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Comparative evaluation between rice straw mulching and herbicides for weed control in jute [*Corchorus olitorius* L.] under *terai* agro-ecological region of West Bengal

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Jute [*Corchorus olitorius* L.] is an important fiber crop in the terai region of West Bengal during *kharif* season. High rainfall during the initial phase of the jute crop results in better germination and growth of jute. Medium to high temperature and high humidity during the exponential growth phase of the crop and availability of water during harvesting of jute for retting make this region ecological suitable for jute cultivation (Mukherjee *et al.,* 2011). However, high humidity and high rainfall during *kharif* season also lead to high weed pressure from different weeds (grasses, sedges and broad-leaved weeds), which, in turn, could lead to yield losses ranging from 52 to 55% in case of *Corchorus capsularis* and from 59 to 75% in case of *C. olitorius* (Sarkar *et al*., 2005). Therefore, low yield of jute in the region could be attributed to heavy infestation of fields by weeds. Manual weeding is a common weed control practice in this region; however, it incurs huge expenditure as labour input costs, and thus, reduces the benefits of jute cultivation. Combined hoeing and hand weeding could become effective in controlling weeds (Prusty *et al*. 1988) and growing of inter-row crops, such as red amaranth (*Amaranthus tricolor*) in jute crops has the capacity to suppress growth of the weeds to a greater extent, compared to hand weeding (Ghorai 2007). Paddy straw mulching could reduce the weed biomass by 68 to 82% (Ghorai *et al*., 2004) and better weed control was recorded by using soil-incorporated, broad-spectrum, pre-emergence herbicides fluchloralin, at 1.0 kg ha^{-1} combined with hand weeding (Rajput, 2000), or trifluralin at 0.75 kg ha^{-1} (Sarkar *et al*., 2005). Post-emergence spray of quizalofop ethyl with adjuvant also controlled the grassy weeds effectively (Ghorai *et al*., 2004). These findings led to the need of studying weed control methods and their economics to be used in integrated weed management practices for controlling weed in jute at terai agro-ecological region of West Bengal.

A field experiment was carried out during *kharif* season of 2009 in the farm of Uttar Banga Krishi Viswavidyalaya with nine treatment combinations. The six herbicide treatments were: (1) flucholarin 1.0 kg ha^{-1} as pre-emergence; (2) flucholarin 0.70 kg ha^{-1} as pre-emergence, followed by hand weeding at 35 days after sowing (DAS) (3) quizalofop ethyl 50 g ha^{-1} as post-emergence treatment at 21 DAS; (4) quizalofop ethyl 50 g ha^{-1} as post-emergence treatment at 21 DAS, followed by hand weeding at 35 DAS; (5) fenoxaprop ethyl 50 g ha^{-1} as post-emergence treatment at 21 DAS; (6) fenoxaprop ethyl 50 g ha^{-1} as post-emergence treatment at 21 DAS, followed by hand weeding at 35 DAS. Additional treatments were: (7) mulching with rice straw at the rate of 8 ton ha^{-1} at 15 DAS after thinning and hand weeding, and (8) a completely weed free treatment (achieved by hand weeding), and (9) a non-weeded control. The nine treatments were tested with three replication plots arranged in a RCBD (randomized complete block design). The jute variety JRO-524 was grown with the spacing of 30 × 5 cm. Fertilizers with NPK ratio of 60:30:30 kg ha^{-1} was used in which phosphorus, potassium and ½ of the total nitrogen were applied as basal, and the remaining nitrogen applied at 35 DAS. The experimental site was situated on medium land with high soil moisture content and the soil was sandy loam in character with pH 5.34-5.8 and organic carbon value 0.62%. The available NO_3-N, NH_4-N, P and K were 117.80, 94.75, 16.35 and 76.9 kg/ha, respectively. Weed dry biomass were recorded at different growth stage of jute from the area enclosed by a quadrate of 0.25 m^2 randomly selected at 2 places in each plot. After that weeds were dried in oven for dry weight measurement. The weed control efficiency (WCE) and weed index (WI) were calculated by using following formulae

$$\text{WCE (\%)} = \frac{\text{Dry weight of weed in control plot} - \text{Dry weight of weed in treated plot}}{\text{Dry weight of weed in control plot}} \times 100$$

$$\text{WI (\%)} = \frac{\text{Fiber n yield in complete weed free plot} - \text{Grain yield in treated plot}}{\text{Fiber yield in complete weed free plot}} \times 100$$

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Table 1: Effect of treatments on dry weight of weeds, weed control efficiency at different days after sowing and weed index

Treatments	Dry weight of weeds(g m^{-2}) at different days after sowing				Weed control efficiency (%) at different days after sowing				Weed index
	30 DAS	60DAS	80DAS	HAR	30 DAS	60DAS	80DAS	HAR	
Fluchloralin 0.70 kg ha^{-1} + HW	156.2	138.2	182.2	176.4	13.80	39.96	28.27	24.67	46.11
Fluchloralin 1.00 kg ha^{-1}	143.2	189.2	216.9	205.1	20.99	17.77	14.61	12.42	58.34
Quizalofop ethyl 50 g ha^{-1}	168.2	215.4	235.1	218.4	7.19	6.39	7.46	6.74	64.28
Quizalofop ethyl 50 g ha^{-1}+ HW	162.5	212.3	231.2	215.6	10.30	7.77	8.98	7.93	60.44
Fenoxaprop ethyl 50 g ha^{-1}	167.1	207.3	223.1	208.2	7.77	9.95	12.19	11.09	55.57
Fenoxaprop ethyl 50 g ha^{-1}+ HW	161.6	203.2	217.1	202.8	10.82	11.73	14.55	13.39	55.11
Mulching after thinning and hand weeding at 15 DAS	17.2	23.5	27.8	29.1	90.49	89.75	89.02	87.57	1.66
Weedy control	181.2	230.2	254.1	234.2	-	-	-		69.89
Complete weed-free									-
SEm (±)	**0.61**	**0.56**	**0.56**	**0.51**					
LSD (0.05)	**1.84**	**1.70**	**1.70**	**1.55**					

Note : DAS- Days after sowing, HW- Hand weeding, HAR- At harvest

Table 2: Effect of treatments on yield attributing characters, fiber yield and economics of jute

Treatments	Plant height (cm)	Basal girth (cm)	Fiber yield of jute (kg ha^{-1})	Net return (₹)	Benefit: cost ratio
Fluchloralin 0.70 kg ha^{-1}+ HW	245	3.56	1980.00	14060.00	2.45
Fluchloralin 1.00 kg ha^{-1}	211	3.20	1530.72	10669.00	2.39
Quizalofop ethyl 50 g ha^{-1}	194	3.01	1312.45	7649.00	1.94
Quizalofop ethyl 50 g ha^{-1}+ HW	205	3.14	1453.57	7743.00	1.80
Fenoxaprop ethyl 50 g ha^{-1}	216	3.33	1632.40	11389.00	2.39
Fenoxaprop ethyl 50 g ha^{-1}+ HW	218	3.33	1649.05	9889.00	2.00
Mulching after thinning and hand weeding at 15 DAS	335	4.59	3613.50	28662.00	2.95
Weedy control	180	2.77	1106.28	6575.00	1.98
Complete weed-free	336	4.65	3674.62	25395.00	2.36
SEm (±)	**1.47**	**0.03**	**1.05**	-	-
LSD (0.05)	**4.41**	**0.08**	**3.15**	-	-

Fibre crop was harvested at 110 to 120 days after emergence and fibre extraction was done by retting in water. The experimental data were subjected to analysis of variance (ANOVA) by using the statistical software INDOSTATE 7.5.

Weed flora and weed dynamics

The weed flora in the jute field was comprised mainly by sedges, grasses and broadleaved, which are characteristic of the weed flora in medium land situation at high soil moisture soil. At the initial stage of jute, the weeds *Cyperus rotundus,* Cyperus iria, *Cynodon dactylon*, *Setaria glauca, Paspalum scrobiculatum* and *Fimbristylis miliacea* became aggressive and constituted the important weeds during the initial 40 DAS. Beyond this stage the growth of the sedges did not increase by much, whereas the emergence of broadleaved weeds - *Ageratum conyzoides* and *Ludwigia parviflora*. Occurred around 30 DAS, and these became dominant weeds during the later part of the crop growth.

Weed control efficiency and weed index

All the herbicidal treatments alone or in combination with hand weeding were found ineffective in controlling the weeds throughout the crop growth, and thus, resulted in poor weed control efficiency of the treatments. Inefficient weed controls are reflected in the high values of the weed indices of the herbicide treated plots. This in turn resulted in increased growth of weeds, which led to reduced fibre yield of jute through severe weed-crop competition (Table 1). The grass herbicides – quizalofop ethyl and fenoxaprop ethyl were only effective on grasses and were not effective on the sedges and broad-leaved weeds, which dominated the plots.. Rainfall occurring after the application of the broad-leaf herbicide fluchloralin caused water stagnation in the field for a short period of time, and this may have diluted the herbicide or resulted in leaching of herbicide from the surface soil, thus reducing its bio-efficacy and persistence in the soil. High soil moisture during the experimental period favoured the rapid emergence and aggressive growth of both grass and broad-leaved weeds in the experimental site. The lowest dry weights of weeds throughout the crop growth was recorded in the mulching treatment, which recorded > 85% weed control efficiency at all stages of the crop growth. The high weed control efficiency and low weed index of the mulching treatment indicated that weed-crop competition was lowest in the mulched treatments, as rice straw mulch may have interfered with the germination, emergence and further growth of weeds. It is well known that the physical cover by mulch could deplete sunlight reaching the soil surface, and this may prevent the seed germination of some weeds (Ghorai, 2007). Red light in solar energy is essential for germination of weeds. The treatments quizalofop ethyl and fenoxoprop ethyl were failed to control the weeds due to high population of sedges and broadleaved weeds at the latter stage of the jute growth.

Yield attributing characters and yield

Among the treatments mulching with rice straw (8 t ha^{-1}) at 15 DAS after thinning and hand weeding was found highly effective in controlling weeds and that resulted in high value of yield attributing characters and consequently fibre yield of jute without having any significant difference with complete weed-free condition (Table 2). Only 1.66% yield reduction occurred in mulching treatment due to presence of weed as compared to complete weed-free plot and thus indicated the effectiveness of rice straw mulching in combating weed problem in jute under terai agro-ecological region of West Bengal.

Economics

Among the weed control treatments, rice straw mulching at 8 t ha^{-1}, applied after thinning and hand weeding at 15 days after sowing, was found effective in controlling weeds, resulting in the highest net return and benefit: cost ratio (28662/- and 2.36). This was followed by flucholarin 0.70 kg ha^{-1} as pre-emergence + hand weeding at 35 DAS in terms of a benefit: cost ratio of 2.45. Therefore, it could be concluded that rice straw mulching could be used in integrated weed management practices in jute and it could help the poor farmers to reap maximum benefit by saving their crop from severs crop-weed competition.

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