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Integrated weed management in jute (*Corchorus olitorius*)

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ABSTRACT

An experiment was conducted at Barrackpore during 2003-2005 to find out suitable eco-friendly and remunerative integrated weed-control approaches for jute cv ëJRO 524í (ëNaviní). Cultural, organic and integrated chemical weed-control methods were found better than conventional manual weeding twice. In cultural method, smothering of weeds by leafy vegetable mixtures [red amaranth (*Amaranthus tricolor* L., cv ëJabakusumí), white amaranth (*Amarantus* spp.) and summer radish (*Raphanus sativus* L. cv ëPaus mulaí] in jute, reduced the dry matter of weeds up to 45% when the field was dominated by grasses and broad-leaf weeds. This was followed by two manual weedings which gave 3.57 t/ha jute fibre (along with 2.9 t/ha red amaranth, 0.6 t/ha white amaranth and 0.7 t/ha summer radish, respectively). The organic approach, rice straw mulch @ 10 t/ha and mixed cropping with same vegetables, followed by one manual weeding produced 3.9 t/ha jute fibre (1.15, 0.64 and 0.94 t/ha red and white amaranth and summer radish, respectively). It reduced the dry matter of weeds by 68 to 82%. In integrated chemical approach, spray of quizalofop ethyl (DT_{50} < 1d) @ 60 g/ha + dhanuvit @ 0.5 to 0.6 l/ha (adjuvant) at 21 DAE combined with 1 hand weeding produced 3.87 t/ha jute fibre. The benefit : cost ratio from conventional, cultural, organic and chemical approaches was 1.50, 1.57, 2.19 and 1.66 respectively. The residue of quizalofop ethyl was found below the detectable limit (0.84 to 4.2 ppm) within 8 days of its application.

Key words: Economics, Fibre yield, Herbicide, Integrated weed management, Mixed cropping, Mulching, Weed smothering

In jute (*Corchorus olitorius*), conventional manual weeding accounts for 40% of the total cost of cultivation, which reduces its net returns (Saraswat, 1974). The fibre yield decreases by 70% under unweeded situation. Manual weeding is still in vogue due to lack of proper selective herbicides and other remunerative cultural methods to address this problem effectively. Adequate information is not available regarding effective weed management in jute over conventional method. In jute, red amaranth (*Amaranthus tricolor*) @ 50 kg/ha as cover crop and rice-straw mulch @ 10 t/ha reduced the weed pressure by 54 and 66%, respectively (Ghorai *et al.*, 2004). Post-emergence herbicide, quizalofop ethyl controlled the grassy weeds in jute field. A survey on weed flora in jute-growing areas in India indicated that 60-70% of the total weed population was dominated by grassy weeds (Saraswat, 1999). A field experiment was conducted to find out farmer-friendly weed-management techniques for jute, adopting cultural, organic and chemical approaches and integrating manual weeding with each.

MATERIALS AND METHODS

A field experiment was conducted during summer and wet seasons during 2003-05 at the research farm of Central Research Institute for Jute and Allied Fibres, Barrackpore. The soil of the experimental site was sandy clay-loam, analysing 44% sand, 28% silt and 28% clay. Available N, P and K contents of the soil were 180, 34 and 133 kg/ha, respectively. Eight treatment combinations were arranged in randomized complete block design with three replicates. Individual gross plots were of 3 x 3 m in size. Most popular jute cultivar 'JRO 524' ('Navin') was sown in the first week of April each year. Cultural (smothering), organic (straw mulching and mixed cropping) and chemical weed-control methods were supplemented with manual weeding for integrated weed management in jute. The treatment combinations were: unweeded control; hand-weeding twice (21 and 35 days after jute emergence, DAE); rice-straw mulch @ 15 t/ha + 2 hand-weeding (21 and 35 DAE) + mixed crop with red and white amaranth and summer radish (10, 2 and 2 kg seed/ha); rice-straw mulch @ 10 t/ha + 2 hand-weedings (21 and 35 DAE) + mixed crop with red and white amaranth and summer radish (10, 2 and 2 kg seed/ha); smothering by mixed cropping red amaranth (10 kg/ha) + white amaranth (2 kg/ha) and summer radish (2 kg/ha) + 2 hand-weedings (21 and 35 DAE); smothering by mixed cropping red amaranth

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(20 kg/ha) + white amaranth (2 kg/ha) and summer radish (2 kg/ha) + 2 hand-weedings (21 and 35 DAE); smothering by mixed cropping red amaranth (30 kg/ha) + white amaranth (2 kg/ha) and summer radish (2 kg/ha) + 2 hand-weedings (21 and 35 DAE); quizalofop ethyl 5% EC @ 60 g + dhanuvit @ 0.5 to 0.6 litre/ha (adjuvant) spray at 21 DAE + one hand-weeding (35 DAE).

Well-rotten FYM 8 t/ha (N 0.5%, P 0.065% and K 0.38%) was applied before final land preparation. Fertilizer dose applied was N, P and K @ 60, 13 and 25 kg/ha in 2003 and 2004; and N, P and K @ 80, 13 and 25 in 2005 to compensate for the N loss through mixed vegetable in jute. Red and white amaranth and summer radish were broadcast immediately after land preparation. Jute seed @ 5 kg/ha were sown subsequently in lines using hand tynes in shallow furrows. Immediately after jute sowing, small rice-straw bundles (summer rice) were laid between the lines on plots allotted for mulching. A post-sowing irrigation was given to all the plots to ensure proper germination. Additional 2 to 3 irrigations were given for better harvest of jute, red and white amaranth and summer radish. During harvest of vegetables at 21 days after emergence (DAE), one hand weeding and thinning of jute was followed. A second weeding was given at 35 DAE. Summer radish was harvested during 35-40 DAE.

Weed samples were collected to find out the dry-matter production/ha by weeds. Soil temperature (8 AM and 2 PM) and moisture were recorded from jute fields (at regular intervals). For analysis of herbicide residue, quizalofop ethyl residue was extracted from the soil and jute leaf samples by maceration with acidic acetone : ethanol : water (2 : 1 : 1) solvent mixture. The extracts were then concentrated and partitioned with hexane : ether (1 : 1) and hydrolysed in dilute alkali solution. The cleaned extract was then derivatized with diazomethane and this extract was finally cleaned on florisil column. The residue were estimated in HPLC equipped with UV-VIS detector along with Chemito 5000 data processor.

RESULTS AND DISCUSSION

Weed flora

The weed flora in the experimental field consisted of grasses like *Echinochloa colonum*, *Digitaria digitata* and *Cynodon dactylon;* sedges like *Cyperus rotundus;* and broad-leaved weeds like *Euphorbia hirta*, *Eclipta alba*, *Phyllanthus niruri*, *Portulaca potulacastrum* etc. However, grassy weed *Echinocloa colonum* dominated over other weeds in the jute field.

Cultural approach

Red and white amaranth and summer radish together as cover crop in jute suppressed the weed growth by 22-25% compared with manual weeding twice at 21 DAE. When grasses and broad-leaf weeds dominated the field, they reduced the dry matter of weeds up to 45% compared with manual weeding twice. The dry matter of weeds under manual weeding was 2.56 t/ha, but under cover crop it was reduced to 1.92 t/ha (Table 1). Ghorai *et al.* (2004) reported weed-smothering ability of red amaranth in mixed jute stand up to 54%. This system yielded 3.5-3.7 t/ha raw jute fibre along with 1.9-2.9 t/ha red amaranth (21 DAE), 0.76-0.90 t/ha white amaranth and 0.75-0.90 t/ha summer radish (30-40 DAE) respectively. Under this system the plant height (269-276 cm) and basal diameter (1.11-1.18 cm) of jute were a little less than under conventional manual weeding twice. However, this cultural approach generated higher net returns (inclusive of vegetable crops) of Rs 18,472 to Rs 20,949/ha compared with Rs 16,147 under manual weeding twice (Table 2). It generated gross returns of Rs 1.48 to1.57 from each Re invested as total variable cost. Ghorai *et al.* (2004) also reported the profitability of this weed-control approach. Ghorai (2007) reported that rainfed mixed cropping is possible under late-sowing condition.

Organic approach

Use of rice-straw mulch @ 10-15 t/ha reduced the production of dry matter of weeds (0.46 to 0.82 t/ha) by 68-82% compared with manual weeding twice (2.56 t/ha) and yielded more jute fibre (3.90-3.95 t/ha) compared with the latter method (3.75 t/ha). It gave higher biomass yield of jute (up to 61.7 t/ha) without affecting the plant height and basal diameter (Table 1). The mulched plots maintained better hydrothermal regime of soil [maintained lower soil temperature (6-8^{0}C) and higher moisture (18.0-23.4%) compared with bare soil (12.6-18.0%) cultivation] in hot summer months (Table 2). This better soil-water environment and weed suppression by mulching increased the jute-fibre yield compared with control. It made the second manual weeding redundant. This method (incluson of cover crops) generated significantly higher net returns of Rs 32,848 to Rs 34,360 compared with manual weeding twice (Rs 16,147/ha). Owing to low labour requirement, the total variable cost of this system was much less than that of manual weeding twice. However, to mulch jute field between the rows, 55 mandays/ha were essential. The benefit : cost ratio of this system varied from 2.19 to 2.32 compared with only 1.50 manual weeding twice. Thus this weed-control method is safer, benign and remunerative to jute farmers. Tindall *et al.* (1991) reported the weed-control ability of straw mulch in tomato field.

Chemical approach integrated with manual weeding

Application of quizalofop ethyl @ 60 g/ha and dhanuvit @ 0.5 to 0.6 l/ha followed by one hand weeding at 21 DAE was found very effective in weed control. It

Table 1. Growth yield and economics of jute crop as affected by different weed-management practices (pooled data)

Treatment	Plant height (cm)	Basal diameter (cm)	Weed bio-mass (t/ha)	Fibre yield (t/ha)	Associate cover-crop yield			Jute biomass yield (t/ha)	Total variable cost	Net returns (x 10^3 Rs/ha)	B : C ratio	Mean soil temperature (°C)	Mean moisture content of soil (%)
					Red amaranth (kg/ha)	Summer radish	White amaranth (t/ha)						
Unweeded check	207	0.08	2.45	1.96				34.1	16.69	8.86	1.53	36.5	10.57
Hand-weeding (HW) twice (21, 35 DAE)	293	1.23	2.56	3.75				56.0	31.74	16.15	1.50	35.96	9.45
Mulch @ 15 t/ha (with red and white amaranth and radish) + 2 HW	283	1.22	0.46	3.95	640	1518	672	61.5	25.92	34.36	2.32	33.04	17.16
Mulch @ 10 t/ha (with red and white amaranth and radish) + 2 HW	280	1.21	0.82	3.90	1148	938	636	61.7	27.57	32.85	2.19	29.95	15.73
Jute + red amaranth (10 kg/ha) + white amaranth and radish, 2 HW	276	1.18	1.98	3.66	1953	938	864	54.6	38.88	18.47	1.48	38.40	9.6
Jute + red amaranth (20 kg/ha) + white amaranth and radish, 2 HW	269	1.11	1.99	3.48	2625	522	907	54.3	38.33	18.78	1.49	37.09	9.65
Jute + red amaranth (30 kg/ha) + white amaranth and radish, 2 HW	272	1.17	1.92	3.57	2928	626	765	59.0	36.44	20.95	1.57	37.75	10.41
Quizalofop ethyl + dhanuvit + 1 HW (35 DAE)	273	1.18	1.41	3.87				57.4	29.69	19.73	1.66	37.50	11.75
SEm±	7	0.03	0.15	0.10				2.0	1.29	3.18	0.16		
CD (P=0.05)	21	0.09	0.44	0.29				5.8	3.74	9.22	0.45		

Table 2. Recovery of quizalofop ethyl in jute leaf and soil samples

Substrate	Amount fortified (ppm)	Amount recovered* (ppm)	Recovery (%)	Average recovery (%)
Jute leaf	1	0.84	84.0	84.33
	2	1.70	85.0	
	5	4.20	84.0	
Soil	1	0.84	84.0	82.00
	2	1.64	82.0	
	3	4.00	80.0	

produced 3.87 t/ha jute fibre and left no phytotoxic effect on the jute crop and soil. The residual analysis of soil and jute plants showed that the herbicide residues in these samples were below the detectable limit even 8 days after spray (Table 2). Spray of quizalofop ethyl alone was sufficient for the plots where grassy weeds dominated. This method also generated higher gross returns of Rs 1.66 from each Re invested as total variable cost, which was Rs 1.50 only from the conventional manual weeding twice. Its net returns were higher (Rs 19,733/ha) compared with that of conventional manual weeding twice (Rs 16,147). Ghorai *et al.* (2004) also reported that this approach is cheaper by Rs 5,000 to 6,000/ ha than conventional two manual weedings. After 7-10 days of spraying this herbicide, one manual weeding was followed to remove the broad-leaf and sedge weeds from jute field. On mixed weed population its weed-control efficacy was 45% over manual weeding twice. But higher weed control efficiency (95-100%) of this herbicide was also obtained when the jute crop was infested primarily with grassy weeds.

Thus the cultural, organic and integrated chemical approaches proved economically viable and farmer-friendly, reducing the cost of cultivation of jute and increasing net returns compared with conventional manual weeding.

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