WEED SUPPRESSION FOR INCREASING PROFITABILITY IN JUTE CULTIVATION BY INCORPORATING LEAFY VEGETABLES (GREEN AMANRANTH AND JUTE)

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CERTIFICATE

This is to certify that the thesis entitled, ***“WEED SUPPRESSION FOR INCREASING PROFITABILITY IN JUTE CULTIVATION BY INCORPORATING LEAFY VEGETABLES (GREEN AMANRANTH AND JUTE)”*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.) IN AGRONOMY,*** *embodies the result of a piece of bona fide research work carried out by* **UMME RUMANA AFROSE,** *Registration No.* ***08-02914*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission

Dated:

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(Prof. Dr. Md.Jafar Ullah)

Supervisor

Place: Dhaka, Bangladesh.

Dedicated

to

My Beloved Parents

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The Author

ABSTRACT

An experiment was conducted at the Agronomy fields of Sher-e-Bangla Agricultural University, Dhaka, during the period from April to August 2013 to study the weed suppression in Jute field by growing leafy vegetables (either green amaranth or incorporating higher jute plants) and thereby increasing the profitability of jute cultivation. The experiment was laid out in a randomized complete block design with 3 replications. The treatments comprised either sole jute cultivation or in combination of fiber jute with jute for leafy vegetable or with amanranth (T_1 = Control, jute only, spacing 30 cm; T_2 = Jute row spacing 30 cm + one line jute (as leafy vegetable) between two adjacent jute lines; T_3 = Jute row spacing 30 cm + jute broadcast (as leafy vegetable) between two adjacent jute lines; T_4 = Paired row jute 15 cm apart + 4 rows amaranth (as leafy vegetable) 15 cm apart between two adjacent paired rows of jute; T_5 = Paired row jute 15 cm apart + broadcast jute (as leafy vegetable) between two adjacent paired rows of jute; T_6 = Jute 30 cm apart + one amaranth line (as leafy vegetable) between two adjacent jute row; T_7 = Jute 30cm apart + broadcast amaranth (as leafy vegetable) between two adjacent jute row; T_8 = Mixed jute for fiber (6 kg ha^{-1}) and amaranth (4 kg ha^{-1}) sown for leafy vegetable; T_9 = Mixed jute for fiber (6 kg ha^{-1}) and amaranth (2 kg ha^{-1}) as leafy vegetable; T_{10} = Paired row jute for fiber 15 cm apart + broadcast amaranth (as leafy vegetable) between two adjacent paired rows of jute; T_{11}= Paired row jute for fiber for fiber 15 cm apart + 3 rows amaranth (as leafy vegetable) between two adjacent paired rows of jute T_{12}= Paired row jute for fiber 15cm apart + 4 rows jute (as leafy vegetable) between two adjacent paired rows of jute; T_{13}= Mixed jute for fiber (6 kg ha^{-1}) and amaranth (8 kg ha^{-1}) for leafy vegetable). Results showed that the greater amount of jute sak was obtained from T_1, T_4, T_6 and T_{10} (over 26 g m^{-2}). The longest jute plant was observed in T_6 (2.67 m). In the 1st weeding the greatest weed infestation was seen in T_{11} but in the second weeding, that was found in T_{13}. Significantly higher jute fiber yields were obtained in T_1, and T_6 (over 3.7 t ha^{-1}). Significantly greater harvest indices were obtained from T_3, T_6, T_9 and T_{12}. (around 40%). The highest costs in respect of weeding (9000 Tk.ha^{-1}) and total costs was obtained with T_1 (76421 Tk.ha^{-1}). T_1 and T_6 showed identical value of jute fiber (over 148000 Tk.ha^{-1}) with the greatest cost in T_1. T_1 and T_6 also showed higher total returns (over 154000 Tk.ha^{-1}). However, the highest net income was obtained with T_6 (94997Tk.ha^{-1}) along with the highest Benefit cost ratio (1.61).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AEZ	Agro Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
C.V.	Coefficient of Variation
E	East
et al.	*et alibi* (and others)
etc.	*et cetra*(and so on)
FAO	Food and Agricultural Organization
Fig.	Figure
HI	Harvest index
i.e.	idest (that is)
DMRT	Duncun's Multiple Range Test
N	North
SAU	Sher-e-Bngla Agricultural University
viz.	Videlict (namely)

Chapter 1

INTRODUCTION

There are different techniques of weed control in crop fields like hand weeding, mechanical weeding, herbicide application etc. Weed suppression is one among them. 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 intercrop, 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 inter/mixed crops and it would incur weeding cost. The money earned by selling the harvested leafy vegetables may meet up the weeding cost at the postharvest period of the inter/mixed crop leafy vegetables.

Inter/mixed cropping, a traditional agricultural practice of cultivating two or more crops in the same space at the same time, is an old and commonly used cropping practice, which aims to match efficiently crop demands to the available growth resources and labor. Given the increasing global demands for food and the relationship of enhanced food production with food security and the need to conserve the natural resources, diversification of planting system is necessary. The goal of diversified agricultural production systems is to reach production stability through improved crop protection and increased productivity and profitability offered by many inter/mixed cropping systems. The main concept of inter/mixed cropping is to get increased total productivity per unit area per unit time besides equitable and judicious utilization of land resources and farming inputs including labour and insurance against failure of one or the other crops. There are ample evidence that the total yield can be increased with inter/mixed cropping over sole cropping. One of the main reasons for higher yields in inter/mixed cropping over sole cropping is that the component crops are able to use resources differently and effectively; so that, when grown together, they complement each other and make better use of growth resources than when grown separately. Andrews and Kassam (1976) stated that intercropping is an age-old practice of growing simultaneously two or more crops in the same piece of land. It is a technique of crop intensification in time and space wherein the competition between crops may occur during the part or whole of crop growth period. It has been a common practice followed by the farmer of India, Africa, Srilanka, West Indies and Bangladesh.

Inter/mixed crop makes greater use of ground and reduces weeds by suppression and greater competition with weeds. Inter/mixed cropping or mixed cropping converts completion of crop weed into profitability by replacing weed plants in the crop field by the same or different additional crop plants. It gives higher income per unit area and acts as an insurance against crop failure in abnormal year. It maintains soil fertility, diversity and stability of crop in the field. It reduces soil runoff and chemical or fertilizer application by complementary shearing of resources. Inter/mixed crop strategies are planting a deep-rooted crop with a shallow-rooted crops or planting a tall crop with a shorter crop. According to Assefa and Ledin (2001), intercropping serves as an insurance against total crop failure in uncertain weather condition, increasing total productivity, equitability and judicial use of land resources and farming inputs including labour.

Fast growing vegetable crops are good for inter/mixed cropping. Vegetable plants can be grown quite closely together in most cases. Many vegetables are quick growing, it makes sense for plot utilization, to plant some of the faster growing vegetables between the row of the slower maturing type or even between the individual plants. Most suitable vegetables for inter/mixed cropping are cauliflower, cabbage, lettuce, carrot, eggplant, spinach, amaranth, kangkong, onion, green peas, tomatoes, peppers, beets etc.

Jute is called golden fiber of Bangladesh and the valuable commodity of trade. It is one of the main cash crops of Bangladesh and the country earns a lot of foreign exchange every year. This helps to improve our socio-economic structure. Many kinds of things are produced namely carpets, bags, ropes, cloths, mats, brushes, painters, false hairs, handicrafts etc. These jute and jute goods of our country are in great demand in the world market. Jute leaves in early stage are used as vegetable in our country and also used to prepare soup in other countries of the world. Diversified byproducts from jute can be used in cosmetics, medicines, paints and other products.

Leafy vegetables are the plants which supplies edible leaves in its various stages of development. They are significant source of vitamins A, C, E and K as well as several vitamin B. They are the rich source of minerals such as calcium, magnesium, iron and potassium. They are also rich in fibers and extremely low in fats and carbohydrates and an excellent source of protein. Leafy vegetables like amaranth and jute (patsak) being short structure and quick growing crops can be easily inter/mixed cropping between two rows of jute at early stage. Inter/mixed cropping leafy vegetables can help to reduce weed population and optimize the use of solar radiation and soil fertility.

Many research findings indicated that weed population density and weed biomass production may be markedly reduced by using inter/mixed cropping strategies. Inter/mixed crop system, light interception and soil cover are usually increased compared monoculture and yield loss due to weed competition is seen to be reduced. The study was designed to assess the efficacy of inter/mixed cropping in reducing weed infestation in jute+ amaranth cultivation system. Krantz *et al.* (1976) concluded that mixed / intercropping leafy vegetables covered risk, earned more profit and stabilized production, improved soil fertility, conserved moisture and facilitated efficient labor distribution.

Above facts and findings indicate that there is possibility of weed suppression in jute field by growing leafy vegetables. Therefore, the present study was undertaken with the following objectives:

i) To assess the extent of weed suppression through incorporation of a leafy vegetable in jute field.

ii) To assess and compare the cost of weeding under inclusion a leafy vegetable in jute.

iii) To assess and compare yield performance of sole jute under sole and incorporation of a leafy vegetable.

Chapter 2

REVIEW OF LITERATURE

The main purpose of this chapter is to review the available studies related to weed suppression in jute field by growing leafy vegetables. Intercropping has many advantages for the farmers. It increases total production, act as insurance against the failure of principle crop and better utilization of interspaces in crops. It reduces the cost of intercultural operations and increases the fertility of soil. It gives higher land equivalent ratio and higher equivalent yield. The important recent studies, which have relevance to the present study are reviewed below.

2.1. **Intercropping system**

Intercropping is a crop intensification practice in which two or more crops are interplanted on the field such that their growth cycle overlaps.

Lakani,1976 and Sivakumar and Virmani,1980, stated that higher yield in terms of total biomass and grain production per unit area in a given season without the use of costly inputs under intercropping system is attributed to better uses of growth resources namely light, moisture and nutrients.

Rao and willy (1980) stated that the crop mixture would also stabilize returns over seasons as the provide more than one commodity and can act as buffer against frequent price change in any one of component crops. Price flactuations are quite common in countries like Bangladesh, where 65 percent of agricultural produce comes from rainfed agriculture.

Andrews and Kassam (1976) stated that intercropping is an age-old practice of growing simultaneously tow or more crops in the same piece of land. It is a technique of crop intensification in time and space wherein the competition between crops may occur during the part or whole of crop growth period. It has been a common practice followed by the farmer of India, Africa, Srilanka, West Indies and Bangladesh.

2.2. **Advantages of intercropping**

The main advantages of intercropping is the more efficient utilization of available resources and the increase productivity compare with each sole crop of the mixture (Hauggaard-Neilsen and Jesssen ,2001)

According to kariaga (2004) intercroppping controls soil erosion by preventing rain drops by hitting bare soil where the trend to seal surface pores, prevent water from entering soil and increase surface erosion.

Reddy and Reddi (2007) mentioned that taller crops acts as wind barrier for short crops. In legume and non-legume intercropping, yield, yield of non-legume increase in intercropping as compare with monocrop.

Mashingaidze(2004) found that by intercropping land was effectively utilized and yield was improved.

Pal and Shehu (2001) found that all legume crops contributed to yield and N uptake of maize either intercropped with legume or grown after legume as sole crop.

According to Assefa and Ledin (2001), intercropping serves as an insurance against total crop failure in uncertain weather condition, increasing total productivity, equitability and judicial use of land resources and farming inputs including labour.

Russell,2002,stated that, intercropping is one way of introducing more biodiversity in to agroecosystem and results from intercropping studies indicate that increased crop diversity may increase the number of ecosystem services provide. Higher species richness may be associated with nutrient cycling characteristics that often can regulate soil fertility, limit nutrient leaching losses and significantly reduces the negetive effect of pests and also including weeds.

2.3. Effect of intercropping of jute with other crops

Agboola and Fayemi (1971) point out that through a number of 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.

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 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) 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.

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.

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

Trenbath (1976) expressed that the main advantage of using legumes in intercropping and mixed cropping was found to be the saving of nitrogen fertilizer.

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.

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 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).

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.

Waghmare*et al.* (1982) showed that legume should benefit in association with non-legume crops.

Sharma *et al*. (1982) conducted that LER measures the crop productivity of a unit area covered by a crop mixture vis-à-vis that of the sole component.

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.

Singh and Singh (1983) reported that highest land equivalent ratio (1.27) was recorded in wheat and gram intercropping system followed by wheat + pea (1.19) and wheat + lentil (1.10).

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 pegionpea resulting an increase in LER by 1.26.

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

Results analyzed that the LER value was influenced by many factors like density, morphology, competitive abilities, and growth duration and management etc. (Fawusi*et al.,* 1982)

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.

Quayyum *et al*. (1987) stated that intercropping 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 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.

Palaniappan (1988) concluded that if the LER was equal to or less than one, it was considered to have no advantage of intercropping over monoculture in term of production. But if LER was more than one under intercropping was considered to have agronomic advantage over monoculture practice.

Singh *et al.* (1988) stated that combined yield of maize + legume was higher both at 1:1 and 1:2 rows than monoculture of maize. It was possibly due to increased yield of maize in addition to bonus yield of legumes.

Karim *et al.* (1990) to study the effect of planting system of maize with rows of groundnut grown as mono and / or intercrop. Maximum grain yield of maize (2.96 t ha^{-1}) was obtained from monoculture in uniform row which was identical to maize uniform row, with two or three rows of groundnut. Higher maize and wheat equivalent yield was found in uniform 3 or paired 6 rows of groundnut. Both the former and later combination gave higher LER (1.44) and net return of Tk. 8719 and 8502 ha^{-1}, having same benefit cost ratio.

Patra *et al.* (1990) described that the association of soybean 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.

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.

Dhingra *et al*.(1991) reported that maize and mungbean under different planting patterns and row orientation where higher maize yield was obtained from intercropping system. The result of the experiment in maize yield was attributed to the complementary effect of mungbean in terms of biological nitrogen fixation.

Nag *et al.* (1996) described that monoculture of maize, cowpea, khesari, mungbean, groundnut and maize intercropped with legumes in paired rows were compared in an experiment conducted 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).

Alteieri (1994) stated that intercropping of compatible plants also encourages biodiversity, by providing a habitat for a variety of insects and soil organisms that would not be present in a single intercrop environment. This biodiversity can in turn

Banik (1994) evaluated that wheat and legume intercropping under 1:1 and 2:1 row ratios and found that the wheat peas intercropping (1:1) gave the highest wheat yield equivalent of 3.02 t ha^{-1} followed by the wheat - lentil intercropping (2.91) which also gave the highest monetary returns.

Singh and Sarawgi (1995) found that the effect of row ratio nitrogen and irrigation in wheat-chickpea intercropping system with row ratios of 2:1 2:2. The best intercropped treatment was where the crops were grown in using the row ratio of 2:1.

Verma *et al*. (1997) observed that wheat and lentils grown alone or intercropped in a 4: 2 row ratio. The wheat in pure stand was given 80 kg N + 16kg P + 16 $kgha^{-1}$ (100% NPK), while sole lentil received 20 kg N + 16 kg P ha^{-1} (100% NP). Intercrops were given 8 different combinations of fertilizers. Wheat grain yield was 3.29 t ha^{-1} in pure stand and 2.73 - 3.12 t ha^{-1} when intercropped. Lentil seed yield was 1.53 t ha^{-1} in pure stand and 0.22 - 0.41 t ha^{-1} when intercropped. The highest wheat-equivalent yield and net returns were obtained when wheat with 100% NPK and intercropped with lentils fertilized with 75% NP.

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.

Tomar *et al.* (1997) demonstrated a field trial on sandy loam soil in winter seasons where wheat was grown alone or intercropped with *Lens culinaris and Cicerarietinum* in 2: 2 or 3: 2 row ratios. Seed yields of all crops were decreased by intercropping. Total plant N content was highest in *Lens culinaris* grown alone increasing N fertilizer rate (0 - 90 kg N ha^{-1}) increased wheat grain yield but did not generally affect legume seed yields.

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.

Dwivedi *et al*. (1998) reported that all intercropping systems had higher total yield and net returns than pure stands. Higher equivalent yields were obtained with intercropping. The land equivalent ratio (LER) values were found to be greater than unity. It was also reported that practicing wheat and pulse intercropping reduced the total weed population significantly compared to the wheat monoculture.

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}.

Malik *et al*. (1998) demonestred a field trial with wheat grown alone or intercropped with lentils, gram or rape. Grain yield of wheat was decreased by 371, 420 and 388 kg ha^{-1} with intercropping of lentil, gram and rape, respectively. However, losses in wheat yield were compensated by increased income from the intercrops. The highest net income with a benefit - cost ratio (2.75) was obtained from wheat - lentil intercropping compared with a BCR of 2.35 for wheat alone.

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 grass pea and yellow sarson with wheat was sustainable over sole wheat. The association of wheat with grass pea 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.

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.

Ashok *et al.* (2001) found that number of tillers per plant of wheat was not significantly affected by wheat based intercropping system.

Ghanbari and Lee (2002) showed that significant effect on spike length of wheat was found with intercropping system. They reported that proper fertilization under intercropping system increased spike length of wheat.

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.

Nargis *et al*. (2004) conducted an experiment on mixed cropping of lentil (100%) and wheat (20, 40, 60 or 80%). It was showed that in lentil, 100% lentil + 40% wheat gave the highest number of branches per plant (3.25), whereas 100% lentil + 60% wheat recorded the greatest plant height (35.70 cm). The maximum number of seeds per plant

(47) and seed yield (1278 kg ha^{-1}) of lentil were obtained under line sowing. Sole wheat (broadcast) produced the tallest plants (89.15 cm) and the longest spikes (9.84 cm). The highest land equivalent ratio (1.52), monetary advantage and benefit: cost ratios (1.84) were recorded for intercropping lentil (100%) and wheat (40%). They also reported that the highest seed yield (2704 kg ha^{-1}) was obtained under line sowing of sole wheat.

Islam (2006) conducted a study and showed that yields of wheat (3.00 — 3.08 t ha^{-1}) were obtained with wheat 100% + grasspea 20% + fertilizer 100% and wheat 100% + grasspea 100% + fertilizer 120% treatments. Highest fodder yield (1.47 t ha^{-1}) was obtained with the treatment of wheat 100% + grasspea 100% + fertilizer 120%. The best land equivalent ratio (LER), benefit-cost ratio (BCR) and total net return were 1.96, 1.558 and 14466.50 Tk. ha^{-1} respectively and these were obtained with the treatment of wheat 100% + grasspea 100% + fertilizer 120%.

Ullah (2007) conducted that higher combined yield, net return, BCR and LER over sole wheat when broadcasted chickpea in between two paired rows of wheat.

Sultana (2007) showed that the highest LER, combined yield, net return and BCR was obtained while wheat + grasspea cultivated under mixed cropping systems.

Hossain *et al.* (2010) calculated higher net return (Tk. 14452 ha^{-1}) and benefit cost ratio (3.06) where they maintain two rows of wheat alternate with one row chickpea with 40-30-20 N, P_2O_5, K_2O Kg ha^{-1}, respectively in a wheat + chickpea intercropping experiment. They also reported that, two rows wheat alternate with one row chickpea gave highest land equivalent ratio(1.29), wheat equivalent yield (3.13 t ha^{-1}), net return (Tk. 164330 ha^{-1}) and benefit cost ratio (4.13) followed by that of 3 : 2 combination in another intercropping experiment.

Khatun (2010) reported that highest LER, gross return, net return, equivalent yield, benefit cost ratio and monetary advantages. She also showed that the planting pattern of one row grasspea fitted in between two paired rows of wheat gave an increase of 1.59% of total grain yield, 84.37% net income, BCR 1.71 and LER 1.38 over normal planting of wheat that compensated losses in wheat yield under intercropping system.

Sarkar and Majumdar (2013) was conducted for consecutive two years from 2007 to 2008 to study the feasibility of growing intercrops in the widely spaced seed crop of olitoriusjute (cv. JRO 524) in TypicUstochrept soil with neutral sandy-loam textured soil having medium fertility. Intercropping of black gram (*vigna mungo*) for fodder in the widely spaced jute seed crop increased the jute seed equivalent yield by 31.3% (from 3.48 q to 4.57 q ha^{-1}). Ricebean (*vigna umbellata*) as intercrop in jute seed crop can also improve the JSEY by 30.5% (from 3.48 q to 4.54 q ha^{-1}). Cowpea and green gram as intercrop in jute seed crop was also increased the JSEY by 15.8 and 15.2 %, 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 influenced 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) was conducted at Mymensingh during the period from 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) T1=Sole Jute 25cm x 5cm spacing, (ii) T2 = Sole Maize at 75cm x

25cm spacing, (iii) T3=Jute + Maize at 75cm x 25 cm spacing, (iv) T4=Sole Maize at 75cm x 50cm spacing, (v) T5=Jute + Maize at 75cm x 50cm spacing, (vi) T6=Sole Maize at 75cm x 75cm spacing, (vii) T7=Jute + Maize at 75cm x 75cm spacing, (viii) T8=Sole Maize at 75cm x 100cm spacing, (ix) T9=Jute + Maize at 75cm x 100cm spacing, (x) T10=Sole Maize at 75cm x 40cm spacing, (xi) T11=Jute + Maize at 75cm x 40cm spacing, (xii) T12 =Sole Maize at 75cm x 60cm spacing, (xiii) T13=Jute + Maize at 75cm x 60cm spacing, (xiv) T14=Sole Maize at 50cm x 50cm spacing, (xv) T15=Jute + Maize at 50cm x 50cm spacing and (xvi) T16=Sole Maize at 25cm x 15cm spacing. The experiment was laid out in a randomized complete block design with three replications. Results revealed that the highest fibre yield of jute was ot 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.

From the above findings it is clear that the intercropping system has advantages in regards of land use, greater yield, monetary benefit etc.

Chapter 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy research farm of Sher-e-Bangla Agricultural University (farm), Dhaka during the period April 2013 to August 2013. The materials used and the methods followed during the experimental period are described in this chapter. A brief description of the experimental site, soil, climate, experimental design, treatments, cultural operations, data collection and their statistical analysis are narrated under the following heads.

3.1. Site and Soil

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 Agro ecological zone 28 (AEZ 28) of "Madhupur Tract". 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%). The physical and chemical characteristics of the experimental field's soil are presented in Appendix 1.

3.2. Climate and weather

The experiment area belongs to the sub tropical climate and 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.

3.3. Planting materials

Two types of crops having dissimilar growth habits were used in this experiment. The crops were jute (O-72) and amaranth (BARI danta 2). In this experiment jute was grown as main crop and amaranth were grown as companion crop. Jute variety O-72 was used as test crop. For suppressing some additional plants were grown in the jute fields as per treatment provisions.

3.4. Seed collection

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

3.5. Experimental treatments

The experiment had 13 treatments of different intercropping of jute with amaranth. The treatments were as follows-

T_1 = Control, jute only, spacing 30 cm

T_2 = Jute row spacing 30 cm + one line jute (as leafy vegetable) between two adjacent jute lines

T_3 = Jute row spacing 30 cm + jute broadcast (as leafy vegetable) between two adjacent jute lines

T_4 = Paired row jute 15 cm apart + 4 rows amaranth (as leafy vegetable) 15 cm apart between two adjacent paired rows of jute

T_5 = Paired row jute 15 cm apart + broadcast jute (as leafy vegetable) between two adjacent paired rows of jute

T_6 = Jute 30 cm apart + one amaranth line (as leafy vegetable) between two adjacent jute row.

T_7 = Jute 30cm apart + broadcast amaranth (as leafy vegetable) between two adjacent jute row.

T_8 = Mixed jute for fiber (6 kg ha^{-1}) and amaranth (4 kg ha^{-1}) sown for leafy vegetable

T_9 = Mixed jute for fiber (6 kg ha^{-1}) and amaranth (2 kg ha^{-1}) as leafy vegetable

T_{10} = Paired row jute for fiber 15 cm apart + broadcast amaranth (as leafy vegetable) between two adjacent paired rows of jute

T_{11}= Paired row jute for fiber for fiber 15 cm apart + 3 rows amaranth (as leafy vegetable) between two adjacent paired rows of jute

T_{12}= Paired row jute for fiber 15cm apart + 4 rows jute (as leafy vegetable) between two adjacent paired rows of jute

T_{13}= Mixed jute for fiber (6 kg ha^{-1}) and amaranth (8 kg ha^{-1}) for leafy vegetable

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 adjacent plot was 1 m 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 × 7 cm. The seeds were sown as continuous in each line following the recommended seed rate or as per treatments. Amaranth was sown maintaining line and plant spacing as 30 cm × 10 cm, respectively.

The jute paired row was created as two jute line brought close together with 15 cm line spacing. Thus 60 cm free space was obtained between two jute paired rows (JPR). In case of T_6, treatment, one row amaranth In T_7 treatment jute and amaranth was broadcast sowing. In T_8 treatment 1: 1 row ratio of jute and amaranth was sowing. In T_9 treatment 2: 1 row ratio of jute and amaranth was sowing. In T_{10} treatment paired row jute and amaranth was broadcast sowing. In T_{11} treatment paired row jute and three line amaranth was sowing. In T_{12} treatment paired row jute and four line amaranth was sowing. In T_{13} treatment 1: 2 row ratio of jute and amaranth was sowing.

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 8, 2013 by disc plough. It was then harrowed again on 9 and 10 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 as per layout of experimental design.

3.7.2. Fertilizer application

The fertilizers of urea, triple superphosphate (TSP) and muriate of potash (MOP) were applied in the plots corresponding to 150, 50 and 50 kg ha^{-1}, respectively. At the time of final land preparation the total amount of TSP, MP and one-third of urea were applied. Rest of the urea was applied in the two equal splits at 25 and 45 days after sowing (DAS).

3.7.3. Seed sowing

Seeds were sown in line on May 13, 2013 as per experimental treatments. The recommended seed rate of Jute in control plot and amaranth were 7 kg and 5 kg ha^{-1}, respectively. However, the seed rate varied depending on the nature of the treatments. Seeds of both the crops were sown in solid lines and then thereafter thinned out extra plants. The thinned plants were weighed and were considered as leafy vegetables.

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3.7.6. Weeding

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

3.7.7. Harvesting and sampling

At full maturity, the jute was harvested plot wise on July 30, 2013. Amaranth was harvested at 50 DAS. Crop of each plot was harvested from 3.5 m^2 separately for yield. Then those were weighted to record the fiber and jute yield which was converted into t ha^{-1}.

3.8. Recording data

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

3.8.1. Jute

1. Plant height
2. Girth circumpherence
3. Dry weight of leaf
4. Dry weight of stick
5. Dry weight of Fiber
6. Dry weight of weed at 1st and 2nd weeding

3.8.2. Amaranth

1. Plant height
2. Yield of amaranth

3.9. Procedure of recording data

The data was taken at 20 days interval. The detail outline of data recording is given below:

3.9.1. Plant height

The heights of 10 plants were measured from the ground level to tip of the plants and then averaged.

3.9.2. Girth circumpherence

Girth circumpherence of 3 plants were measured and then averaged.

3.9.3. Dry weight of jute leaf/plant

Dry weight of 3 jute plants leaves were measured and then averaged.

3.9.4. Dry weight of stick/plant

Dry weight of 3 jute plants sticks were measured and then averaged.

3.9.5. Dry weight of Fiber /plant

Dry weight of 3 jute plants fibers were measured and then averaged.

3.9.6. Per hectare dry weight of jute stick

Dry weight of jute sticks were measured from the harvested plants from the central one m^2 of each plot, dried and then converted in hectare.

3.9.7. Per hectare dry weight of Fiber

Dry weight of jute fiber were measured from the harvested plants from the central one m^2 of each plot, dried and then converted in hectare.

3.9.8. Dry weight of weed 1st and 2nd weeding

Dry weight of weeds in each plot ($3.5m^2$) were collected at 15 and 25 DAS respectively.

3.9.9. Harvest Index (%)

Harvest index was determined by dividing the economic yield (fiber yield) to the biological yield (stick+leaf+fiber) from the same area and then multiplied by 100.

$$\text{Harvest Index (\%)} = \frac{\text{Fiber yield (t ha}^{-1}\text{)}}{\text{stick+leaf+fiber (t ha}^{-1}\text{)}} \times 100$$

3.10. 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.

3.11. 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.

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

3.12. Statistical analysis

Data collected from different parameters were compiled and tabulated in proper form. Appropriate statistical analysis was made by MSTAT C computer package program and the treatment means were compared by least significant difference (LSD) test.

Chapter 4

RESULTS AND DISCUSSION

The objective of this study was to suppress weed in jute field by growing leafy vegetable amaranth or jute. Data on plant characters, yield contributions & yield were recorded to find out the significance of intercropping amaranth with jute.

4.1. Dry weight of weed (1st weeding) At 15 DAS

Dry weight of 1st weeding was significant due to the treatments. The highest value was obtained by T_{11} (80.77) and the lowest value was obtained by T_{13} (16.33). Dry weights of 51.53g, 53.00g, 54.37g were obtained by T_1,T_2,T_3 respectively which were statistically similar. Dry weight of 29.10g, 29.50g, 30.40g, 32.03g, 32.50g were obtained by T_8, T_{10}, T_{12}, T_5 & T_6 respectively which were also statistically similar. The rest of the results were identical and of lower values which were 39.17g, 41.47g and were obtained by T_4 & T_7 respectively.

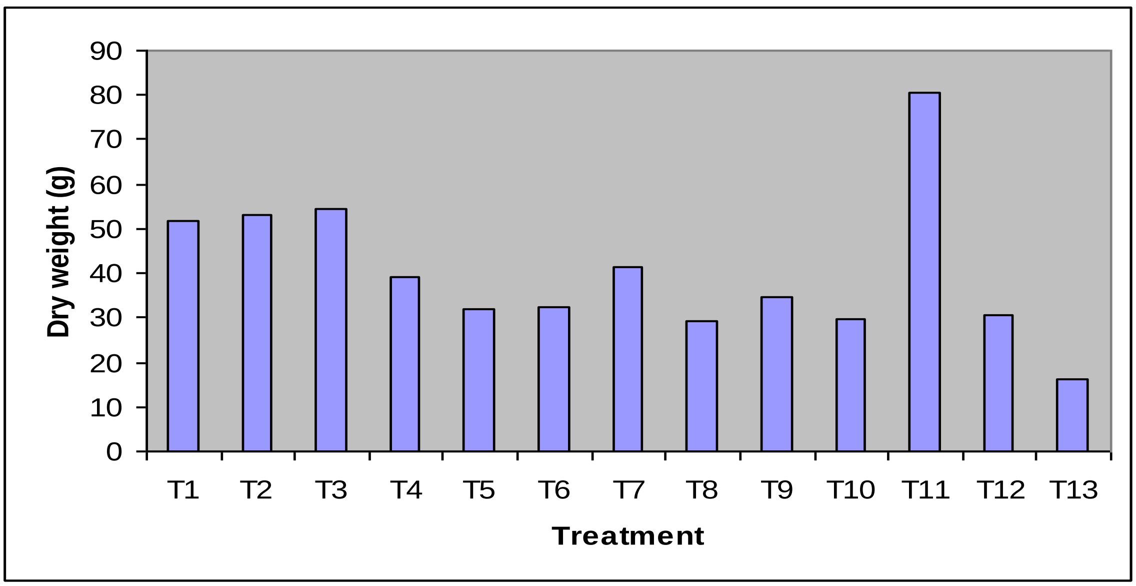

Figure 1. Weed dry weight at 15 DAS as affected by different jute+amathanth/jute production systems

4.2. Dry weight of weed (2nd weeding) at 25 DAS

Dry weight of 2nd weeding was significantly affected by intercropping system. The highest value was obtained by T_4 (113.70) and the lowest value was obtained by T_{13} (17.33).Dry weight of 54.00 g , 47.67g, 42.67g & 40.33g were obtained by T_3,T_2,T_1 & T_7 respectively which were statistically similar. Dry weight of 33.83g, 33.17g, 31.67g, 29.67g, were obtained by T_5, T_9, T_6, T_{10} respectively which were statistically similar. Similarly, the rest of 27.83g , 26.33g, 21.00 dry weight of weed were obtained by $T_{8,}$ T_{12} & T_{11} respectively were also statistically similar although lower than the pre-mentioned ones.

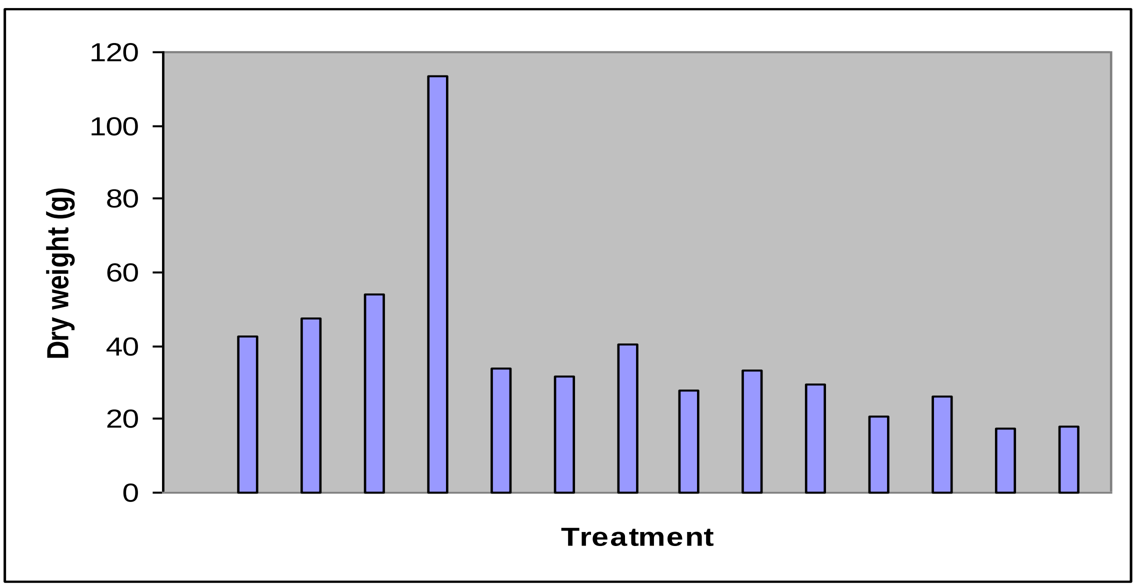

Figure 2. Weed dry weight at 25 DAS as affected by different jute+amathanth/jute production systems

4.3. Thining (1st) of jute (stick+sak) dry weight at 30 DAS

Dry weight of jute (stick + sak) showed significant effect. The highest value was obtained by T_1 (97.87) and the lowest value was obtained by T_3 (26.37).Dry weight of 93.80g , 91.50g & 90.97g were obtained by T_{10},T_4, & T_6 respectively which were statistically similar. Dry weight of 80.87g, 76.73g, 76.27g & 70.00g, were obtained by T_{12}, T_7, T_{11} & T_8 respectively which were statistically similar. The rest of 62.50g , 57.83g, 57.60g & 56.93g dry weight of jute (stick+sak) were obtained by T_9, T_{13}, T_5 & T_2 respectively which were also statistically similar but lower than those mentioned above.

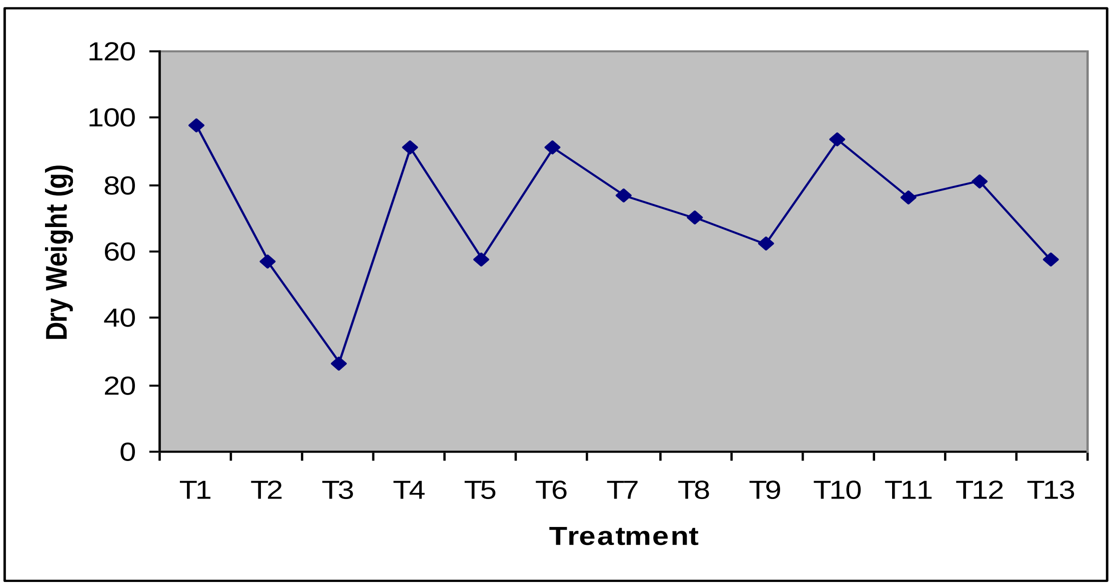

Figure 3. Jute stick + green vegetable dry weight at 30 DAS as affected by different jute+amathanth/jute production systems

4.4. Thining (2nd) of jute (stick+sak) dry weight at 60 DAS

Dry weight of jute (stick + sak) showed significant variation as affected by the treatments. The highest value was obtained by T_1 (97.87g) and the lowest value was obtained by T_3 (26.37g).Dry weight of 93.80g , 91.50g & 90.97g were obtained by T_{10},T_4 & T_6 respectively which were statistically similar. Dry weight of 80.87g, 76.73g, 76.27g & 70.00g, were obtained by T_{12}, T_7, T_{11} & T_8 respectively which were statistically similar. The values of 62.50g , 57.83g, 57.60g & 56.93g of dry weight of jute (stick+sak) obtained from T_9, T_{13}, T_5 & T_2 respectively were lower than the previously mentioned ones; and also statistically similar.

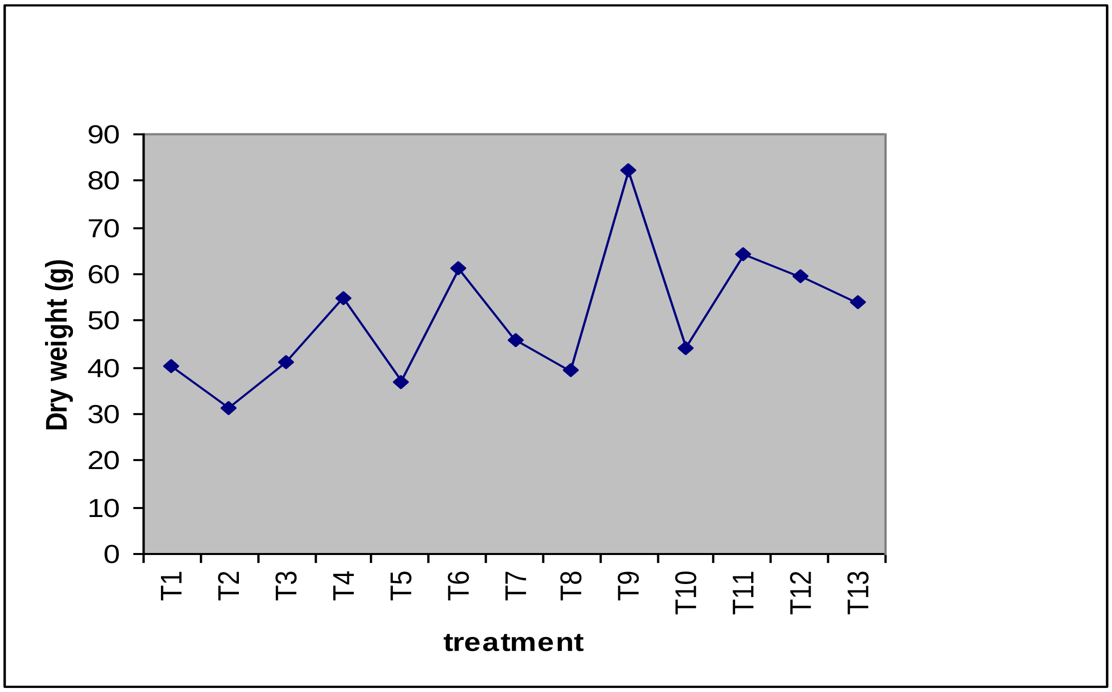

Figure 4. Jute stick + green vegetable dry weight at 60 DAS as affected by different jute+amathanth/jute production systems

4.5. Height of jute plant at 103 DAS

Significant variation was observed in the height of jute plants. The highest value was obtained by T_6 (267.50cm) and the lowest value was obtained by T_3 (167.40cm). The height of 233.90cm, 267.50cm & 217.10cm were obtained by T_1,T_6 & T_{10} respectively showed statistically similar result. The height of 204.00cm, 202.40cm, 207.50cm &

202.10cm were obtained by T_2, T_4, T_5 & T_{12} respectively showed statistically similar results. The values of 190.00cm, 190.00cm, 191.90cm & 183.10cm height of jute plant were obtained by T_7, T_8, T_{13} & T_9 respectively which were also statistically similar.

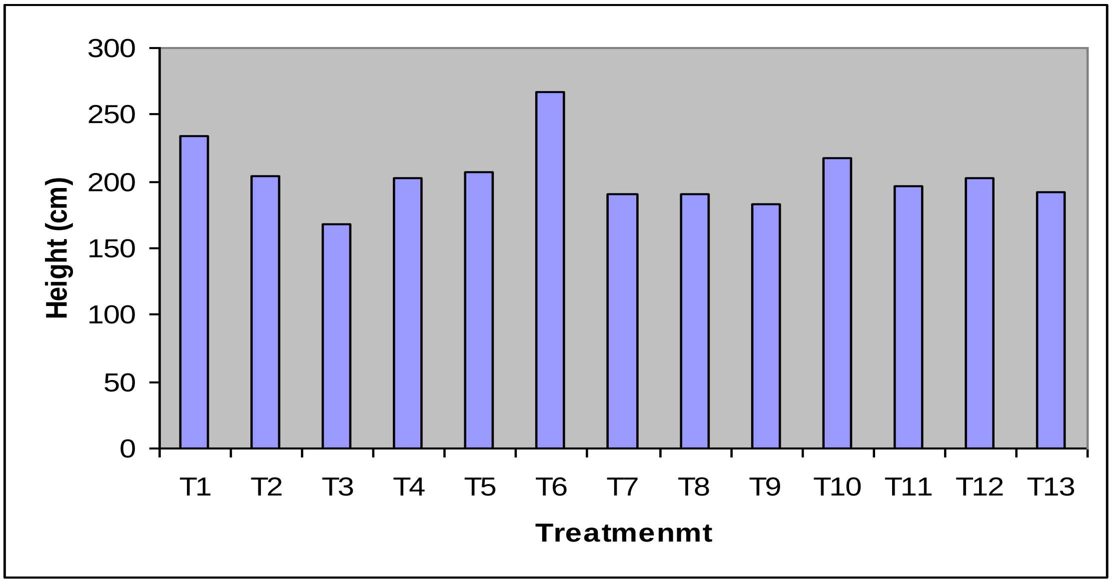

Figure 5. Plant height of jute at 103 DAS as affected by different jute+amathanth/jute production systems

4.6. Girth circumference of jute plants at 103 DAS

Girth circumference of jute plants showed significant variation. Treatment T_5 (2.38cm) showed the highest value & treatment T_3 (1.87cm) showed the lowest value. The girth area of 2.33cm & 2.38cm were obtained by T_1 & T_5 respectively, showed statistically similar results. The girth area of 2.09cm, 2.05cm, 2.08cm, 2.07cm, 2.09cm & 2.00cm were obtained by T_2, T_4, T_6, T_8, T_{12} & T_7 respectively were statistically similar. Similarly, the rest of 2.17cm & 183.10cm height of jute plant were obtained by T_{11} & T_{13} respectively were also statistically similar.

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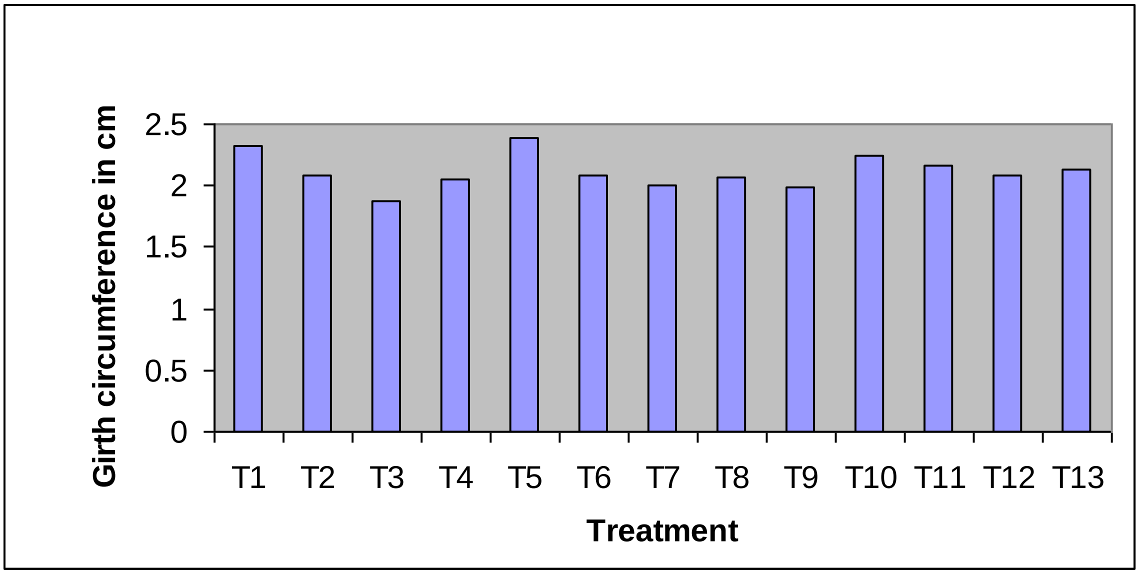

Figure 6. Plant girth of jute at 103 DAS as affected by different jute+amathanth/jute production systems

4.7. Number of jute plants in one linear meter

There was significant variation as observed in the number of jute plants in 1 m. Treatment T_1 (10.00) showed the highest value but treatment T_6 (9.67) showed statistically similar result. The lowest value was showed by T_5 (6.00).Treatment T_2, T_3, T_9, T_{13} were showed statistically similar results. Again, T_{10}, T_{11}, T_{12} were statistically similar. Similarly, the rest of T_4, T_5 & T_8 were also statistically similar.

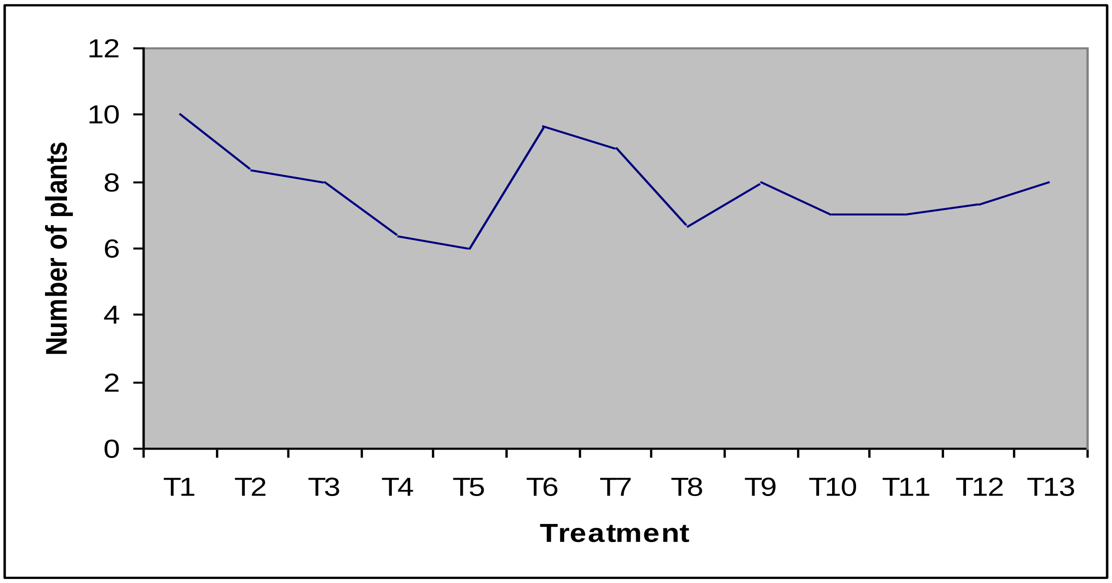

Figure 7. Number of plant in one linear meter affected by different jute+amathanth/jute production systems

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4.8. Height of 3 jute plants at 60 DAS

Height of jute plants was showed significant variation. The highest value was shown by T_7 (225.10cm) which indicates the best result and T_4 (220.00cm), T_{10} (218.90cm) were statistically similar with T_7. The lowest value was showed by T_{12} (173.90cm). The height of T_1, T_3, T_5 & T_9 were statistically similar. Again, $T_{6,}T_8$ & T_{11} were statistically similar. Similarly, the rest of T_2 & T_{13} were also statistically similar

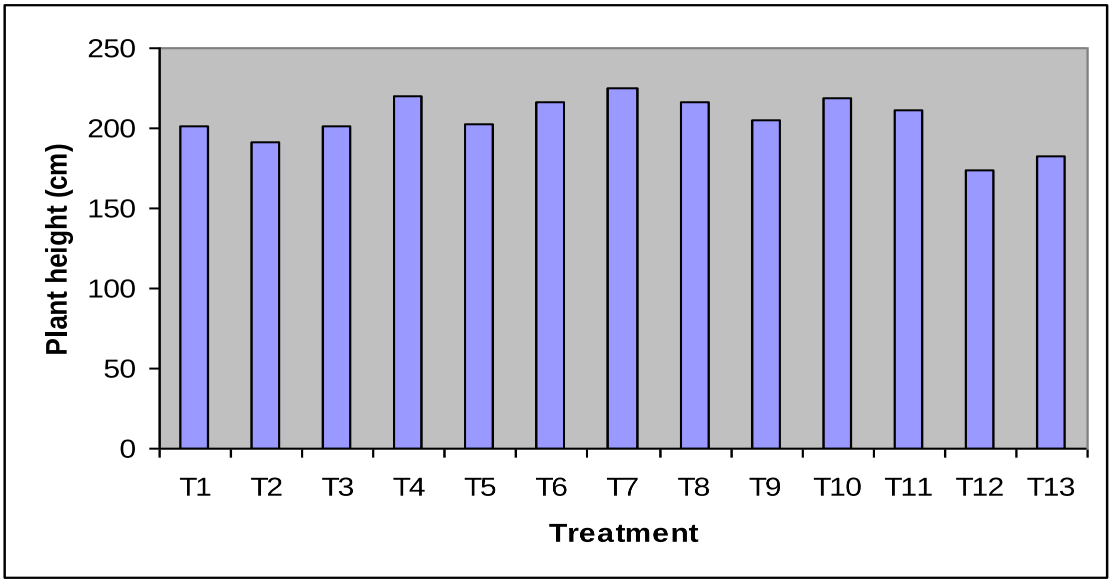

Figure 8. Plant height of jute (cm) at 60 DAS as affected by different jute+amathanth/jute production systems

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4.9. Average plant dry weight of stick of 10 jute plants

Dry weight of stick of jute plants was shown to have significant variation. The maximum value was showed by T_1(8.16g) & the minimum value was showed by T_8 (3.23g)Dry weight of T_4, T_5, T_7, T_{11}& T_{10} were statistically similar. Again, $T_{3,}$ T_9 & T_{12} were statistically similar. Similarly, the rest of T_2 & T_6 were also statistically similar.

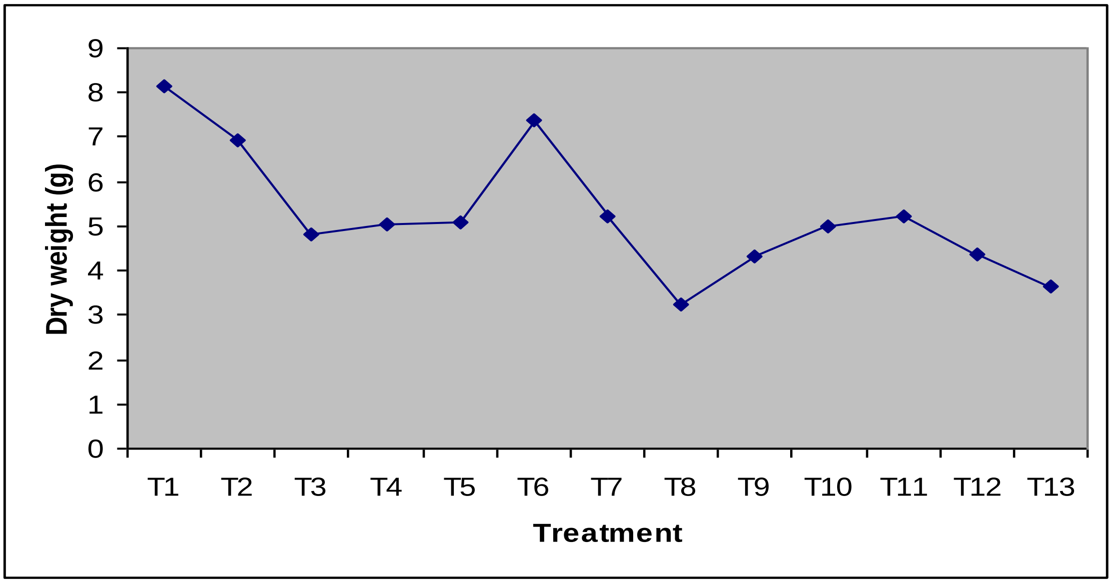

Figure 9. Dry weight of jute stick (g) as affected by different jute+amathanth/jute production systems

4.10. Average plant dry weight of fiber of 10 jute plants

Fiber dry weight of jute plant had significant variation among themselves. Maximum value was showed by T_1 (15.65) & the minimum value was showed by T_8 (6.82). Dry weight of fiber of T_{10} (15.27) was statistically similar with t_{10}.

Dry weight of fiber of T_3 (8.50), T_9 (8.61), T_{12} (8.32) & T_{13} (7.49) was statistically similar with t_8. Dry weight of T_2, T_4, T_5, & T_6 were statistically similar. The rest lower values of T_7 & T_{11} are also statistically similar.

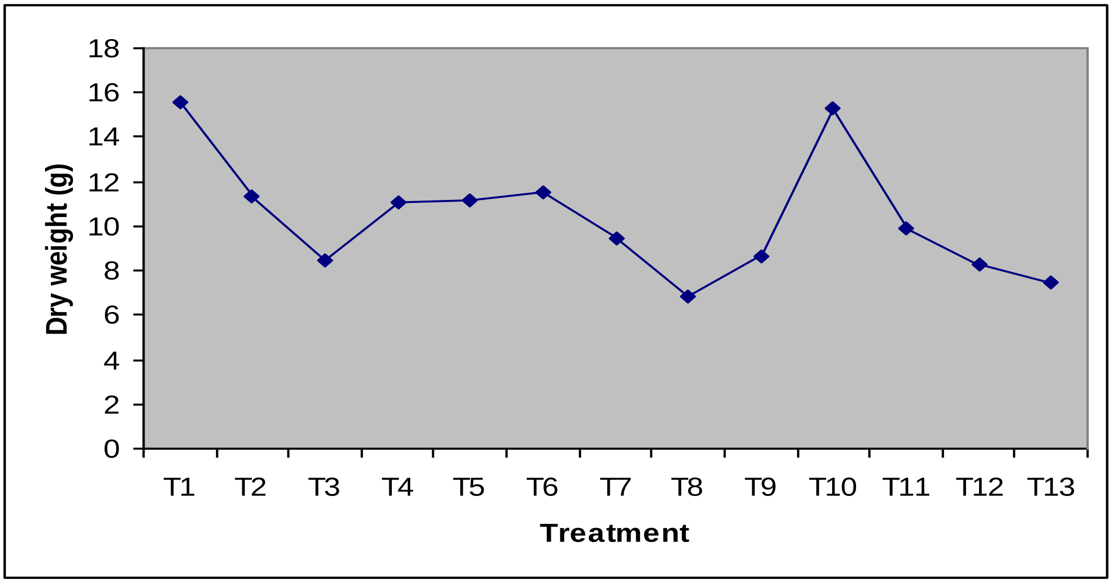

Figure 10. Dry weight of jute fiber (g) as affected by different jute+amathanth/jute production systems

4.11. Per hectare dry weight of jute stick

This character showed significant variations due to treatments. Highest value was T_{11} (4.464) & lowest value was obtained by T_3 (1.860). Treatment T_4, T_5, T_8, T_7 & T_{12} were showed statistically similar results and the rest lower values of T_1, T_2 & T_{10} were also showed statistically similar results (table 1).

4.12. Per hectare dry weight of jute leaves at maturity

Leaves dry weight of jute plant showed significant variations. Maximum value was showed by T_{11} (1.570) & the minimum value was showed by T_3 (0.833). Dry weight of T_2 & T_{10} were statistically similar. Again, Dry weight of T_4, T_7, T_8 & T_9 were statistically similar. Rest treatments were found to be statistically similar in this respect (table 1).

4.13. Per hectare dry weight of jute fiber at maturity

Leaves dry weight of jute plant was seed to have significant variations. Maximum value was showed by T_{11} (3.160) & the minimum value was showed by T_{13} (1.775). Dry weight of fiber of T_3 (1.813) was showed statistically similar results with T_{13}. Dry weight of T_1 , T_5, T_6, T_{10} & T_{12} were statistically similar. Rest treatments were statistically similar in this respect (table 1).

Table 1: Per hectare stick dry weight, leaf dry weight and fiber dry weight of jute (t) as affected by different jute+amathanth/jute production systems

Treatment	Stick dm (t/ha)	Leaf dm (t/ha)	Fiber dm (t/ha)	Total biomass (t/ha)
T_1	5.870ab	1.819ab	3.714ab	11.403
T_2	4.423abc	1.778ab	2.695ab	8.896
T_3	1.860d	0.833b	1.813b	4.507
T_4	3.033abcd	1.110ab	1.942ab	6.085
T_5	2.818abcd	1.140ab	2.073ab	6.031
T_6	3.645bcd	1.866ab	3.703ab	9.214
T_7	3.957abcd	1.485ab	2.700ab	8.142
T_8	3.113abcd	1.176ab	2.200ab	6.489
T_9	2.349cd	1.314ab	2.291ab	5.954
T_{10}	3.701abc	1.488ab	2.713ab	7.902
T_{11}	4.464a	1.570a	3.160a	9.194
T_{12}	3.457abcd	0.896ab	2.981ab	7.334
T_{13}	3.387abcd	1.076ab	1.775b	6.237
LSD 0.05%	6.67	2.91	5.80	
CV(%)	8.09	13.11	13.44	

4.14. Harvest index (%)

Harvest index of jute was significantly affected by different intercropping pattern. Maximum harvest index (34.37) was obtained from T_5 & lowest harvest index (28.45) was obtained from T_{13}.

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Table 2. Showing harvest index

Treatment	Harvest index%
T_1	32.57038d
T_2	30.29451cd
T_3	40.23524cd
T_4	31.91454cd
T_5	34.37241a
T_6	40.18884bcd
T_7	33.16139cd
T_8	33.90353cd
T_9	38.47833abc
T_{10}	34.33308cd
T_{11}	34.37024cd
T_{12}	40.6463ab
T_{13}	28.45e
LSD 0.05	6.01
CV%	9.60

4.15. Length of amaranth (cm) at 34 DAS

Length of amaranth was affected significantly. The highest value was obtained by T_4 (27.00) and the lowest value was obtained by T_{11} (19.23). The length of 25.28cm , 25.10cm, 24.90cm & 24.28cm were obtained by T_{10},T_9,T_{13} & T_7 respectively which were statistically similar. The rest of 22.67 cm and 21.90 cm length of amaranth were obtained by T_8 & T_6 respectively which were also statistically similar.

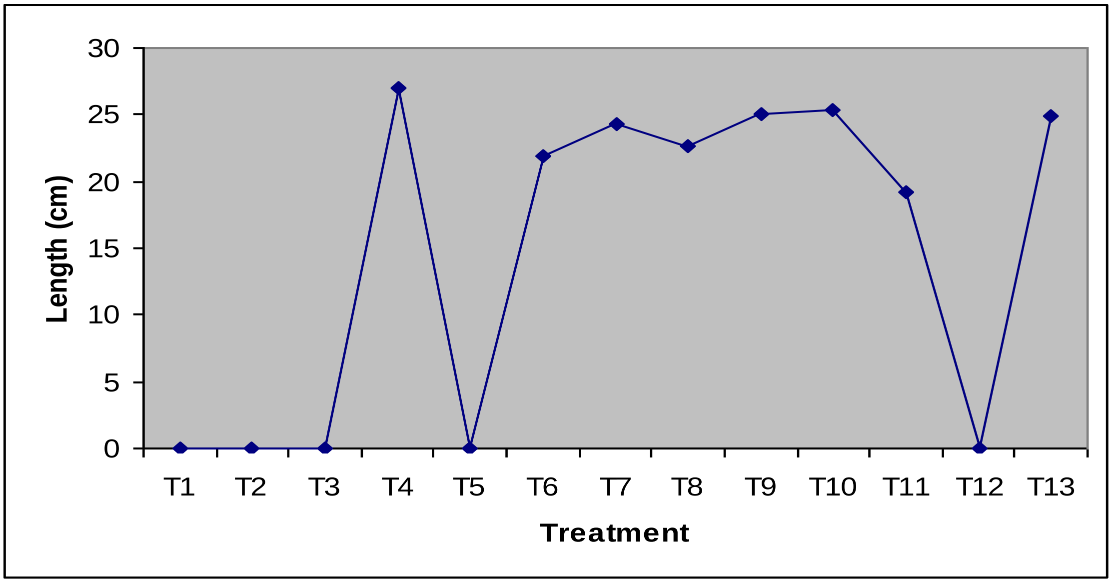

Figure11.Length of green amaranth at 34 DAS as affected by different jute+amathanth/jute production systems

4.16. Per plant dry weight of 3 amaranth plants

Leaves dry weight of 3 amaranth plant had significant variation. Maximum value was showed by T_4 (15.25) & the minimum value was showed by T_{13} (3.22). Dry weight of plants of T_8 (3.5) & T_9 (3.29) was showed statistically similar results with T_{13}. Rest treatments were statistically similar in this respect (Figure 12).

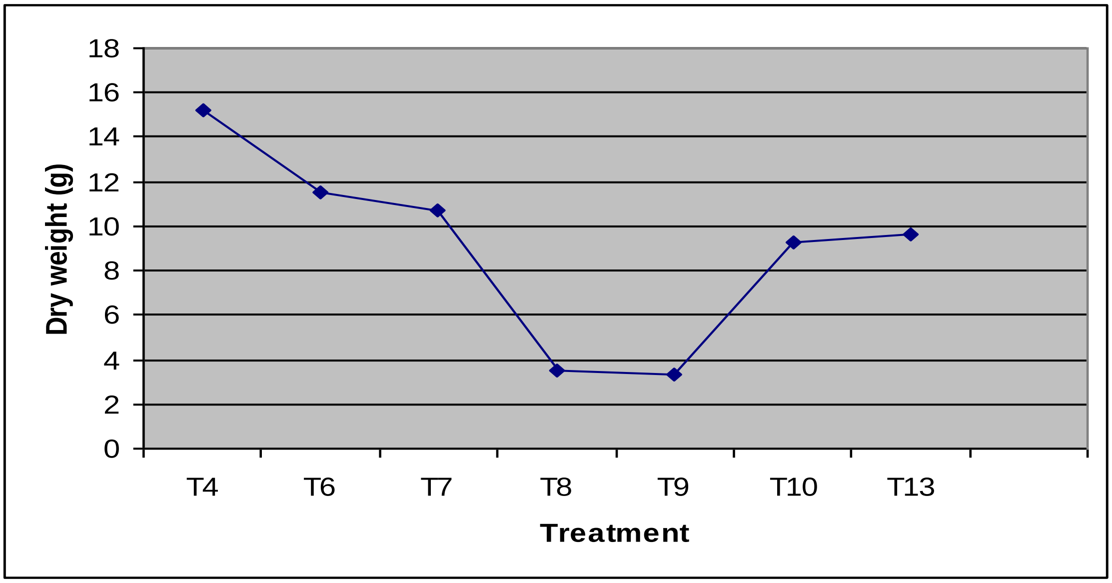

Table 12. Showing per plant dry weight of 3 amaranth plants

4.17. Common cost/ha

Common cost of all treatments are same.

4.18. Cost for thinning

Highest cost of thining of TK. 750/ha was found in treatment T_3, T_5,T_7,T_8,T_9,T_{13} and the lowest value tk.250/ha was obtained by T_4, T_{10},T_{12}.

4.19. Weeding cost

Highest weeding cost tk.9000/ha was found in treatment T_1 and the lowest value tk.300/ha was found in treatment T_8,T_9,T_{10}.

4.20. Total cost for harvesting

Highest total cost of harvesting tk.3500/ha was found in T_8, T_9, T_{13} and the lowest value tk.3000/ha was obtained by T_1.

4.21. Total cost

Highest total cost of tk.67421/ha was found in T_1 and the lowest cost tk.58571/ha was obtained by T_{10}.Other treatments showed more or less similar results.

Table 3. Per hectare costs for different production and harvesting practices (Tk/ha) as affected by different jute+amathanth/jute production systems

		Extra cost/ha for			
	Common Cost/ha	Thinning	Weeding	Harvesting total jute plus sak	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

Price of fiber = Tk.40.00/kg,Price of jute sak Tk.5/kg, Price of amaranth Tk.25/kg

4.22. Value of fiber

Highest value of fiber of TK. 148578/ha was found in treatment T_1 and T_6 was also showed high value of tk.14813/ha. The lowest value tk.71004/ha was obtained by $T_{13.}$

4.23. Value of jute stick

Highest value of fiber of TK. 5870/ha was found in treatment T_1 and the lowest value tk.1860/ha was obtained by $T_{3.}$

4.24. Value of jute sak

Highest value of fiber of TK. 2127/ha was found in treatment T_{11} and the lowest value tk.774/ha and tk. 775/ha was obtained by $T_{8.}$

4.25. Value of green amaranth

Highest value of fiber of TK. 1045/ha was found in treatment T_{10} and the lowest value tk.18/ha was obtained by $T_{1.}$

Table 4. Per hectare returns from different items (Tk/ha) as affected by different jute+amathanth/jute production systems

Treatment	Value of fiber (Tk. ha^{-1})	Value of jute stick (Tk. ha^{-1})	Value of jute sak (Tk. ha^{-1})	Value of amaranth sak (Tk.ha^{-1})
T_1	148578	5870	918	
T_2	107815	4423	808	
T_3	72533	1860	775	
T_4	77689	3033	1805	426
T_5	82933	2818	1364	
T_6	148136	3645	1533	804
T_7	108000	3957	1281	504
T_8	88000	3113	774	875
T_9	91627	2349	2308	931

Treatment	Value of fiber (Tk.ha^{-1})	Value of jute stick (Tk.ha^{-1})	Value of jute sak (Tk.ha^{-1})	Value of amaranth sak (Tk.ha^{-1})
T_{10}	108516	3701	1392	1045
T_{11}	126404	4464	2127	18
T_{12}	119224	3457	2035	
T_{13}	71004	3387	808	1004

ECONOMIC ANALYSIS

4.26. Gross return

The gross return in jute-amaranth intercropping under different row arrangement shown in (Table 5). It was found that the intercropping treatments always gave better gross return than the sole crops. So, it was clear that in the intercropping treatments the gross return was better than the sole cropping practices.

4.27. Net return

Net return over variable cost was found encouraging in the intercropping treatments. Out of the intercropped treatments the highest net return (94997.00 Tk/ha) was found in T_6 followed by T_{11} & T_1. These were mainly due to higher yield of jute and higher market price of amaranth (Table 7).

4.28. Benefit - cost ratio

Benefit cost ratio was significantly affected by different intercropping patterns. When benefit-cost ratio of each treatment was examined it was found that the treatment T_6 gave the highest benefit cost ratio (1.61) which was statistically different from other treatments. The second maximum benefit-cost ratio (1.30) was obtained from T_1. The lowest ratio was given by T_3 (table 5).

Table 5. Showing the gross return, net return, benefit cost ratio of different intercrop treatments.

Treatment	Gross return (Tk.ha^{-1})	Net income (Tk.ha^{-1})	Benefit cost ratio
T_1	155366	87945	1.30
T_2	113046	53400	0.90
T_3	75168	15697	0.26
T_4	82953	23982	0.41
T_5	87115	27744	0.47
T_6	154118	94997	1.61
T_7	113742	54371	0.92
T_8	92762	33291	0.56
T_9	97215	37744	0.63
T_{10}	114654	56083	0.96
T_{11}	133013	74142	1.26
T_{12}	124716	65845	1.12
T_{13}	76203	16432	0.27

Chapter 5
SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka, during the period of April 2013 to August 2013 to study the weed suppression in jute field by growing leafy vegetable amaranth. Thirteen treatments of different intercropping pattern were conducted. The experiment was conducted in randomized complete block design with 3 replications. The experiment materials included one recommended variety of Jute (O-72) & one variety of Amaranth (BARI danta 2).The land preparation was done by a power tiller followed by harrowing, which was again ploughed twice by a power tiller & leveled by laddering. The recommended seed rate of jute was 7 kg/ha while that of amaranth was 5 kg/ha. Seeds of both crops were sown in 13th May 2013 & harvested at required maturity (jute for fiber & amaranth for vegetable purpose).

Crop characters, yield of jute and amaranth were made. Economic performance of the treatments was also evaluated. The data were statistically analyzed & means were compared by least significant difference (LSD).

The results of the experiments showed that of the crop characters and yield of both jute and amaranth were significant due to effect of intercroppping. The highest plant height of jute was obtained by T_6 (267.50) which was Jute 30 cm apart + one amaranth line between two adjacent jute row and the lowest value was obtained by T_3 (167.40) which was Jute 30 cm + jute broadcast between two adjacent jute lines. The highest plant height of amaranth was obtained by T_4 (27.00) which was Paired row jute 15 cm apart + 4 rows amaranth 15 cm apart between two adjacent paired rows of jute and the lowest value was obtained by T_{11} (19.23) which was Paired row jute 15cm apart + 3 rows amaranth between two adjacent paired rows of jute. Again T_5 (Paired row jute 15 cm apart + broadcast jute between two adjacent paired rows of jute) showed the highest girth circumference 2.38 and T_3 showed the lowest girth circumference 1.87.

T_{11} (Paired row jute 15cm apart + 3 rows amaranth between two adjacent paired rows of jute) showed the best significant results for dry weight of stick (57.39), leaves (20.19) and fiber (40.63) of 3 jute plants & T_4 (Paired row jute 15 cm apart + 4 rows amaranth 15 cm apart between two adjacent paired rows of jute) showed maximum results 15.25g for the dry weight of 3 amaranth plants.

Maximum harvest index 34.37% was obtained by T_5 (Paired row jute 15 cm apart + broadcast jute between two adjacent paired rows of jute) and the lowest value 28.45 was obtained by T_{13} (mixed jute 6 kg ha^{-1} and amaranth 8 kg ha^{-1}).

Significantly higher jute fiber yields were obtained in T_1, and T_6 (over 3.7 t ha^{-1}). Significantly greater harvest indices were obtained from T_3, T_6, T_9 and T_{12} (around 40%). The highest costs in respect of weeding (9000 Tk.ha^{-1}) and total costs was obtained with T_1 (76421 Tk.ha^{-1}). T_1 and T_6 showed identical value of jute fiber (over 148000 Tk.ha^{-1}) with the greatest cost in T_1. T_1 and T_6 also showed higher total returns (over 154000 Tk.ha^{-1}). However, the highest net income was obtained with T_6 (94997 Tk.ha^{-1}) along with the highest Benefit cost ratio (1.61).

Due to some climatic reasons & emergence failure of amaranth I could not get the appropriate intercrop results. If my experiments would succeed then I thought T_1 (Control, jute only, spacing 30 cm) & T_6 (= Jute 30 cm apart + one amaranth line (as leafy vegetable) between two adjacent jute row) would be the best treatment.

However, although intercropping has been used traditionally for thousands of years, it is poorly understood from an agronomic perspective. Intercropping system are more challenging to manage than pure stands. So more research is needed for better understanding regarding how to intercrops function & how to develop intercropping systems that are compatible with present farming system.

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APPENDICES

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

A. Physical composition of the soil

Soil separates	(%)	Method employed
Sand	36.90	Hydrometer method (Day, 1995)
Silt	26.40	do
Clay	36.66	do
Texture class	clay loam	do

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

B. Chemical composition of the soil

Sl.	Soil Characteristics	Analytical data	Method employed
1.	organic carbon (%)	0.82	Walkly and Black, 1947
2.	Total N (kg/ha)	1790.00	Bremner & Mulvaney, 1995
3.	Total S (ppm)	225.00	Bardsley and Lancster, 1965
4.	Total P (ppm)	840.00	Olsen and Sommers, 1982
5.	Available N (kg/ha)	54.00	Bremner, 1965
6.	Exchangeable K (kg/ha)	89.50	pratt, 1965
7.	Available S (ppm)	16.00	Hunter, 1984

8.	Ph (1:2.5 soil to water)	5.55	Jeckson, 1958
9.	CEC	11.23	Chapman , 1965

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

Appendix-Il. Monthly Temperature, Rainfall and Relative humidity of the experiment site during the period from April 2013 to August 2013

Year	Month	Air Temperature (0c)			Relative (humidity (%)	Rainfall (mm)
		Maximum	Minimum	Mean		
2013	April	34.44	23.96	29.20	68.08	90.01
	May	33.23	24.11	28.67	86.13	279.9
2013	June	35.12	27.24	31.18	90.27	302.9
	July	31.4	25.8	28.6	81	542
	August	32.0	26.6	29.3	82	361

Source: Bangladesh Meterological Department (Climatic Division), Agargaon, Dhaka-1207