STUDY ON THE INTEGRATED WEED MANAGEMENT IN JUTE

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December, 2020

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By

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REGISTRATION NO.18-09175

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE (MS)

IN

AGRONOMY

SEMESTER: JUNE-DECEMBER, 2020

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CERTIFICATE

This is to certify that the thesis entitled " ***STUDY ON THE INTEGRATED WEED MANAGEMENT IN JUTE*** *"submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***MUHYMINUL AKRAM,*** *Registration. No.* ***18-09175*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated:

Dhaka, Bangladesh

(Dr. Sheikh Muhammad Masum)

Supervisor

DEDICATED TO

MY

BELOVED PARENTS

Acknowledgments

All praises, gratitude, and thanks belong to **Almighty Allah**, Who enabled the author to complete this research work successfully.

The author would like to express his sincere and deepest sense of gratitude and regards to his Supervisor, **Associate Prof. Sheikh Muhammad Masum, Ph.D.** Department of Agronomy, Sher-e-Bangla Agricultural University (SAU), Dhaka for his sincere interest, scholastic guidance, valuable suggestions, and continuous encouragement during the entire period of the study and preparation of this thesis.

The author expresses his heartiest respect and deepest gratitude to his Co-Supervisor, **Prof. Dr. Md. Hazrat Ali**, Vice-Chancellor, Fast Capital University of Bangladesh for his kind help and constructive criticism for conducting the research and in preparation of this thesis.

Profound thanks and indebtedness are also due to all teachers, Department of Agronomy, Sher-e-Bangla Agricultural University (SAU), Dhaka, sympathetic cooperation, and inspirations throughout this study.

Mere diction is not enough to express my profound gratitude and deepest appreciation to my parents for their ever-ending prayer, encouragement, sacrifice, and dedicated efforts to educate me to this level.

The Author

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ABSTRACT

The experiment was conducted at the Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka during April 2019 to August 2019 to find out suitable environment friendly and remunerative integrated weed management for jute (*Corchorus capsularis* L.) var. BJRI Deshi pat-8 (BJC-2197). The growth pattern of infesting major weeds concerning jute grown for fibre in jute fields was also observed. In the experiment, the treatments consisted of twelve weed managements, viz., weedy check, one hand weeding, two hand weeding, rice straw mulch, jute intercropped with mungbean (*Vigna mungo* L) var. BARI Mung-6, pre-emergence herbicide (Pendimethalin @ 600 g ha^{-1} at 2 DAS), post-emergence herbicide (Quizalofop-ethyl @ 50 g ha^{-1} at 20 DAS), pre + post-emergence herbicide, pre-emergence herbicide + one hand weeding, mungbean + pre-emergence herbicide, mungbean + post-emergence herbicide, and mungbean + pre + post-emergence herbicide. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The predominant weeds observed were annual grasses and sedges including nutsedge. Broadleaved weeds occurred in a smaller number and were not a serious problem. 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%). Results revealed that integrated weed management in jute had a significant influence on the growth and yield components of jute. The highest fibre yield (4.09 t ha^{-1}) was obtained from the application of pre-emergence herbicide and one hand weeding and the lowest fibre yield (2.80 t ha^{-1}) was observed from the application of post-emergence herbicide associate with mungbean. All parameters were also significantly influenced by weed management and intercropping with jute at all growth stages of the mungbean. The highest grain yield (1.35 t ha^{-1}) was recorded in the combination of post-emergence herbicide and the lowest grain yield (1.05 t ha^{-1}) was achieved by the weed management with jute. Gross return from the different treatment combinations ranged between 92,795 to 2,95,600 Tk. ha^{-1}. The combination of mungbean with post-emergence herbicide gave the highest return (2,95,600 Tk. ha^{-1}) while the lowest net return (92,795 Tk. ha^{-1}) was obtained from the treatment weedy check. The highest (3.04) benefit-cost ratio (BCR) was found from the integrated weed management of jute intercropped with mungbean and the application of post-emergence herbicide. 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.

LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
%	=	Percent
µg	=	Micro gram
°c	=	Degree Celsius
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
et al.	=	And others
G	=	gram (s)
ha^{-1}	=	Per hectare
HI	=	Harvest Index
Hr	=	Hour
Kg	=	Kilogram
LAI	=	Leaf area index
LSD	=	Least Significant Difference
Max	=	Maximum
Min	=	Minimum
mm	=	millimeter
MoP	=	Muriate of Potash
N	=	Nitrogen
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
ppm	=	Parts per million
RCBD	=	Randomized complete block design
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
T	=	Ton
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
Wt.	=	Weight

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CHAPTER I

INTRODUCTION

Jute is an important cash and fibre crop which belongs to the family Malvaceae and genus *Corchorus*. Two species of jute *Corchorus capsularis* and *Corchorus olitorius* are usually grown by the farmer. About 80% of the total world jute is produced in Bangladesh and India. Jute grows abundantly in Bangladesh having the best quality in comparison with that of India (Zakaria and Syed, 2008). Jute is extensively used throughout the world because of its versatility, durability, and fineness. Its fibre is mainly used in manufacturing various types of industrial products such as hessian, sacking, carpet backing, cloths, mats, blankets, fabrics, packing materials, etc. In Bangladesh, total area under jute production has an estimated 7,49,654 ha, the average yield rate has estimated 11.400 bales ha^{-1} and the total jute production has estimated 75,85,087 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). The fibre is also used to prepare ropes and housing materials for domestic uses. Jute sticks are used as fuel and fences. In recent years, green jute plant is being used as raw materials for paper pulp in paper mills jute and also used for partex and jute geo-textile.

Cultural practices are important management factors that affect the yield of a crop. The hot and humid climate coupled with intermittent rainfall during the jute-growing season, however, encourages weed growth resulting in severe crop-weed competition (Saraswat, 1999); yield losses may be up to 75 to 80% (Sahoo and Saraswat, 1988). 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 niri (hand weeding), and weeding and thinning operations involve about 50% or more of the labour cost (Alam, 2003). Grasses constitute 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.

Herbicides also commonly known as weed killers, are substances used to control unwanted plants. Selective herbicides 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/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 treatment 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 tender and 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.

The production trend to jute is decreased year after year. The main cause of the decreasing trend is low market price; higher production cost and higher weeds infestation. Weed infestation is a great obstacle for higher jute production which is greatly attributed to the increased production cost. 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.

Intercropping is defined simply as growing two or more crop types on one field. The practice of intercropping has been around since farming began. The modernization of farming equipment has changed our farming practices into what they are today, which is largely mono-cropping. Mono-cropping is planting only one crop on a field that was adapted to maximize the number of seeds you could plant on one field and in a shorter period. Looking back on it today, it seems our ancestors were on to something, as there is still a lot of value held in the practice of intercropping.It is a system where two or more crops are grown simultaneously in the same land at the same time. Crop production can be intensified through intercropping (Zandstra, 1979). 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 and/or provides better avenues of employment for the rural folk (Bandyopadhyay, 1984). Andrews (1972) observed that intercropping was found to be helpful to improve the nutritional quality of diet allowed 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.

Therefore the present study was undertaken the following objectives:

- Study the growth behavior of the weeds and the crop
- Estimate the weed control efficiency of integrated weed management
- Determine the herbicidal-cum-cultural treatments in respect of weed-crop competition
- Find out the performance of jute under integrated weed management practices and mungbean as a smoother crop in jute

CHAPTER II

REVIEW OF LITERATURE

Jute being a tropical crop required a warm humid climate. Its commercial cultivation has remained confined to Bangladesh, India and a few other countries in the tropics. The yield potential of jute varieties, fertilizer level and their management are closely interlocking factors determining the efficiency of crop production. Although jute is second only to cotton as a fibre crop. It has received very little attention in respect of its development and scientific culture. The volume of reported scientific information on the aspect of jute production is meager. Review of the research works done so far which are pertinent to the present study is presented below:

2.1 Weed management practice in jute

Ignorance about the herbicidal method of weed management among jute growers is one of the major reasons for the low profitability of jute cultivation. Studies have indicated that the adoption of recommended jute production technologies has the potential to give higher yield and income to the farmers (Chapke, 2012).

Masum *et al.* (2011) conducted a field experiment at Sher-Bangla Agricultural University, Dhaka from April to August 2009 to find out the influence of plant spacing and weed control methods on the yield of *Corchorus capsularis* (cv. CVL-1). The experiment consisted of four plant spacing viz. 20 cm × 10 cm, 25 cm × 10 cm, 30 cm × 10 cm (20, 25 and 30 cm rows with plants spaced at 10 cm intervals in the row) and broadcasting and four weed control methods viz. two times hand weeding with one raking, herbicide Whip Super® 9 EC (Fenoxaprop-P-ethyl: C H ClNO) application at 15 DAS, two hand weeding at 20 and 40 DAS and three times 18 16 5 hand weeding at 15, 30 and 45 DAS. The dominant grass weeds were *Cynodon dactylon* (43%), *Echinochloa colona* (29%) and *Eleusine indica* (22%). Results showed that plant spacing differed significantly and 25 cm × 10 cm spacing gave the highest (3.12 t ha^{-1}) fibre yield which was statistically similar with 20 cm × 10 cm. Two times weeding and one raking gave highest (3.12 t ha-1) fibre yield which was statistically similar with herbicide application

(2.97 t ha^{-1}). Interaction effect showed the highest fiber yield (4.02 t ha^{-1}) was obtained from 20 cm × 10 cm spacing with herbicide application. Whip Super 9 EC @ 615 ml ha^{-1} effectively controlled the grass weeds providing higher fibre yield and net 7.13 Taka return per Tk. invested whereas 6.51, 5.18 and 5.34 Tk. from two hand weedings with one raking, two hand weedings, and three hand weeding, respectively.

Alam and Ali (2010) narrated that 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.

Gliricidia (*Gliricidia sepium*) having no allelopathic effect on corn or beans when intercropped was seen to significantly decrease the population of some weed species in a corn field (Silva *et al.,* 2009). Sinha *et al.* (2009) conducted a field experiment was conducted at the Crop Research Centre of RAU, Pusa, Bihar during kharif 2006 and 2007 to evaluate the comparative efficacy of herbicides fenoxaprop-p-ethyl with standard doses of quizalofop and pendimethalin to control grassy weeds in jute grown for seed production. Losses in seed yield in the control plot were observed at 63.4% in comparison to hand weeding twice. Weed species count at 40 and 60 days after sowing (DAS) was found lowest in fenoxaprop-p-ethyl at 67.5 g ha^{-1} treated plot while seed yield was higher in the fenoxaprop-p-ethyl at 56.25 g ha^{-1}. Morphophysiological attributes of jute viz., plant height, base diameter, number of capsules per plant, 1000 seed weight, and seed yield were found significantly higher in fenoxaprop-p-ethyl at 56.25 g ha^{-1} which showed at par with quizalofop at 62.5 g ha^{-1} among the herbicidal treatments. The highest weed control efficiency was observed in fenoxaprop-p-ethyl at 67.5 g ha^{-1} but yield attributes and yield were found higher in fenoxaprop-p-ethyl at 56.25 g ha^{-1}. The study also revealed post-emergence herbicides-fenoxaprop-p-ethyl and quizalofop are more effective than pre-emergence herbicides pendimethalin in controlling the weeds in jute.

The effects of the cover crop are achieved by a rapid occupation of the open space between the rows of the main crop, which prevents germination of weed seeds and reduces weed growth and development. Germination of weed seeds may be inhibited by a complete light interception by the cover crop or by the secretion of allelochemicals. After the establishment of the weed seedlings, resource competition becomes the cover crop's main weed-suppressing mechanism (Hollander *et al*., 2007). Prasad *et al.* (2007) reported that the post-emergence application of quizalofop ethyl (quizalofop) 5 BC at 0.2%, followed by 1 and 2 hand weedings, cost ratio were 1.92 and 1.62 over untreated control and 1.58 and 1.28 over farmers practice, respectively.

Smith (2006) reported that the herbicide application during crop establishment markedly inhibited the growth of both seedling weeds and crops. The mixture caused the highest weed and crop injury. Pendimethalin at 0.33 kg hit had minimal effect on these crops. Weed growth, weed tolerance of herbicide treatment, and crop seedling injury were higher in tossa jute. The use of low pendimethalin doses in an integrated weed management system will ensure effective control of seedling weeds, and prevent crop injury and residue accumulation in edible plant produce. Rice straw mulch at 10 t ha-' in-between rows increased the fibre production by 33% over conventional manual weeding twice (Gorai *et. al* 2008). Sitangshu (2006) conducted in the medium fertile neutral soil (pH 7.1) of Barrackpore, West Bengal to screen post-emergence herbicides for weed management in jute (cv. JRO 524). The highest weed control efficiency (WCE) of 96.6% was noted for the hand weeding treatment. Among the herbicides, Fenoxaprop-p-ethyl at 75 g ha^{-1} showed the highest WCE (86.6%), closely followed by Quizalofop ethyl (79%). The dominant grass weed was Echinochloacolona (96%) and the broadleaved weeds (3%) included *Physalis minima* and *Phyllanthus niruri*. Post-emergence application of Fenoxaprop-pethyl @ 75 g ha^{-1} or Quizalofop-ethyl @ 50 g ha^{-1} at 21 days after sowing (when the grass weeds are at the four-leaf stage) effectively controlled the grass weeds giving higher jute fibre yield and net return per rupee invested (2.0 and 1.87 respectively). The use of herbicide either does not allow the weed seeds to germinate when used as pre-emergence or reduces weed plant growth when used as post-emergence.

Adenawoola *et al.* (2005). observed that 11w frequency of weeding conducive to optimum growth and yield of jute in Nigeria. Results indicated that weeding once as early as 2, 3, or 4 weeks after sowing (WAS) was not as beneficial to the growth and yield of jute as two weedings conducted at 2 and 5 WAS or 3 and 6 WAS. Weeding once every week throughout crop growth significantly ($P<0.05$) enhanced all growth and yield parameters over most of the treatments. Bearing in mind the economics of labour input and yield, two weeding operations at 2 and 5 was the most promising of all the treatments. Maintaining a uniform population of intercrops reduces the relative abundance of the dominant weed population (Poggio, 2005). Grasses constitute the dominant weed flora in jute fields and its management using pre-emergence herbicides like Trifluralin is possible, provided the farmers get sufficient time for land preparation and herbicide application before sowing (Sarkar *et al*., 2005). Manuel and Panneerselvam (2005) reported that the predominant weeds in the area were *Cyperus rotundus*, *Cynodon dactylon, Daclyloclenium aegyptium, Echinochloa colona*, *Panicum repens*, *Acalypha indica*, *Commelina benghalensis, Cleome viscosa*, *Corchorus olitorius,* and *Trianthemaponula castrum*. Hoeing resulted in the lowest weed dry weight (197.60 kg/ha). The highest cane yields were obtained with hoeing (97.60 t ha^{-1}), (2.0 kg atrazine ha^{-1}), (94.60 t ha^{-1}), and 1.5 kg pendimethalin ha^{-1} (92.33 t ha^{-1}).

Light transmittance and soil temperature amplitude are reduced more by living than by desiccated mulches. In addition, seedlings that emerge successfully are at a competitive disadvantage with established smother crops. Direct competition for essential growth resources is the main form of weed suppression by any smother crop, which may be perennial or annual (Francisco and Pedro, 2004). Abhigit *et al.* (2004) reported that in three weed management practices: no weeding, manual weeding twice at 3 and 6 weeks after sowing (WAS), and wheel hoeing twice at 3 and 6 WAS. Among the three weed management treatments, the manual weeding twice at 3 and 6 WAS, which recorded the lowest weed population and weed dry weight during the entire crop period and the highest fibre yield of jute, was the best.

Alam (2003) observed that in Bangladesh, weeds are generally controlled by raking and niri (hand weeding), and weeding and thinning operations involve about 50% or more of the labour cost. The decrease in weed incidence in a crop through intercropping is dependent on several factors, such as cultivar, climate conditions (Kuchinda *et al.*, 2003).

Billore and Brown (2001) found that in Soyabean cultivation, two-hand weeding and 2-inter cultivation (farmers practice) were carried out on the 3rd and 6th weeks after sowing. The prominent weed species during the experiment were *Echinochloa crusgalli*, *Dinebra arabica, Digilarias anguindis, Cyperus rutundus, Cynodon dactylon, Euphorbia geniculata. Digera arvensis, Eclipta alba, Corchorus olitorius* and *Aclypha indica*. The maximum and minimum nodules were associated with application Fenoxoprop-p-ethyl at 70 g ha^{-1} and 2-hand weeding, respectively. The nodule dry weight was maximum in 2 inter cultivation, whereas it was minimum with weedy control. Almost all herbicides controlled weeds effectively at 30 days after sowing. At 60 days after sowing, lactofen and imazethapyr did not affect the number of weeds but showed a reduction in the dry weight of weeds.

Gupta and Bhattacharya (2000) found that some viable chemical weed management technology is thus imminent to sustain raw jute fibre production by the small and marginal farmers. The stale seedbed technique is worthy in controlling composite weed flora in different field crops. A stale seedbed is one where initial 1-2 flushes of weeds are destroyed before planting a crop. Intercropping is also considered as an alternative to herbicide use, by reducing or suppressing weed growth (Liebman and Davis, 2000). Rajput (2000), explained that the application of fluchioralin at 1.0 kg/ha at 3 days before sowing, followed by hand-weeding 4 weeks after sowing + 2wheel-hoeing at 3 and 5 weeks after sowing recorded the lowest weed density and weed dry weight. Fibre yield, the net return, and benefit: cost ratio were higher with this treatment. The increase of jute fibre yield ranged from 40.3% to 69.1% due to different weed management practices over unweeded control.

A well-established, living green manure crop can potentially inhibit the germination and establishment of weeds more effectively than desiccated cover crop residues or areas with natural plant residues (Teasdale, 1998).

Singh ans Singh (1994) reported that the application of Butachlor plus two mechanical weedings might be a potential substitute for conventional manual weeding for achieving good returns and saving man-hours.

Kathiresan and Veerabadran (1991) studied the integrated weed management system of herbicide plus one hand weeding which was compared with manual weeding and herbicides alone, along with unweeded control. They observed that weed infestation was lower on integrated weed management plots which affected higher nutrient uptake by crop and consequently increased yield.

Gaffer *et al.* (1988) found that eight treatments-no weedings, hand weeding, weeding by hand hoe, and Basalin at 1.50, 1.75, 2.00, 2.25, and 2.50 g ha^{-1} were included in the experiment to evaluate the effectiveness of Basalin as a weedicide in jute (*Corchorus capsuiris*). Different doses of Basalin controlled 81-92 of *Echinochloa crusgalli*. 51-59 *Eleusine indica* and 52-85 *Scirpus mucronatus* out of nine weed species identified to infest the crop. The other infested weeds including *Cyperus rotundas* were either not sensitive or slightly sensitive to Basalin. Baslin had some adverse effects on the germination of jute seeds; however, no phytotoxicity was noticed on jute plants, and weeding produced the highest fibre yield per plot which was identical to that of Basalin treatment at 1.75 t ha^{-1}. The lowest fibre yield was obtained from no weeding treatment which was identical to other Basalin treatments and weeding by hand hoe. Hossain *et al.* (1988) observed that the stage of harvest had a significant effect on all the agronomic characters of tossa jute studied. The average flowering stage produced a maximum fibre yield of 3242 kg per hectare which was significantly higher than those of early (top splitting) and late (early pod) stages. Though all the first and second-degree interaction effects were not significant on all the agronomic characters, the higher doses of fertilizer, closer spacing, and later stages of harvest in any combination showed the tendency of higher productivity. Sahoo and Saraswat (1988) found that the hot and humid climate coupled with intermittent rainfall during the jute-growing season, however, encourages weed growth resulting in severe crop-weed competition, yield losses may be up to 75 to 80% (Saraswat, 1999).

Hashim *et al.* (1987) reported that the CVL- I. Dhabdhabcy and O-9897 to find out yield due to different management practices like the number of raking, weeding, and theft combinations. The results showed that the treatment consisting of three hand weeding gave the maximum yield and was closely followed by one raking tine weeding treatment which produced 3.15 and 3.08 t ha^{-1} fiber, respectively, both of which were significantly superior to the rest of the weeding treatments.

Hashim and Hossain (1986), reported that the Cv. CVL-1 was assessed at three sites at Kishorganj, Rangpur, and JAES, Jagir. Except for Kishorganj there was no significant difference in yield due to treatments where the highest yield was obtained in broadcast seeding @ 9.88 kg hi^{-1}. However, the location effect was found to be significant. Combined analysis showed higher yield at spacing 15 cm x 15 cm and 18 cm xl 8 cm compared to other spacings and seed rates. The 1-uglier yield was obtained at Jagir among the locations.

Hashim *et al.* (1984) tested that the six treatments viz. (Ti) line sowing with 2 hoeings at 15 and 45 days; (T_2) line sowing with 3 hoeing at 15, 30, and 45 days; (T_3) line sowing with 2 hand weeding at 30 and 45 days. Broadcast with one raking at 15 days and one hand weeding at 30 days; (T_5). Broadcast sowing with one raking at 15 days and 2 hands weeding at 30 & 45 days; (T_6). Broadcast sowing with one raking at 15 days, one hand weeding at 30 days. one tanabach at 45 days, and one katabach at 60 days after sowing, to find out suitable methods of cultural practices for minimizing the cost of production and attaining optimum yield of fibre in *C. capsularis*. There was a significant difference in yield due to different treatments and a significantly higher yield was obtained (1.89 t ha^{-1}) in broadcasting sowing (T_6) with one raking at 15 days, one hand weeding at 30 days, one Tanabach at 45 days, and one Katabach at 60 days after sowing.

Saha and Paul (1981) reported the dry matter production, partition, and yield of *C. capsularis* L. cv. D-154 and *C. olitorius* L. cv. C.G. For dry matter yield, ten harvests were taken at 4 days intervals and dry weight at the early stages of growth, but at the later stages, the relative order was reversed with L. having a higher dry weight. Significant species differences were observed at many stages of growth. For yield and yield components, plants were harvested 98 days after sowing. *C. olitorius* L. had variety had significantly greater plant height middle stem diameter and green weight as well as fibre yield. For better yield, selection should be based on the stem diameter, at the base and middle, and the plant height.

Ahad and Wahahb (1980 a) explained that the minimize weeding cost by intercropping mungbean with *C. capsularis* Cv. D-154 results indicated that sowing of mungbean after 20 days of jute sowing (Jute + mungbean) gave the maximum yield of mungbean as well as jute without any further cost of weeding. Ahad and Wahahb (1980 b) reported that the weeding operations after 10, 20, 30, 40, 50 days after emergence (DAE) and again weeding operation up to 10, 20, 30, 40 and 50 DAE were compared with no weeding and normal weeding practice results revealed that normal practice gave higher Yield compared to other treatments. Hashim (1980) observed that the management practices like number of raking, weeding about different cultivars (CVL-1, O-9897 and CVE-3) were conducted in different locations (Faridpur, Kishorganj, and Chandina) to economize crop production. One raking and one hand weeding gave significantly higher yield across different locations compared to other treatments consisting of more intercultural operations (i.e. 3 hand weedings, 2 raking+ I hand weeding, and 1 raking +1 weeding + Tanabach & Katabach).

Application of smoother crop

Cover crops have many potential benefits, they also have a few disadvantages that may be minimized by careful management. For suppressing weeds we have to select an aggressive species that will cover the ground quickly. If is there a cover crop that will protect the soil by suppressing annual weeds, we have to plant a cover crop at the proper time (CAS, 2015).

Intercropping groundnuts between rows of maize spaced at 50 cm and 75 cm was compared with sole crops of maize and groundnut. Intercropped groundnut significantly suppressed weed infestation compared with the sole crops of maize and groundnut. Weed infestation was consistently lower in maize planted at an intra-row spacing of 75 cm in mixture with three groundnut stands in the inter-row between two maize stands and maize planted at 50 cm in a similar mixture with two groundnut stands compared with the other cropping methods (Lagoke *et al.*, 2014). However, although such Improved weed suppression by any crop can be achieved through increased crop density and spatial uniformity (Marín and Weiner, 2014). Intercropping groundnuts between rows of maize spaced at 50cm and 75cm was compared with sole crops of maize and groundnut. Intercropped groundnut significantly suppressed weed infestation compared with the sole crops of maize and groundnut. Weed infestation was consistently lower in maize planted at intra row spacing of 75cm in mixture with three groundnut stands in the inter-row between two maize stands and maize planted at 50cm in a similar mixture with two groundnut stands compared with the other cropping methods (Lagoke *et al.*, 2014).

Field experiments were conducted at the farm of Tamil Nadu Agricultural University, Coimbatore, India during 2007 and 2008 to assess the weed population, dry matter production, weed smothering efficiency, and yield of seed cotton in a cotton-based cropping system with conjunctive use of NPK and bioinoculants. The maximum weed suppression of 54.5 and 44% was observed in the cotton + Sesbania system as compared to pure crop of cotton during both years. The maximum cotton equivalent yield of 2052 and 1895 kg ha^{-1} was recorded in the cotton + onion system which was at par with the cotton + Sesbania system with a cotton equivalent yield of 2010 and 1894 kg ha^{-1} during 2007 and 2008, respectively (Marimuthu and Subbian, 2013).

Maintaining a uniform population of intercrop(s) reduces the relative abundance of the dominant weed population (Poggio, 2005).

In intercropping as a technique of weed control the number of weeds per unit area decreases (Javanshir *et al.*, 2000).

2.2 Effect of intercropping of jute with other crops in weed management

Gorai (2008) experimented at Barrackpur, India during 2003-2005 and found that smothering of weeds by leafy vegetable mixtures *Amaranthus tricolor*, *Amaranthus* spp. and Raphanus sativus in jute reduce the dry matter of weeds up to 45% when the field was dominated by grasses and broad-leaf weeds.

Weeds can also be suppressed by intercropping. This practice can also help to suppress weeds and increase the likelihood of being able to reduce herbicide use in the cropping system. Intercropping involves growing more than one crop in the same field at the same time. One main crop with one or more secondary crops (intercrop) inter-seeded for weed suppression maximizes the yield of the main crop (Liebman and Dyck, 1993).

Singh (1983) reported that maximum benefit occurs when component crops are sown in wider row spaces for the tall crop component without reducing its plant population. Such spatial arrangement augments the utilization of available space, soil nutrients, and solar radiation for companion crops. Therefore technique of paired row planting has been developed to harness the maximum advantage from an intercropping system.

Rathore *et al.* (1980) showed that paired planting of maize + blackgram at 30/60 cm using the inter paired space for growing blackgram, significantly increased the production and income compared with the standard method of planting of maize at 60 cm row spacing.

Singh (1979), observed that sorghum gave maximum yield and monetary advantages when grown between paired rows of maize. He reported that components crops being grown in wider spaces of paired row system enable the plants to utilize efficiently the soil nutrients and solar radiation. The farmers demonstrated different types of intercropping and mixed cropping. The common mixture comprised of a dwarf and tall type of legume and a non-legume. Grasspea is a popular choice of the farmers for mixed cropping with cereals and oilseeds such as wheat, barley, grain sorghum, mustard, linseed, or safflower (Agrikar, 1979).

Andrews and Kassam (1976) concluded that the degree of spatial and temporal overlap in the two crops can vary somewhat, but both requirements must be met for a cropping system to be an intercrop. Numerous types of intercropping, all of which vary the temporal and spatial mixture to some degree, have been identified. Dalrymple (1976) showed that net returns per unit area and return per unit time of work were increased by increasing cropping index even up to 300 following the intercropping technique.

Saxena (1972) conducted that crops of varying maturity needed to be chosen so that a quick maturing crop completes its life cycle before the grand period of growth of the wheat crop. Andrews (1972) observed that intercropping was found to be helpful to improve the nutritional quality of diet allowed 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.

Agboola and Fayemi (1971) point out that through several studies, it was revealed that intercropping covered the risk of crop failure, earned more profit, stabilized production, increased soil fertility, and conserved soil moisture. It also increased the total yield and returns in terms of unit land area.

Based on the above research findings present research was undertaken to evaluate the integrated weed management practices in jute.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the agronomy research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during March 2019 to July 2019 to study integrated weed management in jute. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials that were used for the experiment, treatment, and design of the experiment, growing of crops, data collection procedure, and procedure of data analysis that followed in this experiment has been presented under the following headings:

3.1 Location

The Experiment was carried out at the Agronomy research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during March 2019 to July 2019 to study the integrated weed management in the jute field.

3.2 Site selection

The experimental field was located at 90^{o} 22 E longitude and 23^{0} 41 N latitude at an altitude of 8.6 meters above sea level. The land was located at 28 Agro-ecological zone (AEZ 28) of “Madhupur Tract” (Appendix I). It was deep red-brown terrace soil and belongs to the “Nodda” cultivated series. The soil was clay loam in texture having pH 5.70 and organic matter 2.35%.

3.3 Climate and weather

The experiment area under the sub-tropical climate is characterized by high temperature, high humidity, and heavy rainfall with occasional gusty winds in the Kharif -1 season (March-July) and rainfall associated with moderate temperature during the Kharif-1 season (March-July). The monthly average air temperature, relative humidity and total rainfall during the study period (March to July) are shown in Appendix II.

3.4 Planting materials

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)

The variety was developed by BJRI in 2013 which is the most popular and widely cultivated variety in the Kharif-1 season. This plant is green in color, stem slight red, leaf is green wide and oval-shaped. It attains a plant height of 3.5-4.0 m and the plant basal diameter can be up to 22 mm. Slight salt-tolerant, mosaic disease tolerant. This cultivar matures at 115-120 days of planting and cultivar gives an average fiber yield of 3 t ha^{-1}.

BARI Mung-6

The variety was developed by BARI in 2013 which is the most popular and widely cultivated variety in Kharif-1 and Kharif-2 seasons.This plant is green in color and plant height ransing from 40-45 cm.It is variety photo insensitive and grown in late Rabi season Crop duration 55-58 days and seed yield 1.06 t ha^{-1}.

Mulching Materials

Rice straw is used as mulch.

Herbicide

Pre-emergence herbicide: Pendimethalin @ 600 g ha^{-1} at 2 DAS

Post-emergence herbicide: Quizalofop-ethyl @ 50 g ha^{-1} at 20 DAS

3.5 Seed collection

Seeds of BJRI Deshi Pat-8 (BJC-2197) and BARI Mung-6 were collected from Agronomy Department of Bangladesh Jute Research Institute and Siddque Bazar, Dhaka, respectively.

3.6 Experimental treatments

The experiment had 12 treatments of different weed management of jute. The treatments were as follows –

T_1= Weedy check

T_2= One hand weeding

T_3 = Two hand weeding

T_4 = Straw mulch

T_5 = Jute + mungbean

T_6 = Pre-emergence herbicide

T_7 = Post-emergence herbicide

T_8 = Pre+ 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+ Post-emergence herbicide

3.7 Experimental Design and Layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental field was divided into three blocks each of which represents a replication. Each block was divided into 12 plots in which treatments were distributed at random distance maintained between the two plots was 1m and between blocks was 1.5 m and plot size was 1.75 m × 2 m. It is mentioned that jute was sown maintaining line and plant spacing as 20 cm × 10 cm. respectively.

3.8 Details of the field operations

The cultural operations that were carried out during the experimentation are presented below:

3.8.1 Land preparation

The land was first ploughed on Feb 15, 2019, by disc plough. It was then harrowed again on 25 and 26 Feb to bring the soil in a good tilth condition. The clods of the land were hammered to make the soil into small pieces. Weeds, stubbles, and crop residues were cleaned from the land. Finally ploughed thoroughly with a power tiller and then laddering was done to obtain a desirable tilth and land preparation was done on March 10, 2019. The layout was done as per the experimental design on March 11, 2019.

3.8.2 Fertilizer application

For the jute, fertilizers were applied at the rate of 150, 50, and 50 kg ha^{-1} of urea, TSP, and MoP, respectively. One-third of urea and other fertilizers were broadcasted during the time of final land preparation. Rest urea was top-dressed in two equal splits on 20 and 35 days after sowing.

3.8.3 Seed sowing

Seeds were sown in line on March 15, 2019, as per experimental treatments. The recommended seed rate of Jute in control plot and mungbean was 7 kg and 35 kg ha^{-1}, respectively. Seeds of both the crops were sown in solid lines and then thereafter thinned out extra plants.

3.9 Intercultural operations

3.9.1 Thinning

The emergence of seedlings was completed within 10 days after sowing. The seedlings were thinned out two times during the study period where one healthy plant was allowed to grow in each hill. First thinning was done after 15 days of sowing which was done to remove unhealthy and lineless seedlings. The second thinning was done 10 days after the first thinning.

3.9.2 Gap filling

Seedlings were transferred to fill in the gaps where seeds failed to germinate. The gaps were filled in within two weeks after the germination of seeds.

3.9.3 Weeding

Weeds were controlled through two weedings at 15, 30, and 90 days after sowing (DAS). The weeded plants were weighed to measure weed suppression by incorporation of extra crops or more plants.

3.9.4 Irrigation

First irrigation was done after the first weeding. After that, irrigation was applied by observing the soil moisture condition.

3.10 Disease and pest management

Soon after emergence, Jute seedling was infested by Mealybugs. Hand-picking and spraying of Sumithion (2 ml L^{-1} of water) and Zet powder were applied as control measures

3.11 Harvesting

At harvest, 1 m^2 area of one sample was harvested from each plot leaving an adequate border for recording data on plant height and top, middle and base diameter of the plants. The plant height and diameters were recorded from 10 randomly selected plants with the help of bamboo scale and slide calipers, respectively.Jute plant was cut at the ground level with the help of a sickle. The fibre and stick yields were recorded from whole individual plot. Then fibre and stick yields were recorded from 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.

3.12 Jute retting

The Bundles of jute 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 (SN) and other aquatic weeds. The depth of water was sufficient to allow the jute bundle to float. Alam and Ali (1981), reported that at least a depth of 1.8 m. water is required for ideal retting.

3.13 Fiber stripping

Tute 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.

3.14 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.

3.15 Data collection

After harvest, firstly 5 randomly selected plants of a plot were cut at the ground level with sickle and bundled and tagged carefully for recording some necessary morphological and seed yield and quality contributing parameters. This process was followed for all the plots individually. The harvested plants of each treatment were brought to the cleaned threshing floor and capsules were separated from pants by hand and allowed for drying well under bright sunlight. Finally, seed weights were taken on an individual plot basis at a moisture content of 12% and converted into kg ha^{-1}.

3.16 Data recording

Weed Parameter

- Weed density (no. m^{-2})
- Weed relative density (%)

Jute Parameter

- Plant height (cm)
- Number of leaves $plant^{-1}$
- Base diameter / Middle diameter /Top diameter
- Fiber weight $plant^{-1}$ (g)
- Stick weight $plant^{-1}$ (g)
- Fibre yield (t ha^{-1})
- Stick yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest Index (%)
- Benefit cost ratio(BCR)

Procedure of sampling for weed parameters

Weed density (no. m^{-2})

Data on different weed species were recorded at 20, 30 and 40 days after sowing (DAS). Observations on weed density were recorded using the quadrate method.

Weed density (no. m^{-2}) = (Total number of weeds)/(Total surveyed area)

Weed Relative Density (%)

The frequency of different weeds was determined and the density of each species was calculated. Weeds inside the quadrate measuring 1m x 1m were identified and counted.

Relative Density (%) = (Density of each species)/(Total density of all weed species) ×100

Jute Data recording procedure

Plant height: The plant height was measured by a cm and meter scale at the final harvest taking the reading from ground level to the tip of plants.

Number of leaves plant^{-1}: Number of internodes were numbered manually at final harvest taking the reading from ground level to the tip of plants.

Base / Middle /Top diameter: The diameters of the different portions of plants were determined by slide calipers (mm).

Fibre weight plant^{-1}: Jute was retted properly under slow-moving water. Fibres were extracted from the plants and it was dried in sun. The dried fibres were weighed by a spring balance.

Fibre yield: Jute was retted properly under slow-moving water. Fibres were extracted from the plants and it was dried in the sun. The dried fibres were the weight by a spring balance and weight of dry fibre m^{-2} and compute as t ha^{-1}.

Stick yield: The sticks were also dried properly in sun for a week and the sticks were weighed in a balance to record the yield of jute sticks m^{-2} and t ha^{-1}.

Harvest Index: The harvest index was calculated on a dry basis with the help of the following formula Economic yield (fibre weight)

$$HI\ (\%) = \frac{\text{Fiber Yield}}{\text{Fiber Yield} + \text{Stick yield}} \times 100$$

Mungbean data recording procedure:

Plant height (cm): Ten plants were collected randomly from each plot. The height of the plants was measured from the ground level to the tip of the plant at 15, 30,45, and 60 days after sowing (DAS).

Number of branches plant^{-1}: Ten plants were collected randomly from each plot. Number of fruit-bearing branches per plant was counted from each plant sample and then averaged at 15, 30, 45, and 60 days after sowing (DAS).

Pods plant^{-1} (no.): Number of pods plant^{-1} was counted from the 10 plant sample and then average pod number was calculated.

Seeds pod^{-1} (no.): Number of seeds pod^{-1} was counted from 10 pods of plants and then average seed number was calculated.

Weight of 1000 seeds (g): 1000-seeds were counted which were taken from the seeds sample of each plot separately, then weighed in an electrical balance, and data were recorded.

Seed yield (t ha^{-1}): Seed yield was recorded based on total harvested seeds plot^{-1} (1 m^2) and was expressed in terms of yield (t ha^{-1}). Seed yield was adjusted to 12% moisture content.

Stover yield (t ha^{-1}): After the separation of seeds from the plant, the straw and shell of the harvested area were sun-dried and the weight was recorded and then converted to t ha^{-1}.

Biological yield (t ha^{-1}): The summation of seed yield and above ground stover yield was the biological yield.

Biological yield = Grain yield + Stover yield.

Harvest index (%): Harvest index was calculated on dry basis with the help of the following formula Economic yield (seed weight) HI (%) =Seed yield/Biological yield ×100

Benefit-cost ratio (BCR)

To compare better performance, the benefit-cost ratio (BCR) was calculated. BCR value was computed from the total cost of production and gross return according to the following formula. Benefit-cost ratio (BCR) =Gross return (Tk. ha^{-1}) /Total cost of production (Tk. ha^{-1})

3.17 Statistical analysis

The data obtained from the experiment on various parameters were statistically analyzed in 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).

CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the experiment regarding integrated weed management in jute have been presented, discussed and compared in this chapter. The analytical results have been presented in figures, tables and appendices. Detailed discussions on the presented results and possible interpretations are provided in this chapter under the following headings and sub-headings.

A detailed discussion on weed management of Jute the result is presented below:

4.1.1 Weed Infestation

In this 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. A similar result was also observed by Hasanuzzaman *et al.* (2008). In this study, it was also observed that grasses and sedges were dominating weed species.

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

Botanical Name	Family	Types weed	Relative density(%)	
			30DAS	60 DAS
Cynodon dactylon	Poaceae	Grass	42	31
Echinochloa colona	Poaceae	Grass	32	21
Eleusine indica	Poaceae	Grass	20	12
Cyperus rutundus	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

4.1.2 Plant Height

Effect of weed management

Weed management practices had a significant effect on plant height (Table 2 and Appendix VI). Plant height was also affected by the different weed management at 30, 45, 60, 75, 90 and 105 DAS. At 105 DAS, numerically the tallest plant (252 cm) was obtained from T_9 (Pre-emergence herbicide and one hand weeding plot) and the shortest plant (212.33cm) was obtained from T_{11} (Post-emergence herbicide and mungbean). A similar result was also observed by Smith (2006).

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

Treatment	Plant height (cm)					
	30 DAS	45D AS	60 DAS	75 DAS	90 DAS	105DAS
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	113.33 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

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

Note: : 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+ 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+ post-emergence herbicide.

4.1.3 Number of leaves plant^{-1}

Effect of weed management

Weed management practices had a significant effect on a number of leaves plant^{-1}(Table 3 and Appendix VII). The number of leaves plant^{-1}was also 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 number of leaves plant^{-1}(12.73, 43.20, 115.00, 117.00, 104.60 and

83.27) was obtained from T_9 (pre-emergence herbicide and one hand weeding) and at 45, 60, 75, 90 and 105 DAS the lowest number of leaves plant^{-1}(20.80, 24.40, 83.73, 94.93, 74.60 and 49.27) was obtained from T_{11} (post-emergence herbicide and mungbean) and at 30 DAS lowest number of leaves plant^{-1} (9.60) was obtained from T_{11}.

Table 3. Effect of weed management on the number of leaves of jute

Treatment	**Number of leaves**					
	30DAS	**45DAS**	**60DAS**	**75DAS**	**90DAS**	**105DAS**
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

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

Note: : 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+ 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+ post-emergence herbicide

4.1.4 Plant diameter (mm)

Table 4 reveals that base, middle, and top diameter are significantly influenced by different weed management practices (Appendix VIII). The highest base diameter (11.00 mm) was found from T_9 (pre-emergence herbicide and one hand weeding) and the lowest base diameter (8.43mm) was found from T_{11} (mungbean and 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 (5.37mm) was found from T_{11}(mungbean and post-emergence herbicide). The highest top diameter (4.66 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 and post-emergence herbicide) Sitangshu and Sarkar (2006) also found a similar result.

4.1.5 Fiber weight plant^{-1} (g)

The fibre weight was significantly affected by different weed management practices (Table 4 & Appendix VIII). The highest fibre weight plant^{-1} (36.67 g) was obtained fromT_9 (pre-emergence herbicide and one hand weeding) and the lowest fibre weight plant^{-1} (24.00g) was obtained from obtained fromT_{11} (mungbean and post-emergence herbicide).

Table 4. Effect of weed management on base diameter, middle diameter, top diameter, and fiber weight plant^{-1} of jute

Treatment	Base diameter (mm)	Middle diameter (mm)	Top diameter (mm)	Fiber weight plant^{-1} (g)
T_1	9.20 f	5.93 g	2.97 fg	26.00 i
T_2	9.80 df	6.17 f	3.53 d	28.67 f
T_3	10.00 cdf	7.30 d	3.88 c	31.67 c
T_4	8.93 fg	5.57 h	2.92 g	30.00 e
T_5	10.03 b	7.80 c	3.87 c	26.67 h
T_6	10.20 bc	8.00 b	3.93 c	30.67 d
T_7	8.80 g	5.70 h	3.05 f	32.67 b
T_8	9.70 e	6.80 e	3.43 e	28.00 g
T_9	11.00 a	8.20 a	4.66 a	36.67 a
T_{10}	10.07 bcd	8.00 b	4.24 b	28.67 f
T_{11}	8.43 h	5.37 i	2.70 h	24.00 j
T_{12}	9.13 f	6.07 fg	2.88 g	28.67 f
LSD 5%	0.2985	0.1365	0.09275	0.5798
CV (%)	6.34	4.14	5.44	4.04

In a column means having similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Note: 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+ 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+ post-emergence herbicide

4.1.6 Stick weight plant^{-1} (g)

The stick weight differed significantly among different weed management practices (Table 5 & Appendix VIII). The highest stick weight per (107.67 g) was obtained fromT_9 (pre-emergence herbicide and one hand weeding) and stick weight plant^{-1} (75.33g) was obtained from T_{11} (mungbean and post-emergence herbicide).

4.1.7 Fibre yield

Due to different weed management practices, fibre yield was varied significantly (Table 5 and Appendix IX). Numerically the highest fibre yield (4.09 t ha^{-1}) was obtained from T_9 (pre-emergence herbicide and one hand weeding) and the lowest fibre yield (2.80 t ha^{-1}) was observed from T_{11} (mungbean and post-emergence herbicide). Sarkar *et al.* (2012) 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. Sinha *et al.* (2009) reported that herbicides fenoxaprop-p-ethyl, quizalofop, and pendimethalin successfully control grassy weeds in jute.

4.1.8 Stick Yield

The stick yield was significantly affected by weed management practices (Table 5 and Appendix IX). The highest stick yield (7.00 t ha^{-1}) was obtained from T_9 (pre-emergence herbicide and one hand weeding) and the lowest (5.38 t ha^{-1}) from T_{12} (mungbean+pre+post-emergence herbicide)that was statistically similar to T_1 (5.47 t ha^{-1}) (weedy check). Sitangshu and Sarkar (2006), also found a similar result.

4.1.9 Harvest Index

The harvest index was significantly influenced by the different weed management practices (Table 5 and Appendix IX). 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 and post-emergence herbicide). Such a result was in agreement with those of Hossain *et al.* (1988).

Table 5. Effect of weed management on stick weight plant^{-1}, fibre yield, stick yield, and harvest index of jute

Treatment	Stick weight plant^{-1} (g)	Fibre yield (t ha^{-1})	Stick yield (t ha^{-1})	Harvest Index (%)
T_1	83.67 e	2.90 h	5.47 g	34.67 f
T_2	86.00 e	3.10 g	5.83 ef	34.63 f
T_3	91.00 d	3.33 de	5.98 d	35.70 bc
T_4	91.67 d	3.38 d	6.23 c	35.13 e
T_5	77.33 g	3.27 f	5.90 de	35.60 cd
T_6	93.33 c	3.53 c	6.43 b	35.40 cde
T_7	76.00 h	3.88 b	6.90 a	35.93 b
T_8	75.33 h	3.28 ef	6.24 c	34.43 fg
T_9	107.67 a	4.09 a	7.00 a	36.83 a
T_{10}	100.67 b	3.13 g	6.00 d	34.23 g
T_{11}	75.33 h	2.80 i	5.77 f	32.63 h
T_{12}	101.67 b	2.95 h	5.38 g	35.33 de
LSD $_{5\%}$	1.312	0.05987	0.1237	0.3145
CV (%)	3.04	3.69	4.14	1.84

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.

Note: 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+ 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+ post-emergence herbicide

Performance of mungbean as the results smoother crop is presented below:

4.2.1 Plant height

The plant height was significantly influenced by weed management and intercropping with jute at all growth stages of mungbean (Table 6 & Appendix X). At 15, 30, and 60 DAS, the highest plant height (11.27, 36.00 and 75.00 cm, respectively) was recorded in T_{11} (mungbean and post-emergence herbicide) but At 45 DAS, the highest plant height

(69.70 cm) was recorded in T_{12} (post-emergence herbicide and two hand weeding), 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} treatment. The result under the present study was in partial agreement with the findings of Chattha *et al.* (2007). Who found that among different weed control methods, chemical-weeding at 2 - 3 leaf stage of Weeds + hand-weeding at 50 DAS gave maximum plant height compared to weedy check treatment.

Table 6. 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}	6.40 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}	9.27 b	33.97 b	69.70 a	75.00 a
LSD $_{5\%}$	0.886	0.9172	2.723	2.353
CV (%)	9.47	2.75	4.17	3.27

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.

Note: T_5= Jute + Mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

4.2.2 Number of branches plant^{-1}

Branches plant^{-1} was significantly influenced by different weed management and intercropping with jute at all growth stages of mungbean (Table 7 & Appendix XI). At 15 DAS, the highest number of branches plant^{-1} (4.00) was recorded in T_5 (pre-emergence herbicide), At 30 and 60 DAS, the highest number of branches plant^{-1} (5.27 and 8.00) was recorded in T_{12} (Post-emergence herbicide and two hand weeding plot) and at 45 DAS, the highest number of branches plant^{-1} (6.93) was recorded in T_{11} (mungbean and post-emergence herbicide).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 the number of branches plant^{-1}.

Table 7. Effect of weed management on number of 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

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.

Note: T_5= Jute + Mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

4.2.3 Pods number plant^{-1}

The number of pods plant^{-1} was significantly influenced by weed management and intercropping with jute at all growth stages of mungbean (Figure 1 and Appendix XII). It was remarked from the present study that the increasing number of weeding significantly increased the number of pods plant^{-1}. T_5 (pre-emergence herbicide plot) treatment produced the maximum number of pods plant^{-1} (10.33). The minimum number of pods plant^{-1}(7.33) was achieved with T_{10} (pre-emergence herbicide and two hand weeding). The result under the present study was in agreement with the findings of Akter *et al.* (2013) and Khan *et al.* (2011). 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}.

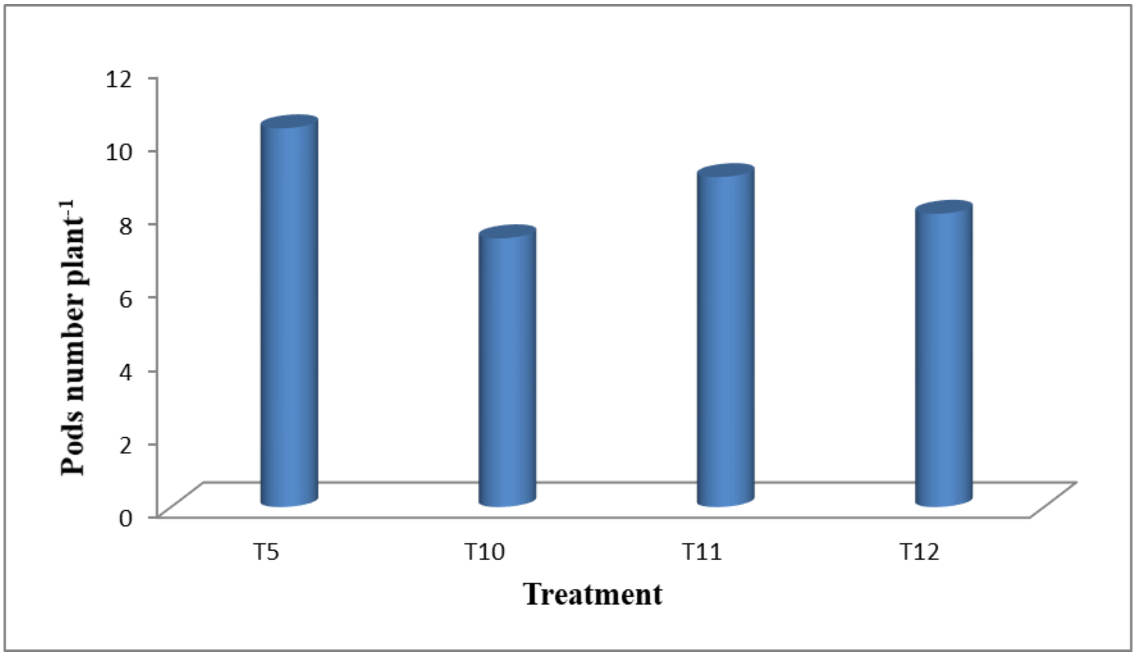

Figure 1. Effect of different weed management on pods number plant^{-1} of mungbean.

Note: T_5= Jute + mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

4.2.4 Pod length (cm)

Results presented in figure 4 on pod length influenced by the number of weeding and intercropping with jute were not statistically significant(Figure 2 and Appendix XII). The highest pod length (8.01cm) was recorded in T_{10} (pre-emergence herbicide and two hand weeding) and the lowest pod length (7.43 cm) was achieved by T_5 (jute and mungbean) that was statistically similar to T_{11} (mungbean and post-emergence herbicide) (7.46).

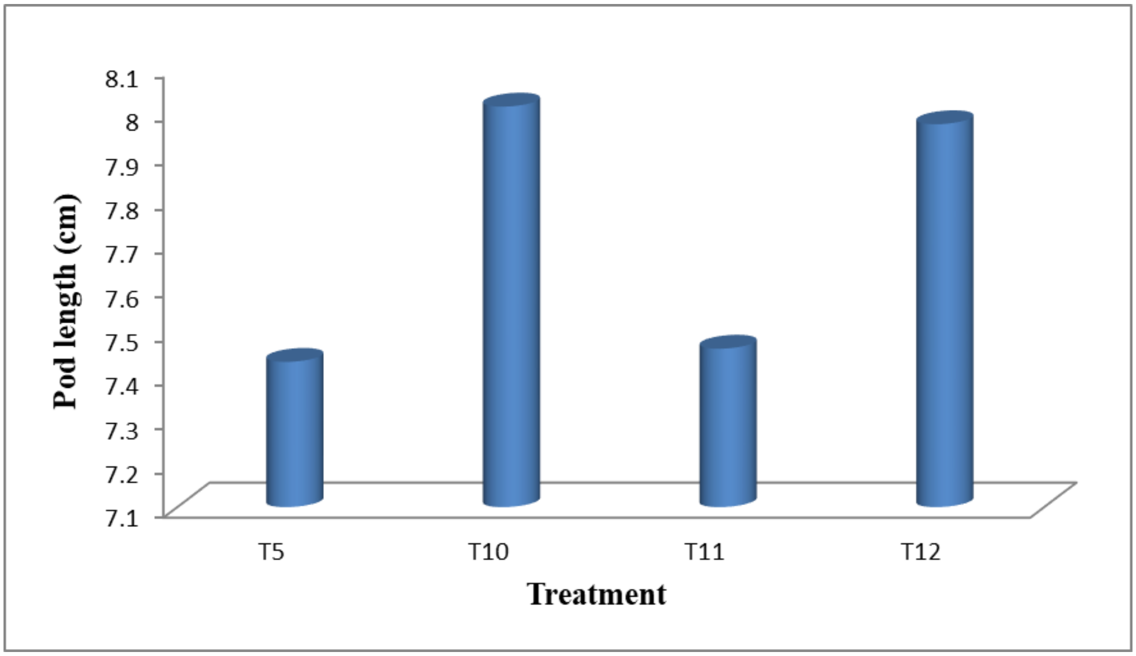

Figure 2. Effect of different weed management on pod length of mungbean.

Note: T_5= Jute + mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide.

4.2.5 Number of seeds pod^{-1}

Number of seeds pod^{-1} influenced by weed management and intercropping with jute were not statistically significant(Figure 3 and Appendix XII). It was mentioned from the present study that the highest number of seeds pod^{-1} (9.33) was recorded in T_{11} (mungbean and post-emergence herbicide)and the lowest number of seeds pod^{-1} (8.69) was achieved by T_5 (jute and mungbean) that was statistically similar to T_{10} and T_{12}. Similar findings were found by kundu *et al.* (2009). They said that seeds pod^{-1} was highest in the treatment having quizalofop-p-ethyl @ 50 g a.i. ha^{-1}at 21 DAE + HW at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl @ 50 g a.i. ha^{-1}at 14 DAE + HW at 21 DAE.

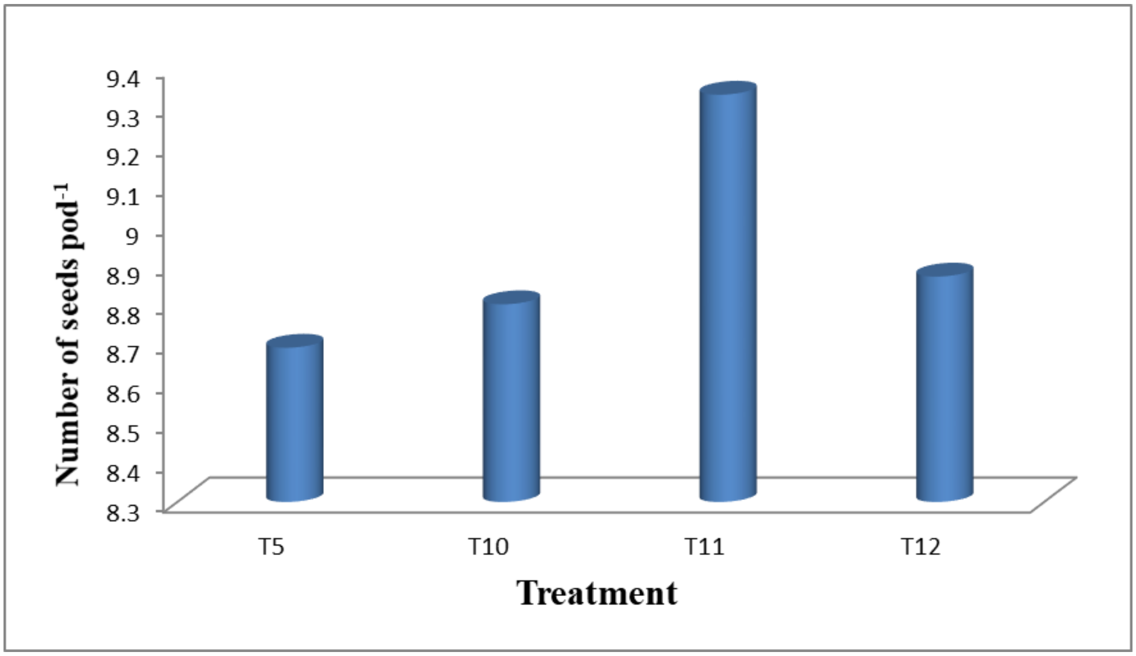

Figure 3. Effect of different weed management on Number of seeds pod^{-1} of mungbean.

Note: T_5= Jute + mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

4.2.6 Weight of 1000 seeds (g)

Results showed that the weight of 1000 seeds influenced by weed management and intercropping with jute was statistically significant (Figure 4 and Appendix XII). It is mentioned from the present study that the highest weight of 1000 seeds (40.23 g) was recorded in T_{11} and T_{12} (post-emergence herbicide and one hand weeding plot and Post-emergence herbicide and two hand weeding), whereas the lowest weight of 1000 seeds (33.40 g) was achieved by T_5 (jute and mungbean). Similar findings were found by Khan *et al.* (2011). The highest values (40.39 and 38.95 g) of 1000-seeds weight of mungbean in hand weeding plots with 17 and 5 percent increase over control were recorded by them.

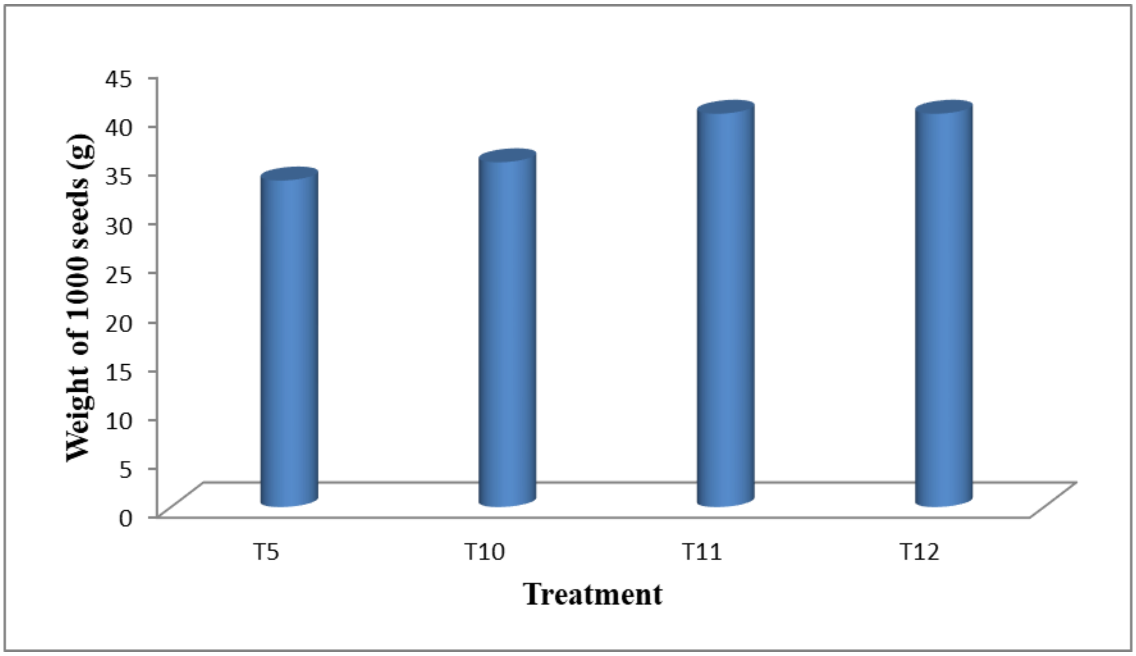

Figure 4. Effect of different weed management on the weight of 1000 seeds of Mungbean.

Note: T_5= Jute + mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

4.2.7 Seed yield (t ha^{-1})

Grain yield of mungbean influenced by weeding and intercropping with jute was statistically significant (Figure 5 and Appendix XIII). The highest grain yield (1.35 t ha^{-1}) was recorded in T_{11} (post-emergence herbicide and one hand weeding) while the lowest grain yield (1.05 t ha^{-1}) was achieved by T_5 (jute and mungbean). Khan *et al.* (2011) investigated that hand-weeding produced a higher yield (1092 and 743.3 kg ha^{-1}) of mungbean compared to control (631 and 518.8 kg ha^{-1}).

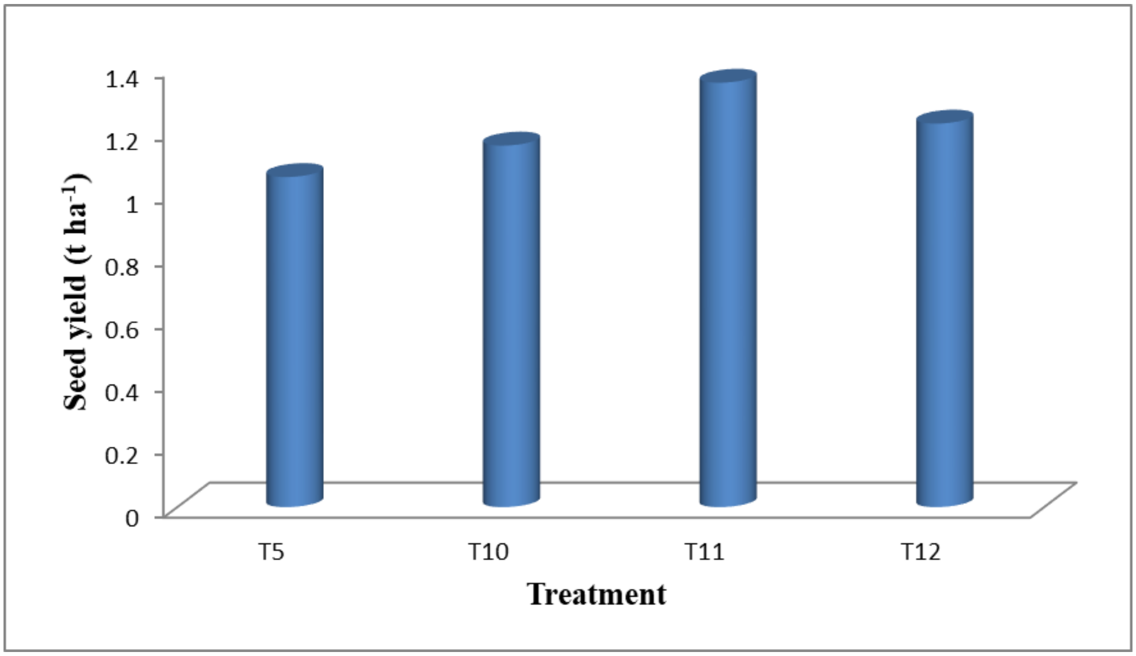

Figure 5. Effect of different weed management on seed yield of mungbean.

Note: T_5= Jute + mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

4.2.8 Stover yield (t ha^{-1})

Stover yield of mungbean varied not significantly due to different weed managements and intercropping with jute (Figure 6 and Appendix XIII). The highest stover yield (2.58 t ha^{-1}) was observed from T_{11} (mungbean and post-emergence herbicide) while the lowest stover yield (2.40 t ha^{-1}) from T_{10} (pre-emergence herbicide and two hand weeding) which was statistically similar with T_5 (2.44) and T_{12} (2.46).

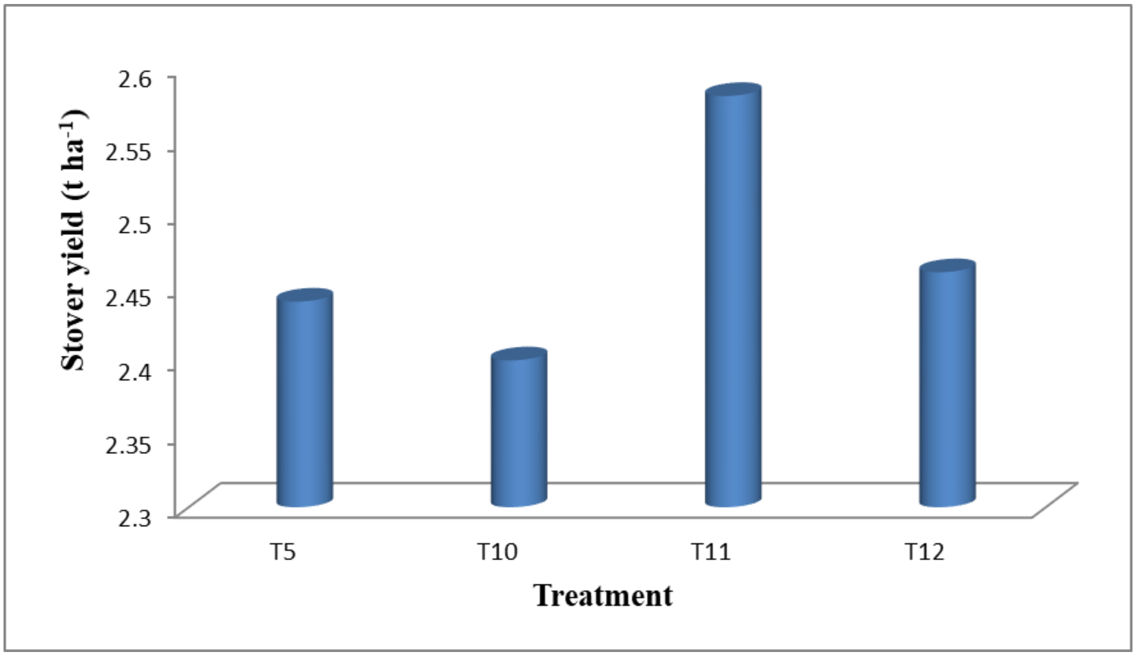

Figure 6. Effect of different weed management on stover yield of mungbean.
Note: T_5= Jute + mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

4.2.9 Biological yield (t ha^{-1})

The biological yield was significantly influenced by the level of weeding and intercropping with jute (Figure 7 and Appendix XIII). It was mentioned from the present study that the increasing number of weeding significantly increased biological yield. The highest biological yield (3.93 t ha^{-1}) was recorded in T_{11}(mungbean and post-emergence herbicide) and the lowest biological yield(3.48 t ha^{-1}) was achieved by T_5 (jute and mungbean) that was statistically similar to T_{10} (pre-emergence herbicide and two hand weeding) (3.55 t ha^{-1}).

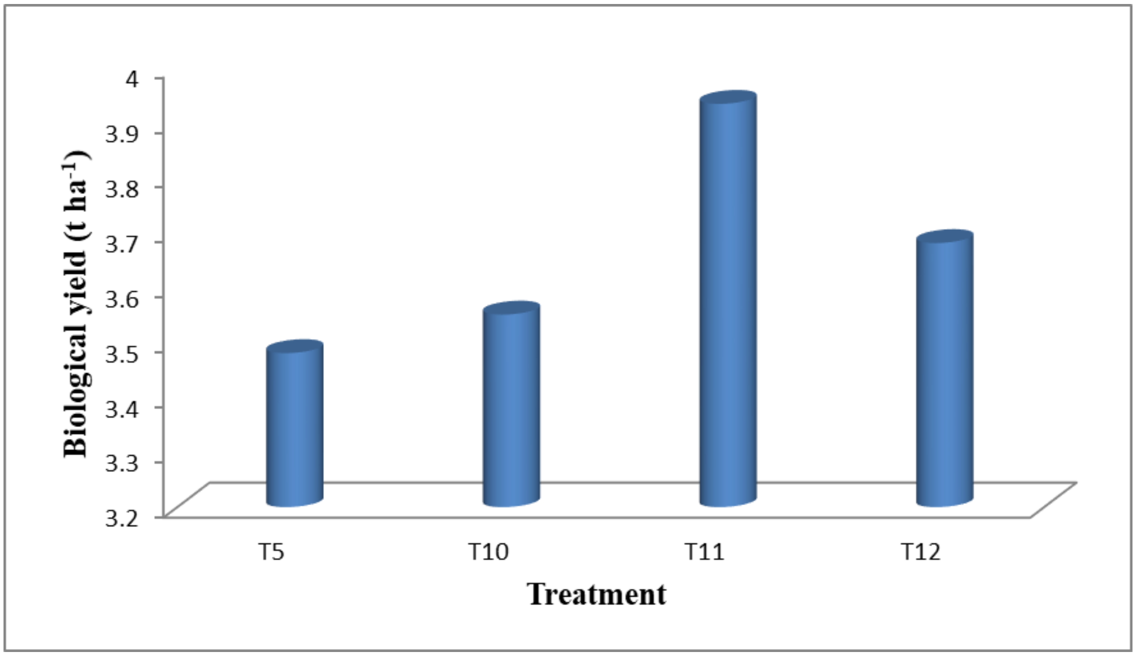

Figure 7. Effect of different weed management on biological yield of mungbean.

Note: T_5= Jute + mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

4.2.10 Harvest Index

Harvest index was significantly influenced by weeding and intercropping with jute (Figure 8 and Appendix XIII). It is calculated from the present study that the highest harvest index (34.27%) was recorded in T_{11} (mungbean and post-emergence herbicide) and the lowest harvest index (29.97%) was achieved by T_5 (jute and mungbean).

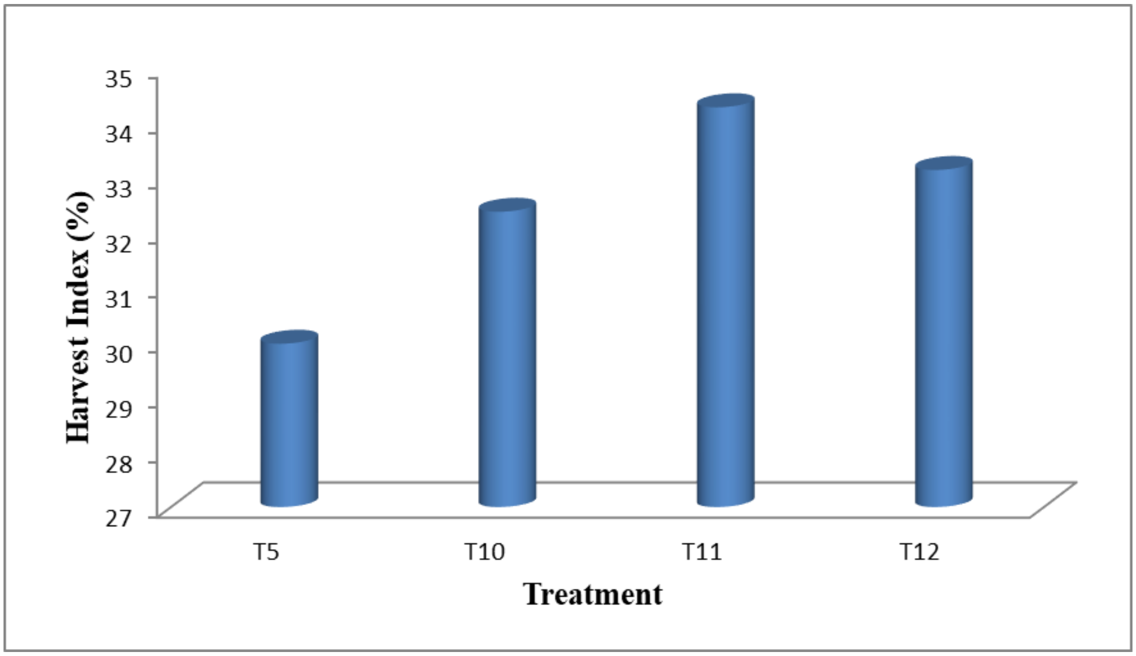

Figure 8. Effect of different weed management on harvest index of mungbean.

Note: T_5= Jute + mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

4.2.11 Benefit-cost ratio

The cost and return analysis were done and have been presented in table 8. Total costs of production were recorded for all the treatments of unit plot and calculated on a hectare^{-1} basis the price of jute stick, jute fiber, seed yield, and stover yield at the local market rate were considered.

The total cost of production ranges between Tk. 79980 to Tk. 97200 per hectare among the different treatment combinations. The highest cost of production Tk. 97200 per ha was involved in the treatment of T_{11}, while the lowest cost of production was Tk. 79980 per ha was involved in the treatment of T_1. Gross return from the different treatment combinations ranges between Tk 92795 to 295600 per ha. Among the different treatments, T_{11} gave the highest return Tk. 295600 per ha while the lowest net return Tk. 92795 was obtained from the treatment T_1.

The benefit-cost ratio (BCR) was highest (3.04) in the treatment combination T_{11}

Table 8. Showing the gross return, net return, benefit-cost ratio of different treatments on the integrated weed management of jute

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

Note: 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+ 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+ post-emergence herbicide

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the research field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during April 2019 to 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, 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+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+post-emergence herbicide). The experiment was laid out in a randomized complete block design (RCBD) with three replications. Necessary intercultural operations were done as and when necessary.

The entire amount of TSP, MoP, gypsum, zinc sulphate, and borax were applied during the final preparation of the experimental plot. Urea was applied in two equal installments as top dressing at tillering and panicle initiation stages. Different intercultural operations such as gap filling, irrigation, drainage, weeding, etc. were done as and when required. The crop was harvested at full maturity and five hills were randomly selected from each unit plot before harvest for recording different data on plant characters and yield components. The harvested crop was retteded and dried. Duncan's Multiple Range Test (DMRT) compared all the collected data with the help of MSTAT-C software.

The results of the experiment revealed that some of the crop characteristics and yield of jute and mungbean were significant due to weed management. 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.

Results of the experiment revealed that integrated weed management in jute had a significant influence on growth and yield components. The tallest plant (252.0 cm) was obtained from T_9 (pre-emergence herbicide and one hand weeding plot) and the shortest plant (212.33cm) was obtained from T_{11} (post-emergence herbicide and one hand weeding plot). The highest number of leaves plant^{-1}(12.73, 43.20, 115.00, 117.00, 104.60 and 83.27) was obtained from T_9 (pre-emergence herbicide and one hand weeding plot) and at 45, 60, 75, 90, and 105 DAS the lowest number of leaves plant^{-1} (49.27, 83.73, 94.93, 74.60 and 49.27) was obtained from T_{11} (post-emergence herbicide and one hand weeding plot) and at 30 DAS lowest number of leaves plant^{-1} (9.60) was obtained from T_1 (weedy check plot). The highest base diameter (11.00 mm) was found from T_9 (pre-emergence herbicide and one hand weeding plot) and the lowest base diameter (8.43mm) was found from T_{11} (mungbean and post-emergence herbicide).

The highest middle diameter (8.20 mm) was found from T_9 (pre-emergence herbicide and one hand weeding plot) and the lowest middle diameter (5.37mm) was found from T_{11}(mungbean and post-emergence herbicide). The highest top diameter (4.60 mm) was found from T_9 (pre-emergence herbicide and one hand weeding plot) and the lowest top diameter (2.70 mm) was found from T_{11} (mungbean and post-emergence herbicide). The highest fibre weight plant^{-1} (36.67 g) was obtained fromT_9 (pre-emergence herbicide and one hand weeding) and the lowest fibre weight plant^{-1} (24.00g) was obtained from T_{11}(mungbean and post-emergence herbicide).

The highest stick weight per (107.67 g) was obtained from T_9 (pre-emergence herbicide and one hand weeding) and stick weight plant^{-1} (75.33g) was obtained from obtained from T_8 and T_{11} (one hand weeding plot and post-emergence herbicide and one hand weeding). The highest fibre yield (4.09 t ha^{-1}) was obtained from T_9 (pre-emergence herbicide and one-hand weeding). Significantly lowest stick yield (2.80 t ha^{-1}) was observed from T_{11} (post-emergence herbicide and one hand weeding). 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 and post-emergence herbicide) that was statistically similar to T_1 (5.47 t ha^{-1}) (weedy check).

The 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 and post-emergence herbicide).

All parameters were significantly influenced by weed management and intercropping with jute at all growth stages of mungbean. At 15, 30, and 60 DAS, the highest plant height (11.27, 36.00, and 75.00 cm, respectively) was recorded in T_{11} (post-emergence herbicide and one hand weeding) but at 45 DAS, the highest plant height (69.70 cm) was recorded in T_{12} (post-emergence herbicide and two hand weeding), 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} treatment. At 15 DAS, the highest number of branches plant^{-1} (4.00) was recorded in T_5 (jute and mungbean), At 30 and 60 DAS, the highest number of branches plant^{-1} (5.27 and 8.00) was recorded in T_{12} (post-emergence herbicide and two hand weeding) and At 45 DAS, the highest number of branches plant^{-1} (6.93) was recorded in T_{11} (mungbean and post-emergence herbicide) and the lowest was achieved with T_{10} (3.60, 4.53, 6.07 and 6.67, respectively). T_5 (jute and mungbean) treatment produced a maximum number of pods plant^{-1} (10.33). The minimum number of pods plant^{-1}(7.33) was achieved with T_{10} (pre-emergence herbicide and two hand weeding). The highest pod length (8.01cm) was recorded in T_{10} (pre-emergence herbicide and two-hand weeding) and the lowest pod length (7.43 cm) was achieved by T_5 (pre-emergence herbicide). The highest number of seeds pod^{-1} (9.33) was recorded in T_{11} (post-emergence herbicide and one hand weeding) and the lowest number of seeds pod^{-1}(8.69) was achieved by T_5 (pre-emergence herbicide). The highest weight of 1000 seeds (40.23 g) was recorded in T_{11} and T_{12} (mungbean and post-emergence herbicide and post-emergence herbicide and two hand weeding), whereas the lowest weight of 1000 seeds (33.40 g) was achieved by T_5 (jute and mungbean). The highest grain yield (1.35 t ha^{-1}) was recorded in T_{11} (post-emergence herbicide and one hand weeding) while the lowest grain yield (1.05 t ha^{-1}) was achieved by T_5 (jute and mungbean). The highest stover yield (2.58 t ha^{-1}) was observed from T_{11} (mungbean and post-emergence herbicide) while the lowest stover yield (2.40 t ha^{-1}) from T_{10} (pre-emergence herbicide and two hand weeding). The highest biological yield (3.93 t ha^{-1}) was recorded in T_{11}(mungbean and post-emergence herbicide) and the lowest biological yield (3.48 t ha^{-1}) was achieved by T_5 (jute and mungbean). The highest harvest index (34.27%) was recorded in T_{11} (mungbean and post-emergence herbicide) and the lowest harvest index (29.97%) was achieved by T_5 (jute and mungbean).

The highest cost of production Tk. 97200 per ha was involved in the treatment of T_{11}, while the lowest cost of production was Tk. 79980 per ha was involved in the treatment of T_1. The highest net return Tk. 295600 per ha was involved in the treatment T_{11}, while the lowest net return was Tk. 92795 per ha was involved in the treatment of T_1. The benefit-cost ratio (BCR) was found to be the highest (3.04) in the treatment combination T_{11}. The results revealed that T_{11} (mungbean+post-emergence herbicide) treatment gave the highest BCR among the treatments. It may be concluded that the planting mungbean+post-emergence herbicide management of jute of intercropping system gives the highest gross and net return and also the highest benefit-cost ratio is obtained from this treatment combination.

Based on the above discussion it could be concluded in a nutshell for the present research that the combination of mungbean with a post-emergence herbicide like Quizalofop-ethyl will be the highest profitable along with weed management. 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. However, 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 are compatible with the present farming system.

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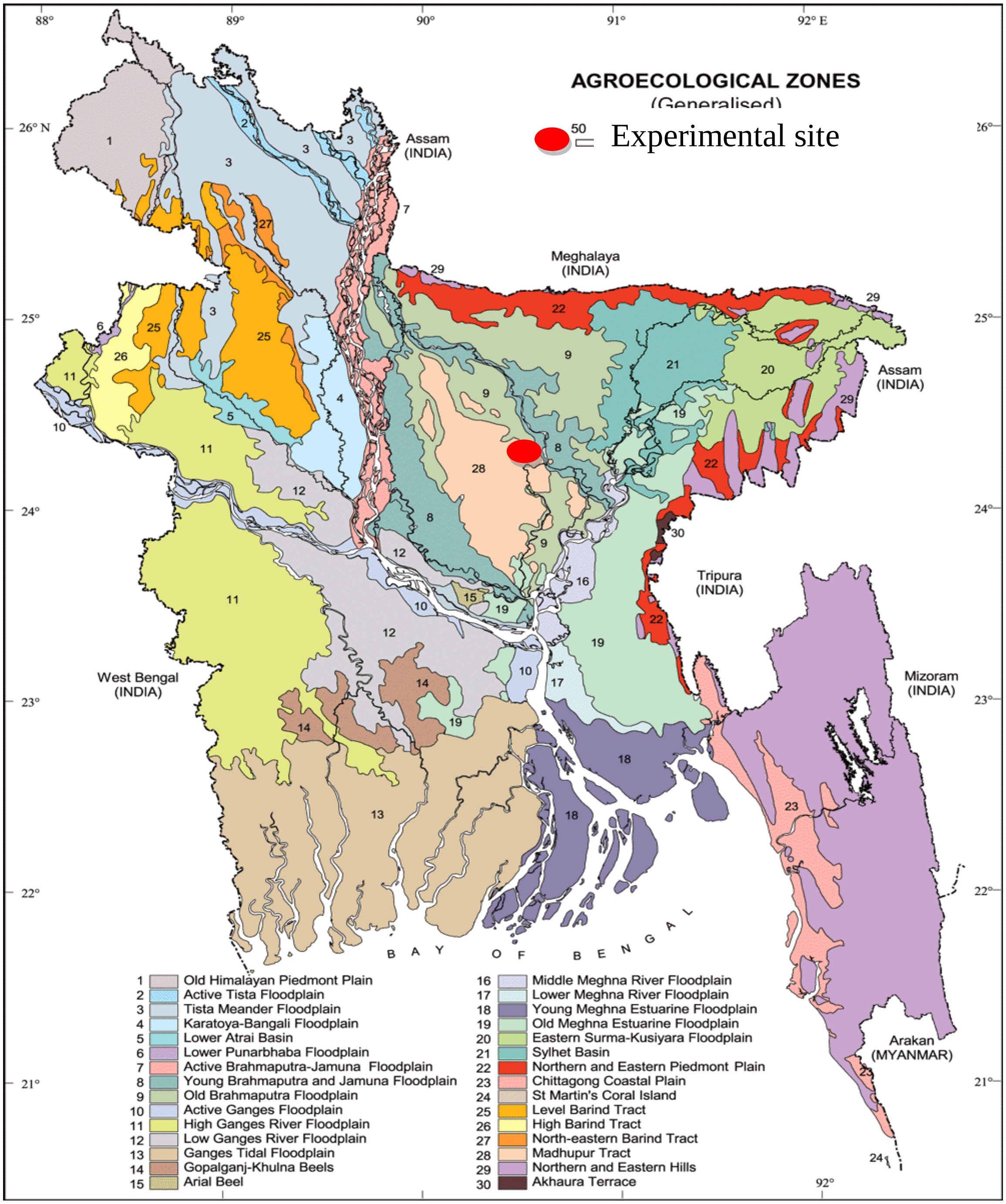
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix-II. Physical and Chemical characteristics of initial soil (0-15cm depth) before seed sowing)

A. Physical composition of the soil

Soil separates	(%)
Sand (2.00 – 0.5 mm dia)	26
Silt (0.5 – 0.002 mm dia)	45
Clay (below 0.002 mm dia)	29
Texture class	Silty clay

Source: Characteristics of experimental soil was analyzed at Soil Resource Development Institute (SRDI), Farmgate, Dhaka.

B. Chemical composition of initial soil (0-15 cm)

pH	5.6
Organic Matter (%)	0.78
Total Nitrogen (%)	0.03
Available P µg/g	20.54
Exchangeable K meq/100g	0.10
Available S µg/g	0.45

Source: Characteristics of experimental soil was analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix-III. Monthly Temperature, Rainfall and Relative humidity of the experiment site during the period from April 2019 to August 2019

Year	Month	Air Temperature (^{0}C)			Relative Humidity (%)	Rainfall (mm)
		Maximum	Minimum	Mean		
2019	April	37	28	33	54	225.1
	May	39	29	35	61	259.3
	June	36	29	35	67	273.6
	July	34	28	31	74	380.6
	August	33	27	30	71	365.3

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207

Appendix IV. Effect of weed management onno.of pod plant^{-1}, pod length (cm), no. of seed pod^{-1} and 1000 seed weight (g) of Mungbean

Treatment	No. of pod plant^{-1}	Pod length (cm)	No. of seed pod^{-1}	1000 seed weight (g)
T_5	10.33 a	7.43 b	8.69 b	33.40 c
T_{10}	7.33 c	8.01 a	8.80 b	35.27 b
T_{11}	9.00 b	7.46 b	9.33 a	40.23 a
T_{12}	8.00c	7.97 a	8.867 b	40.23 a
LSD $_{5\%}$	1.013	0.2278	0.3489	1.197
CV (%)	8.76	2.96	3.92	3.31

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.

Note: T_5= Jute + mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

Appendix V. Effect of weed management on seed yield, straw yield, biological yield and harvest index of Mungbean

Treatment	Seed Yield ($t\ ha^{-1}$)	Stover Yield ($t\ ha^{-1}$)	Biological Yield ($t\ ha^{-1}$)	Harvest Index (%)
T_5	1.05 d	2.44 b	3.48 c	29.97 d
T_{10}	1.15 c	2.40 b	3.55 c	32.37 c
T_{11}	1.35 a	2.58 a	3.93 a	34.27 a
T_{12}	1.22 b	2.46 b	3.68 b	33.13 b
$LSD_{5\%}$	0.03159	0.07064	0.09477	0.4331
CV (%)	2.17	2.88	2.54	1.34

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.

Note: T_5= Jute + mungbean, T_{10}= Mungbean + Pre-emergence herbicide, T_{11}= Mungbean + Post-emergence herbicide, and T_{12}= Mungbean+Pre+ Post-emergence herbicide

Appendix VI. Means square values for plant height (cm) of jute at different days after sowing.

Sources of variation	DF	Means square values at different days after sowing					
		30	45	60	75	90	105
Replication	2	331.017	401.905	98.111	103.861	34.333	230.028
Factor A	11	313.306	512.106	566.210	456.626	484.795	306.634
Error	22	106.579	59.904	124.384	68.558	36.697	81.816

NS= Not Significant, *= Significant at 5% level of Probability, **= Significant at 1% level of Probability.

Appendix VII. Means square values for number of leaves of jute at different days after sowing

Sources of variation	DF	Means square values at different days after sowing					
		30	45	60	75	90	105
Replication	2	8.493	40.341	65.640	75.123	55.231	25.468
Factor A	11	1.969	126.128	180.099	121.549	279.194	252.357
Error	22	0.910	6.967	29.263	31.255	24.286	15.201

NS= Not Significant, *= Significant at 5% level of Probability, **= Significant at 1% level of Probability.

Appendix VIII. Means square values for plant diameter (mm), fibre wt. plant^{-1}, stick wt. plant^{-1}of jute

Sources of variation	DF	Plant Diameter (mm)			Fibre wt. plant^{-1}	Stick wt. plant^{-1}
		Base	Middle	Top		
Replication	2	0.427	0.141	0.144	1.194	29.778
Factor A	11	1.662	3.416	1.147	33.361	377.785
Error	22	0.373	0.078	0.036	1.407	7.202

NS= Not Significant, *= Significant at 5% level of Probability, **= Significant at 1% level of Probability.

Appendix IX. Means square values for fibreyield, stick yield and harvest index of jute

Sources of variation	DF	Fibre Yield (t ha^{-1})	Stick Yield (t ha^{-1})	Harvest Index (%)
Replication	2	0.002	0.007	0.214
Factor A	11	0.444	0.752	3.301
Error	22	0.015	0.064	0.414

NS= Not Significant, *= Significant at 5% level of Probability, **= Significant at 1% level of Probability.

Appendix X. Means square values for plant height (cm) of mungbean at different days after sowing.

Sources of variation	DF	Means square values at different days after sowing			
		15	30	45	60
Replication	2	0.023	1.278	2.170	44.760
Factor A	3	13.781	19.383	60.787	201.640
Error	6	0.787	0.843	7.430	5.547

NS= Not Significant, *= Significant at 5% level of Probability, **= Significant at 1% level of Probability.

Appendix XI. Means square values for number of branches plant^{-1} of mungbean at different days after sowing.

Sources of variation	DF	Means square values at different days after sowing			
		15	30	45	60
Replication	2	0.063	0.303	0.063	0.390
Factor A	3	0.101	0.323	0.449	0.946
Error	6	0.121	0.063	0.472	0.652

NS= Not Significant, *= Significant at 5% level of Probability, **= Significant at 1% level of Probability.

Appendix XII. Means square values for No. of pod plant^{-1}, Pod length, No. of seed pod^{-1}and 1000 seed weight of Mungbean

Sources of variation	DF	No. of pod plant^{-1}	Pod length (cm)	No. of seed pod^{-1}	1000 seed weight (g)
Replication	2	3.583	0.026	0.108	4.551
Factor A	3	15.861	0.296	0.241	25.050
Error	6	1.028	0.052	0.122	1.436

NS= Not Significant, *= Significant at 5% level of Probability, **= Significant at 1% level of Probability.

Appendix XIII. Means square values for seed yield, straw yield, biological yield and harvest index of Mungbean

Sources of variation	DF	Seed Yield (t ha^{-1})	Straw Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (%)
Replication	2	0.006	0.017	0.042	0.061
Factor A	3	0.049	0.019	0.119	9.940
Error	6	0.001	0.005	0.009	0.188

NS= Not Significant, *= Significant at 5% level of Probability, **= Significant at 1% level of Probability.

Plate 1. Entire field of the experiment

Plate 2. Weedy check plot of the experiment

Plate 3. Rice straw mulch application

Plate 4. Mungbean cultivation as intercrop with jute

Plate 5. Performance of pre-emergence herbicide in jute

Plate 6. Entire jute field during harvesting stage