V2 recorded highest mean maximum rooting depth (38.3 cm), significantly higher maximum LAI (1.8) but lower harvest index over the other two.

Biomass accumulation

The Table 4 showed significantly higher average above ground biomass production under leaf mulches over control with acacia recording highest (74.7 to 456 g/m^2) followed by glyricidia (60.7 to 242 g/m^2) and chan (58 to 199 g/m^2) at different growth stages of crop. Like other growth parameters, the biomass accumulation was also found to be significantly higher in V2 (65 to 298.5 g/m^2) over V1 and V3 at different phenophases.

Table 4. Biomass accumulation (g/m^2) in blackgram under different leaf mulches

	at 100% flowering				At 100% pod filling				at harvest			
Mulches	Cultivars			Mean	Cultivars			Mean	Cultivars			Mean
	V1	V2	V3		V1	V2	V3		V1	V2	V3	
M0	47	55	60	54.0	158	150	132	146	180	179	150	169
M1	57	71	54	60.7	219	259	186	221	249	284	192	242
M2	75	77	72	74.7	300	481	128	303	332	491	216	456
M3	62	56	56	58.0	170	207	154	177	195	240	162	199
Mean	60.0	65.0	61.0		212.0	274.0	154.0		239.0	298.5	180.5	
CV (%)			15.1			5.5				9.4		
			CD (P=0.05)	SEm±		CD (P=0.05)		SEm±		CD (P=0.05)		SEm±
Variety			1.64	0.381		2.04		0.474		1.23		0.286
Mulch			1.40	0.440		1.74		0.404		1.05		0.330
Variety x Mulch			1.87	0.764		2.32		0.948		1.40		0.572

Considering the yield, water-use, water use-efficiency, rooting depth, biomass, LAI acacia proved to be the best leaf mulch followed by glyricidia and chan. Glyricidia having quick degradability may be used as green leaf manure or as mulch in combination with acacia or chan. Chan conserving more surface moisture may be used for summer/rabi crops at the later stages of growth to increase residual moisture for succeeding crop in uplands of Tripura. Among the three cultivars, V2 (B-3-8-8) was found most efficient in utilizing soil moisture.

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