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JUTE GROWTH AND YIELD INFLUENCED BY INTEGRATED WEED MANAGEMENT

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ABSTRACT

Weed infestation is one of the major biotic stresses of jute crop reducing jute productivity. Integrated weed management has emerged as a profitable and environment friendly approach for managing the weeds in crop field. To this point of view an experiment was conducted at the research field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from April-August 2019 to study the effect of integrated weed management in jute. In the experiment, the treatment consisted of twelve weed management, *viz*., T_1 = weedy check, T_2 = one hand weeding, T_3 = two hand weeding, T_4 = straw mulch, T_5 = mungbean and jute intercropping, T_6= pre-emergence herbicide (pendimethalin @ 600 g ha^{-1} at 2 DAS), T_7 = post-emergence herbicide (quizalofop-ethyl @50 g ha^{-1} at 20 DAS), T_8 = pre-emergence and post-emergence herbicide, T_9 = pre-emergence herbicide + one hand weeding, T_{10} = mungbean + pre-emergence herbicide, T_{11} = mungbean with post-emergence herbicide, and T_{12} = mungbean with pre-emergence and post-emergence herbicide. The experiment was laid out in a randomized complete block design with three replications. Among the weed species, maximum relative weed density was observed for *Cynodon dactylon* (42%) at 30 DAS which was followed by *Echinochloa colona* (32%) and *Eleusine indica* (20%). Weeding treatments significantly reduced the weed population. The results of the experiment revealed that different agronomic characteristics and yield of jute and mungbean were significantly differing due to different weed management approaches. Plant height, leaves plant^{-1}, plant diameter, fiber weight plant^{-1}, stick weight plant^{-1}, fiber yield, stick yield and harvest index of jute was highest with the weed management by using pre-emergence herbicide along with one hand weeding (T_9). One the other hand, lowest growth and yield performance was observed in control and mungbean intercropping with post-emergence herbicide. The results also revealed that intercropping mungbean with post-emergence herbicide application for weed management in jute gives the highest gross, net return and the highest benefit-cost ratio.

Keywords: Weed density, fibre crop, jute, mungbean, herbicide, intercropping

INTRODUCTION

Jute is popularly known as the golden fibre of Bangladesh, which is one of the cheapest and the strongest natural fibre. Jute is an important cash and fibre crop which belongs to the family Malvaceae and there are two commercial species of jute *Corchorus capsularis* and *Corchorus olitorius* usually grown by the farmer. About 80% of the total world jute is produced in Bangladesh and India. Its fibre is mainly used in manufacturing various types of industrial products such as hessian, sack, carpet backing, cloths, mats, blankets, fabrics, packaging materials, etc. Bangladesh earns a significant foreign currency by exporting raw jute and jute goods worldwide. Bangladesh had been the single largest exporter of jute fibre until 1960, and the country's share of world exports varied from 90-95% (Rahman and Khaled, 2011). In Bangladesh, total area under jute production has been estimated as 0.75 million ha, the average yield rate has estimated 11.40 bales ha^{-1}, and the total jute production has estimated 7.58 million bales in the year 2018-2019 (BBS, 2020). Bangladesh earns about 6-7% foreign exchange through exporting raw jute and jute goods (Islam and Ali, 2017). Jute production is decreasing with time and the main cause of that is low market price; higher

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production cost. However, during cultivation, jute faces several biotic and abiotic stresses (Mamun *et al*., 2016). Along with these stresses, weed infestation in jute field is one of the major factors affecting jute production (Islam, 2014).

The magnitude of yield loss due to weeds in jute ranged between 52-72% in *C. capsularis* and 59-75% in *C. olitorious*. Maximum weed infestation is found up to the third to sixth week of crop age. If weed is not managed properly during jute seed cultivation, jute yield performance is severely affected. The hot and humid climate coupled with intermittent rainfall during the jute-growing season in Bangladesh, encourages weed growth resulting in severe crop-weed competition in jute field (Saraswat, 1999).

Cultural practices are important management factors that affect the yield of a crop. Weeding is one of the most important cultural practices for crop plants to take nutrients, moisture, light, space and sometimes controlling many diseases, organisms, and insect pests (Alam *et al.,* 2010). But the most effective and economic cultural practices for weed control in jute crops are not known by our farmers. In Bangladesh, weeds are generally controlled by raking and nirani (hand weeding), and weeding and thinning operations involve about 50% or more of the labor cost (Alam, 2003). Weed can be managed through different ways, including the application of weedicide and an effective way of weed control practice is important for higher crop yield leading to better economic benefit (Gaffer *et al*., 1988). Herbicides also commonly known as weed killers are substances used to control unwanted plants. The dominant weed flora in jute fields and its management using pre-emergence herbicides is possible (Sarkar *et al.,* 2005), provided the farmers get sufficient time for land preparation and herbicide application before sowing.

Selective herbicides can be used to control specific weed species while leaving the desired crop relatively unharmed, while non-selective herbicides (sometimes called total weed killers in commercial products) can be used to clear waste ground, industrial and construction sites, railways and railway embankments as they kill all plant material with which they come into contact. Apart from selective and non-selective, other important distinctions include persistence (also known as residual action: how long the product stays in place and remains active), means of uptake (whether it is absorbed by above-ground foliage only, through the roots, or by other means), and mechanism of action (how it works).

The use of herbicides as pre-emergence and post-emergence treatments can control weeds before they emerge from the soil so that crops can germinate and grow in the weed-free environment or with minimum competition during their seedling stage. This is not possible with other methods of weed control. In broadcast sown and narrow spaced crops herbicides prove very effective in reaching every weed. Mechanical methods are not so effective in such crops. In wide-spaced crops, mechanical methods are effective for controlling weeds in rows but it leaves the intra-row weeds. Herbicides reach all places and control the weeds i.e., inter-row and intra-row weeds.

Intercropping is the system where two or more crops are grown simultaneously in the same land at the same time. Intercropping is not only a means of augmentation of crop production and monetary returns over space and time but also provides insurance against total crop failure. Intercropping was also found to be helpful to better control of weeds, decreased the incidence of insect pests, increased land equivalent ratio, reduced soil erosion, and helped in the better use of sunlight and water. However, the most efficient and economic cultural methods for controlling weed have not been known to farmers of Bangladesh. So, it is necessary to find out an alternative method to control weed with minimum cost.

MATERIALS AND METHODS

Planting materials and weed management treatments

The experiment was carried out at the Agronomy research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh during the period from March-July 2019 to study the integrated weed

management in the jute field. Two types of crops having dissimilar growth habits were used in this experiment. The crops were jute (*Corchorus capsularis* L.) and mungbean (*Vigna mungo* L.). In this experiment, jute was grown as the main crop, and mungbean was grown as a cover crop. BJRI Deshi Pat-8 (BJC-2197) variety was used which is the most popular and widely cultivated variety in the Kharif-1 season. It attains a plant height of 3.5-4.0 m and the plant basal diameter can be up to 22 mm. This cultivar matures at 115-120 days of planting. The cultivar gives an average fiber yield of 3 t ha^{-1}. BARI Mung-6 is the most popular and widely cultivated variety in Kharif-1 and Kharif-2 seasons. Plant height of this variety is 40-45 cm. It can be grown in kharif-1, kharif-2, and late rabi season in Bangladesh. Crop duration of this mungbean variety is 55-58 days with seed yield 1.06 t ha^{-1}. The seeds of BJRI Deshi Pat-8 (BJC-2197) and BARI mung-6 were collected from the BJRI and BARI, respectively. For the jute, fertilizers were applied at the rate of 150, 50, and 50 kg ha^{-1} of urea, TSP, and MoP, respectively and BARI recommended dose of fertilizer was applied for mungbean. One-third of urea and other fertilizers were broadcasted during the time of final land preparation. Rest two-third of urea was top-dressed in two equal splits on 20 and 35 days after sowing (DAS) for jute. The experiment was laid out in a Randomized Complete Block Design with three replications. The plot size was 1.75 m × 2.00 m. The experiment had 12 treatments of different weed management of jute, viz., T_1 = Weedy check, T_2 = One hand weeding, T_3 = Two hand weeding, T_4 = Straw mulch, T_5 = Mungbean and jute intercropping, T_6 = Pre-emergence herbicide, T_7 = Post-emergence herbicide, T_8 = Pre-emergence + Post-emergence herbicide, T_9 = Pre-emergence herbicide + One hand weeding, T_{10} = Mungbean + Pre-emergence herbicide, T_{11} = Mungbean + Post-emergence herbicide, T_{12} = Mungbean+ Pre-emergence + Post-emergence herbicide. Rice straw is used as mulch. Seeds were sown in line on March 15, 2019, as per experimental treatments. The recommended seed rate of jute and mungbean was 7 kg and 35 kg ha^{-1}, respectively were sown in the field. Necessary intercultural operations were done as and when necessary. Pre-emergence herbicide pendimethalin at the rate of 600 g ha^{-1} at 2 DAS and post-emergence herbicide quizalofop-ethyl at the rate of 50 g ha^{-1} at 20 DAS was applied according to the treatments. At harvest, each 1 m^2 area of one sample was harvested from each plot leaving an adequate border for recording data on plant height, top, middle and base diameter of the jute plants. The plant height and diameters were recorded from 10 randomly selected plants with the help of bamboo scale and slide calipers, respectively. The jute plant was cut at the ground level with the help of a sickle. The fibre and stick yields were recorded from the whole individual plot. Then the harvested jute plants were made into bundles. The bundle is attached with the tag level. The bundles of each plot were then left into stake separately for 3-5 days for defoliation. The defoliation jute leaf was kept into the respective plot to incorporate with the soil.

Jute plant retting

The bundles of jute plants were put into jag means by arranging the bundle in row and cross row pattern in retting pond. After making the jag it was steeped in pond water with the help of water hyacinth and other aquatic weeds. The depth of water was 1.8 m to allow the jute bundle to float.

Fiber stripping

The jute fiber was stripped from the stick manually after the completion of proper retting. At fiber stripping the upper layer of bark was removed from the lower portion of the jute plant by hand pushing to minimize the cuttings. The fiber was washed in clean water to ensure quality fiber.

Drying of fiber and stick

The fiber was dried on bamboo bar under direct sunshine for 4-5 days to complete drying. The dryness of fiber was observed by 'hand touch' to ensure the dryness. The fiber bundles were assorted plot-wise, tag labels, and weighed. Jute sticks were also dried continuously for seven days to get dry sticks and then weighed.

Plant height, branches plant^{-1}, pods plant^{-1}, seeds pot^{-1}, 1000-seed weight, seed yield, stover yield were recorded for mungbean. The data obtained from the experiment on various parameters were statistically analyzed using MSTAT–C computer program. The mean values for all the parameters were calculated and the analyses of variance for the characters were accomplished by Duncan's Multiple Range Test (DMRT) at a 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Weed infestation

In the present study, the jute field was infested with different types of weeds. The relative density of these weed species was also different (Table 1). Twelve different weed species were observed in the plots of the study where most of them were grass weeds. Among the weed species maximum relative weed density was observed for *Cynodon dactylon* (42 %) at 30 DAS which was followed by *Echinochloa colona* (32%) and *Eleusine indica* (20%). Relative weed species of many several weeds decreased at later stages. In our previous study, it was observed that those grasses and sedges were dominating weed species in jute field (Masum *et al*., 2011). A similar result was also observed that grass 37%, and sedge 52% and the broad-leaved weeds 11% were dominated in jute field where *C. dactylon*, *E. colonum* and *E. indica* were seriously infested (Hossain *et al.*, 2012).

Table 1. Relative density (%) of different weed species at two different growth stages in jute field

Botanical name	Family	Types weed	Relative density (%)	
			30 DAS	60 DAS
Cynodon dactylon	Poaceae	Grass	42	31
Echinochloa colona	Poaceae	Grass	32	21
Eleusine indica	Poaceae	Grass	20	12
Cyperus rotundus	Cyperaceae	Sedge	3	2
Leucas aspera	Labiatae	Broad leaf	1	1
Solanum carolinense	Solaneaceae	Broad leaf	1	1
Brassica kaber	Cruciferae	Broad leaf	-	-
Paspalum comersoni	Poaceae	Grass	-	-
Paspalum distichum	Poaceae	Grass	-	-
Cyperus difformis	Cyperaceae	Sedge	-	-
Solanum nigrum	Solaneaceae	Broad leaf	-	-
Euphorbia hirta	Euphorbiaceae	Broad leaf	-	-

Note: (-) = Trace percentage

Effect of weed management on agronomic performance of jute

Plant height

Weed management practices had a significant effect on plant height (Table 2). Plant height was affected by the different weed management at 30, 45, 60, 75, 90 and 105 DAS. At 105 DAS, the tallest plant (2.52 cm) was obtained from T_9 (Pre-emergence herbicide and one hand weeding plot) and the shortest plant (212.33 cm) was obtained from T_{11} (mungbean with post-emergence herbicide). A similar result was also observed by Smith *et al*. (2006).

Table 2. Effect of weed management on plant height of jute

Treatment	Plant height (cm)					
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
T_1	50.90 h	96.23 g	131.67 f	170.00 f	202.33 g	221.33 c
T_2	75.23 bc	130.00 b	162.67 b	202.00 b	223.33 b	234.33 b
T_3	69.53 d	126.00 cd	150.00 d	203.00 b	212.67 e	219.67 c
T_4	77.37 b	125.00 cd	160.33 bc	196.00 c	212.67 e	232.33 b
T_5	63.77 ef	101.20 f	141.67 e	182.33 e	201.00 g	220.00 c
T_6	70.40 cd	128.33 bc	155.00 cd	196.33 c	218.33 c	221.33 c
T_7	67.83 de	123.00 d	159.33 bc	202.33 b	216.00 cd	224.00 c
T_8	76.70 b	131.33 b	151.00 d	193.00 c	214.33 de	222.67 c
T_9	88.13 a	142.67 a	175.00 a	210.33 a	235.33 a	252.00 a
T_{10}	69.40 fg	113.67 e	150.33 d	187.33 d	207.33 f	223.33 c
T_{11}	57.13 g	11333 e	124.00 g	172.67 f	183.67 h	212.33 d
T_{12}	62.13 fg	123.00 d	150.67 d	194.00 c	214.00 de	222.33 c
LSD 5%	5.046	3.783	5.452	4.047	2.961	4.421
CV (%)	10.12	6.39	7.39	4.30	2.86	4.01

T_1= weedy check, T_2=one hand weeding, T_3=two hand weeding, T_4= straw mulch, T_5=mungbean and jute, T_6= pre-emergence herbicide, T_7=post-emergence herbicide, T_8= pre-emergence + post-emergence herbicide, T_9=pre-emergence herbicide + one hand weeding, T_{10}=mungbean + pre-emergence herbicide, T_{11}=mungbean + post-emergence herbicide and T_{12}=mungbean + pre-emergence + post-emergence herbicide. Mean was calculated from three replicates for each treatment. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Leaves plant^{-1}

Weed management practices had a significant effect on leaves plant^{-1} (Table 3). The leaves plant^{-1} was affected by the different weed management at 30, 45, 60, 75, 90, and 105 DAS. At 30, 45, 60, 75, 90, and 105 DAS, the highest leaves plant^{-1} (12.73, 43.20, 115, 117, and 104.60) was obtained from T_9 (pre-emergence herbicide and one hand weeding) and at 30, 45, 60, 75, 90 and 105 DAS, respectively and the lowest leaves plant^{-1} (9.60, 20.80, 83.73, 94.93, 74.60 and 49.27) was obtained from T_{11} (mungbean with post-emergence herbicide).

Table 3. Effect of weed management on the leaves plant^{-1} of jute

Treatment	Leaves plant^{-1}					
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS
T_1	11.13 cde	20.80 g	100.67 f	99.53 e	85.80 e	71.27 c
T_2	11.93 b	33.67 bc	109.67 b	109.33 bc	88.27 de	75.93 b
T_3	11.20 cde	34.07 bc	106.00 cd	110.00 b	86.67 e	72.33 c
T_4	11.60 bc	33.47 bc	108.00 bc	99.00 e	76.20 f	71.33 c
T_5	10.13 f	23.33 f	101.67 ef	106.00 d	98.40 b	62.53 e
T_6	11.53 bcd	33.07 cd	104.00 de	106.00 d	96.67 bc	67.40 d
T_7	10.93 e	31.93 d	106.67 bc	109.27 bc	104.60 a	54.20 f
T_8	11.07 de	34.53 b	109.67 a	99.47 e	87.53 df	63.07 e
T_9	12.73 a	43.20 a	115.00 b	117.00 a	104.33 a	83.27 a
T_{10}	10.80 e	25.40 e	105.00 d	106.80 cd	95.53 c	66.80 d
T_{11}	9.60 g	24.40 ef	83.73 g	94.93 f	74.60 f	49.27 g
T_{12}	11.53 bcd	24.40 ef	99.53 f	98.93 e	89.87 d	65.73 d
LSD 5%	0.4663	1.290	2.644	2.733	2.409	1.906
CV (%)	8.53	8.74	5.19	5.34	5.43	5.83

T_1= weedy check, T_2=one hand weeding, T_3=two hand weeding, T_4= straw mulch, T_5=mungbean and jute, T_6= pre-emergence herbicide, T_7=post-emergence herbicide, T_8= pre-emergence + post-emergence herbicide, T_9=pre-emergence herbicide + one hand weeding, T_{10}=mungbean + pre-emergence herbicide, T_{11}=mungbean + post-emergence herbicide and T_{12}=mungbean + pre-emergence + post-emergence herbicide. Mean was calculated from three replicates for each treatment. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Plant diameter

Plant diameter (base, middle, and top) are significantly influenced by different weed management practices (Table 4). The highest base diameter (11.00 mm) was found from T_9 (pre-emergence herbicide and one hand weeding) and the lowest base diameter (8.43 mm) was found from T_{11} (mungbean + post-emergence herbicide). The highest middle diameter (8.20 mm) was found from T_9 (pre-emergence herbicide and one hand weeding) and the lowest middle diameter (5.37 mm) was found from T_{11} (mungbean + post-emergence herbicide). The highest top diameter (4.60 mm) was found from T_9 (pre-emergence herbicide and one hand weeding) and the lowest top diameter (2.70 mm) was found from T_{11} (mungbean + post-emergence herbicide). Sitangshu and Sarkar (2006) also found a similar result.

Table 4. Effect of weed management on base, middle and top diameter of jute

Treatment	Base diameter (mm)	Middle diameter (mm)	Top diameter (mm)
T_1	9.20 f	5.93 g	2.97 fg
T_2	9.80 df	6.17 f	3.53 d
T_3	10.00 cdf	7.30 d	3.88 c
T_4	8.93 fg	5.57 h	2.92 g
T_5	10.03 b	7.80 c	3.87 c
T_6	10.20 bc	8.00 b	3.93 c
T_7	8.80 g	5.70 h	3.05 f
T_8	9.70 e	6.80 e	3.43 e
T_9	11.00 a	8.20 a	4.66 a
T_{10}	10.07 bcd	8.00 b	4.24 b
T_{11}	8.43 h	5.37 i	2.70 h
T_{12}	9.13 f	6.07 fg	2.88 g
LSD $_{5\%}$	0.29	0.13	0.09
CV (%)	6.34	4.14	5.44

T_1=weedy check, T_2=one hand weeding, T_3=two hand weeding, T_4= straw mulch, T_5=mungbean and jute, T_6= pre-emergence herbicide, T_7=post-emergence herbicide, T_8= pre-emergence + post-emergence herbicide, T_9=pre-emergence herbicide + one hand weeding, T_{10}=mungbean + pre-emergence herbicide, T_{11}=mungbean + post-emergence herbicide and T_{12}=mungbean + pre-emergence + post-emergence herbicide. Mean was calculated from three replicates for each treatment. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Effect of weed management on fiber and stick performance of jute

Fiber weight plant^{-1}

The fibre weight was significantly affected by different weed management practices (Figure 1A). The highest fibre weight plant^{-1} (36.67 g) was obtained from T_9 (pre-emergence herbicide and one hand weeding) and the lowest fibre weight plant^{-1} (24 g) was obtained from obtained from T_{11} (mungbean + post-emergence herbicide).

Stick weight plant^{-1}

The stick weight differed significantly among different weed management practices (Figure 1B). The highest stick weight plant^{-1} (107.67 g) was obtained from T_9 (pre-emergence herbicide and one hand weeding) and the lowest stick weight plant^{-1} (75.33 g) was obtained from T_8 (pre-emergence + post-emergence herbicide) and T_{11} (mungbean + post-emergence herbicide).

Fibre yield

Due to different weed management practices, fibre yield was varied significantly (Figure 2A). The highest fibre yield (4.09 t ha^{-1}) was obtained from T_9 (pre-emergence herbicide and one hand weeding). Significantly the lowest fibre yield (2.80 t ha^{-1}) was observed from T_{11} (mungbean + post-emergence herbicide). Sarkar *et*

al. (2005) found that the fibre yield was significantly influenced by weeding. They reported the highest fibre yield (4.65 t ha^{-1}) was obtained from herbicides application and the lowest (2.23 t ha^{-1}) from no weeding. The pre-emergence application of 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 (Dutta and Mondal, 2021). However, Sinha *et al.* (2009) revealed that the post-emergence herbicides like fenoxaprop-p-ethyl and quizalofop were more effective than pre-emergence herbicide like pendimethalin in controlling the weeds in jute. It is recommended that farmers can apply pretilachlor as pre-emergence followed by quizalofopethyl + ethoxysulfuron as post-emergence, depending on the level of infestation of grasses during the initial crop growth period of jute (Dutta and Kheroar, 2020). However, integrated weed management is more effective than pre-emergence or post-emergence herbicides alone. Das *et al*. (1994) 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.

Stick Yield

The stick yield was significantly affected by weed management practices (Figure 2B). The highest stick yield (7.00 t ha^{-1}) was obtained from T_9 (pre-emergence herbicide and one hand weeding) and the lowest (5.37 t ha^{-1}) from T_{11} (mungbean + post-emergence herbicide) that was statistically similar to T_1 (5.47 t ha^{-1}) (weedy check). Sitangshu and Sarkar (2006) found a similar result.

Harvest Index

The harvest index was significantly influenced by the different weed management practices (Figure 2C). Significantly highest harvest index (36.83%) was obtained from T_9 (pre-emergence herbicide and one hand weeding) and the lowest harvest index (32.63%) was observed from T_{11} (mungbean + post-emergence herbicide).

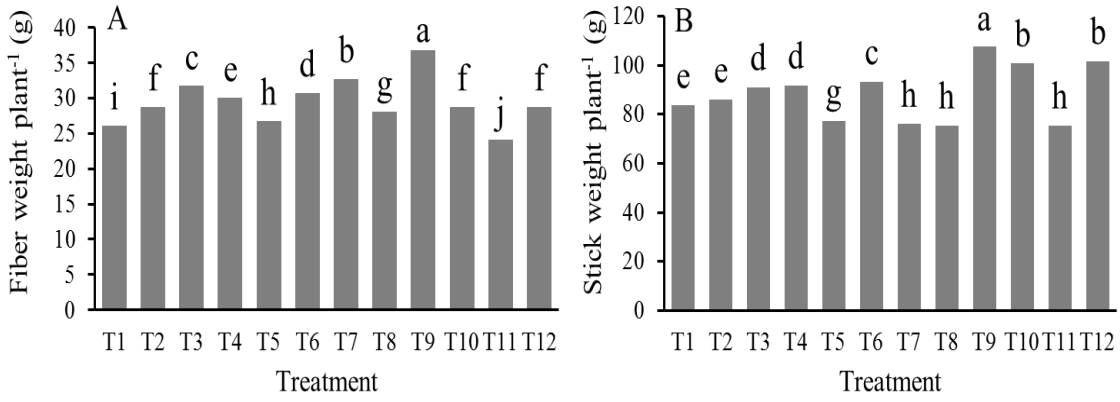


Fig. 1. Effect of weed management on (A) fiber weight plant^{-1} (B) stick weight plant^{-1} of jute. T_1= weedy check, T_2=one hand weeding, T_3=two hand weeding, T_4= straw mulch, T_5=mungbean and jute, T_6= pre-emergence herbicide, T_7=post-emergence herbicide, T_8= pre-emergence + post-emergence herbicide, T_9=pre-emergence herbicide + one hand weeding, T_{10}=mungbean + pre-emergence herbicide, T_{11}=mungbean + post-emergence herbicide and T_{12}=mungbean + pre-emergence + post-emergence herbicide. Mean was calculated from three replicates for each treatment. Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD test.

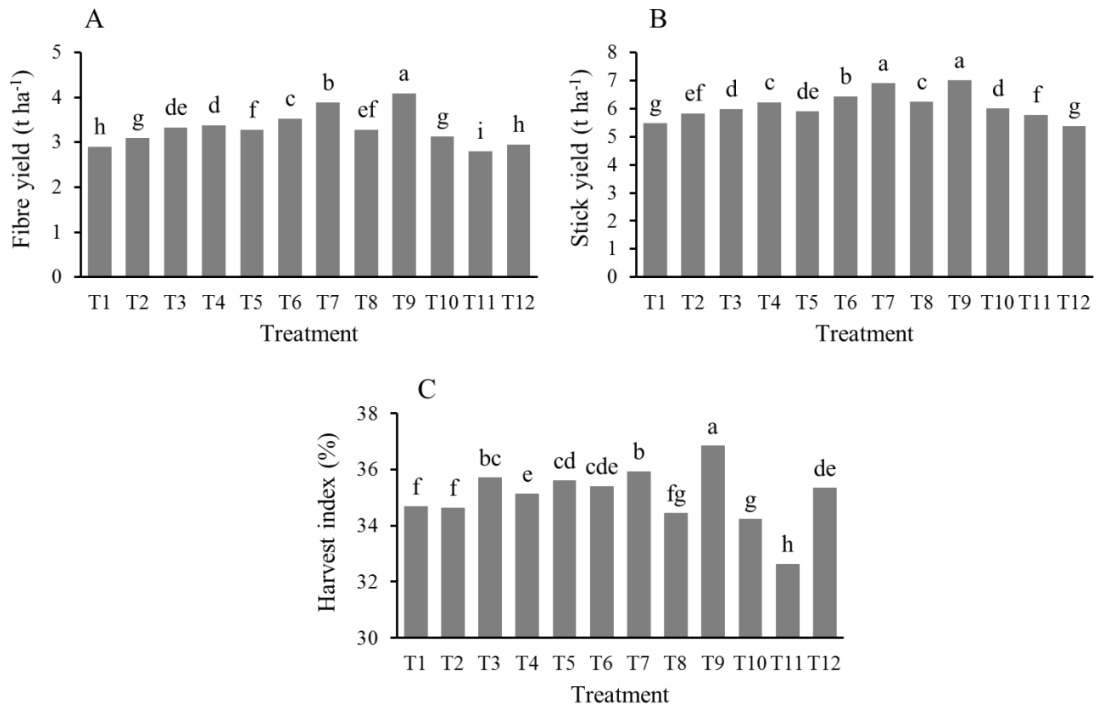


Fig. 2. Effect of weed management on (A) fibre yield, (B) stick yield and (C) harvest index of jute. Mean was calculated from three replicates for each treatment. T_1= weedy check, T_2=one hand weeding, T_3=two hand weeding, T_4= straw mulch, T_5=mungbean and jute, T_6= pre-emergence herbicide, T_7=post-emergence herbicide, T_8= pre-emergence + post-emergence herbicide, T_9=pre-emergence herbicide + one hand weeding, T_{10}=mungbean + pre-emergence herbicide, T_{11}=mungbean + post-emergence herbicide and T_{12}=mungbean + pre-emergence + post-emergence herbicide. Mean was calculated from three replicates for each treatment. Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD test.

Performance of mungbean as the intercropping with jute crop for weed management

Plant height

The plant height was significantly influenced by weed management and intercropping with jute at all growth stages of mungbean (Table 5). At 15, 30, and 60 DAS, the highest plant height (11.27, 36, and 75 cm, respectively) was recorded in T_{11} (mungbean + post-emergence herbicide) but at 45 DAS, the highest plant height (69.70 cm) was recorded in T_{12} (mungbean + pre-emergence + post-emergence herbicide), where the lowest was measured at 15, 30, 45 and 60 DAS (6.40, 29.90, 59.07 and 64.07 cm, respectively) in T_{10} (mungbean + pre-emergence herbicide) treatment.

Branches plant^{-1}

Branches plant^{-1} was significantly influenced by different weed management and intercropping with jute at all growth stages of mungbean (Table 6). At 15 DAS, the highest number of branches plant^{-1} (4.00) was recorded in T_5 (mungbean and jute intercropping), at 30 and 60 DAS, the highest number of branches plant^{-1} (5.27 and 8.00) was recorded in T_{12} (mungbean + pre-emergence + post-emergence herbicide) and at 45 DAS, the highest number of branches plant^{-1} (6.93) was recorded in T_{11} (mungbean + post-emergence herbicide) and the lowest was achieved with T_{10} (3.60, 4.53, 6.07 and 6.67 respectively). Muhammad *et al.* (2004) reported that weeding was applied twice, i.e., at 10 and 35 days after sowing significantly affected of branches plant^{-1}.

Table 5. Effect of weed management on plant height of mungbean

Treatment	Plant height (cm)			
	15 DAS	30 DAS	45 DAS	60 DAS
T_5	10.53 a	33.63 b	66.77 b	67.07 b
T_{10}	6.400 c	29.90 c	59.07 c	64.07 c
T_{11}	11.27 a	36.00 a	65.97 b	75.00 a
T_{12}	9.273 b	33.97 b	69.70 a	75.00 a
LSD 5%	0.8862	0.9172	2.723	2.353
CV (%)	9.47	2.75	4.17	3.27

T_5=mungbean and jute intercropping, T_{10}=mungbean + pre-emergence herbicide, T_{11}=mungbean + post-emergence herbicide and T_{12}=mungbean + pre-emergence + post-emergence herbicide. Mean was calculated from three replicates for each treatment. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Table 6. Effect of weed management on branches plant^{-1} of mungbean

Treatment	Number of Branches Plant^{-1}			
	15 DAS	30 DAS	45 DAS	60 DAS
T_5	4.00 a	5.13 a	6.47ab	7.53 a
T_{10}	3.60 b	4.53 b	6.07 b	6.67 b
T_{11}	3.87 ab	5.13 a	6.93 a	7.60 a
T_{12}	3.67 ab	5.27 a	6.80 a	8.00 a
LSD 5%	0.3475	0.2507	0.6863	0.8066
CV (%)	9.20	5.02	10.46	10.84

T_5=mungbean and jute intercropping, T_{10}=mungbean + pre-emergence herbicide, T_{11}=mungbean + post-emergence herbicide and T_{12}=mungbean + pre-emergence + post-emergence herbicide. Mean was calculated from three replicates for each treatment. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Pods plant^{-1}

Pods plant^{-1} was significantly influenced by weed management and intercropping with jute at all growth stages of mungbean (Figure 3A). It was remarked from the present study that the increasing number of weeding significantly increased the number of pods plant^{-1}. T_5 (mungbean and jute intercropping) treatment produced the maximum number of pods plant^{-1} (10.33). The minimum pods plant^{-1} (7.33) was achieved with T_{10} (mungbean + pre-emergence herbicide). Akter *et al.* (2013) observed that three-stage weeding (emergence-flowering and flowering-pod setting and pod setting-maturity) ensured the highest number of pods (22.03) plant^{-1}.

Pod length

Results presented in Figure 3B on pod length influenced by the number of weeding and intercropping with jute was statistically significant. The highest pod length (8.01 cm) was recorded in T_{10} (mungbean with pre-emergence herbicide) and the lowest pod length (7.43 cm) was achieved by T_5 (mungbean jute intercropping) that was statistically similar (7.46) to T_{11} (Mungbean with post-emergence herbicide).

Seeds pod^{-1}

Results presented in Figure 3C on the seeds pod^{-1} influenced by weed management and intercropping with jute were statistically significant. The highest seeds pod^{-1} (9.33) was recorded in T_{11} (mungbean with post-emergence herbicide) and the lowest number of seeds pod^{-1} (8.69) was achieved by T_5 (mungbean-jute intercropping) that was statistically similar to T_{10} and T_{12}. Similar findings were found by Kundu *et al*. (2009) reported that seeds pod^{-1} was highest in the treatment having quizalofop-p-ethyl at 50 g a.i. ha^{-1} at 21 days after emergence (DAE) + hand weeding at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl at 50 g a.i. ha^{-1} at 14 DAE + hand weeding at 21 DAE.

Weight of 1000 seeds

Results showed that the weight of 1000 seeds were influenced by weed management and intercropping with jute was statistically significant (Figure 3D). It is mentioned from the present study that the highest weight of 1000 seeds (40.23 g) was recorded in T_{11} (Mungbean with post-emergence herbicide) and T_{12} (mungbean with pre-emergence and post-emergence herbicide), whereas the lowest weight of 1000 seeds (33.40 g) was achieved by T_5 (mungbean-jute intercropping). Similar findings were found by Khan *et al.* (2011).

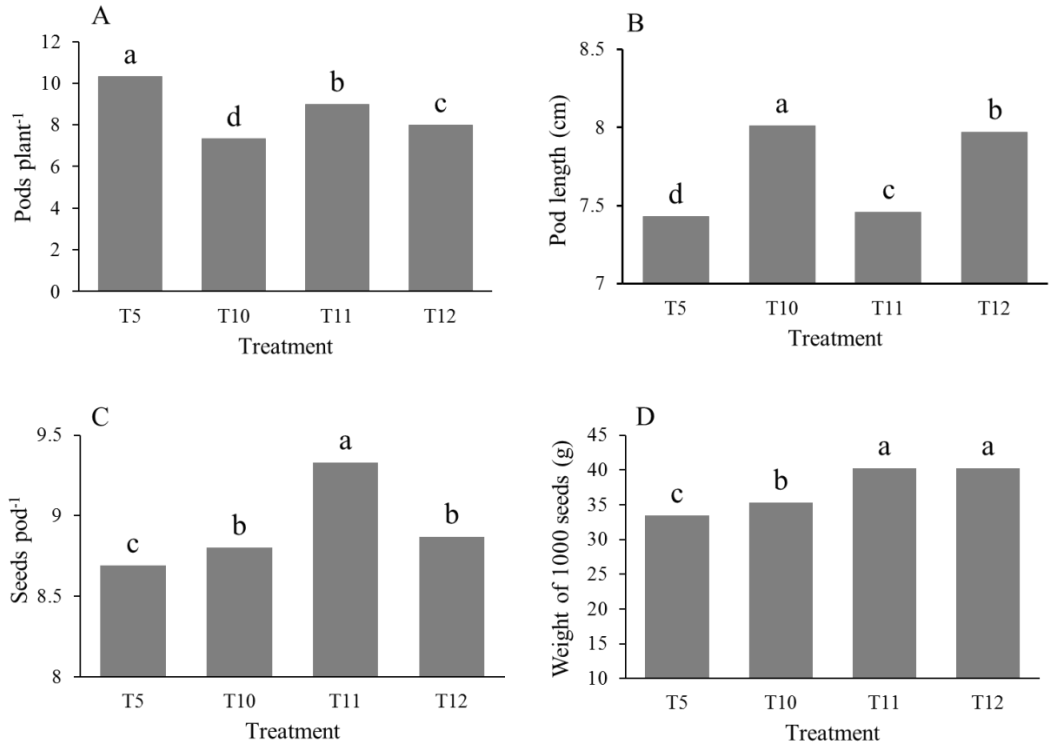


Fig. 3. Effect of weed management on (A) pods plant^{-1}, (B) pod length, (C) seeds pod^{-1} and (D) weight of 1000 seeds of mungbean. T_5= mungbean and jute, T_{10}= mungbean + pre-emergence herbicide, T_{11}= mungbean + post-emergence herbicide and T_{12}=mungbean + pre-emergence + post-emergence herbicide. Mean was calculated from three replicates for each treatment. Mean was calculated from three replicates for each treatment. Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD test.

Seed yield

Seed yield of mungbean influenced by weeding and intercropping with jute was statistically significant (Figure 4A). The highest grain yield (1.35 t ha^{-1}) was recorded in T_{11} (mungbean with post-emergence herbicide) while the lowest grain yield (1.05 t ha^{-1}) was achieved by T_5 (mungbean-jute intercropping). Sinha *et al*. (2009) revealed that the post-emergence herbicides were more effective than pre-emergence herbicide in controlling the weeds. Sarkar (2006) 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 DAS effectively reduced the grassy weeds like *E. colona* and broadleaved weeds like *Physalis minima* and *Phyllanthus niruri*. Application of fenoxaprop-p-ethyl 9% EC at 615 ml ha^{-1} at 15 DAS controlled grassy weeds very efficiently in crop field and gave higher yield than control treatment (Ali *et al*., 2012).

Stover yield

Stover yield of mungbean was not significantly different due to various weed managements and intercropping with jute (Figure 4B). The highest stover yield (2.58 t ha^{-1}) was observed from T_{11} (mungbean with post-emergence herbicide) while the lowest stover yield (2.40 t ha^{-1}) from T_{10} (mungbean with pre-emergence herbicide).

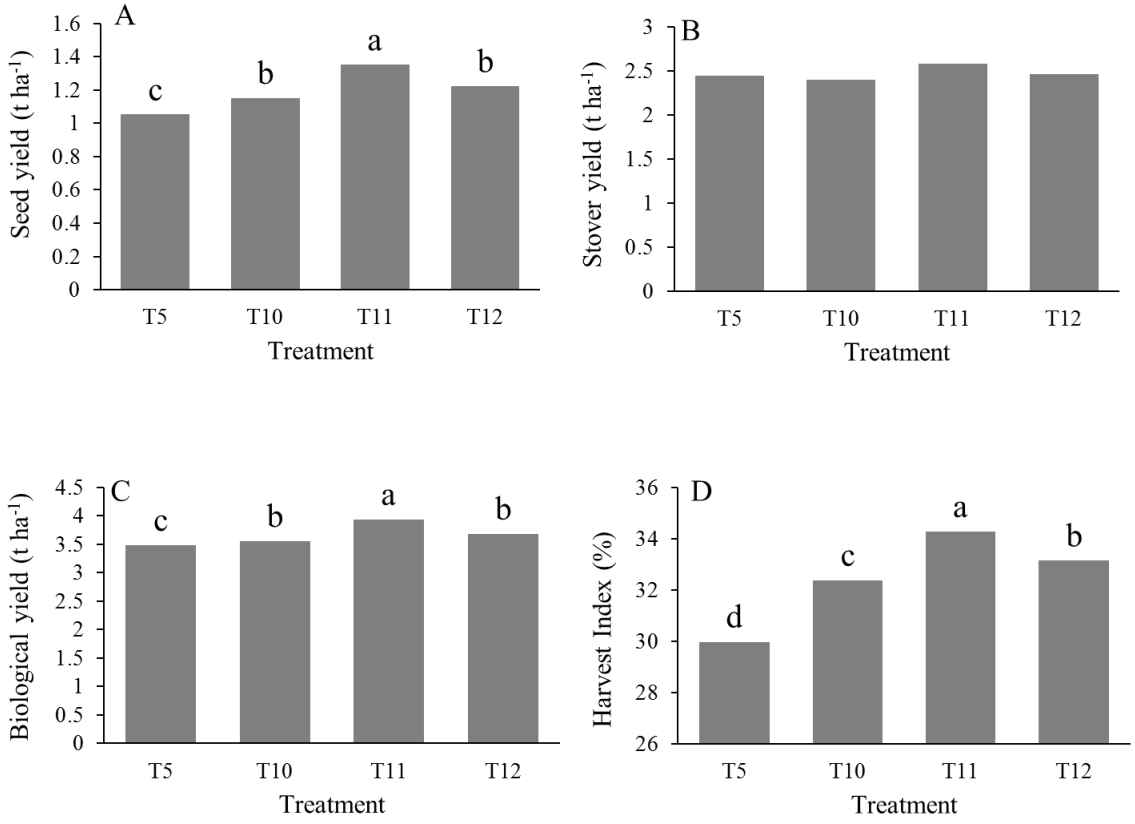


Fig. 4. Effect of weed management on (A) seed yield, (B) stover yield, (C) biological yield and (D) harvest index of mungbean. T_5= mungbean and jute, T_{10}= mungbean + pre-emergence herbicide, T_{11}= mungbean + post-emergence herbicide and T_{12}=mungbean + pre-emergence + post-emergence herbicide. Mean was calculated from three replicates for each treatment. Mean was calculated from three replicates for each treatment. Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD test.

Biological yield

The biological yield was significantly influenced by the level of weeding and intercropping with jute (Figure 4C). The highest biological yield (3.93 t ha^{-1}) was recorded in T_{11} (mungbean with post-emergence herbicide) and the lowest biological yield (3.48 t ha^{-1}) was achieved by T_5 (mungbean-jute intercropping) that was statistically similar to T_{10} (mungbean with pre-emergence herbicide) (3.55 t ha^{-1}).

Harvest Index

Harvest index was significantly influenced by weeding and intercropping with jute (Figure 4D). It is calculated from the present study that the highest harvest index (34.27%) was recorded in T_{11} (mungbean

with post-emergence herbicide) and the lowest harvest index (29.97%) was achieved by T_5 (mungbean-jute intercropping).

Cost and return analysis in respect to weed management strategies

The cost of crop cultivation through weed management is considered as one of the vital factors to the farmers for net return. The cost and return analysis were done and have been presented in table 7. Total cost of the production was recorded for all the treatments of unit plot and calculated on a ha^{-1} basis to the price of jute stick, jute fiber, seed and stover yield of mungbean at the local market. The total cost of production ranges between Tk. 79980 to Tk. 97200 ha^{-1} among the different treatment combinations. The highest cost of production Tk. 97200 ha^{-1} was involved in the treatment of T_{11} (mungbean + post-emergence herbicide), while the lowest cost of production was Tk. 79980 ha^{-1} was found in the treatment of T_1. Gross return from the different treatment combinations ranges between Tk 92795 to 295600 ha^{-1}. Among the different treatments, T_{11} gave the highest return Tk. 295600 ha^{-1} while the lowest net return Tk. 92795 was obtained from the treatment T_1. The benefit-cost ratio was found to be the highest (3.04) in the treatment combination $T_{11.}$ It was reported that intercropping red amaranth, jute shak and kangkong with kenaf resulted in significant yield reduction of kenaf in weed management but increased net return and benefit-cost ratio (Nur *et al*., 2021). Intercropping of jute with red amaranthus had 2nd highest benefit-cost ratio in weed management (Das *et al*., 2008).

Table 7. Showing the gross return, net return, benefit-cost ratio of different weed management

Treatments	Gross return (Tk. ha^{-1})	Total cost of production (Tk. ha^{-1})	Net return (Tk. ha^{-1})	Benefit-cost ratio (BCR)
T_1	172775	79980	92795	1.16
T_2	198780	86500	112280	1.30
T_3	191850	87000	104850	1.21
T_4	205540	86400	119140	1.38
T_5	291600	96750	194850	2.01
T_6	241370	86450	154920	1.79
T_7	235980	86500	149480	1.73
T_8	224670	86600	138070	1.59
T_9	250430	87400	163030	1.87
T_{10}	305900	96900	209000	2.16
T_{11}	392800	97200	295600	3.04
T_{12}	321350	96750	224600	2.32

T_5= mungbean and jute intercropping, T_{10}= mungbean + pre-emergence herbicide, T_{11}= mungbean + post-emergence herbicide and T_{12}=mungbean + pre-emergence + post-emergence herbicide. Mean was calculated from three replicates for each treatment.

CONCLUSION

Considering the results, it can be concluded that T_9 (pre-emergence herbicide along with one hand weeding) weed management treatment was the best option for higher growth and productivity of jute. One the other hand, lowest growth and yield performance was observed in control and mungbean intercropping with post-emergence herbicide. However, intercropping jute and mungbean with post-emergence herbicide application for weed management in jute gives the highest gross, net return and the highest benefit-cost ratio. Although the intercropping approaches of weed management resulted in significant yield reduction of jute but increased net return and benefit-cost ratio. Therefore, this experiment showed that higher profitability in jute cultivation can be achieved by the adoption of integrated weed management practices like intercropping with mungbean along with recommended herbicide application. Although integrated weed management and intercropping have been used traditionally for thousands of years, it is poorly understood from an agronomic perspective. Integrated weed management and intercropping system are more challenging to manage than pure stands.

So, more research is needed for a better understanding regarding how to intercrops function and how to develop intercropping systems that is compatible with the present farming system.

REFERENCES

Akter, R., Samad, M. A., Zaman, F. and Islam, M. S. 2013. Effect of weeding on the growth, yield and yield contributing characters of mungbean (*Vigna radiata* L.). *J. Bangladesh Agri. Univ.* 11(1): 53–60.

Alam. A. T. M. M., Hossain, M. S., Islam, M. M., Ahmed, I. and Hamidi. M. A. 2010. Effect of weeding and thinning practices on fibre yield and economics of deshi jute. *Bangladesh J. Weed Sci*. 1(1): 31-34.

Alam. S. M. 2003. Weed control method. *Bangladesh. J. Jute Fib. Res.* 10(1): 42-47.

Ali, M. H., Islam, M. S., Karim, M. F. and Masum, S. M. 2012. Influence of weed control methods and plant spacing on the yield of white jute (*Corchorus capsularis*). *Pakistan J. Weed Sci. Res.* 18:1-6.

BBS (Bangladesh Bureau of Statistics). 2020. Statistical Yearbook of Bangladesh. Bureau of Statistics. Stat. Div. Min. Plan, Govt. People's Rep. Bangladesh. Dhaka.

Das K., Guha, B., Patgiri, O. K., Thakuria, K. and Borgohain, B. 1994. Weed management in tossa jute (*Corchorus olitorius*). *Indian J. Agron*. 39(1):87-92.

Das, K., Guha, B., Zaman, A. S. N. 2008. Productivity and profitability of tossa jute (*Corchorus olitorius*) under different weed management practices in jute-toria cropping system. *Madras Agri. J.* 95(7-12): 353-358.

Dutta, S. and Mondal, T. 2021. A review on physical, chemical and integrated weed management in jute. *J. Pharm. Innov*. 10(8): 1106-1109

Dutta, S., Kheroar, S. 2020. Effect of integrated weed management on weeds, yield and economics of tossa jute (*Corchorus olitorius* L.) production. *Indian J. Agron*. 65(4): 479-484.

Gaffer, M. A., Iqbal, T. M. T. and Alam, M. S. 1988. "Bij o Agachsa (in Bengali)". Published by T.M.J.B. Iqbal, Village- Monipotal, P.O. Meghai, Sirajganj. pp.221-238.

Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. 2nd edn. John Wiley and Sons. New York. pp.1-704.

Hossain, M. S., Islam, M. M., Alam, A. T. M. M., Ahmad, I. and Alam, M. J. 2012. Species identification, density evaluation and green weight of weeds in deshi jute (*Corchorus capsularis* L.) growing areas of Bangladesh. *Bangladesh J. Weed Sci*. 3(1&2): 47-52.

Islam, M. M. 2014. Research advances of jute field weeds in Bangladesh: A review. *J. Sci. Tech.* 4(4): 254-268.

Islam, M. M. and Ali, M. S. 2017. Economic importance of jute in Bangladesh: Production, research achievements and diversification. *Intl. J. Eco. Theo. Appl.* 4(6): 45-57.

Khan, R. U., Rashid, A. and Khan, M. S. 2011. Impact of various rates of pendimethalin herbicide on weed control, seed yield and economic returns in mungbean under rainfed conditions. *J. Agric. Res.* 49(4): 171-177.

Kundu, R., Bera, P. S. and Chari, K. B. 2009. Effect of different weed management practices in summer mungbean [*Vigna radiata* L.] under new alluvial zone of West Bengal. *J. Crop Weed*. 5(2): 117-121.

Mamun, M. A., Shamsi, S. and Bashar, M. A. 2016. Estimation of interrelationships among some quality factors of jute seeds. *Dhaka Uni. J. Biol. Sci*. 25(10): 9–17.

Masum, S. M., Ali, M. H., Islam, M. S. and Sultana, S. 2011. Influence of plant spacing and post emergence herbicide on the yield of white jute (*Corchorus capsularis*). *Int. J. Sustain. Agric.* 3(3): 82-87.

Muhammad, A. N., Rashid, A. and Ahmad, M. S. 2004. Effect of seed inoculation and different fertilizer levels on the growth and yield of mungbean (*Vigna radiata* L.). *Bangladesh J. Agron.* 3: 40-42.

Nur, I., Kundu, B., Chowdhury, M., Mukul, M., Ferdush, J. and Khan, M. 2021. Weed management of kenaf (*Hibiscus cannabinus*) through intercropping leafy vegetables and cultural practices. *SAARC J. Agri.* 19(1): 165–176.

Rahman, M. and Khaled, N. 2011. Global market opportunities in export of jute. CPD Working Paper 93. Centre for Policy Dialogue (CPD). p.1-40.

Saraswat, V. N. 1999. Weed management in jute and jute-based cropping system. *In*: P. Palit, S. Pathak and D.P. Singh, eds. Jute and Allied Fibres Agriculture and Processing. Barrackpore: Central Research Institute for Jute and allied Fibres. pp. 193-200.

Sarkar, S., Bhattacharjee, A. K. and Mitra, S. 2005. Weed management in jute by Trifluralin (48% EC) in the early jute-weed competition phase. *J. Crop Weed*. 2: 30–33.

Sinha, N. K., Singh, D. and Roy, D. K. 2009. Weed management strategies in jute grown for seed production in calcareous soils of north Bihar. *Indian J. Weed Sci.* 41(1&2): 19-22.

Sitangshu, S. and Sarkar, G. 2006. Weed management in jute (*Corchorus olitorius* L.) by post emergence herbicides. *Tropical J. Agric*. 44(1/2): 71-73.

Smith, M. A. K. 2006. Comparing weed and crop seedling response to pre-emergence pendimethalin application in *Corchorus olitorius* and *Abelmoschus esculentus*. *Crop Prot.* 25(120): 1221-1226.