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Effect of integrated weed management practices on weed growth and soil microbes of tossa jute (*Corchorus olitorius*) in the New Alluvial Zone of West Bengal

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Abstract
A field experiment was conducted during pre-*kharif* season of 2010 and 2011 at the C-Block Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani to find out the effect of different weed management practices on weed growth and soil microbes of jute (cv. *JRO-524*). The experiment was designed with eight treatments (weed management practices) and tested under Randomized Block Design with three replications. The weed management practices comprised of different doses of chemical herbicides like Fenoxaprop-P-Ethyl and Quizalofop-Ethyl as post emergence spray at 30 DAS; botanical herbicides like Calotropis and Parthenium (5% raw extract) as pre emergence spray at 1 DAS in combination with hand weeding. The lowest weed density, weed dry weight was recorded in hand weeding twice at 15 and 30 DAS closely followed by Quizalofop-Ethyl @ 100 g ha^{-1} at 30 DAS + Hand weeding at15 DAS. In successive years also, the highest weed control efficiency and fibre yield was found in hand weeding twice at 15 and 30 DAS which was at par with Quizalofop-Ethyl @100 g ha^{-1} at 30 DAS + Hand weeding at15 DAS. Maximum population of soil micro flora was found in the Quizalofop-Ethyl @ 100 g ha^{-1} at 30 DAS + Hand weeding at 15 DAS at the harvest stage of crop. From the present experiment, it can be concluded that the spraying of Quizalofop-Ethyl @ 100 g ha^{-1} at 30 DAS + Hand weeding at 15 DAS would be beneficial practice to the jute farmer of West Bengal.

Keywords: jute, chemical herbicide, botanical herbicide, hand weeding

Introduction
Tossa jute (*Corchorus olitorius* L.), is an important cash crop in the states of eastern India. Intermittent rain associated with hot and humid climate during the jute growing season in alluvial plains encourages profuse weed growth (Sarkar, 2003) [12] and about 60-75% yield loss may occur in jute (Sarkar *et al*., 2010) [16]. Jute fields are infested with different types of weeds. 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) [18]. Weeding is one of the most important cultural practices for the crop plants to take nutrients, moisture, light, space and sometimes controlling many diseases, organisms and insect pests (Alam *et al.*, 2010) [1]. About 35% of the total cost of production goes to weeding only if done manually (Saraswat, 1980) [17] which drastically reduce the profitability. Among the available post emergence herbicides, Quizalofop Ethyl (5% EC) was found effective to control grassy weeds in jute (Ghorai *et al*., 2004; Bhattacharya *et al*., 2004) [3, 2]. Fenoxaprop-ethyl also showed promise for grass weed control in jute (Sarkar, 2006) [13]. Again, *Calotropis* raw leaf and stem extracts has been used as herbicide and it has been found that the raw extract applied @ 5 ml/ litre of water as pre emergence in Soybean (Ghosh, 2008) [4] and also in Paddy found useful to control grass and broadleaves categories of weeds. According to Ghosh *et al*. (2007) [5], the *Parthenium* extracts are also useful as herbicides; 5% water extract is able to control the grassy weeds. Therefore, a field experiment was designed with an objective to find out farmer-friendly integrated weed-management approach for jute through combination of organic and chemical methods with manual weeding.

Materials and Methods
A field experiment was conducted in Gangetic alluviam sandy loam neutral soil (pH 6.9) at C-Block Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia (23.5°N, 89°E and 9.75 m altitude) during pre-*kharif* season of 2010 and 2011. The experiment was laid out in randomized block design (RBD), replicated thrice with seven treatments [Fenoxaprop-P-Ethyl @ 67.5 g ha^{-1} at 30 DAS (days after sowing) + Hand Weeding at 15 DAS, Fenoxaprop-P-Ethyl

@ 135.0 g ha^{-1} at 30 DAS + Hand Weeding at 15 DAS, Quizalofop-Ethyl @ 50 g ha^{-1} at 30 DAS + Hand Weeding at 15 DAS, Quizalofop-Ethyl @ 100 g ha^{-1} at 30 DAS + Hand Weeding at 15 DAS, *Calotropis* raw extract @ 5% at 1 DAS + Hand Weeding at 30 DAS, *Parthenium* raw extract @ 5% at 1 DAS + Hand Weeding at 30 DAS, Twice hand weeding at 15 DAS and 30 DAS, Unweeded control] in 5.0 x 4.0 m size plots. Jute seed (*JRO 524*) was sown at a row spacing of 20 cm in the third week of April and harvested 120 days later. All other standard agronomic practices including plant protection measures recommended for *Olitorius* jute were followed. Herbicides were applied using 500 liters of water ha^{-1} with a flat fan nozzle attached in a high volume Knapsack sprayer as per schedule. Observations on weed density, weed biomass, fibre yield and stick yield were recorded and analyzed using the analysis of variance technique. The evaluation of soil microbes population was done on agar plate containing appropriate media following serial dilution technique and pour plate method (Pramer and Schmidt, 1966) [11]. Thornton's agar media for total bacterial count (Thornton, 1922) [20], Martin's rose Bengal streptomycin agar media for total fungi count (Martin, 1950) [8], and Jensen's agar media for total actinomycetes counts (Jensen, 1930) [6] were used. Weed control efficiency (Mani *et al*., 1973) [7] was calculated by using the following formula:

$$\text{Weed control efficiency (\%)} = \frac{\text{Dry weight of weeds in unwedded control - Dry weight weeds in treatment plot}}{\text{Dry weight of weeds in unwedded control}} \times 100$$

Results and discussion

Weed flora

The dominant weed flora in the jute field consisted of i) Grasses: *Digitaria sanguinalis, Dactyloctenium aegyptium, Echinochloa colona, Eleusine indica, Bracharia mutica ii)* sedges: *Cyperus rotundus iii*) *Digera arvense, Euphorbia hirta, Phylanthus niruri, Alternenthera philoxeroides, Physalis minima, Amaranthus viridis, Cleome viscose etc.* Similar results were found by Sarkar *et al*., 2005 [14]; Sarkar, 2006 [13]; Masumi *et al*., 2011 [9]; Mukherjee *et al*., 2011 [10].

Effects on weeds

At 45 DAS unweeded control treatment plots recorded the highest density for grasses, sedges and broad leaf weeds (Table 1). Density was lowest for all types of weeds in twice hand weeding at 15 DAS and 30 DAS closely followed by Quizalofop-Ethyl @ 100 g ha^{-1} at 30 DAS + Hand Weeding at 15 DAS (grass 12.2 m^{-2}, sedge 14.7 m^{-2} and broad leaf 15.74 m^{-2} respectively). Comparable result was found in case of Fenoxaprop-P-Ethyl @ 135.0 g ha^{-1} at 30 DAS + Hand Weeding at 15 DAS. These observations corroborate the findings obtained by Sinha *et al*., 2009 [19].

Twice hand weeding at 15 DAS and 30 DAS resulted in the lowest dry weight of weeds (15.64 g m^{-2}). Highest total dry weight of weeds (51.69 g m^{-2}) was found in unweeded control at 45 DAS as there was no weed management practices involved which is consistent with the observations of Ghorai *et al*., (2004) [3] and Sarkar *et al*., (2005) [14]. The combined effect of chemical and mechanical approach in Quizalofop-Ethyl @ 100 g ha^{-1} at 30 DAS + Hand Weeding at 15 DAS recorded very low weed dry weight (17.05 g m^{-2}) which was at par with Fenoxaprop-P-Ethyl @ 135.0 g ha^{-1} at 30 DAS + Hand Weeding at 15 DAS (17.69 g m^{-2}) as also observed by Sarkar *et al*., 2006 [13]. On the other hand botanical herbicides failed to give a comparable result.

Table 1: Effect of different weed management treatments on weed density, total weed dry weight, weed control efficiency, fibre yield and stick yield of jute (*Two years pooled data*)

Treatments	Weed density (Number m^{-2}) at 45 DAS			Total dry weight of weeds (g m^{-2}) at 45 DAS	Weed Control Efficiency (%) at 45 DAS	Fibre Yield (t ha^{-1})	Stick Yield (t ha^{-1})
	Grass	Sedge	Broad leaf				
Fenoxaprop-P-Ethyl 9 EC @ 67.5 g ha^{-1} + Hand Weeding at15 DAS	17.0	16.0	21.54	19.03	63.18	3.50	8.63
Fenoxaprop -P-Ethyl 9 EC @ 135.0 g ha^{-1} + Hand Weeding at 15 DAS	15.0	15.0	17.81	17.69	65.78	3.79	9.22
Quizalofop-Ethyl 5 EC @ 50 g ha^{-1} + Hand Weeding at 15 DAS	15.7	15.7	18.98	18.41	64.38	3.68	8.97
Quizalofop-Ethyl 5 EC @ 100 g ha^{-1} + Hand Weeding at 15 DAS	12.2	14.7	15.74	17.05	67.01	3.92	9.44
Calotropis raw extract @ 5% + Hand Weeding at 30 DAS	23.7	18.0	27.48	21.90	57.63	2.94	7.75
Parthenium raw extract @ 5% + Hand Weeding at 30 DAS	21.0	16.8	23.67	20.64	60.07	3.01	8.22
Twice hand weeding at 15 DAS and 30 DAS	11.0	11.7	14.30	15.64	69.74	3.95	9.44
Unweeded control	55.8	30.2	57.68	51.69	-	2.07	5.19
S. Em($\pm$)	3.06	1.34	4.87	1.01	-	0.06	0.13
C.D. (5%)	9.25	4.06	14.77	3.11	-	0.18	0.40

Table 2: Effect of different weed management treatments on soil microbes of jute. (*Two years pooled data*)

Treatments	Total Bacteria (CFU x 10^6 g^{-1} of soil)		Actinomycetes (CFU x 10^5 g^{-1} of soil)		Fungi (CFU x 10^4 g^{-1} of soil)	
	Initial	Harvest	Initial	Harvest	Initial	Harvest
Fenoxaprop-P-Ethyl 9 EC @ 67.5 g ha^{-1} +Hand Weeding at15 DAS	37.00	93.93	38.67	59.67	54.33	77.33
Fenoxaprop -P-Ethyl 9 EC @ 135.0 g ha^{-1} +Hand Weeding at 15 DAS	35.00	105.17	44.00	68.00	53.67	93.67
Quizalofop-Ethyl 5 EC @ 50 g ha^{-1} + Hand Weeding at 15 DAS	38.67	112.69	39.00	66.67	53.67	91.67
Quizalofop-Ethyl 5 EC @ 100 g ha^{-1} + Hand Weeding at 15 DAS	38.00	120.37	37.33	72.33	54.00	98.00
Calotropis raw extract @ 5% + Hand Weeding at 30 DAS	38.33	89.28	39.67	56.67	54.33	80.67
Parthenium raw extract @ 5% + Hand Weeding at 30 DAS	38.54	99.09	39.00	57.00	49.00	80.99
Twice hand weeding at 15 DAS and 30 DAS	36.67	75.59	38.67	52.01	51.67	63.67
Unweeded control	37.67	76.57	39.67	56.34	53.67	69.68
S. Em($\pm$)	1.18	2.52	1.44	0.81	0.79	0.60
C.D. (5%)	NS	7.64	NS	2.46	NS	1.83

Weed control efficiency

Calotropis raw extract @ 5% at 1 DAS + Hand Weeding at 30 DAS followed by *Parthenium* raw extract @ 5% at 1 DAS + Hand Weeding at 30 DAS resulted the lowest weed control efficiency. From the result, it appeared that pre emergence application of botanical herbicide followed by mechanical weeding was unable to control the weeds during the early growth stages of jute. However, twice hand weeding at 15 DAS and 30 DAS noted the highest weed control efficiency (69.74%) followed by Quizalofop-Ethyl @ 100 g ha^{-1} at 30 DAS + Hand Weeding at 15 DAS (67.01%) and Fenoxaprop-P-Ethyl @ 135.0 g ha^{-1} at 30 DAS + Hand Weeding at 15 DAS (65.78%). A similar trend was also observed by Sarkar *et al*., 2006 [13]. It was due to better control of all types of weeds through hand weeding and adequate suppression of grassy weeds by the chemicals.

Fibre yield and stick yield

Twice hand weeding at 15 DAS and 30 DAS recorded highest fibre yield (3.95 t ha^{-1}) and stick yield (9.44 t ha^{-1}). Quizalofop-Ethyl @ 100 g ha^{-1} + Hand Weeding at 15 DAS came up with fibre yield (3.92 t ha^{-1}) and stick yield (9.44 t ha^{-1}) statistically at par with hand weeding twice (fibre yield 3.95 t ha^{-1} and stick yield 9.44 t ha^{-1}). Among the other chemical treatments, appreciable amount of yield was also obtained from Fenoxaprop-P-Ethyl @ 135.0 g ha^{-1} + Hand Weeding at 15 DAS (fibre yield 3.79 t ha^{-1} and stick yield 9.22 t ha^{-1}) which was comparable with the finding of Sarkar *et al*., 2013 [15]. Botanical herbicide treatments failed to produce the comparable yield during the experiment in comparison to the other treatments.

Effect on soil microbes

At the crop harvest stage, all the treatments showed increase in total bacteria, actinomycetes and fungi population in soil compared to initial population before sowing of jute. Lowest population of soil microbes at harvest was observed in twice hand weeding at 15 DAS and 30 DAS (total bacteria 75.59 X 10^6 CFU g^{-1} of soil, actinomycetes 52.01 X 10^5 CFU g^{-1} of soil and fungi 63.67 X 10^4 CFU g^{-1} of soil). Even in the chemical treatment plots population of soil microbes did not decrease in comparison to initial value. Similar trend was observed by *Ghorai et al.*, 2013. Quizalofop-Ethyl @100 g ha^{-1} + Hand Weeding at 15 DAS recorded the highest (total bacteria 120.37 X 10^6 CFU g^{-1} of soil, actinomycetes 72.33 X 10^5 CFU g^{-1} of soil and fungi 98.00 X 10^4 CFU g^{-1} of soil) soil microbes population at crop harvest stage closely followed by Fenoxaprop-P-Ethyl @ 135.0 g ha^{-1} + Hand Weeding at 15 DAS and Quizalofop-Ethyl @ 50 g ha^{-1} + Hand Weeding at 15 DAS.

Conclusion

Considering the weed control efficiency, fibre yield and microbial population of the treatment plots in this experiment, it can be concluded that chemical methods combined with one hand weeding can replace hand weeding twice and bio herbicides. Among the treatments, Quizalofop-Ethyl @ 100 g ha^{-1} + Hand Weeding at 15 DAS gave the economic yield statistically at par with twice hand weeding (at 15 & 30 DAS). It can further be concluded that Quizalofop-Ethyl @100 g ha^{-1} + Hand Weeding at 15 DAS is less labour intensive in comparison to twice hand weeding at 15 and 30 DAS as it incurs lesser labour cost and hence, can be recommended to the jute farmer of West Bengal.

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