WEED SUPPRESSION IN JUTE FIELD BY GROWING LEAFY VEGETABLES

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WEED SUPPRESSION IN JUTE FIELD BY GROWING LEAFY VEGETABLES

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Dedicated

to

My Beloved Parents

CERTIFICATE

*This is to certify that the thesis entitled "**WEED SUPPRESSION IN JUTE FIELD BY GROWING LEAFY VEGETABLES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **SHARMIN SULTANA**, Registration No.* **08-03024,** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that any help or sources of information as has been availed of during the course of this work has been duly acknowledged & style of the thesis have been approved and recommended for submission.

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ABSTRACT

The experiment was carried out at the Agronomy research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from April, 2013 to August, 2013 to study the weed suppression in jute field by growing leafy vegetables. Thirteen treatment combinations were T_1 = Control, jute only, spacing 30 cm, T_2 = Jute 30 cm + one line jute between two adjacent line, T_3 = Jute 30 cm+ jute broadcast between two adjacent jute lines, T_4 = Paired row jute 15 cm apart + jute 15 cm apart between two adjacent paired rows of jute, T_5 = Paired row jute 15 cm apart + Broadcast jute between two adjacent paired rows of jute, T_6 = Jute 30 cm apart + one kangkong line between two adjacent jute row, T_7 = Jute 30 cm apart + broadcast kangkong between two adjacent jute row, T_8 = Mixed jute (4 kg/ha) and kangkong (4 kg/ha), T_9 = Mixed jute (4 kg/ha) and kangkong (2 kg/ha), T_{10} = Paired row jute 15 cm apart + Broadcast kangkong between two adjacent paired rows of jute, T_{11} Paired row jute 15 cm apart + 3 rows kangkong between two adjacent paired rows of jute, T_{12} = Paired row jute 15 cm apart + 4 rows kangkong between two adjacent paired rows of jute, T_{13}= Mixed jute (6 kg/ha) and kangkong (8 kg/ha), The experiment was conducted in Randomized Complete Block Design with three replications. The results of the experiment revealed that some of the crop characteristics and yield of jute and kangkong were significant due to intercropping systems. The maximum return from jute green vegetable was obtained from T_4 (52514 Tk./ha). T_{12} showed the highest amount of kangkong yield (11581 kg/ha). The highest dry weight of fiber (3166 kg ha^{-1}) was obtained from T_{10}. The treatment T_{12} gave the highest gross return Tk.307206 per ha. Among the different treatments T_{12} gave the highest net return Tk.248335 per ha. The benefit cost ratio (BCR) was found to be the highest (4.22) in the treatment combination T_{12}.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
%	=	Percent
µg	=	Micro gram
^{0}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
MP	=	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

Chapter 1

INTRODUCTION

Jute (*Corchorus sp*.) is an important and the largest natural fiber crop belonging to the genus *Corchorus*, family Tiliaceae, is an eco ‑ friendly and the major cash crop of Bangladesh. Jute fiber is produced mainly from white jute (*C. capsularis*), and tossa jute *(C. olitorius*). In Bangladesh, jute sector accounts as a whole for 10% labour and 7% of GDP. Among the jute growing countries of the world, Bangladesh ranks second in respect of production. By exporting jute and jute goods the country earns about 9 per cent of total foreign currency. Its fibre is primarily used for making hessian, sacks and carpet backing clothes. Besides the use of jute fibre, jute sticks and root stamps are traditionally used as fuel in the rural areas. In addition, jute plants improve soil productivity because of its massive leave dropping and root proliferation in the field. Now-a-days attempt is being made to popularize the jute plants for making pulp in the paper mills. Jute and jute based products are put to a wide range of uses. Food and Agricultural Organization (FAO) has declared 2009 as the International Year for Natural Fiber which reflects the importance of this group of commodities to many countries.

Intercropping is the system where two or more crops 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).

Kangkong is a fast growing, vine-like plant that spreads along the ground or water surface, and is reluctant to climb. It is a close relative to sweet potato but is grown for its succulent growing tips and not roots or tubers. There are two recognized types, the upland type, *Ipomoea reptans* is more common throughout the Pacific and adapted to moist soils compared to the lowland or aquatic kangkong (*Ipomoea aquatica*) which is adapted to flooded conditions.

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). An effective weed management practice is necessary for higher crop production and better economic return (Gaffer *et al*. 1988). But, most effective and economic cultural practices for weed control in jute crop are not clearly known to 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 lobour cost (Alam,2003).

Weeding is a must to concern jute cultivation, if not weeded properly yield reduction may incur about 90%. Weeds share nutrient elements from the same soil. Some weeds are voracious and quick growing. These cover desired crop plant within a short period of time. These weeds affect light interception and passing of wind and affect photosynthesis in jute plant and ultimately crop will receive stunted growth and in a consequence yield of crop will reduce (Islam and Rahman, 2008; Kundu, 1959)

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 attribute 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* (Central Research Institute for Jute and Allied Fibres). Maximum weed infestation is found up to the third to sixth week of crop age.

The critical period of crop-weed competition in jute was found to be 15 and 60 days after sowing.

There are different management of weed suppression like hand weeding, mechanical weeding, herbicide application etc. weed plants grow and dominate in the inter row spaces of field at the early growth stage of jute. If leafy vegetables are grown as inter crop, they would compete with and suppress weeds for the period before harvesting the intercrops. Farmers can sell these leafy vegetables and earn money for meeting the subsequent cost of jute production. But, there will remain possibilities of weeds infestation at the post-harvest period of the intercrops and it would incur weeding cost. The money earned by selling the harvested leafy vegetables may meet up the weeding cost at the post harvest period of the intercrop leafy vegetables.

Above facts and findings indicate that weed suppression in jute field by growing leafy vegetables. Therefore, the present study was undertaken based on the following objectives:

i)To assess the extent of weed suppression through intercropping by leafy vegetables.

ii) To assess and compare the cost of weeding due to intercrop.

iii) To assess and compare yield performance of jute under sole and intercrop condition.

Chapter 2

REVIEW OF LITERATURE

An attempt has been made in this chapter to present a brief review of research in relation to weed suppression in jute field by growing leafy vegetables through inter or mixed cropping technique. Intercropping has many advantages for the farmers. It increases total production, acts as insurance against failure of the principal crop and better utilization of interspaces in crops. It reduces the cost of intercultural operation along with weeding and increase the fertility of the soil. It gives higher land equivalent ratio and higher equivalent yield. Intercropping or mixed cropping also suppress and smother the weed plants and even prevent germination of weed seeds that reside in the soil prior to seeding of crop plant(s).

2.1 Effect of intercropping of jute with other crops

Agboola and Fayemi (1971) pointed out through a number of studies 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.

Saxena (1972) conducted trials and concluded 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 wheat crop.

Andrews (1972) observed that intercropping was found to be helpful to improve 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 (IRRI, 1973). Andrews and Kassam (1976) reviewing the results of an experiment 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 which was also attributed to the reduction of weed growth due to intercropping.

Hasanuzzaman (1976) reported that the increased production of wheat and its acreage in Bangladesh, crop combination like wheat and potato; Tobacco and wheat; mustard and wheat; Flax and wheat, legume and wheat, etc. were shown to be encouraging in terms of combined productivity and the reduced cost of weed control.

Krantz *et al.* (1976) concluded that mixed / intercropping legume and non-legume covered risk, earned more profit (combined yield plus reduced weeding cost) and stabilized production, improved soil fertility, conserved moisture and facilitated efficient labor distribution.

Hoque *et al.* (1978) showed that mixed cropping of wheat - lentil and gram - mustard at various seed ratios found that wheat - gram gave the best production per unit area with 50 : 100 or 50 : 50 wheat - gram combinations giving about 50% increase in production. Such increased productivity may be attributed to the replacing weed plants by the intercrop in terms of the resource use.

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 the soil nutrients and solar radiation efficiently. In such cases if the sorghum was not grown the resources between two adjacent paired rows of maize could have been used up by the weeds.

The farmers demonstrated different types of intercropping and mixed cropping. The common mixture comprised of a dwarf and tall type of a legume and a non-legume. Grasspea is popular choice of the farmers for mixed cropping with cereals and oil seeds such as wheat, barley, grain sorghum, mustard, linseed or safflower (Agrikar, 1979). This is mainly because of the faster growth of grasspea covering the ground before weed plants do the same.

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 standard method of planting of maize at 60 cm row spacing. Such extra benefit from intercrop may be attributed to the replacement of weed plants by growing the blackgram.

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 the companion crops. Therefore technique of “paired row” planting has been developed to harness the maximum advantage from an intercropping system. Under this system, if any companion crop is not grown in the wider space, weed plants occupy the place causing resource drainage and incurring more weeding cost.

Gupta and Sharma (1984) reported that sorghum in paired rows of 30 cm + 60 cm did not reduce yield when compared to that from uniform rows of 45 cm and in addition a yield of 2.11 t ha^{-1} was obtained from pigeonpea resulting an increase in LER by 1.26. Such a benefit might have been achieved as weed

plants did not infest vigorously as the space between two paired rows of pigeonpea.

Natarajan and Willey (1985) concluded that the yield advantages of intercropping due to better and over all use of resources by the companion crop which was the substitute of weed plants.

Manson *et al*. (1986) reported that intercropping did not always increase the total yield. Sometimes it decreased the yield. Cassava yields were decreased by 2.3 to 4.7 t ha^{-1} when intercropped with cowpea or peanut. In fact the profitability of the intercropping depends on the compatibility of the crops grown. If the companion crop is highly competitive with the main crop the profitability is reduced as it happens with the weed-crop association for example.

Quayyum *et al*. (1987) examined intercropping of maize at row distances of 75, 100 and 125 cm with one, two and three rows of chickpea between maize rows. Two years data revealed that intercropping of maize grown at a spacing of 75 x 25 cm with two rows of chickpea produced the highest total maize equivalent yield of 5590 kg ha^{-1}. This was 22% higher than the yield of sole crop of maize. Maize + chickpea, yield gave the highest net return of Tk. 12803 ha^{-1} and highest LER of 1.35 indicating that the mixture was 35% more efficient in terms of land utilization than sole crop of maize. In such as case, the chickpea did not allow the weeds to grow or reduced the growth rate of the weed plants.

Patra *et al.* (1990) described that the association of soybean with maize gave the highest combined yield at both 1:1 and 1:2 row ratios, whereas the association between maize and sesame recorded the lowest combined yield due to severe competition. In this case, probably sesame competed with the main crop (maize) like a weed.

Humphrey *et al* (1991) demonstrated the compatibility of soybean with cassava in their intercrop system. The target farmers easily adapted the new crop (soybean) to their cassava-based system. No reduction of cassava root yield was observed by intercropping with soybean which instead may slightly increase yield of associated cassava by 6%. Intercropped soybean yield was higher than sole by 12%. Data from farmers' fields also suggest a minimum of two weedings required for soybean + cassava intercrop. Poor seed viability and consequent poor germination remain an important problem for farmers as none of the farm level storage methods evaluated was satisfactory. If the crop was sown sole, the number of weeding might had been above two.

Nag *et al.* (1996) evaluated the monoculture of maize, cowpea, khesari, mungbean, groundnut and maize intercropped with legumes in paired rows during 1993-94. highest maize equivalent yield (6973 kg ha^{-1}) was obtained from maize + mungbean intercropping, but maize + groundnut combination gave highest maize equivalent yield (5615 kg ha^{-1}) in 1994-95. Maize + mungbean and maize + groundnut also gave highest net return (Tk. 50952 ha^{-1} and Tk. 40245 ha^{-1}) during 1993-94 and 1994-95, respectively. On an average maize + cowpea and maize + khesari combination gave the highest benefit cost ratio (5.34 and 5.32) and land equivalent ratio (1.35). Probably the best combination was successful due to suppression of weed growth. However, no data regarding the extent of weed infestation were not generated from this trial.

Alam *et al.* (1997) stated that wheat + chickpea, wheat + lentils and wheat + peas reduced the total weed population by 26, 12 and 28% and weed biomass by 31, 13 and 27% respectively, compared to the wheat monoculture.

Markunder *et al*. (1997) observed that the mixed cropping or intercropping of wheat with lentil increased the productivity per unit area compared to sole cropping of wheat or lentil. Intercropping reduces weed infestation.

Ahmed and Saeed (1998) demonestred an experiment on wheat and lentil intercropping at row ratios of 4: 3, 5:3, 8:3 or 10:3.Wheat grain yield was highest (4040 kg ha^{-1}) with the 10:3 row ratios. This treatment produced lentil seed yield of 441 kg ha^{-1}. The second highest yield was obtained form 8:3 ratio whereas wheat was 3760 kg and lentil was 481 kg ha^{-1}. Basically optimizing row ratio of the main crop and intercrop also governs the production of weed plants along with the use of production resources.

Ahmed *et al*. (1998) examined that wheat and lentil were grown alone or intercropped in 80 cm X 100 cm strips or wheat: lentil row ratios of 4:3, 5:3, 8:3 or 10:3. Wheat grain yield was highest (4040 kg ha^{-1}) with the 10:3 intercrop. This treatment produced lentil seed yield of 424 kg ha^{-1}. The 8:3 intercrop produced wheat grain yield of 3760 kg and lentil seed yield of 481 kg and the highest net return, which was only slightly higher than the returns obtained with the 10: 3 intercrop.

Rahman (1999) described that intercropping of grasspea and yellow sarson with wheat was sustainable over sole wheat. The association of wheat with grasspea under either 3:1 or 1:1 was more sustainable, which accounted for better value with respect to biological parameters and was economically more remunerative probably there was not drastic weed growth in such row arrangement. Rahman (1999) and Miah (1982) showed that wheat and grasspea intercropping proved as sustainable over sole crop.

Thakur *et al.* (2000) demonstrated that chickpea + safflower intercropping in 3:1 and 6:2 row ratios were superior to pure stands of either crop components and to chickpea + mustard and chickpea + linseed. Such row arrangement probably prevented weeds from being dominated in the field.

Nargis and Krishna (2003) showed that weed was significantly controlled by wheat + sunflower and wheat + linseed at 3:1 and 3:1 row ratios, respectively.

Islam *et al*. (2014) was conducted during 2010 and 2011 to find out the suitable crop combination for increasing total productivity, return and maximize land utilization through intercropping system. Six treatments viz. Brinjal 100% + Red amaranth 100%, Brinjal 100% + Leaf amaranth 100%, Brinjal 100% + Jute as patshak 100%, Brinjal 100% + Mungbean 60%, Brinjal 100% + Blackgram 60% and sole of base crops (brinjal) were used in the study. Results showed that different intercropping combination did not influence yield and yield contributing characters of brinjal. The yield of brinjal comparatively lower in intercropping but total productivity increased due to additional yield of leafy vegetables and legumes. The increases in total productivity in terms of brinjal equivalent yield (BEY) was 8.80 to 26.67 t/ha in intercrop combination compared to base crop. All the intercropping combinations were higher in terms of brinjal equivalent yield, gross return and benefit cost ratio (BCR) over sole crops. Among the intercropping combinations, Brinjal 100% (100 cm × 75 cm) + Mungbean 60% (three rows mungbean in between brinjal rows maintained 30 cm apart rows with continuous seeding) was the most feasible and profitable intercropping system in respect of brinjal equivalent yield (20.85 t/ha), gross return (Tk.312750/ha), gross margin (Tk.212693/ha) and benefit cost ratio (3.13).

Kaysar *et al.* (2014) conducted an experiment at Mymensingh through April to September 2008 to explore the feasibility of growing maize for fodder as an intercrop in jute and also to study its effect on yield of jute. The experiment consisted of sixteen treatments viz. (i) T_1=Sole Jute 25cm x 5cm spacing, (ii) T_2 = Sole Maize at 75cm x 25cm spacing, (iii) T_3=Jute + Maize at 75cm x 25 cm spacing, (iv) T_4=Sole Maize at 75cm x 50cm spacing, (v) T_5=Jute + Maize at 75cm x 50cm spacing, (vi) T_6=Sole Maize at 75cm x 75cm spacing, (vii) T_7=Jute + Maize at 75cm x 75cm spacing, (viii) T_8=Sole Maize at 75cm x 100cm spacing, (ix) T_9=Jute + Maize at 75cm x 100cm spacing, (x) T_{10}=Sole Maize at 75cm x 40cm spacing, (xi) T_{11}=Jute + Maize at 75cm x 40cm spacing, (xii) T_{12} =Sole Maize at 75cm x 60cm spacing, (xiii) T_{13}=Jute + Maize at 75cm x 60cm spacing, (xiv) T_{14}=Sole Maize at 50cm x 50cm spacing, (xv) T_{15}=Jute + Maize at 50cm x 50cm spacing and (xvi) T_{16}=Sole Maize at 25cm x 15cm spacing. Results revealed that the highest fibre yield of jute was not significantly reduced with the treatment Jute + Maize at 75cm x 25cm spacing. The highest fodder yield (7.40 t ha^{-1}) was obtained in Jute + Maize at 75cm x 25cm spacing and lowest fodder yield (1.57 t ha^{-1}) found in Jute + Maize at 75cm x 100cm spacing. Intercropping system of Jute +Maize at 75cm x 25cm spacing produced the highest yield of jute fibre (2.3 t ha^{-1}). In intercropping, the yields of jute and maize were reduced but the gross return and benefit cost ratio were higher than those in sole crops. Results revealed that maize fodder could be successfully grown as intercrop in jute. Jute + Maize at 75 cm x 25 cm spacing appeared to be the promising maize fodder intercropping practice.

2.2 Weeding practice in jute and other crops

Sitangshu Sarkar (2006) was conducted in the medium fertile neutral soil (pH 7.1) of Barrackpore, West Bengal to screen postemergence herbicides for weed management in jute (cv. JRO 524). 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 highest WCE (86.6%), closely followed by Quizalofop ethyl (79%). The dominant grass weed was *Echinochloa colona* (96%) and the broadleaved weeds (3%) included *Physalis minima* and *Phyllanthus niruri*. Post-emergence application of Fenoxaprop-p-ethyl @ 75 g ha-1 or Quizalofop ethyl @ 50 g ha-1 at 21 days after sowing (when the grass weeds are at 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). Use of herbicide either does not allow the weed seeds to germinate when used as pre-emergence or reduces weed plant's growth when use as post emergence.

2.3 Weed control by means of growing a short duration cover / suppressor /smothering crop

A cover crop planted correctly and managed well can give nearly 100% weed control while it is growing, and substantial weed management benefits in subsequent vegetables (LGU, 2011). However, although such 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 through suppressing annual weeds, we have to plant a cover crop at the proper time (CAS, 2015). An improved weed suppression by any crop can be achieved through increased crop density and spatial uniformity (Marín and Weiner, 2014).

The effects of 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 complete light interception by the cover crop or by secretion of allelo-chemicals. After the establishment of the weed seedlings, resource competition becomes the cover crop's main weed suppressing mechanism (Hollander *et al*., 2007).

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) interseeded for weed suppression maximizes yield of the main crop (Liebman and Dyck. 1993).

In intercropping as a technique of weed control the number of weeds per unit area decreases (Javanshir et al., 2000). Maintaining uniform population of intercrop(s) reduces the relative abundance of dominant weed population (Poggio, 2005; Asgharipour and Armin, 2010). The decrease in weed incidence in a crop through intercropping is dependent on several factors, such as cultivar, climate conditions (Kuchinda et al., 2003), sowing,fertilizer rates (Olasantan et al., 1994).

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 intrarow spacing of 75cm in mixture with three groundnut stands in the inter-row between two maize stands and maize planted at 50cm in similar mixture with two groundnut stands compared with the other cropping methods (Lagoke *et al*., 2014).

Gliricídia (*Gliricidia sepium*) having no allelopathic effect on corn or beans when intercropped was seen to significantly decrease the population of some weed species in corn field (Silva *et al.*, 2009).

Intercropping is also considered as an alternative to herbicide use, by reducing or suppressing weed growth (Liebman & Davis, 2000). Reduction in herbicide use is one of modern agriculture's main interests (Ngouajio et al., 1999) and several alternatives are being investigated with this objective, including intercropping (Carruthers *et al.*, 1998).

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). 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 José Severino; Pedro Jacob Christoffoleti, 2004).

Research carried out with annual legume smother crops (Fernandes *et al.,* 1999) has shown that *Crotalaria breviflora*, *Crotalaria spectabilis* and pigeon pea reduce weed density, especially in plots with *C. spectabilis* and*C. breviflora*. In the state of Paraná-Brazil, research with annual legume smother crops, including pigeon pea, as a companion crop to corn, resulted in enough weed control, so that no other weed management practice was necessary (Francisco José Severino; Pedro Jacob Christoffoleti, 2004).

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 cotton + Sesbania system as compared to pure crop of cotton during both the years. The maximum cotton equivalent yield of 2052 and 1895 kg ha^{-1} was recorded in cotton + onion system which was at par with cotton + Sesbania system with cotton equivalent yield of 2010 and 1894 kg ha-1 during 2007 and 2008, respectively (Marimuthu and Subbian, 2013).

Chapter 3

MATERIALS AND METHODS

This chapter represents a brief description of the experimental site, soil, climate, experimental design, treatments, cultural operations, data collection and their statistical analysis.

3.1 Location

The Experiment was carried out at the Agronomy research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from April, 2013 to August, 2013 to study the Weed suppression in jute field by growing leafy vegetables.

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 the 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 "Nodda" cultivated series. The soil was clay loam in texture having P^{H} was 5.70. Organic matter content was medium (2.35%).

3.3 Climate and weather

The experiment area under the sub tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in Kharif season (April- August) and rainfall associated with moderately temperature during the kharif-1 season (April- August). The monthly average air temperature, relative humidity and total rainfall during the study period (Aril to August) is 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 olitorius* L.) *and* kangkong (var; or co.). In this experiment jute was grown as main crop and kangkong were grown as companion crop. Jute variety O-72 was used as test crop.

3.5 Seed collection

The seeds of O-72 were collected from Bangladesh Jute Research Institute (BJRI), Dhaka. Kangkong seeds were collected from Siddique Bazaar, Dhaka.

3.6 Experimental treatments

The experiment had 13 treatments of different intercropping of jute with kangkong. The treatments were as follows –

T_1 = Control, jute only, spacing 30 cm

T_2 = Jute 30 cm + one line jute between two adjacent line

T_3 = Jute 30 cm+ jute broadcast between two adjacent jute lines

T_4 = Paired row jute 15 cm apart + Jute 15 cm apart between two adjacent paired rows of jute

T_5 = Paired row jute 15 cm apart + Broadcast jute between two adjacent paired rows of jute

T_6 = Jute 30 cm apart + one kangkong line between two adjacent jute row

T_7 = Jute 30 cm apart + broadcast kangkong between two adjacent jute row

T_8 = Mixed jute (4 kg/ha) and kangkong (4 kg/ha)

T_9 = Mixed jute (4 kg/ha) and kangkong (2 kg/ha)

T_{10} = Paired row jute 15 cm apart + Broadcast kangkong between two adjacent paired rows of jute

T_{11} Paired row jute 15 cm apart + 3 rows kangkong between two adjacent paired rows of jute

T_{12} = Paired row jute 15 cm apart + 4 rows kangkong between two adjacent paired rows of jute

T_{13}= Mixed jute (6 kg/ha) and kangkong (8 kg/ha)

3.6 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 13 plots in which treatments were distributed at random. The distance maintained between two plots was 1m and between blocks was 1.5 m. The plot size was 1.75 m x 2 m. It is mentioned here that the jute was sown maintaining line and plant spacing as 30 cm X 7 cm. The seeds were sown as continuous in each line following the recommended seed rate or as per treatments. Kangkong were sown maintaining line and plant spacing as 30 cm X 10 cm, respectively.

3.7 Details of the field operations

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

3.7.1 Land preparation

The land was first ploughed on April 7, 2013 by disc plough. It was then harrowed again on 8 and 9 April 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 April 14, 2013. The layout was done as per experimental design on Apri 15, 2013.

3.7.2 Fertilizer application

For 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 two-third of urea was top dressed in two equal splits on 20 and 35 days after sowing.

3.7.3 Seed sowing

Seeds were sown in line on May 13, 2013 as per experimental treatments. The recommended seed rate of Jute and kangkong were 7 kg and 80 kg ha^{-1}, respectively.

3.7.4 Weeding

Weeds were controlled through intercropping system.

3.7.5 Thinning

Thinning was done at 26 days after sowing (DAS) and 34 DAS.

3.7.6Harvesting and sampling

At full maturity, the jute was harvested plot wise on July 25, 2013. Kangkong was harvested three times at 40, 55 and 70 DAS. Crop of each plot was harvested from 3.5 m^2 separately for yield. Then those were weighted to record the fibre and jute yield which was converted into t ha^{-1}.

3.8 Recording of data

The following data of crops were collected during the study period:

3.8.1 Jute

1. Plant height (cm)
2. Dry weight of leaf ha^{-1}
3. Dry weight of stick ha^{-1}
4. Dry weight of Fiber hat^{-1}
5. Dry weight of weed $1m^2$
6. Biological yield (t ha^{-1})
7. Harvest index (%)

3.8.2 Kangkong

1.Yield of kangkong

3.9 Economic Analysis

Total number of labors used for different operations were recorded along with cost of variable inputs to compute the variable cost of different treatments. The cost and return analysis was done for each treatment on per hectare basis.

3.10 Benefit-cost ratio (BCR)

In order to compare better performance, benefit-cost ratio (BCR) was calculated. BCR value was computed from the total cost of production and gross return according to the following formula.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return (Tk. ha}^{-1}\text{)}}{\text{Total cost of production (Tk. ha}^{-1}\text{)}}$$

3.11Statistical analysis

The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program (Russel, 1986). The mean values were separated using least significant difference (LSD) test at 5% level of significance. The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test (Gomez and Gomez, 1984).

Chapter 4

RESULTS AND DISCUSSION

The present experiment was conducted to determine weed suppression in jute field by growing leafy vegetables. The results have been presented and discussed under the following headings:

4. 1 Dry weight of weed (g)

Dry weight of weed was significantly affected by intercropping system of jute with kangkong (Figure. 1). At 14 DAS there was no remarkable effect of planting system on the treatments. But at 22 DAS the significantly higher weed was found with T_4 and T_9 (over 60 g/m^2). At 68 DAS the significantly the higher weed dm was obtained with T_2 (over 100 g/m2) followed by T_1 (g/m^2). The highest dry weight of weed (229 g) was obtained from T_2 treatment followed by T_1 (200 g) and T10 (196 g) (Fig. 2). Significantly the lower dry weight of weed (around 160 g) was obtained from T_3-T_7, T_9, T_{11} and T_{13} treatments.

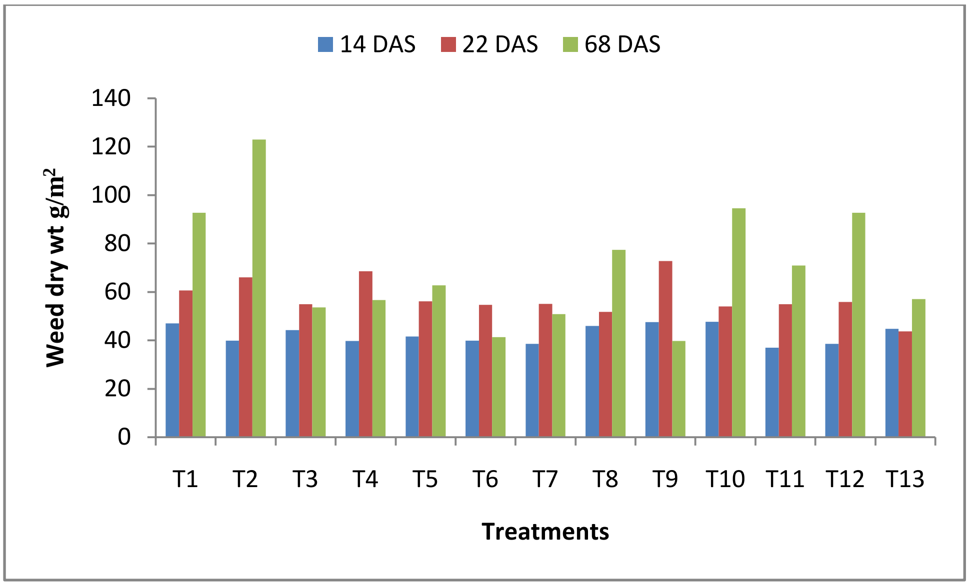

Figure. 1: Dry weight of weed as influenced by Jute+Kangkong/jute planting systems

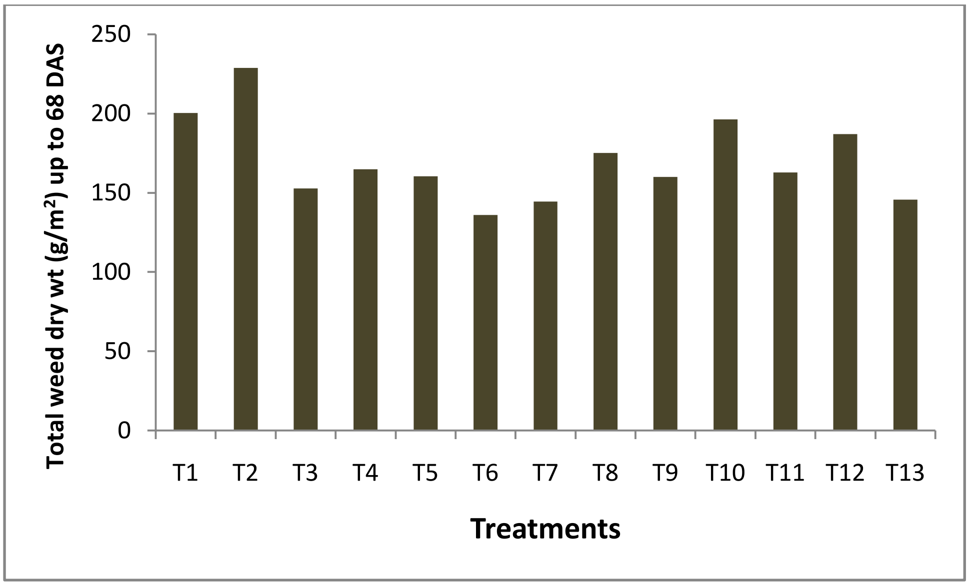

Figure. 2: Total dry weight of weed up to 68 DAS as influenced by Jute+Kangkong/jute planting systems

4.2 Jute sak Yield (kg/ha) at different stages

Jute green vegetable was obtained from thinning and also from the treatments in which jute green vegetable was incorporated. At 26 DAS, the highest jute green vegetable was obtained from T_{12} (around 3000 kg./ha) followed by T_2, T_3, T_4 and T_9 (over 2000 kg/ha) (Figure. 3). T_5, T_{7-8} showed lower jute vegetable (around 1100 kg/ha). At 34 DAS, the highest jute leafy vegetable was obtained from T_4 (over 3000 kg/ha). Other treatments showed lower jute leafy vegetable (1745-2080 kg/ha).

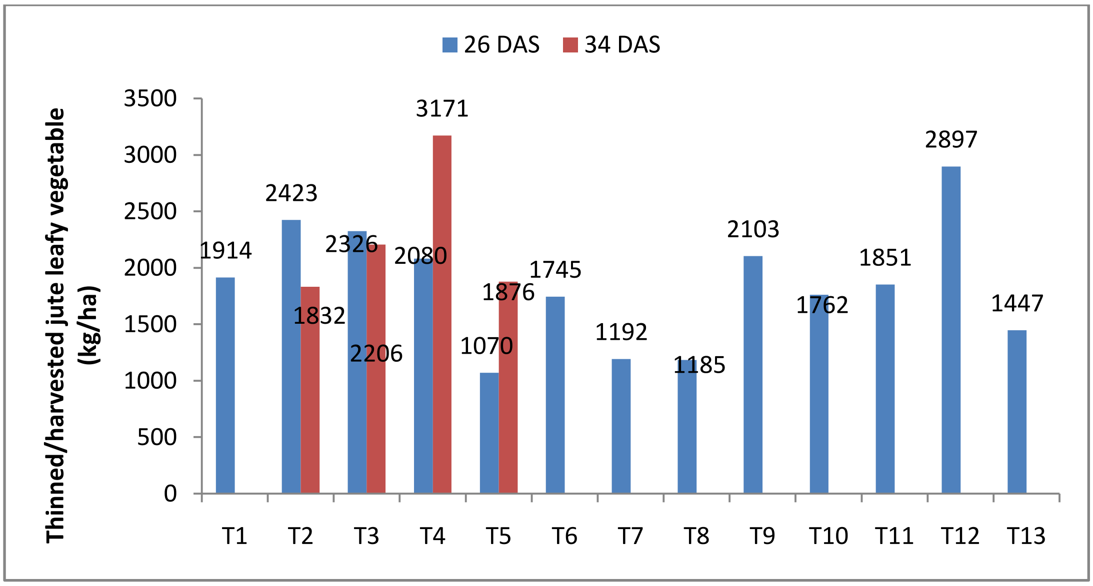

Figure. 3 Harvested jute sak at different stages at affected by different jute+kangkong/jute green vegetable planting system

4.3 Total jute leafy green vegetable yield (kg/ha)

The highest leafy jute vegetable was obtained from T4 (5251 kg/ha) followed by T_3 (4531) and T_2 (4255 kg/ha) (Figure. 4). T_5 showed the lowest jute leafy vegetable yield (2946 kg/ha) among the incorporated jute leafy vegetable treatments.

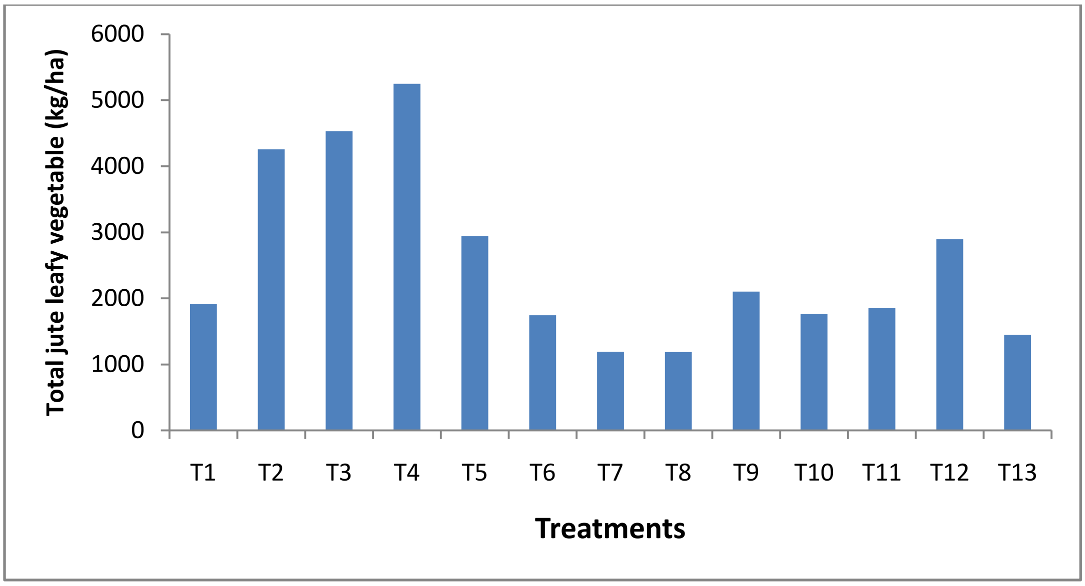

Figure. 4 Total jute leafy green vegetable yield at affected by different jute+kangkong/jute green vegetable planting system

4.4 Total return from jute sak/ha

Jute was thinned at two stages; at 26 and 34 DAS, weighed fresh and the value converted in to Tk./ha. It was seen that comparatively and remarkably higher return was obtained from T_2-T_5 (Tk. 29457-52514/ha) (Figure. 5). The return from jute green vegetable

The maximum return from jute green vegetable was obtained from T_4 (52514 tk./ha) followed by T_2 (42552 Tk/ha) and T_3 (45314 Tk/ha). The remarkably lower returns were obtained from T_7 and T_8 (around 12000 tk/ha). This reduction in the return from jute green vegetable may be attributed to the lack of extra jute plants below the set population density in these treatments. T_1 and $T_{6\text{-}13}$ produced such lower amount of jute green vegetable giving lower returns (11847-29000 Tk./ha) as in these plants between two adjacent jute lines, kangkong plants were accommodated.

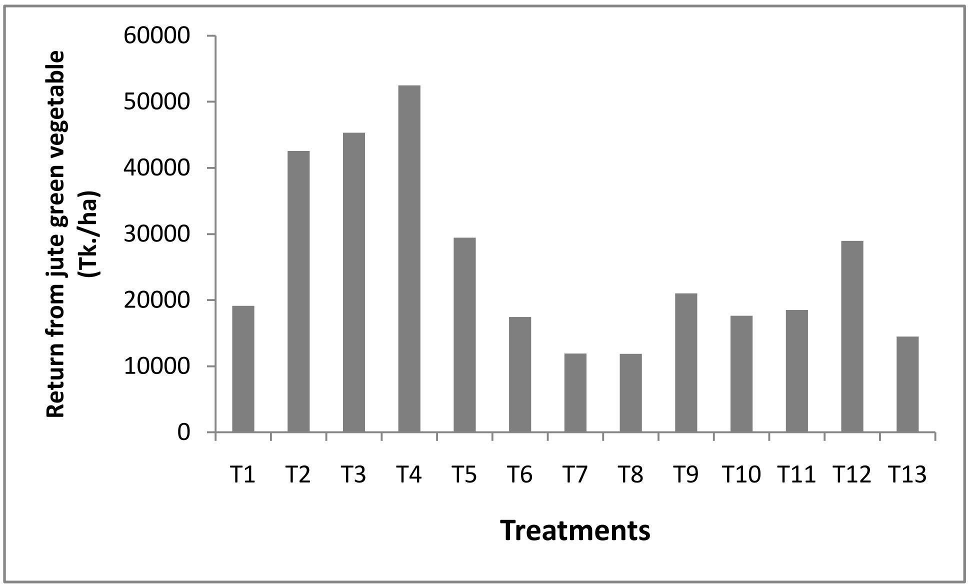

Figure. 5 Return from thinned and grown jute green vegetable in different Jute+kangkong/jute green vegetable planting system.

4.5. Kangkong yield (t ha^{-1})

Kangkong green vegetable was harvested at 35, 53 and 67 DAS. T_1 to T_5 did not have kangkong in their fileds. At 35 DAS, the highest kangkong yield was obtained from T_{12} (5104 kg/ha) followed by T_6, T_7, T_{11} and T_{13} (around 3000 kg/ha. Yield of kangkong varied significantly due to different intercropping systems (Fig. 6). At 53 DAS, the highest kangkong yield was produced by T_8 (3809 kg/ha) followed by T_{12} and T_{13} (over 2800 kg/ha). Other treatments showed intermediate kangkong vegetable yields (1900-2400 kg/ha).

At 67 DAS, the T_{12} showed the highest yield (3600 kg/ha) which was followed by T_8 and T_{11} (2238-2476 kg/ha). Other treatments showed the yields in the range of 619-1809 kg/ha.

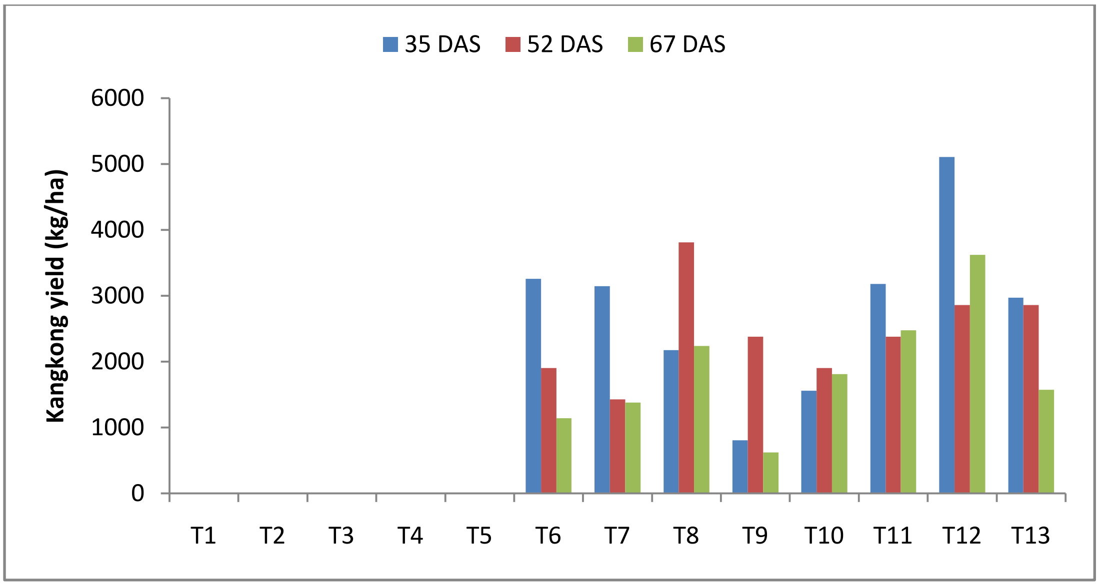

Figure. 6 Yield of kangkong at different harvesting dates as influenced by intercropping systems with jute

4.6 Total kangkong leafy vegetable yield (kg/ha)

The treatments T_1-T_5 did not have kangkong incorporated in the plots (Figure. 7). Among other plots, T_{12} showed the highest amount of kangkong yield (11581 kg/ha) followed by remarkably lesser yields with T_8, T_{11} and T_{13} (7398-8038 kg/ha). T_9 had the lowest kangkong yield (3804 kg/ha). Other treatments showed intermediate values (5272-6303 kg/ha).

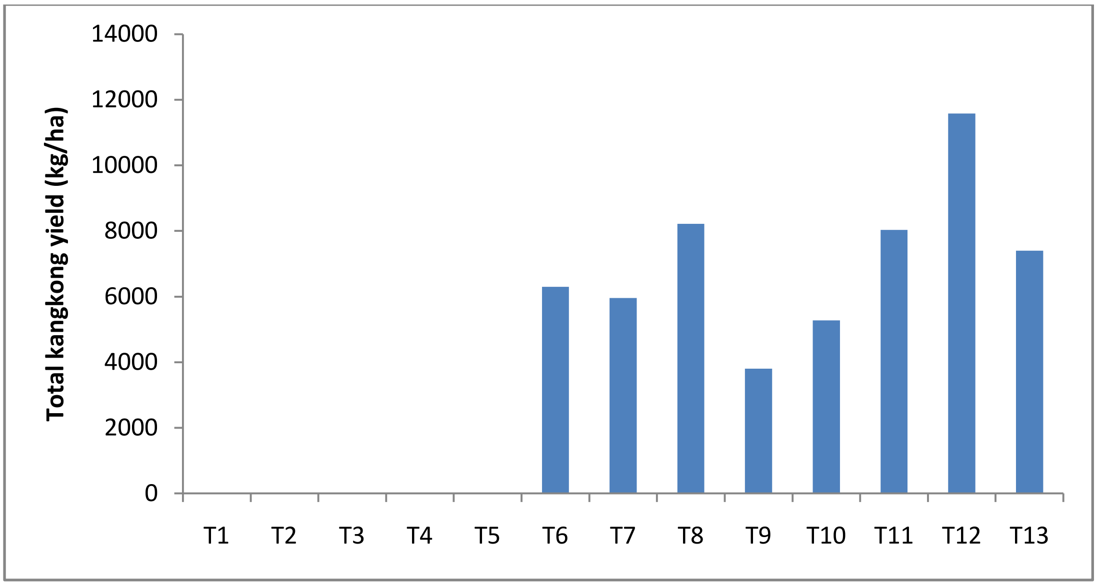

Figure. 7 Total kangkong leafy vegetable yield (kg/ha)as influenced by intercropping systems with jute

4.7 Performance of jute as the main crop

4.7.1 Plant height (cm)

Plant height of jute was significantly affected by the intercropping with kangkong. Plant height increased with the advancement of plant age (Figure. 8).

At harvest, the tallest plant (214.10 cm) was obtained from T_{10} treatment and the shortest plant was obtained from T_2 treatment (175.10 cm) which was statistically similar with $T_{3,}$ T_4 and T_9 treatments.

Islam (2006) reported that, plant height of wheat varied significantly due to intercropping system.

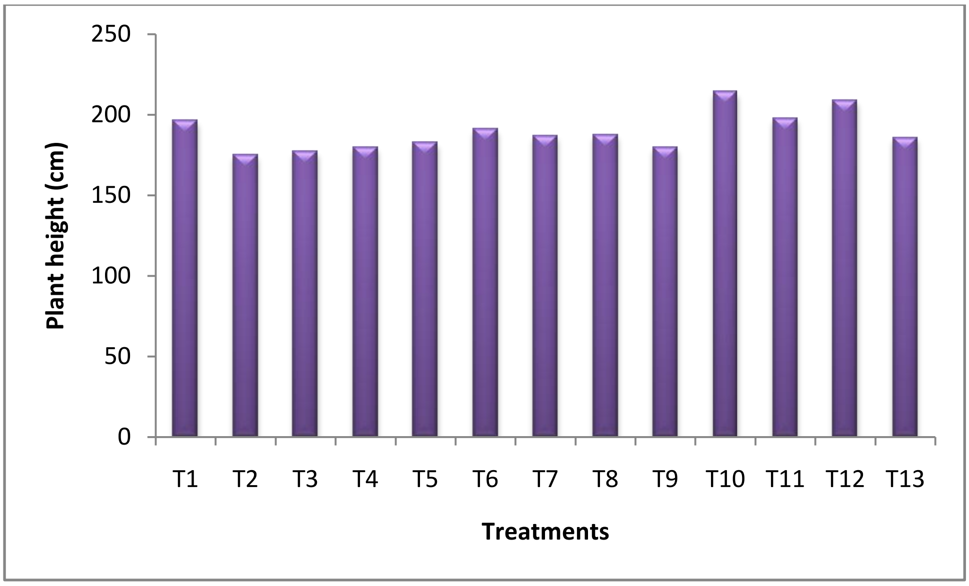

Figure. 8 Plant height of Jute as influenced by by different jute+kangkong/jute leafy vegetable planting system

4.7. 2 Dry weight of leaf ha^{-1} (kg)

Dry weight of leaves ha^{-1} was significantly affected by intercropping with kangkong (fig. 9). The highest dry weight of leaves (1483.00 kg ha^{-1}) was obtained from T_{12} treatment and the lowest dry weight of leaves (768.00 kg ha^{-1}) was obtained from T_2 treatment, it was statistically similar with T_7 treatment.

However, dissimilar findings were also found by Islam (2006) who showed that dry matter weight of wheat was significantly affected by intercropping system.

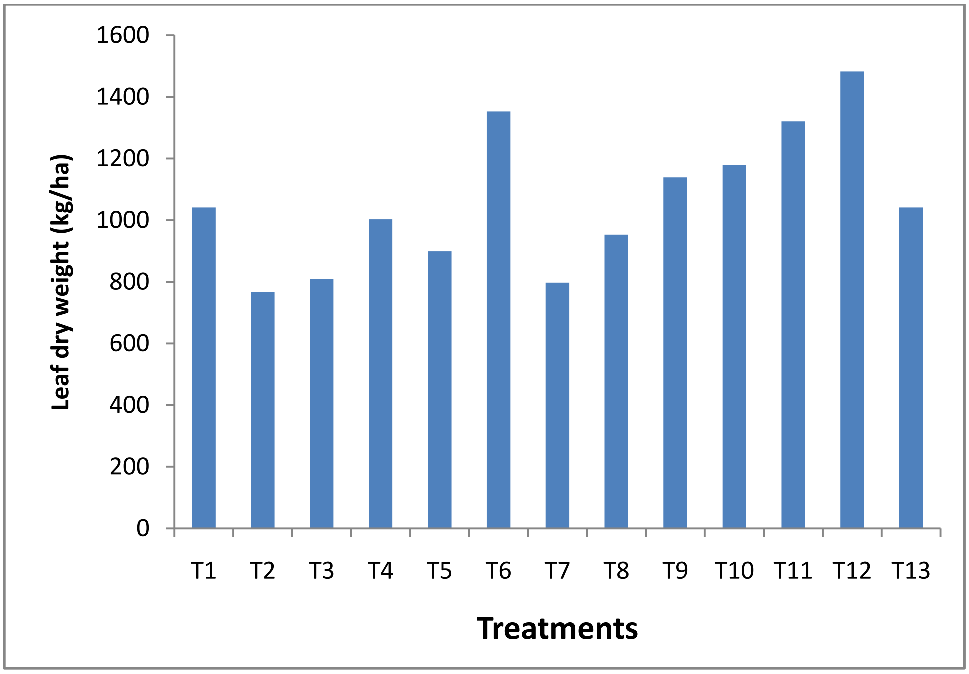

Figure. 9 Leaf dry weight (kg/ha) of jute at maturity as influenced by different jute+kangkong/jute leafy vegetable planting system

4. 7.3 Dry weight of fiber (kg ha^{-1})

Dry weight of fiber ha^{-1} was significantly affected by intercropping with kangkong (Figure. 10). The highest dry weight of fiber (3166 kg ha^{-1}) was obtained from T_{10} treatment and the lowest dry weight of fiber (1875 kg ha^{-1}) was obtained from T_2 treatment, it was statistically similar with T_7 and T_8 treatment.

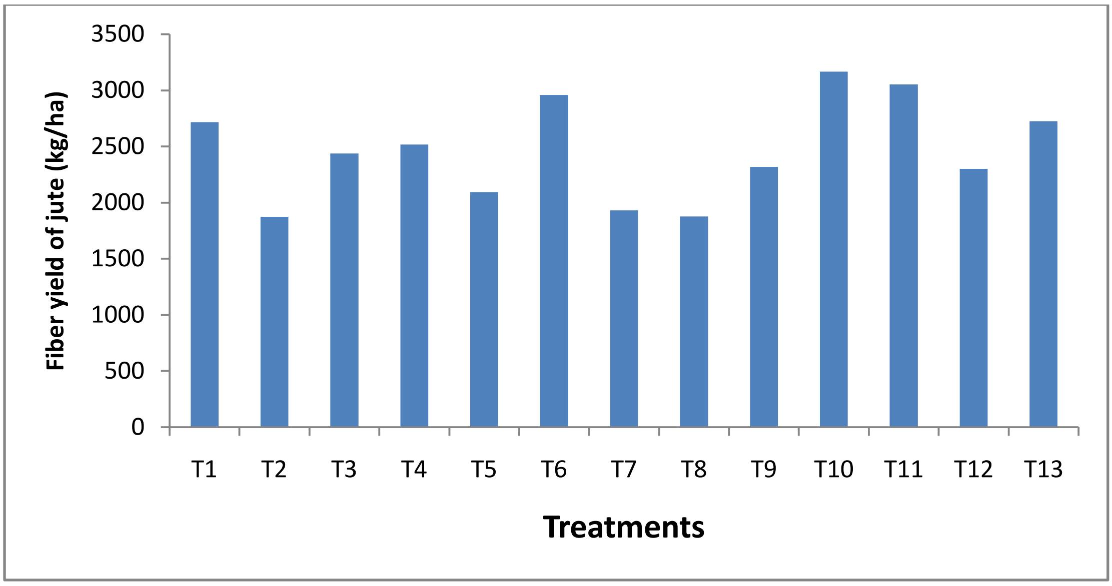

Figure. 10 Fiber dry weight (kg/ha) of jute at maturity as influenced by different jute+kangkong/jute leafy vegetable planting system

4.7.4 Dry weight of stick (kg ha^{-1})

Dry weight of stick ha^{-1} was significantly affected by intercropping with kangkong (Figure.11). The highest dry weight of stick (3611.00 kg ha^{-1}) was obtained from T_{11} treatment and the lowest dry weight of stick (2116.00 kg ha^{-1}) was obtained from T_2 treatment, it was statistically similar with $T_7$and T_8 treatment.

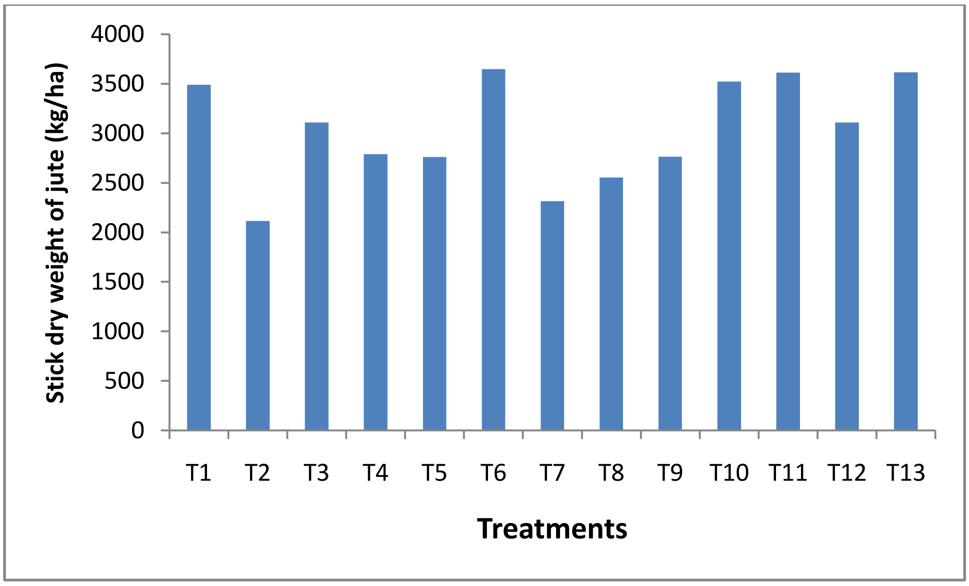

Fig. 11 Stick dry weight of jute stick as influenced by different jute+kangkong/jute leafy vegetable planting system

4.7.5 Biological yield (kg ha^{-1})

Biological yield of jute was affected significantly by different intercropping system of jute with kangkong (figure. 12). The highest biological yield (7985.55 kg ha^{-1}) of jute was obtained from T_{11} treatment. The lowest fiber yield (4758.51 kg ha^{-1}) was obtained from T_2 treatment.

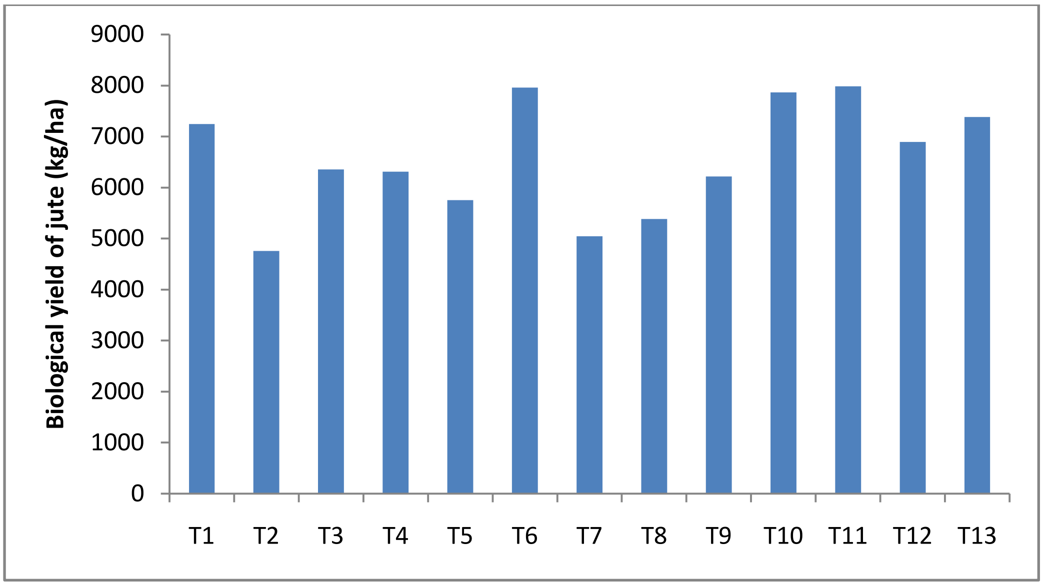

Figure. 12 Biological yield of jute stick as influenced by different jute+kangkong/jute leafy vegetable planting system

4.7.6 Harvest Index (%)

Harvest Index of jute was varied significantly by intercropping with kangkong (figure. 13). The highest (40.24%) harvest index was obtained from T_{10} treatment. The lowest (33.40%) harvest Index was obtained from T_{11} treatment.

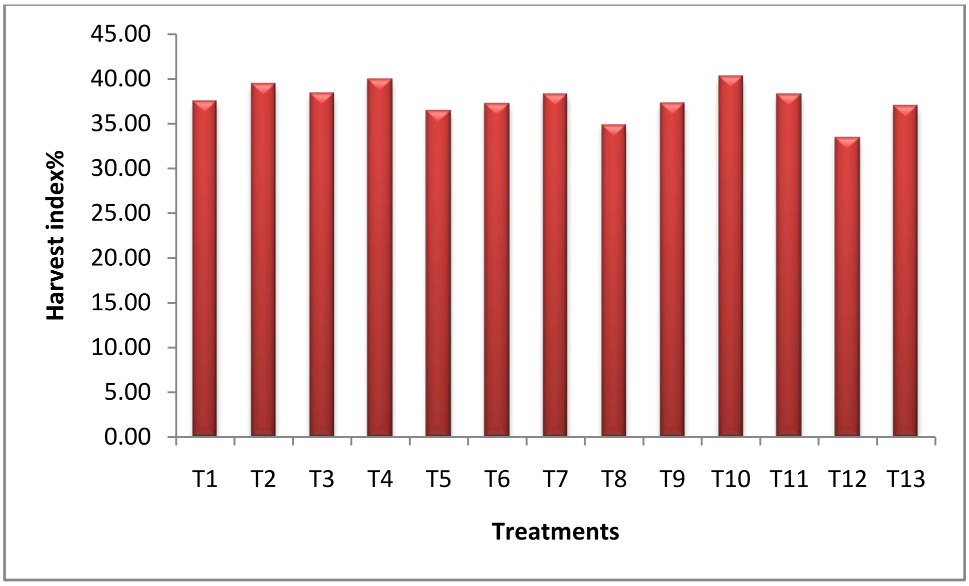

Figure. 13 Harvest index of jute stick as influenced by different jute+kangkong/jute leafy vegetable planting system

4.7.7 Retrun from fiber of jute (Tk./ha)

The maximum return from fiber of jute was obtained from T_{10} (126637 tk./ha) followed by T_{11} (122118 Tk/ha) (Figure. 14). The remarkably lower returns were obtained from T_2 (74993 Tk/ha).

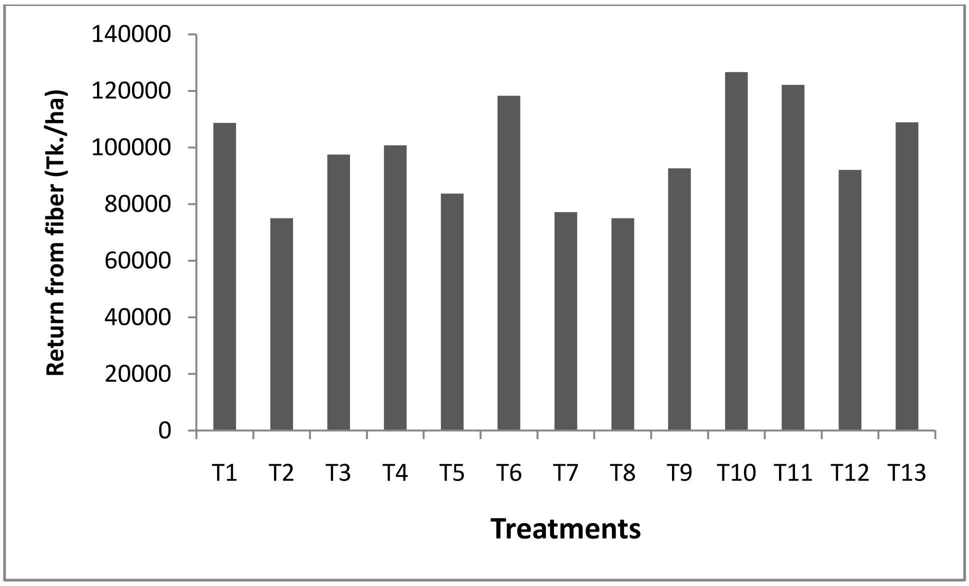

Figure. 14 Monitory return from jute fiber as influenced by different jute+kangkong/jute leafy vegetable planting system

4.7.8 Return from jute stick

The maximum return from stick of jute was obtained from T_6 (7299 Tk./ha) followed by T_{11} (7223 Tk/ha) (Figure. 15). The remarkably lower returns were obtained from T_2 (4232 Tk/ha).

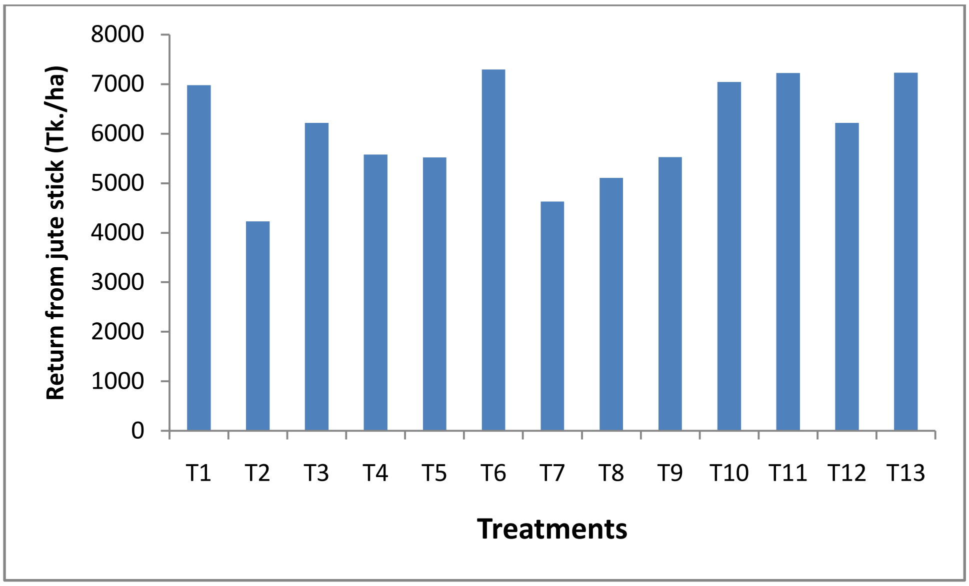

Figure. 15 Monitory return from jute stick as influenced by different jute+kangkong/jute leafy vegetable planting system

4.7.9 Total return form jute

Total return from the different treatment range between Tk 79224 and 133682 per ha (Figure. 16). Among the different treatment T_{10} gave the highest return Tk. 133682 per ha while the lowest return Tk. 79224 was obtained from the treatment T_2.

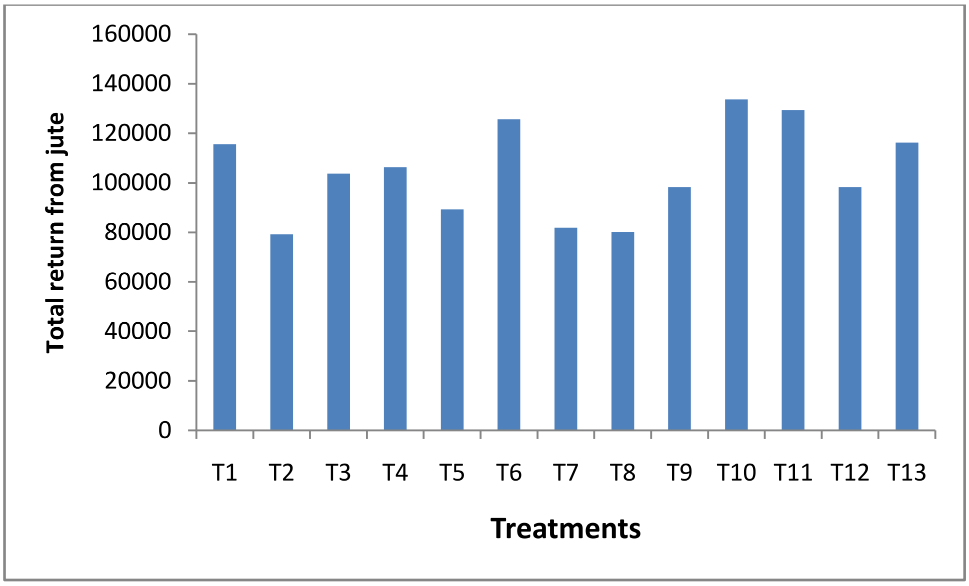

Figure. 16 Total return from jute by different jute+kangkong/jute leafy vegetable planting system

4.8 Total return (jute+kangkong vegetable+jute vegetable) from jute+kangkong/jute leafy vegetable planting system

Combined return (from jute stick, jute fiber, jute leafy vegetable and kangkong leafy vegetable)/ as influenced by different jute+kangkong/jute leafy vegetable planting system. Combined return from the different treatment range between Tk 126009 and 307206 per ha (Figure. 17).

Among the different treatment T_{12} gave the highest return Tk. 307206 per ha while the lowest return Tk. 126009 was obtained from the treatment T_2.

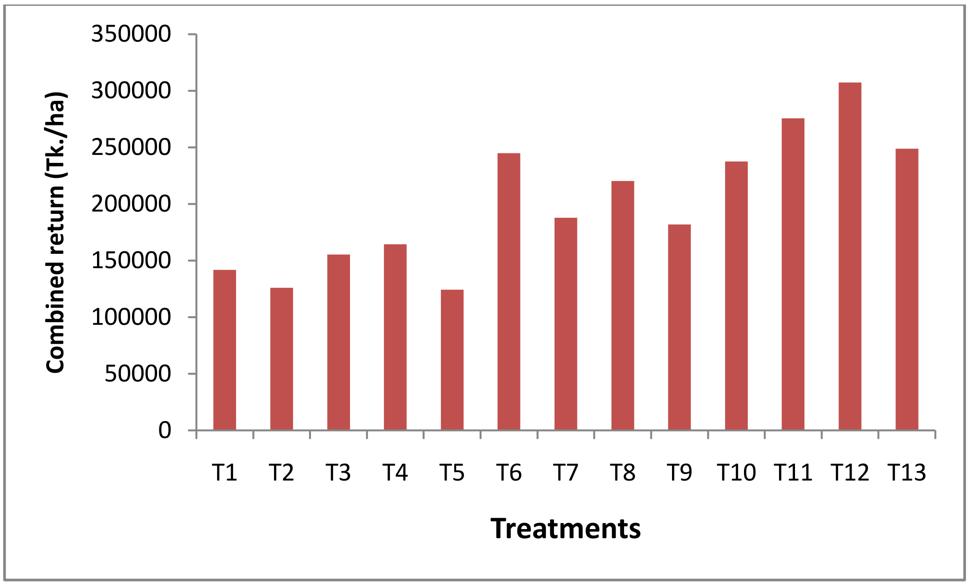

Figure. 17 Combined return (from jute stick, jute fiber, jute leafy vegetable and kangkong leafy vegetable)/ as influenced by different jute+kangkong/jute leafy vegetable planting system

4.9 Benefit – cost ratio

The cost and return analysis were done and have been presented in table 1. Total costs of production were recorded for all the treatments of unit plot and calculated on per hectare basis the price of jute stick, jute fiber, jute leafy vegetable and kangkong leafy vegetable at the local market rate were considered.

The total cost of production ranges between Tk. 58571 and Tk. 67421 per hectare among the different treatment combinations (Appendix III). The highest cost of production Tk. 67421 per ha was involved in the treatment T_1, while the lowest cost of production Tk. 258571 per ha was involved in the treatment of T10. Gross return from the different treatment combinations range between Tk 126009 and 307206 per ha.

Among the different treatment T_{12} gave the highest return Tk. 248335 per ha while the lowest net return Tk. 66363 was obtained from the treatment T_2.

The benefit cost ratio (BCR) was found to be the highest (4.22) in the treatment combination T_{12}.

Table 1. Cost and return of jute stick, jute fiber, jute leafy vegetable and kangkong leafy vegetable)/ as influenced by different jute+kangkong/jute leafy vegetable planting system

Treatments	**Gross return (Tk./ha)**	**Total cost of production (Tk./ha)**	**Net return (Tk./ha)**	**Benefit cost ratio (BCR)**
T_1	141750	67421	74329	1.10
T_2	126009	59646	66363	1.11
T_3	155285	59471	95814	1.61
T_4	164424	58971	105453	1.79
T_5	124205	59371	64834	1.09
T_6	244898	59121	185777	3.14
T_7	187761	59371	128390	2.16
T_8	220417	59471	160946	2.71
T_9	181852	59471	122381	2.06
T_{10}	237432	58571	178861	3.05
T_{11}	275650	58871	216779	3.68
T_{12}	307206	58871	248335	4.22
T_{13}	248866	59771	189095	3.16

Chapter 5

SUMMARY AND CONCLUSION

The experiment was carried out at the Agronomy research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from April, 2013 to August, 2013 to study the Weed suppression in jute field by growing leafy vegetables. Thirteen treatment combinations were T_1 = Control, jute only, spacing 30 cm, T_2 = Jute 30 cm + one line jute between two adjacent line, T_3 = Jute 30 cm+ jute broadcast between two adjacent jute lines, T_4 = Paired row jute 15 cm apart + kangkong 15 cm apart between two adjacent paired rows of jute, T_5 = Paired row jute 15 cm apart + Broadcast jute between two adjacent paired rows of jute, T_6 = Jute 30 cm apart + one kangkong line between two adjacent jute row, T_7 = Jute 30 cm apart + broadcast kangkong between two adjacent jute row, T_8 = Mixed jute (4 kg/ha) and kangkong (4 kg/ha), T_9 = Mixed jute (4 kg/ha) and kangkong (2 kg/ha), T_{10} = Paired row jute 15 cm apart + Broadcast kangkong between two adjacent paired rows of jute, T_{11} Paired row jute 15 cm apart + 3 rows kangkong between two adjacent paired rows of jute, T_{12} = Paired row jute 15 cm apart + 4 rows kangkong between two adjacent paired rows of jute, T_{13}= Mixed jute (6 kg/ha) and kangkong (8 kg/ha), The experiment was conducted in Randomized Complete Block design with three replications.

The results of the experiment revealed that some of the crop characteristics and yield of jute and kangkong were significant due to intercropping systems.

The highest dry weight of weed (229 g) was obtained from T_2 treatment. Lower dry weight of weed (around 160 g) was obtained from T_3-T_7, T_9, T_{11} and T_{13} treatments. At 34 DAS, the highest jute leafy vegetable was obtained from T_4 (over 3000 kg/ha). The highest leafy jute vegetable was obtained from T4 (5251 kg/ha). The maximum return from jute green vegetable was obtained from T_4 (52514 tk./ha). The highest kangkong yield was obtained from T_{12} (5104, kg/ha) at 35 DAS. At 53 DAS, the highest kangkong yield was produced by T_8 (3809 kg/ha). At 67 DAS, the T_{12} showed the highest yield (3600 kg/ha). T_{12} showed the highest amount of kangkong yield (11581 kg/ha). The tallest plant (214.10 cm) was obtained from T_{10} treatment. The highest dry weight of leaves (1483.00 kg/ ha) was obtained from T_{12} treatment. The highest dry weight of fiber (3166 kg/ ha) was obtained from T_{10}. The highest dry weight of stick (3611.00 kg/ ha) was obtained from T_{11} treatment. The highest biological yield (7985.55 kg/ha) of jute was obtained from T_{11}. The highest (40.24%) harvest index was obtained from T_{10} treatment. The maximum return from fiber of jute was obtained from T_{10} (126637 Tk./ha) followed by T_{11} (122118 Tk./ha). The maximum return from stick of jute was obtained from T_{11} (7299 Tk./ha) followed by T_{11} (7223 Tk./ha). T_{10} gave the highest return 133682 Tk. /ha. The different treatment T_{12} gave the highest return 307206 Tk./ ha.

Among the different treatment T_{12} gave the highest return 248335 Tk./ha while the lowest net return Tk. 66363 was obtained from the treatment T_2.

The benefit cost ratio (BCR) was found to be the highest (4.22) in the treatment combination T_{12}.

The results revealed that T_{12} (Paired row jute 15 cm apart + 4 rows jute between two adjacent paired rows of jute) treatment gave highest BCR among the treatments.

It may be concluded that the planting paired row jute 15 cm apart + 4 rows jute between two adjacent paired rows of jute of intercropping system give the highest gross and net return and also the highest benefit cost ratio is obtained from this treatment combination.

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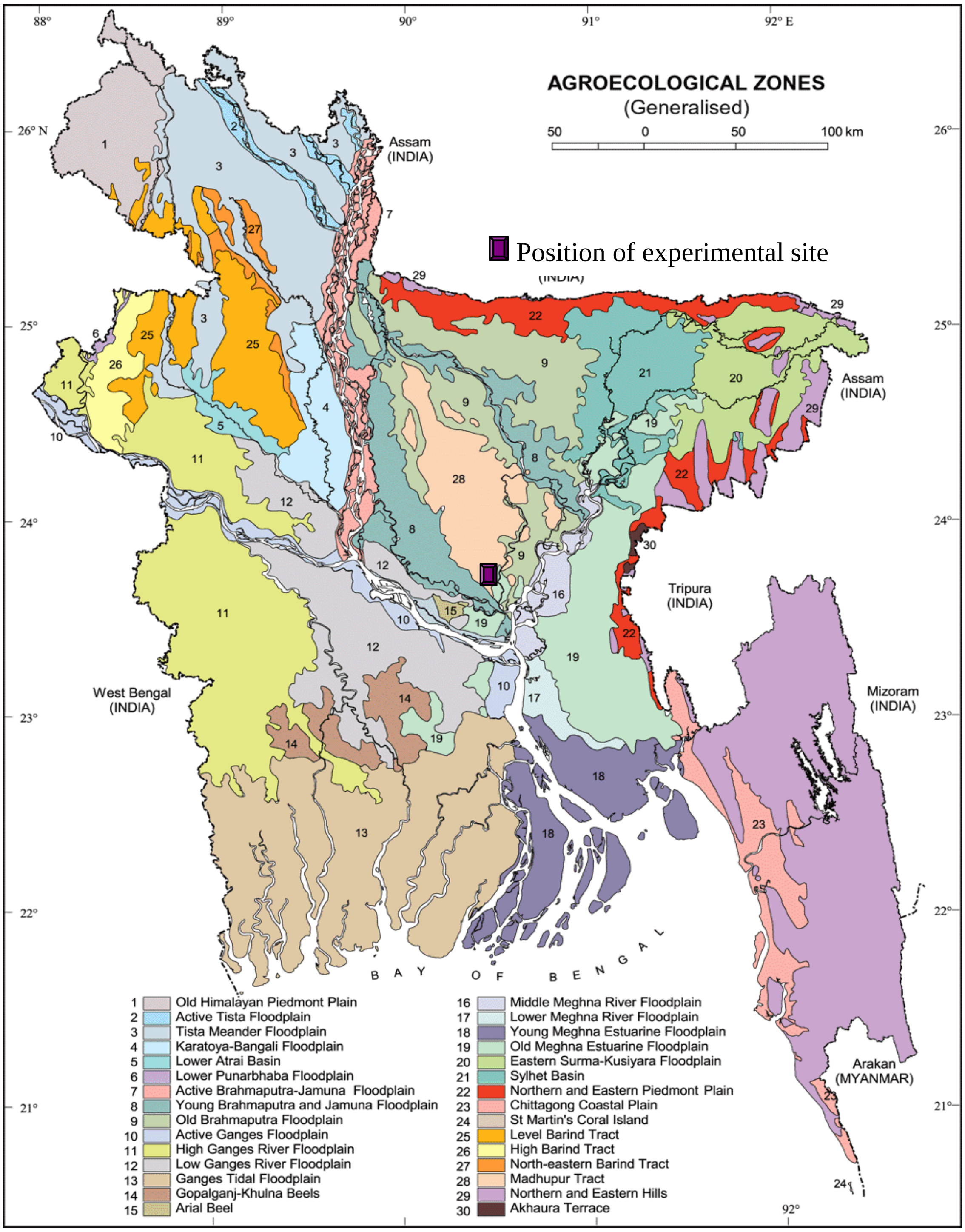
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly average air temperature, relative humidity and total rainfall of the experimental site during 2013

Month	Air temperature (^0C)			RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
April	32.98	23.72	28.35	88.24	65
May	34.00	24.65	34.33	79.55	155
June	33.85	26.15	30.0	69.05	184
July	34.20	24.50	29.35	89.5	281

Source: Bangladesh Mateorological Department (climate and weather division), Agargaon, Dhaka

Appendix III. Chemical properties of the soil of experiment field before seed sowing

CHARACTERISTICS	VALUE
pH	5.70
Organic matter (%)	2.35
Total N (%)	0.12
K (me/100 g soil)	0.17
P (Mg/g soil)	8.90
S (Mg/g soil)	30.55
B (Mg/g soil)	0.62
Fe (Mg/g soil)	310.40
Zn (Mg/g soil)	4.82

Source: Soil Resource Development Institute (SRDI), Krishi Khamar Sharak, Dhaka

Appendix IV. Per hectare costs for different production and harvesting practices (Tk./ha) as affected by different jute+kangkong/jute production systems

Treatments	Costs	Extra cost/ha for			
	Common Cost/ha	Thinning	weeding	Harvesting total jute plus stick	Total costs
T_1	54921	500	9000	3000	67421
T_2	54921	625	900	3200	59646
T_3	54921	750	600	3200	59471
T_4	54921	250	600	3200	58971
T_5	54921	750	600	3100	59371
T_6	54921	500	600	3100	59121
T_7	54921	750	600	3100	59371
T_8	54921	750	300	3500	59471
T_9	54921	750	300	3500	59471
T_{10}	54921	250	300	3100	58571
T_{11}	54921	250	600	3100	58871
T_{12}	54921	250	600	3100	58871
T_{13}	54921	750	600	3500	59771

Source: Bangladesh Jute Research Institute

Plate 1: Field view of experimental plot

Plate 2 : Control plot of jute

Plate 3 : Paired row of jute and kangkong

Plate 4 : Bunch of kangkong