INTERCROPPING MAIZE WITH CHICKPEA, GRASS PEA, MUNGBEAN AND GROUNDNUT

MD. NAZMUL HASSAN SUMUN

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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INTERCROPPING MAIZE WITH CHICKPEA, GRASS PEA, MUNGBEAN AND GROUNDNUT

By

MD. NAZMUL HASSAN SUMUN
Reg. No. 05-01783

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APPROVED BY:

(Prof. Md. Sadrul Anam Sardar) **Supervisor**	**(Prof. Dr. Md. Fazlul Karim)** **Co-Supervisor**

(Prof. Dr. A. K. M. Ruhul Amin)
Chairman
Examination Committee

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Ref: *Dated:*

CERTIFICATE

This is to certify that the thesis entitled, **"Intercrop Maize With Chickpea, Grass pea, Mungbean and Groundnut"** 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 **MD. NAZMUL HASSAN SUMUN,** Registration No. **05-01783** 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 of during the course of this investigation has been duly acknowledged.

Dated: June 2011

Place: Dhaka, Bangladesh

(Md. Sadrul Anam Sardar)
Professor
Department of Agronomy
Sher-e-Bangla Agricultural University
Supervisor

DEDICATED TO

MY

BELOVED PARENTS

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The Author

INTERCROPPING MAIZE WITH CHICKPEA, GRASS PEA, MUNGBEAN AND GROUNDNUT

ABSTRACT

An experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from December, 2010 to May, 2011 to study the influence of intercropping system in maize with chickpea, Grass pea, Mungbean, and Groundnut. The trial was layed out in a Randomized Complete Block Design (RCBD) with 3 replications. The experiment comprised of nine treatments viz, T_1= Sole maize, T_2= Sole chickpea, T_3= Sole Grass pea, T_4= Sole Mungbean, T_5= Sole Groundnut, T_6= Maize Paired row + 2 rows of chickpea, T_7= Maize Paired row + 2 rows of Grass pea, T_8= Maize Paired row + 2 rows of Mungbean, T_9= Maize Paired row + 2 rows of Groundnut. The collected data were statistically analyzed and the means were adjudged by LSD at 5% level of significance. In case of maize the tallest plant, highest number of cob/plant, cob length, cob diameter and yield was recorded in treatment T_1 (sole maize) where as the highest thousand grain weight was obtained from T_7 & T_8 i.e. maize intercrop with Grass pea and Mungbean respectively. In intercropped plants though the highest yield and best yield contributing characters except 1000 seed weight were from sole crop shall the intercrop performed better in terms of economic contributing characters. Maize Paired row + 2 rows of Mungbean showed better relative yield of maize than other intercropping systems. All the intercropping systems showed higher net return than sole maize or sole other intercrop. The highest net return (Tk 84200 ha^{-1}) was recorded from T_6 though higher cost was involved and was followed by T_8 (Tk 79500 ha^{-1}). The highest BCR (2.95) was obtained from T_6 followed by T_7 (2.94) and T_8 (2.93).So in this study intercropping paired rows of maize + two rows of chickpea would agronomically feasible and economically profitable (i.e., maize equivalent yield, LER, relative yield, gross return, net return, BCR etc).

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SOME COMMONLY USED ABBREVIATIONS AND SYMBOLS

ABBREVIATION	FULL WORD
%	Percent
°C	Degree Celsius
@	At the rate
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BD	Bangladesh
BCR	Benefit Cost Ratio
cm	Centi-meter
CV%	Percentage of Coefficient of Variation
DAS	Days After Sowing
df	Degrees of Freedom
et al.	And others
etc.	Etcetera
FAO	Food and Agricultural Organization
g	Gram (s)
GN.	Genotype Number
HI	Harvest Index
hr.	Hour (s)
j.	Journal
kg	kilogram (s)
LER	Land Equivalent Ratio
m	Meter
M.P.	Muriate of Potash
NS	Not Significant

SOME COMMONLY USED ABBREVIATIONS AND SYMBOLS

ABBREVIATION	FULL WORD
RCBD	Randomized Complete Block Design
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
t/ha	Tons per hectare
T.S.P.	Triple Super Phosphate
Univ.	University
WP	Wetable powder
YPP	Yield per plant

Chapter I

Introduction

Chapter 1
INTRODUCTION

Maize *(Zea mays* L.) is one of the leading cereals of the world. It originates from sub-tropical regions, probably from the highlands of Mexico and today is a leading crop in many temperate regions (Miedema, 1982). Maize area is increasing in Bangladesh for its diversified use, higher yield potentiality and well fitted in existing agro-climatic condition and cropping patterns. Chickpea, Grass pea, Mungbean are pulse crop and Groundnut is oil seed crop. Probably they are originated from South-West Asia and it is distributed throughout Asia and Europe. These crops are important grain legume with high value of protein. Also are important source of human food as well as animal feed and helps in managing soil fertility (Sharma and Jodha, 1984).

There are many established and speculated advantages for intercropping system such as higher grain yields, greater land use efficiency and improvement of soil fertility by the component legume crops (Willey, 1979a) The main advantage for the use of legumes in intercropping and mixed cropping is as the saving of N-fertilizer. To popularize maize and avoid competition with other crops, intercropping is a good technique where farmers may produce maize with other crops (pulses, oilseeds, vegetables etc.). Pulses can mobilize organic P in both hydroponic and soil cultures, leading to an site-specific facilitation in utilization of organic P in intercropping (Li *et al*., 2004). In the tropical and sub-tropical regions, cereal-legumes intercropping are the most popular practices because of its many additional advantages (Willey, 1979 a; Karim *et al*., 1990). Intercropping becomes more productive and economic when both the crops differ with genetic makeup, photosynthetic pathway, growth habit, growth duration and demand of different growth resources (Fukai, S and Tenbath, B.R. 1993). Intercrop productivity also depends on the light availability within the canopy of component crops (Isoda et al., 1992; Takahashi, T. and Nakaseko, K. 1993). Therefore, crop selection should be done in such a way that maximum light might be intercepted by the intercropped canopy for higher biomass and economic productivity. Sustainability of intercropping system depends on many factors such as production potential of component crops, cost of production and market prices of the commodities. Despite many advantages of cereal-legumes intercropping system all crop combination are not equally profitable (Shah *et al.*, 1991). Instead of uniform row of maize, paired row planting of maize is an advantageous management which ultimately improves the gross return by accommodating different legume crops between the wider spaces of paired maize rows. Sorghum gave maximum yield and monetary advantages when grown between paired rows of maize. The component crops being grown in wider spaces of paired row system enable the plants to utilize efficiently the soil nutrients and solar radiation (Singh, 1981). In cereal-legume intercropping system, legumes are considered as nitrogen economy and favored the yield of component crop. However, the extents of biological nitrogen fixation of different legume are not generally same in a particular environment and often varied with the change of crop environments. The quantity of nitrogen fixed by the legumes component in cereal-legume intercropping system depends on species, morphology and the competitive abilities of the component crops (Ofori and Stern, 1987). Therefore, the quantity of nitrogen saved by different legumes also determines the economics of cereal-legume intercropping systems.

Sufficient information on maize-legume intercropping system is not available in our country as there is a lot of research information on cereal-legume intercropping systems in different countries.

Therefore, the research work has been under taken keeping in mind the following objectives:

1. To study the influences of different maize-legume intercropping combination on yield and yield attributes of maize-legume intercropping system in Bangladesh and
2. To observe the economic performance of maize-legume intercropping system.

Chapter II

Review of Literature

Chapter 2
REVIEW OF LITERATURE

The experiment was carried out to study the performance of intercropping system of maize with chickpea, grass pea, mungbean and groundnut. The research works related to the present study are scanty in Bangladesh although some relevant researches have been done in other countries of the world. Thus, the research works relevant to the present study have been reviewed and presented in this chapter:

Jahansooz *et al.* (2007) recorded that the lack of a yield advantage of mixed cropping with poor canopy development and low yielding capacity of chickpea; it was unable to compensate for its reduced population density in the mixture. Grain yield of chickpea in the mixed crop (chickpea-maize) averaged just 29% that of its solo crop (chickpea-sugarcane), whereas wheat grown in mixture (wheat-maize) produced 72% the yield for wheat- sugarcane. Supplementary irrigation from early spring onwards in 1995 increased yield for chickpea-maize by 44% over that of chickpea-sugarcane, while yield for wheat-maize fell to 65% that for wheat-very millimeter of irrigation water increased yield by 10.0, 3.8 and 12.5 kg ha^{-1}for wheat- sugarcane, mixed crop and chickpea- sugarcane, respectively. Mixed cropping did not affect the time taken by either wheat or chickpea to attain maximum growth rate, flowering or maturity. The land equivalent ratio (LER) based on grain yield for wheat-chickpea intercropping were 1.01 in 1994, 1.02 without irrigation in 10 with irrigation in 1995. Neither radiation-use-efficiency nor water-use-efficiency was improved by mixed cropping compared with wheat- sugarcane. The poor performance of the mixed crop was ascribed to its poor canopy development early, in the season, especially by the chickpea that resulted in low intercepted PAR and transpiration. it is concluded that there was no advantage of growing wheat and Chickpea in mixed crops in southern cereal belts of Australia if total biomass or grain yield is the primary purpose.

For increasing land use efficiency and weed suppression intercropping plays a pivotal role. A field experiment was carried out on wheat *(Triticum aestivum* L. emend. Fiori and paol) chickpea *(Cicer arietinum* L.) mono- and intercropping with various weeding (0, 1, or 2 hand-weeding operations) and row spacing (20 or 30 cm) treatment in the eastern plateau region of India over consecutive five winter seasons. Chickpea yield was significantly reduced by wheat when intercropped. However total productivity and land use efficiency were higher under the intercropping system as compared to monocrops of either species. There was a significant reduction in weed density and biomass for the intercropping system over both monocrops. Wheat facilitated an increase in nodule number and dry weight in chickpea under intercropping over monocrops, moreover, root length of chickpea was greater when intercropped. These findings suggest that intercropping wheat and chickpea increase total productivity per unit area, improve land use efficiency and weeds, a menacing pest in crop production. Considering the experimental finding wheat-chickpea (30 cm) with two weeding may be recommended for yield advantage, higher net income, more efficient utilization of resources, and weed suppression as a biological control in eastern plateau region of India (Banik *et al*, 2006).

Singh *et al.* (2006) reported that seed treatment (wheat) and wider row spacing (wheat and lentil) resulted in a definite and consistent increase in yields as compared to untreated seed and closer spacing, respectively. Fertilizer and weed management were an important aspect for increasing overall crop productivity. Intercropping of 'raya' rainfed rabi crops viz. wheat, lentil and chickpea increased the crop yield by 10-25%, clearly elucidating the beneficial advantage of intercropping under rainfed conditions.

Maize cv. H-216 was intercropped with different combinations of chickpea cv. JG-315 indian mustard cv. Pusa Bold black gram *(Vigna mungo)* cv. DPU-88-31, soybean cv. JS-335 and sesame cv. Krishna in a field experiment was conducted in Madhya pradesh India during the 1997-99. Intercropping maize with soybean and chickpea resulted the highest mean maize equivalent yield during 1997-1998 (124.24) and and 1998-99(95.33) and the highest gross monetary returns (Rs. 35,318), net monetary returns (Rs. 25.468), land use efficiency (61.5%), production efficiency (Rs. 101.7/ha/day The highest benefit cost ratio (2.85) was observed in intercropping maize with black gram and chickpea (Thakur, 2003).

Yield and nutrient acquisitions by intercropped wheat, maize and soybean were all significantly greater than for sole wheat, maize and soybean with the exception of K acquisition by maize. Intercropping advantages in yield (40-70% for wheat intercrop with maize and 28-30% for wheat intercropped with soybean) and in nutrient acquisition by wheat resulted from both the border and inner-row effects. The relative contribution to increasing biomass was two-thirds from the border-row effect and one-third from the inner-row effect. Similar trends were noted for N, P and K accumulation. During the crop growth period, lasting for about 80 days from maize or soybean emergence to wheat harvesting, yield and nutrient acquisition by intercropped wheat increased significantly while those by maize or soybean intercropped with wheat decreased significantly. Comparison of overall N and K acquisition by intercropping weighted means of those of sole cropping revealed interspecific facilitation in nutrient acquisition during crop growth (Li *et al.*, 200la).

Three field experiments were conducted at Baiyun in 1997 and at Jingtan in 1997 and 1998 to test the hypothesis in wheat/maize and wheat/soybean intercropping. The rates of dry matter accumulation in the intercropped maize (10.0-20.1 g/m^2 per day) were significantly lower than those in the sole maize (17.1-34.8 g/m^2 per day) during the early stage from 7 May to 3 August, while mostly intercropped with wheat. After 3 August, however, the rates of intercropped maize, increasing to 58.9-69.9 g/m per day significantly greater than in sole maize (22.7-51.8 g/m^2 per day) at Baiyun site in 1997 and nutrient acquisition showed the same trends as growth. At Jingtan site in 1998, the disadvantage of the border row of intercropped maize resulted from interspecific competition diminished after wheat harvest and disappeared at maize maturity. It was concluded that there was indeed recovery of growth after wheat harvesting in wheat/maize and wheat/soybean intercropping. However, the recovery was under N_oP_o treatment. The interspecific competition, facilitation and recovery are together contributed to yield advantage of intercropping (Li *et al.*, 2001).

A study was conducted in South Africa during the 1998-1999 seasons to evaluate the performance of pigeon pea cultivars with varying maturity periods, with maize in 2 intercropping systems (alley planting and same row planting systems). Short-duration (SD) maize components EWF-2 was intercropped with SD pigeon pea cultivars ICPL 87091 and ICPL 87105 in one trail, and with medium-duration (MD) and long-duration(LD) cultivars ICPL 6927 and ICEAP 00040, respectively, in a second trail. Yield of both crops in intercropping systems were generally lower than in monocropping systems. Significant yield reduction was observed under alley intercropping for LD and MD cultivars. Average land equivalent ratio was the same (1.24) in both systems in the SD trail, while LER in the LD-MD trail was 1.37 under alley intercropping and 1.77 under same row intercropping (Mathews *et al.*, 2001).

The question of the impact of chickpea genotypes differing in potential N fixation on system performance of a chickpea-wheat rotation under dry land conditions is addressed. The results showed the trade-off between the gains or losses in chickpea and wheat yields by introducing chickpea with different traits into the rotation (Robertson *et al.*, 2000).

It was reported 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 (Singh *et al.*, 1988).

Patra *et al.* (1999) observed the increase number of cobs per plant due to temporal complementary in maize-legume association. They also reported that the yield of all the intercrops with maize decreased compared with their sole crops. More shading effect from maize particularly at 1:1 row ratio its early vigor might be reduced the yield of intercrop.

Patra *et al*. (1990) reported that association of soybean gave the highest combined yield at both the row ratios, whereas the association between maize and sesame recorded the lowest combined yield due to severe competition. In cereal-legume intercropping system, yield Induction of legumes has been reported in almost all cases. It has been observed that the yield of both the crops reduce when intercropped, but combined yield could be higher. It was observed that the yield of legume is usually more depressed in mixed cropping than that of non-legume (Akinola *et al.,* 1971).

An experiment was conducted to study the effect of planting system of maize with rows of groundnut grown as mono and intercrop. Maximum grain yield of maize (2.96t/ha) was obtained from monoculture in uniform row which was identical to maize, uniform row with two or three row groundnut. Higher maize and groundnut equivalent yield was found in uniform 3 or 6 paired rows of groundnut. Both the former and the later combination gave higher LER (1.44) and net return of Tk. 8719 and 8502/ha, having same befit cost ratio (Karim *et al.,* 1990). The magnitude of yield advantage of intercroping system could be determined by the use of LER value (Ofori and Stern, 1987).

The concept of LER or relative yield total assumed an important way in evaluating the benefit of intercropping of two dissimilar crops grown in the same field (Fisher, 1977). If LER is more than 1.00 then intercropping gives agronomic advantages over monoculture practice. The higher is the LER, the more is the agronomic benefit of intercropping systems (Palaniappan, 1988).

When intercropped maize with legumes, the highest LER (1.74) was obtained from maize + fieldpea combination (Uddin and Sattar, 1993). Maize + frenchbean in row ratio of 1:2 recorded the highest LER (1.61) and lowest LER (1.07) was found in maize + greengram system in 3:1 ratio (Pandita *et al*., 1998). The above values indicated that intercropping system is more efficient in utilizing resources and resulted higher productivity than the sole cropping.

An intercropping experiment with maize and mungbean under different planting patterns and row orientation was conducted where higher maize yield was obtained from intercropping system (Dhingra *et al*, 1991).

Singh (1978) and Reddy and Reddy (1981) did not observe any adverse effect of maize yield due to intercropping with legumes.

Singh *et al.* (1986) conducted an intercropping experiment with maize, soybean and black gram under varying condition and nitrogen levels and concluded that yields of the mixed stand with maize at 50,000 plants/ha were higher than maize at 37500 or 75000 plants/ha.

Quayumi *et al.* (1987) conducted an experiment on intercropping maize at row distance 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 25 ×25cm with two rows of chickpea produced the highest total maize equivalent yield of 5590kg/ha. It was 22% higher than the yield of sole crop of maize. Two combined, maize + chickpea, gave the highest net return of Tk 12803.00/ha and the highest LER x LER of 135 indicating that the mixture was 35% more efficient in terms of land utilization than a sole crop of maize.

Kalra and Gangwar (1980) reported that total productivity was increased by 29 to 37.5 present with the application of nitrogen @ 80-120 kg/ha as compared with 40 kg/ha in an intercropping system of maize and legume. They also reported that the application of 80 kg N/ha was economically profitable. In an experiment, Gangwar and Kalra (1984) found that maize intercropped with legume and fertilized with 120 kg N/ha gave more yield than the application of 80 kg N/ha.

Various special arrangements of maize (*Zea mays* L.) were tried in attempt to improve grain yield of soybean [Glycine max (L.) Merr.] Intercropping in the same row without substantially reducing the maize yield. The experiment was conducted in 1980 and 1981 in Iowa; U.S.A. Intercropping reduced soybean yields by 87% compared with solo cropping, principally because of reduced plant growth and pod set. Harvest index of soybeans was not altered. Compared with a 70 cm×30 cm(row x intra-row) plant arrangement, grouping maize plants two or three to a hill in wider intra-row (70 cm x 60 cm), and (70 cm x 90 cm) improved soybean growth and pod set, reduced its lodging, and allowed greater seed yield. Widening rows to 87cm and 105cm failed improve soybean performance.

Improve maize growth, as a consequence of a 135 kg/ha N application, reduced intercrops growth and yield. Intercropping without applied N did not reduce maize yield compared with monocropping without N. Hence, the additional soybean yield from intercropping was supplemental. When 135 kg/ha N was applied, however, intercropping tended to reduce maize yield slightly, though not significantly, resulting total maize plus soybean yield about the same as for maize monocropping with N. Thus, when N was applied, there was no supplementary legume yield from intercropping (Chui and Shibles, 1984).

Singh (1983) observed that sorghum gave the maximum yield and monetary, advantages when grown between paired rows of maize. He reported that component crops being grown in wider spaces of paired row system enable the plants to utilize efficiently soil nutrients and solar radiation.

Karim *et al.* (1990) reported monetary advantage from groundnut intercropping between paired rows of maize. Maximum benefit occurred when component crops are sown in wider row spaces for the all tall crop component without reducing its plant population such spatial arrangement augments the utilization of available space, soil nutrient and solar radiation for the companion crops. Therefore, the technique of paired row plating has been developed to harness the maximum advantage from an intercropping system (Singh, 1983).

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

Yadav (1981) obtained the highest yield of maize at 120 kg N/ha in maize + pigeon pea intercrop pigeon pea as an intercrop did not increase the yield of maize at any level of Nitrogen,

Rajasekaran *et al.* (1983) concluded that maximum economic return was obtained by growing maize with black gram or onion with 100 kg N/ha. But application of 135 kg N/ha significantly increased grain yield compared with 65 or 100 kg N/ha. The highest total yield and net return was obtained from maize and groundnut intercropping at the plant population levels of 4.4 x 104 maize and 16.6 x 104 groundnut plants per hectare with 120 kg N/ha than 30 kg N/ha (Quayyum *et al.*1985).

Islam (1982) found that the highest LER value (1.55) was obtained when maize was intercropping with black gram at 44,444 maize plants/ha + 1, 11,111 black gram plants/ha with 20 kg N/ha instead of 120 kg N/ha. The maize yield increased by intercropping 103 percent with cowpeas, 16 to 82 percent with mungbean, 16 to 42 percent with groundnut and 25 to 68 percent with beans (Gunasena *et al.*, 1979). They indicated that yields of all legumes decreased in the intercropping system.

Hashem (1983) reported that maize yield was reduced in intercropping with cowpea by 19% at 100% maize + 50% cowpea combination but total yield advantage increased by 25% compare to sole crop of maize. Average increase of total grain production ranged from 29.5 to 92.5 percent as a result of maize + legumes intercropping system (Kalra and Ganwar, 1980).

Islam (1982) found 19 and 16 percent yield reduction of maize than a solo maize in maize + black gram intercropping systems at population levels of 44,444 maize plants/ha and 1,11,111 black gram plants/ha. But total yield advantage increased by 47 and 55 percent, respectively.

From the reviews cited above it could be concluded that there is an ample scope of intercropping maize with legumes. Bangladesh is currently facing acute shortage of pulses crops and edible oil, due to severe competition of pulse crops with other rabi crops and HYV boro rice.

Chapter III

Materials and Methods

Chapter 3

MATERIALS AND METHODS

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from December, 2010 to May, 2011. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout of experimental design, intercultural operations, data recording and their analyses.

3.1 Experimental site

The experimental site was located under the Agro-ecological zone 28 (Madhupur Tract) having the red brown trace soils and acid basin clay.

3.2 Soil

The soils were slightly acidic in reaction with very low status of organic matter, low moisture holding capacity and low fertility level. Soils were mainly phosphate fixing and low in K. (Appendix I).

3.3 Climate

The crop was grown in winter season when the day length (sunshine period) reduced to 10.5-11.0 hours. Maximum and minimum temperature were ranged as 24.5°C - 29.6°C and 13.9°C - 21.5°C, respectively during the cropping period. Relative humidity was ranged from 61.0% - 70.6%. The monthly average temperature, humidity, rainfall and sunshine hours prevailed at the experimental area during the cropping season are presented in Appendix II.

3.4 Experimental treatments

The following treatments were tested

T_1= Sole maize

T_2= Sole chickpea

T_3= Sole Grass pea

T_4= Sole Mungbean

T_5= Sole Groundnut

T_6= Maize Paired row + 2 rows of chickpea

T_7= Maize Paired row + 2 rows of Grass pea

T_8= Maize Paired row + 2 rows of Mungbean

T_9= Maize Paired row + 2 rows of Groundnut

3.5 Experimental design

The experiment was conducted in a Randomized Complete Block Design (RCBD) with 3 replications. Each block was divided into 9 unit plots in which treatments were applied at random and there were 27 unit plots in the experiment. The size of the each plot was 4 m×3 m and each plot was separated by 0.75 m wide and the distance between the blocks were 1.00 m. Lay out of the experiment following RCBD was done on 11 December 2010.

3.6Cultural operations

The details of different cultural operations performed during the course of turn are given below:

3.6.1 Land preparation

The land was opened on 09 December, 2010 by a tractor-drawn rotary plough followed by laddering. Weeds and stubble were collected and removed.

3.6.2 Plant population and planting system

In all the treatments the recommended plant population of maize and other legume crops were maintained in case of sole plantation. Maize was sown in paired row (PR) system for intercropping. In PR method, two maize rows were sown at 75 cm distance and two paired rows were separated by a distance of 90 cm. Plant to plant distance for maize was 25 cm in both the methods. Two rows of Chickpea, Grass pea, Mungbean and groundnut were sown in between two paired rows. The spacing for Chickpea, Grass pea, Mungbean and groundnut was 30cm x 10 cm, 30cm x 10cm, 30cm x 5cm and 30cm x 10cm respectively.

3.6.3 Seed sowing

Seeds were sown in line on 18 December, 2010. Two to three seeds of maize per hill were dibbled at 5 cm depth of the furrows maintaining a hill distance of 25 cm. chickpea, grass pea, mungbean and groundnut seeds were sown at 5 cm depth maintaining standard distance of hill. Crop variety for the experiment was used namely BARI Hybrid Maize-5 for maize, BARI chola-5 for chickpea, BARI Kheshari-2 for grass pea, BARI Mung-3 for Mungbean, BARI China Badam-6 for groundnut. Irrigation was applied in the furrows for better germination of the seeds.

3.6.4 Gap filling and thinning

Seeds were germinated at 4-6 days after sowing (DAS). Gap filling was done at 10 DAS. Thinning of excess plants was done at 20 DAS to keep one plant per hill of maize and 15 cm between plants in row, for other crops.

3.6.5 Weeding

Weeding was done manually at 21 DAS both in sole and intercropped treatments to reduce competition for nutrients, lights and space.

3.6.6 Plant protection

Adequate plant protection measures were taken for better establishment of the plants. Provex 2 g per kg seed was used before seed sowing for seed treatment. Diazinon 60 EC @ 2.5 ml per liter, Sumithion @ 2 ml per liter water at 15 and 35 DAS were applied to prevent caterpillar, for pod borer applied Desis 2.5 EC @ 1ml per liter of water when pod is formation. There was no diseased infestation in maize. Earthling up was practiced against lodging of maize plants.

3.6.7 Application of fertilizer

Maize sole and Maize and Legume intercrop plant received a uniform application of 120, 60, 40 kg/ha of N, P_2O_5, K_2O as Urea, TSP and MP respectively. Maize treatments as sole and incorporated were given nitrogen fertilizer in three splits 1st as basal, 2nd at 25 DAS and 3rd at 60 DAS. Sole chickpea, grass pea, mungbean and groundnut received application of 20, 40, 20 kg/ha of N, P_2O_5, K_2O as Urea, TSP and MP respectively per hectare.

3.6.8 Irrigation

Irrigation was done at 25 days interval of 3 times.

3.7 Data recorded at harvest

In case of Maize the whole plant was harvested and taken to the threshing floor after that the cob was collected and threshed for collecting grain the grain was then dried in sun. In case of Chickpea, Grass pea and

Mungbean, the whole plant was harvested and taken to the threshing floor for drying. After drying grains were collected. In case of Groundnut the whole plant was harvested with nuts and dried in threshing floor. Therefore the nuts were collected.

3.7.1 Crop characters

For determining the crop characters, 10 plants each of maize, chickpea, grass pea, mungbean and groundnut from each plot were collected. The following data were recorded from the sampled plants.

3.7.1.1 Data for Maize

(i) Cob number/plant (ii) Cob length (cm) (iii) Cob diameter (cm) (iv) No. of grains per cob (v) 1000-grain weight (g) (vi) Grain yield (kg/ha)

3.7.1.2 Data for Chickpea, Grass pea, Mungbean

(i) No. of branches per plant (ii) No. of pods per plant (iii) No. of seeds per pod (iv) 1000-grain weight (g) (v) Seed yield (kg/ha)

3.7.1.3 Data for groundnut

(i) No. of nuts per plant (ii) No. of seeds per nut (iii) 1000-nut weight (g) (iv) Seed yield (kg/ha)

3.7.2 Grain yield

An area of 1 m^2 (4 m x 3 m) was harvested from both sole and intercropped treatments. The pods and cobs were threshed. Grains were cleaned and dried in the sun. The grain weight was adjusted to 12% moisture and per plot grain yield of maize, chickpea, grass pea, mungbean and groundnut was recorded and then per plot yield was converted into per hectare yield.

3.8 Relative yield

It was determined with following formula:

$$\text{Relative yield} = \frac{\text{Yield of component crop}}{\text{Yield of sole crop}}$$

3.9 Equivalent yield

Yield of individual crop was converted into equivalent yield by converting yield of intercrops into the yield of sole crops on the basis of prevailing market prices of individual crop (Anjaneyulu *et. al.*, 1982). Market prices are presented in the table.

$$\text{Maize equivalent yield} = \text{Ym} + \frac{\text{Yi x Pi}}{\text{Pm}}$$

Where,

Ym = Yield of maize (kg/ha)

Yi = Yield of intercrop (kg/ha)

Pi = Price of intercrop (TK/ha)

Pm = Price of maize (TK/ha)

3.10 Land equivalent ratio (LER)

Harwood (1979) defined LER as the area needed under sole cropping to give as much produce as one hectare of intercropping or mixed cropping at the same management level, expressed as a ratio. LER was calculated by the following formula as given by Willey (1979 a).

$$\text{LER} = \frac{\text{Yml}}{\text{Ym}} + \frac{\text{Ylm}}{\text{Yl}}$$

Where,

Yml = Yield of maize when intercropped with chickpea, mungbean, grass pea and groundnut

Ym = Yield of sole maize

Ylm = Yield of chickpea, mungbean, grass pea and groundnut when intercropped with maize

Ym = Yield of sole chickpea, mungbean, grass pea and groundnut

LER= Relative yield of maize + relative yield of chickpea

3.11 Economics

The total man hours used for the different field operations including harvesting and threshing were recorded on the basis of fixed area and time requirement that finally over converted to Tk/ha along with the cost of variable input to determine the variable cost of different treatments. The cost and monetary return of different treatments were computed on the basis of prevailing market price of maize, chickpea, grass pea, mungbean and groundnut seeds.

3.12 Benefit cost ratio (BCR)

Benefit cost ratio (BCR) of different treatments were calculated as follows:

$$\text{BCR} = \frac{\text{Gross return (TK/ha)}}{\text{Variable cost of cultivation (TK/ha)}}$$

3.13 Statistical analysis

The data collected on different parameters under the experiment were statistically analyzed to obtain the level of significance using the computer MSTAT package program developed by Russel (1986). The differences between pairs of means were compared by Least Significant Difference (LSD) at 5 % level of significance as stated by Gomez and Gomez (1984).

Chapter IV

Results and Discussion

Chapter 4
Result and Discussion

The results obtained from the experiment are described and discussed in this chapter. The crop characters of maize and different intercrops along with their yield and the evaluation of profitability of intercropping system have been presented and discussed under separate heads and sub-heads as follows:

4.1 Crop characters of Maize

4.1.1 Plant height

Plant height is a vertical spatial distribution of plant. There was no significant variation among the treatments (Table 1). The tallest (241 cm) plant was recorded in treatment T_1 (sole maize) followed by T_6 (228 cm). The shortest (218 cm) plant was recorded in treatment T_9 (Maize Paired row + 2 rows of Groundnut). From the above results, it appears that the higher plant height was recorded in sole crop. Karim *et al.* (1990) found the similar results which supported the present study.

4.1.2 Number of cob/plant

There was no significant variation in case of number of cob/plant. Numerically the highest number of cob (4) was obtained from T_1 (Sole maize) where as the rest of the treatments (T_6-T_9) showed similar trends. Numerically the lowest number of cob (3) was obtained from T_6 (Maize Paired row + 2 rows of chickpea), T_7 (Maize Paired row + 2 rows of grass pea), T_8 (Maize Paired row + 2 rows of mungbean), and T9 (Maize Paired row + 2 rows of Groundnut).

4.1.3 Cob length

Significant variation in cob length was noticed in different treatments (Table 1). The longest cob (20.6 cm) was observed in treatment T_1. The second maximum cob length (18.47 cm) obtained with T_6 followed by T_8 (18.40). The shortest cob (16.52 cm) was observed in treatment T_9(Table 1). From the results, it appears that cob length was longer in sole maize. The above results of cob length are also in full agreement with Patra *et al.* (1999).

4.1.4 Cob diameter

Significant variation in cob diameter was noticed in different treatments (Table 1). The highest cob diameter (13.42 cm) was observed in treatment T_1 followed by T_9 (12.95 cm). The lowest cob diameter (12.35 cm) was observed in treatment T_7. From the results, it appears that cob diameter was maximum in sole maize. The above results of cob length are also observed by Patra *et al.* (1999).

4.1.5 Number of grains per cob

Grains/cob, the most important yield attribute, was significantly different among the treatments (Table 1). Treatment T_1 produced the highest number of grains/cob (400.3). T_8 gave the second highest number of grains per cob (348.70). On the other hand, treatment T_9 produced the lowest number of grains per cob (308.00) followed by T_6 (310.00). This result also revealed that sole maize had higher number of grains/cob than the intercrop. From the above result it may be said that sole maize planting dominated over paired row maize planting with intercrop in respect of number of grains/cob. Patra *et al.* (1999), also found maximum number of grain/cob in sole maize in an intercropping system

4.1.6 1000-grain weight

Thousand grain weights represent grain size. The effect of various treatments on 1000-grain weight was not significant (Table 1). Numerically treatment T_1 showed the lowest 1000-grain weight (228 g). The maximum thousand grain weight was obtained from T_7 & T_8 (231 g). From this result, it appears that 1000-grain weight was higher in intercropping maize than the sole maize. Dhingra *et al.* (1991) reported that maximum 1000-grain weight was obtained from intercropping of maize with mungbean which was in full agreement with the present study.

4.1.7 Grain yield

There was a remarkable difference among the treatments in respect of grain yield (Table 1). Treatment, T_1 produced the highest grain yield (4.2 t/ha). Maize paired row with two rows of mungbean (T_8) produced the second highest grain yield (3.7 t/ha). On the other hand, T_9 produced the lowest grain yield (3.1 t/ ha). From these results, it was observed that sole maize produced higher grain yield over the paired row system with other intercrops. This result was also supported by the result of Karim *et al.* (1990) who stated that maximum grain yield of maize was obtained from monoculture in uniform row.

Table 1. Cob characters, Plant height, Number of cob/plant, Number of grains/cob, 1000-grain weight, and Grain yield of maize as sole and intercrop as influenced by different intercropping system

Treatment	Plant height (cm)	Number of cob/plant	Cob characters		Number of grains/cob	1000-grain weight (g)	Grain yield (t/ha)
			Length (cm)	Circumference			
T_1	241	4	20.6	13.42	400.3	228	4.2
T_6	228	3	18.47	12.83	310.0	230	3.4
T_7	225	3	16.96	12.35	333.0	231	3.6
T_8	227	3	18.40	12.88	348.7	231	3.7
T_9	218	3	16.52	12.95	308.3	229	3.1
LSD $_{(0.05)}$	NS	NS	1.986	NS	36.25	NS	0.610
CV %	12.23	13.55	3.95	2.70	0.39	1.02	4.17

NS= Non significant CV=coefficient of variation

T_1 = Sole maize
T_6 = Maize Paired row + 2 rows of chickpea
T_7 = Maize Paired row + 2 rows of Grass pea
T_8 = Maize Paired row + 2 rows of Mungbean
T_9 = Maize Paired row + 2 rows of Groundnut

4.2 Crop characters of intercrop

4.2.1 Number of pods/plant

Pods/plant, the most important yield attribute, varied among the intercrop crop treatments (Table 2). In case of chickpea intercrop, chickpea as sole crop (T_2) produced 65.4 number of pods/plant where as the chickpea as intercrop with maize (T_6) produced 55.3 number of pod/plant. In case of grass pea intercrop, grass pea as sole crop (T_3) produced 35.5 number of pods/plant where as the intercrop with maize (T_7) produced 32.4 number of pod/plant. In case of mungbean intercrop, mungbean as a sole crop (T_4) produced 45.5 number of pods/plant where as the mungbean intercrop with maize (T_8) produced 40.1 number of pods/plant. In case of groundnut intercrop, groundnut as a sole crop (T_5) produced 29 number of nut/plant where as groundnut as the intercrop with maize (T_9) produced 26 number of nuts/plant. These results revealed that sole crop had higher number of pods/plant than the intercrop. Similar results were obtained from the study of Jahansooz *et al.* (2007).

4.2.3 Number of seeds/pod

Seeds/pod also varied among the intercrop crop treatments (Table 2). In case of sole chickpea treatment chickpea as sole crop (T_2) produced 2.8 number of seeds/pod where as chickpea the as intercrop with maize (T_6) produced 2.2 number of seeds/pod. In case of grass pea sole crop (T_3) produced 3.9 number of seeds/pod where as the grass pea as intercrop with maize (T_7) produced 3.4 number of seeds/pod. In case of mungbean sole crop (T_4) produced 14.3 number of seeds/pod where as the intercrop with maize (T_8) produced 12.1 number of seeds/pod. In case of groundnut sole crop (T_5) produced 1.9 number of seeds/nut where as the groundnut as intercrop with maize (T_9) produced 1.8 number of seeds/nut. The above results in respect of number of seeds per pod were supported by the study of Singh *et al.* (2006)

4.2.4 1000-seed weight

1000-seed weight also varied among the intercrop crop treatments (Table 2). In case of chickpea intercrop, chickpea as sole crop (T_2) produced 133.7 g/1000-seed where as the chickpea as intercrop with maize (T_6) produced 139.9g/1000 seed. In case of grass pea intercrop, grass pea as a sole crop (T_3) produced 48.7 g/1000-seed where as the grass pea as intercrop with maize (T_7) produced 50.3 g/1000-seed. In case of mungbean intercrop treatment, Mungbean as a sole crop (T_4) produced 25.45 g/1000-seed where as mungbean as intercrop with maize (T_8) produced 26.48 g/1000-seed. In case of groundnut intercrop, groundnut as sole crop (T_5) produced 499 g/1000-seed where as groundnut as the intercrop with maize (T_9) produced 495 g/1000-seed. From this result, it appears that 1000-seed weight was higher in intercropping practices than the sole crop which is consistent with the result of Thakur (2003).

4.2.5 Seed yield

Yield is the most important attribute in case of any crop cultivation. Yield of sole and intercrop also varied among the crops (Table 2). In case of chickpea intercrop treatment, chickpea as sole crop (T_2) produced 1.4 t/ha of seeds where as chickpea as intercrop with maize (T_6) produced 1.1 t/ha of seeds. In case of grass pea intercrop treatment, grass pea as sole crop (T_3) produced 1.6 t/ha of seeds where as grass pea as intercrop with maize (T_7) produced 1.4 t/ha of seeds. In case of mungbean intercrop treatment, mungbean as sole crop (T_4) produced 1.1 t/ha of seeds where as mungbean as intercrop with maize (T_8) produced 0.9 t/ha of seeds. In case of groundnut intercrop treatment, groundnut as sole crop (T_5) produced 2.7 t/ha of seeds where as groundnut as intercrop with maize (T_9) produced 1.0 t/ha of seeds. The results obtained from the experiment keeps in with the study of Thakur (2003) in respect of seed yield. More shading effect of maize particularly at its early vigour might reduce the yield of intercrips.

Table 2. Crop characters, Number of pods/plant, Number of seeds/pod, 1000-seed weight and yield of Chickpea, grass pea, Mungbean, Groundnut as sole and intercrop as influenced by intercropping system

Treatment	Number of pods/plant	Number of seeds/pod	1000 seed weight (g)	Seed yield (t/ha)
Chickpea				
T_2	65.4	2.8	133.7	1.4
T_6	55.3	2.2	139.9	1.1
Grass pea				
T_2	35.6	3.9	48.7	1.6
T_7	32.4	3.4	50.3	1.4
Mungbean				
T_3	45.5	14.3	25.45	1.1
T_8	40.1	12.1	26.48	0.9
Groundnut				
T_4	29	1.9	499	2.7
T_9	26	1.8	495	1.0

T_2 = Sole Chickpea
T_3 = Sole Grass pea
T_4 = Sole Mungbean
T_5 = Sole Groundnut
T_6 = Maize Paired row + 2 rows of Chickpea
T_7 = Maize Paired row + 2 rows of Grass pea
T_8 = Maize Paired row + 2 rows of Mungbean
T_9 = Maize Paired row + 2 rows of Groundnut

4.3 Evaluation of intercropping system

Total land productivity is a basic consideration in evaluating intercropping system where land holdings are very meagre. For this purpose, relative yields, land equivalent ratio (LER) and benefit cost ratio could be the better indicators of intercropping. These were computed and presented in Table 3 & 4 and illustrated under different heads:

4.3.1 Relative yield

In all the intercrop treatments, relative yield of maize and other crop was reduced (Table 3). However, Maize Paired row + 2 rows of Mungbean showed better relative yield of maize than other intercropping combinations. In intercrop treatments, the yield reduction in maize and other intercrop might be due to inter and intra plant component competition or antagonistic relationship between maize and other crops. These results were in conformity with the results of Hashem (1983).

4.3.2 Maize equivalent yield

In case of maize equivalent yield all the intercrop treatments showed better performance. The highest maize equivalent yield was recorded in maize intercrop with chickpea (1.1) and the lowest maize equivalent ratio was found in maize intercrop with grass pea (0.1).

4.3.3 Land equivalent ratio (LER)

The difference between actual and expected yield (where, LER=1) compute an idea of a relative yield advantage in an intercropping system which is expressed as Land Equivalent Ratio (Table 3). Yield advantage was obtained from all the intercropping treatments. Intercropping maize with different intercrop systems gave LER advantages. Maximum LER (1.73) was obtained from maize intercropped with grass pea (T_7). The higher LER in intercrop treatments also indicates that the maize could be intercropped with other crop for higher production and better utilization of resources. This result is also supported by the result of Uddin and Sattar (1993).

Table 3. Relative yield, maize equivalent yield, land equivalent ratio of different treatments

Treatments	Maize		Chickpea		Grass pea		Mungbean		Groundnut		Maize Equivalent yield	LER
	Grain yield	Relative yield	Seed yield	Relative yield	Seed yield	Relative yield	Seed yield	Relative yield	Seed yield	Relative yield		
T_1	4.2	1.0	---	---	---	---	---	---	---	---	4.2	1.0
T_2	---	---	1.4	1.0	---	---	---	---	---	---	1.4	1.0
T_3	---	---	---	---	1.6	1.0	---	---	---	---	1.6	1.0
T_4	---	---	---	---	---	---	1.1	1.0	---	---	1.1	1.0
T_5	---	---	---	---	---	---	---	---	2.7	1.0	2.7	1.0
T_6	3.4	0.80	1.1	0.78	---	---	---	---	---	---	1.1	1.58
T_7	3.6	0.85	---	---	1.4	0.88	---	---	---	---	0.1	1.73
T_8	3.7	0.88	---	---	---	---	0.9	0.81	---	---	0.7	1.69
T_9	3.1	0.73	---	---	---	---	---	---	1.0	0.37	0.8	1.10
CV %												2.24

CV= Coefficient of variation

T_2 = Sole Chickpea
T_3 = Sole Grass pea
T_4 = Sole Mungbean
T_5 = Sole Groundnut
T_6 = Maize Paired row + 2 rows of Chickpea
T_7 = Maize Paired row + 2 rows of Grass pea
T_8 = Maize Paired row + 2 rows of Mungbean
T_9 = Maize Paired row + 2 rows of Groundnut

4.4 Economical profitability

4.4.1 Gross return

The highest total gross return (Tk 127200 ha^{-1}) was recorded in treatment T_6 followed by treatment T_8 (Tk 120600 ha^{-1}) (Table 4). Similar results had also been reported from maize intercropped with soybean and chickpea by Thakur (2003).

4.4.2 Total variable cost of cultivation

The higher cost was involved in treatment T_6 whereas the lowest total variable cost of cultivation (31110 Tk/ha) was required for sole maize (Table 4).

4.4.3 Net return

The highest net return (Tk. 84200 ha^{-1}) was recorded from T_6 though higher total variable cost was involved and was followed by T_8 (Tk. 79500 ha^{-1}). The lowest net return (Tk. 24600 ha^{-1}) was obtained from sole grass pea (T_3) followed by sole mungbean (Tk 34000 ha^{-1}). From monetary point of view, the T_6 was the best intercropping system. All the intercropping systems showed higher net return than sole maize or sole other intercrop (Table 4). Similar result had also been reported from maize intercropped with soybean and chickpea by Thakur (2003).

4.4.4 Benefit cost ratio (BCR)

The highest BCR (2.95) was obtained from T_6 followed by T_7 (2.94) and T_8 (2.93). In contrast, the lowest BCR (1.78) was obtained from T_3. The result showed that the higher BCR was obtained from intercropping maize and chickpea than the sole maize or sole chickpea (Table 4). The results obtained from the present study are consistent with the results of Khaleque *et al.* (1990).

Table 4. Economic analysis of different intercropping system

Treatments	Grain yield (t/ha)					Gross return (Tk)						Total variable cost of Cultivation (Tk.)	Net return (Tk)	BCR
	Maize	Chickpea	Grass pea	Mungbean	Groundnut	Maize	Chickpea	Grass pea	Mungbean	Groundnut	Total			
T_1	4.2	---	---	---	---	75600	---	---	---	---	75600	31100	44500	2.43
T_2	---	1.4	---	---	---	---	84000	---	---	---	84000	32700	51300	2.56
T_3	---	---	1.6	---	---	---	---	56000	---	---	56000	31400	24600	1.78
T_4	---	---	---	1.1	---	---	---	---	66000	---	66000	32000	34000	2.06
T_5	---	---	---	---	2.7	---	---	---	---	135000	108000	39000	69000	2.76
T_6	3.4	1.1	---	---	---	61200	66000	---	---	---	127200	43000	84200	2.95
T_7	3.6	---	1.4	---	---	648000	---	49000	---	---	113800	38700	75000	2.94
T_8	3.7	---	---	0.9	---	66600	---	---	54000	---	120600	41100	79500	2.93
T_9	3.1	---	---	---	1.0	55800	---	---	---	50000	105800	40000	65800	2.62
CV %						0.06						1.02	0.32	0.97

CV= Coefficient of variation

T_1 = Sole maize
T_2 = Sole Chickpea
T_3 = Sole Grass pea
T_4 = Sole Mungbean
T_5 = Sole Groundnut
T_6 = Maize Paired row + 2 rows of Chickpea
T_7 = Maize Paired row + 2 rows of Grass pea
T_8 = Maize Paired row + 2 rows of Mungbean
T_9 = Maize Paired row + 2 rows of Groundnut

Chapter V

Summary and Conclusion

Chapter 5

SUMMARY AND CONCLUSION

An experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from December, 2010 to May, 2011 to study the influence of intercropping system in maize with chickpea, Grass pea, Mungbean, and Groundnut. Randomized Complete Block Design (RCBD) with 3 replications was used as experimental design. The experiment comprised of seven treatments viz, T_1= Sole maize, T_2= Sole chickpea, T_3= Sole Grass pea, T_4= Sole Mungbean, T_5= Sole Groundnut, T_6= Maize Paired row + 2 rows of chickpea, T_7= Maize Paired row + 2 rows of Grass pea, T_8= Maize Paired row + 2 rows of Mungbean, T_9= Maize Paired row + 2 rows of Groundnut. The collected data were statistically analyzed and the means were adjudged by LSD at 5% level of significance.

Seeds were sown in line on 18 December, 2010. In all the treatments, the recommended plant population of maize and chickpea, grass pea, mungbean, groundnut was maintained per hectare. An observation at harvest was made on yield and yield contributing characters in each treatment.

In case of maize the tallest plant, highest number of cob/plant, cob length, cob diameter and yield was recorded in treatment T_1 (sole maize) where as highest thousand grain weight was obtained from T_7 & T_8 i.e. maize intercrop with grass pea and mungbean respectively. In case of intercropped plants the highest yield and best yield contributing characters except 1000 grain weight were found in sole crop but the intercrops performed better in terms of economic contribution.

Total land productivity is a basic consideration in evaluating intercropping system where land holdings are very meagre. For this purpose, relative yields, land equivalent ratio (LER) and benefit cost ratio were computed. In all the intercrop treatments, relative yield of maize and other crop was reduced. However, Maize Paired row + 2 rows of Mungbean showed better relative yield of maize than other intercropping combinations. In intercrop treatments, the yield reduction in maize and other intercrop might be due to inter and intra plant component competition or antagonistic relationship between maize and other crops.

Yield advantage was obtained from all the intercropping treatments. Intercropping maize with different intercropping systems gave LER advantages. Maximum LER (1.73) was obtained from maize intercropped with grass pea (T_7). The highest total gross return (Tk 127200 ha^{-1}) was recorded in treatment T_6 followed by treatment T_8 (Tk 120600 ha^{-1}). The higher cost was involved in treatment T_6 whereas the lowest total variable cost of cultivation (31110 Tk/ha) was required for sole maize (Table 4).

The highest net return (Tk 84200 ha^{-1}) was recorded from T_6 though higher cost was involved and was followed by T_8 (Tk 79500 ha^{-1}). The lowest net return (Tk 24600 ha^{-1}) was obtained from sole grass pea (T_3) followed by sole mungbean (Tk 34000 ha^{-1}). From monetary point of view, the T_6 was the best intercropping system. All the intercropping systems showed higher net return than sole maize or sole other intercrop. The highest BCR (2.95) was obtained from T_6 followed by T_7 (2.94) and T_8 (2.93). In contrast, the lowest BCR (1.78) was obtained from T_3. The results showed that the higher BCR was obtained from maize - chickpea intercropping than the sole maize or sole chickpea.

Therefore, cultivation of maize in intercropping system with chickpea, Grass pea, Mungbean, and Groundnut would be profitable due to higher yield. So, T_6 (Maize Paired row + 2 rows of chickpea) may be recommended as intercrop with maize in intercropping system although it needs more trials under farmer's field conditions at different agro-ecological zones of Bangladesh. Finally the results lead to the conclusion that,

I. All the intercropping treatments had better performance in respect of productivity over sole crop under intercropping system and
II. Intercropping paired rows of maize + two rows of chickpea would agronomically feasible and economically profitable (i.e., maize equivalent yield, LER, relative yield, gross return, net return, BCR etc).

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APPENDICES

Appendix I: Physiochemical properties of the soil prior to seed sowing

Characteristics	Value	Interpretation	Critical value
% sand	26		
%silt	45		
%clay	29		
Textural class		Silty-clay	
pH	56	Slightly acidic	
Organic carbon (%)	0.45		
Organic matter (%)	0.78	Very low	
Total N (%)	0.03	Very low	0.12
Available P	20.00		7.0
Exchangeable K (me/ 100 g soil)	0.10	Low	0.12
Available S (ppm)	45	Very high	10.0

Source: Fertilizer Recommendation Guide 2005, BARC.Soil Resources Development Institute (SRDI), Dhaka-1207

Appendix II: Monthly average air temperature, relative humidity and total rainfall of the experimental site during the period from December, 2007 to May, 2008.

Month	Relative	Temperature (°C)			Rainfall (mm)	Sunshine(hr)
		Maximum	Minimum	Mean		
December	69.5	29.5	13.6	24.0	3.0	5.7
January	70.6	26.9	16.2	21.5	00	5.5
February	68.5	24.5	18.2	19.2	4.0	5.6
March	61.0	28.9	18.9	23.4	3.0	5.8
April	62.5	29.5	20.3	24.9	3.0	5.8
May	62.1	29.6	21.5	25.5	3.5	8.3

Source: Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka-1212.