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A review on physical, chemical and integrated weed management in jute

Sukanya Dutta and Triptesh Mondal

Abstract
India is the largest jute producing country in the world. Jute growing area is also found highest in this country. But actually jute crop is growing in 0.55% area of the gross cropped area of India. About 50 lakh people are involved in raw jute farming, trading and industrial purposes. The fibre yield of jute has increased more than double from 1947 to till date and it has been possible through the development of high-yielding, fertilizer responsive varieties and improved production technologies only. The changing climate coupled with different soil conditions has often exposed the crop to many biotic and abiotic stresses which affects the fibre yield and quality. Weed infestation is one of the major biotic stresses of jute crop. Among the different weed controlling methods, physical and chemicals methods were very much popular. Hand weeding is the most common physical method for effective weed control. But around 40% of total cost of production incurred in hand weeding operation. Chemical weed management consumes lower cost than hand weeding and provides statistically *at par* yield. Again excess application of herbicide chemicals beyond the recommended rate causes harm to the jute plants present in the field and develop resistance in weeds. Integrated weed management has emerged as a profitable and environment friendly approach for managing the weeds. In this review, some effective physical, chemical and integrated weed management methods have been discussed.

Keywords: Hand weeding, integrated weed management, Jute

Introduction
Jute is one of the most important commercial cash crops in India. Jute is cultivated by the small and marginal farmers of Indo-Bangladesh subcontinent and other countries like China, Nepal, Thailand, Myanmar and Brazil (Ghorai *et al.*, 2013) [16]. India contributes around 55.10% of world's jute production (FAO, 2013) [12]. As a textile fibre, jute is counted after cotton in monetary terms (Roy, 2010) [33]. Technological improvement is still not visible in the farmers' field and jute cultivation tends to be labour intensive with about 70% of the cost incurred for human labour. According to Naik and Karmakar (2016) [32], most energy intensive and costly field operations in jute are weeding and thinning. Hand weeding is an age old practice in jute. It is slow and cumbersome method. This operation alone accounts for about 30-40% of total cost of production (Islam, 2014) [23] and consumes 40-50% of the total labour required for cultivation though achieved higher weed-control efficiency and fibre yield when done twice in jute at certain interval (Kumar *et al.*, 2017) [24]. Ghorai *et al.* (2013) [16] reported that weed infestation can cause 40-70% yield loss if it is not controlled properly.
Previously, a number of investigators advocated in their report for replacement of costly and inconvenient manual hand weeding by herbicides for weed management in jute (Borgahain *et al.*, 1990) [6]. These studies emphasized the need of herbicidal control of weeds in jute fields. Further the nature of infestation and distribution of weeds widely vary even within the jute growing localities. Since the time of germination of weed seeds and jute seeds are almost same, the time of application would determine the efficiency of the herbicides. Datta and Chakraborty (1983) [10] found the importance of herbicide application timing for the increasing the effectiveness of the herbicide in controlling the weeds in a jute field. Similarly, the formulation of herbicide is another important factor for achieving increased selectivity and efficiency. Presently effective and economic weed management in cultivated crops is increasingly done with the application of two or more herbicides in a combination. This is actually done for broad spectrum herbicidal action in order to check different weed species those are difficult to control by application of a single herbicide. It is also often been found that immediately after the peak vegetative growth of the crop, herbicidal application either alone or in combination may not be able to restrict the second flush of weed in the fields but

this weed flush may also cause considerable competition with the existing crop in the field. Experimental results of combining chemical and cultural methods have been found promising in control of different weed species in jute fields. Experiments conducted in jute with physical, chemical and their integration have revealed a significant reduction of weed density and biomass.

Weeds associated with jute

Saraswat and Mukherjee (1983) [34] observed a large difference in the habitat and the lifespan of different weed species due to variation in climatic and soil conditions. According to the previous report of many researchers (Ghorai, 2008 [14, 17]; Ali *et al.*, 2012 [2]; Mukherjee *et al.*, 2014 [31]; Islam, 2014 [23]; Kumar *et al.*, 2015 [26, 27] and Kumar *et al.*, 2018) [25], the pre-dominant weed flora associated with jute field consisted of grasses like *Brachiaria ramosa*, *Brachiaria reptans*, *Cyanodon dactylon*, *Digitaria sanguinalis*, *Digitaria digitata*, *Echinocloa colona*, *Eleusine indica*, *Setaria glauca*, sedges like *Cyperus rotundus*, *Cyperus difformis* and broadleaved weeds like *Physalis minima*, *Elipta alba*, *Euphorbia hirta*, *Portulaca oleracea*, *Phyllanthus nururi*, *Fimbristylis dochotama*, *Amaranthus spinosus*, *Amaranthus viridis*, *Trianthema portulacastrum*, *Ageratum conyzoides* and *Polygonum orientale*. Generally, sedges and grassy weeds are found more problematic in jute fields.

Crop-weed competition in jute

Gogoi and Kalita (1992) [19, 20] found that the critical of crop-weed competition period in *capsularis* jute ranges between 15 and 60 days after sowing (DAS). Kumar *et al.* (2015) [26, 27] calculated the start of critical crop-weed competition period was 7 DAS and end of critical crop-weed competition period was 42 DAS in *olitorius* jute.

Physical or mechanical weed management in jute

According to Adenawoola *et al.* (2005) [1], hand weeding is most widely practiced weed control technique throughout the tropics because it reduces the fear of toxic residue retaining in the field coupled with the lack of knowledge of farmer about their proper use. Gogoi *et al.* (1992) [19, 20] reported that the highest weed control efficiency, better crop growth and the maximum fibre yield was obtained under the treatment, hand weeding done at 21 and 42 DAS which was statistically similar to the treatment, application of fluazifop-p-butyl at 0.4 and 0.6 kg a.i ha^{-1} at 21 DAS. Guha and Das (1998) [21] observed that two hand weedings performed better than hand hoeing several times in jute field. Das *et al.* (2008) [8] reported that two hand weedings at 3 and 5 weeks after sowing showed the tallest plants, maximum basal diameter and lowest dry weight of weeds which ultimately provided the highest fibre yield. Ghorai *et al.* (2012) [18] reported that CRIJAF Nail Weeder used at 4-5 DAS controlled 80 to 85% of composite weeds flora and increased fibre yield in jute. Ghorai (2007) [13] mentioned that soil solarization is a safe method which can give higher fibre yield of jute over the manual weeding and herbicidal control of weeds.

Chemical weed management in jute

Biswas (1986) [7] reported that the pre-emergence application of pendimethalin at the rate of 0.75 to 2.0 kg ha^{-1} showed its detrimental effect on the jute plants. Biswas (1995) [5] also noticed that the germination of jute seeds was least affected to the tune of 3-12% only due to application of pendimethalin at the rate of 1.5 kg ha^{-1} where well decomposed FYM was incorporated in soil at the rate of 15 t ha^{-1} at 20 days before sowing of jute. The pre-emergence application of some other herbicides like alachlor at 2 kg ha^{-1} and metolachlor at 3 kg ha^{-1} considerably reduced the emergence of jute plants while trifluralin at the rate of 0.5 kg ha^{-1} significantly enhanced the mean stem volume and stem fresh weight (Leycock *et al.*, 1978) [28]. Sarkar (2006) [35] reported that post-emergence application of fenoxaprop-p-ethyl at the rate of 75 g ha^{-1} or quizalofop ethyl at the rate of 50 g ha^{-1} at 21 days after sowing (when the grassy weeds are at four-leaf stage) effectively reduced the grassy weeds like *Echinochloa colona* and broadleaved weeds like *Physalis minima* and *Phyllanthus niruri*. Application of oxyfluorfen at the rate of 1.5 ml/litre as post-emergence at 25 days after emergence (DAE) between the rows of jute plants effectively controlled broad-leaved weeds and sedges (ICAR-CRIJAF, Director's report, 2009). Application of fenoxaprop-p-ethyl 9% EC at 615 ml ha^{-1} at 15 DAS controlled grassy weeds very efficiently in jute field and gave higher fibre yield than control treatment (Ali *et al.*, 2012) [2]. Sinha *et al.* (2009) [36] revealed that the post-emergence herbicides, fenoxaprop-p-ethyl and quizalofop were more effective than pre-emergence herbicide, pendimethalin in controlling the weeds in jute. Farmers can apply pretilachlor as pre-emergence followed by quizalofop-ethyl + ethoxysulfuron as post-emergence, depending on the level of infestation of grasses during the initial crop growth period of jute (Dutta and Kheroar, 2020) [11].

Integrated weed management in jute

Borgohain *et al.* (1990) [6] reported that fluchloralin significantly reduced weed growth and increased fibre yield of jute. There was no significant difference among fluchloralin at 1.0 and 1.5 kg a.i ha^{-1} applied as PPI or pre-emergence application whereas fluazifop-p-butyl at 0.4 kg ha^{-1} applied 21 DAS + 1 hand weeding at 35 DAS provided more efficient control of weeds than 0.6 kg of Fluazifop-p-butyl applied 2 DAS + 1 hand weeding at 35 DAS, fluchloralin at 1.0 kg ha^{-1} applied 3 or 7 DAS + 1 hand weeding at 35 DAS and pendimethalin at 0.75 kg ha^{-1} applied 1 day prior to sowing. All these integrated weed control treatments showed more effective weed control than 2 hand weeding operations alone. Maximum fibre yield was recorded with the 0.4 or 0.6 kg Fluazifop-p-butyl treatments. Das *et al.* (1994) [7] reported that pendimethalin at 0.75 kg ha^{-1} applied at 1 day before sowing + hand weeding at 35 DAS proved to be the best among all the herbicidal treatments in terms of controlling weeds, providing higher fibre yield with a higher benefit-cost ratio. Fluchloralin (1.0 kg ha^{-1}) applied as pre-plant spray at 3 days before sowing, combined with one hand weeding at 35 DAS resulted in fibre yield comparable to the plots which were hand-weeded twice at 21 and 35 DAS, respectively (Asokaraja and Jeyaraman, 1995; Mishra and Bhol, 1996) [3, 30]. Ghorai *et al.* (2008) [14, 17] investigated that the application of butachlor at the rate of 1.0-3.0 kg ha^{-1} at 7-10 days before sowing + 1 hand weeding at 25-30 DAS controlled all the weeds present in jute field including *Cyperus rotundus*. ICAR-CRIJAF, Director's report (2009) [22] also described that the application of butachlor 50% EC at 0.83-1.0 kg a.i. ha^{-1} from 7 days prior to sowing to 3 DAS controlled weed infestation for next 3 weeks. It effectively controlled the infestation of *Cyperus difformis* in jute growing areas. After that one hand weeding or one wheel hoeing is necessary just after the emergence of the next weed flush for controlling the

weed infestation. Majumdar *et al.* (2010) [29] investigated that one hand weeding + trifluralin at the rate of 0.75 kg a.i. ha^{-1} recorded significantly higher fibre yield over the control. This treatment also recorded substantially higher levels of available nutrients over other herbicidal treatments. Ghorai (2008) [14, 17] reported that combination of quizalofop ethyl at 60 g ha^{-1} + dhanuvit at 0.5 – 0.6 litre ha^{-1} (adjuvant) at 21 DAE and 1 hand weeding at 35 DAE provided significantly higher fibre yield of jute than cultural weed control treatments and statistically *at par* with conventional/manual and organic weed control treatments. According to Ghorai *et al.* (2009) [15] and Ghorai *et al.* (2013) [16], quizalofop ethyl 5% EC at the rate of 45 to 60 g a.i. ha^{-1} at 21 DAE followed by one manual weeding or one wheel hoeing at 35 DAE was economic for weed control in jute. Datta *et al.* (2017) [9] investigated that quizalofop-ethyl @100 g ha^{-1} at 30 DAS + hand weeding at 15 DAS gave highest fibre yield among all the herbicidal treatments and also gave highest benefit-cost ratio. Das *et al.* (2008) [8] revealed that mulching with wheat straw at the rate of 10 t ha^{-1} had highest benefit-cost ratio. Intercropping of jute + red amaranthus treatment had 2nd highest benefit-cost ratio which was followed by quizalofop ethyl at the rate of 50 g a.i. ha^{-1} + adjuvant at the rate of 1 ml litre^{-1} at 21 DAE + one hand weeding at 35 DAE treatment. Ghorai *et al.* (2013) [16] reported that glyphosate 2.46 kg SL ha^{-1} and 2,4-D 2 kg ha^{-1} in combination, and glyphosate 2.46 kg SL ha^{-1} and pyrazosulfuron-ethyl 60g ha^{-1} in combination followed by one hand weeding were found to be promising for controlling the mixed weed flora in jute field. Jena *et al.* (2017) [24] investigated that the application of pre and post-emergence herbicides + 1 hand-weeding gave higher return over the control in jute cultivation. Dutta and Kheroar (2020) [11] reported that quizalofop-ethyl 5% EC at the rate of 60 g a.i. ha^{-1} + ethoxysulfuron 15% WDG at the rate of 100 g ha^{-1} at 20 DAS followed by one hand weeding at 35 DAS achieved higher fibre yield than hand weeding twice at 20 and 35 DAS. This integrated weed management approach was found economically effective in controlling all the weeds presented in jute field as an alternative to hand weeding practice which was closely followed by ethoxysulfuron 15% WDG at the rate of 100 g ha^{-1} at 20 DAS + one hand weeding at 35 DAS treatment.

Table 1: Integrated weed management of irrigated jute by quizalofop ethyl 5% EC vs. some other weed management practices (pooled over 2 years)

S. No.	Treatments	Weed biomass (t ha^{-1})	Fibre yield (t ha^{-1})	Net return (Rs ha^{-1})
1.	Quizalofop ethyl 5% EC @60 g a.i. ha^{-1} + Dhanuvit @0.5-0.6 litre ha^{-1} at 21 DAE + 1 hand weeding at 35 DAE	1.41	3.87	19733
2.	Hand weeding twice at 21 DAE and 35 DAE, respectively	2.56	3.75	16147
3.	Straw mulching @10 t ha^{-1} + 2 hand weeding	0.82	3.90	32484
4.	Jute + red amaranth (10 kg ha^{-1}) + white amaranth and Radish + 2 hand weeding	1.98	3.66	18474
5.	Jute + red amaranth (20 kg ha^{-1}) + white amaranth and Radish + 2 hand weeding	1.99	3.48	18782
6.	Jute + red amaranth (30 kg ha^{-1}) + white amaranth and Radish + 2 hand weeding	1.92	3.57	20949
7.	Unweeded check	2.45	1.96	8863
8.	Hand weeding	2.56	3.75	16147
9.	Mulch @15 t ha^{-1} (with red and white amaranth and radish) + 2 hand weeding	0.46	3.95	34360
10.	Mulch @10 t ha^{-1} (with red and white amaranth and radish) + 2 hand weeding	0.82	3.90	32848

***Source*:** Ghorai *et al.* (2008) [14, 17]

Conclusion

The highest fibre yield in jute could be achieved with 2 hand weeding at 21 DAE and 35 DAE as a mechanical weed control option. Among the chemical weed management treatments, Application of quizalofop ethyl 5% EC @60g a.i. ha^{-1} and Ethoxysulfuron @100g ha^{-1} at 20 DAS when applied alone could effectively control all the catagories of weeds with reduction in cost of production than manual weeding. In case of integrated weed management, quizalofop ethyl 5% EC @ 60g a.i. ha^{-1} + Ethoxysulfuron @ 100g ha^{-1} at 20 DAS + 1 hand weeding at 35 DAS treatment could provide the best and cost effective weed control with obtaining statistically *at par* fibre yield with the manual weeding twice.

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