EFFECT OF ROW ARRANGEMENT AND NITROGEN ON THE YIELD OF MAIZE INTERCROPPED WITH MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF ROW ARRANGEMENT AND NITROGEN ON THE YIELD OF MAIZE INTERCROPPED WITH MUNGBEAN" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in AGRONOMY, embodies the result of a piece of *bona fide* research work carried out by ABUL KALAM MUHAMMAD AHAD, Registration No. 00482 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 duly been acknowledged.

Dated: 28/12/06

Place: Dhaka, Bangladesh

Prof. Dr. Md. Fazlul Karim

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DEDICATED TO
MY
BELOVED PARENTS

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ABSTRACT

An experiment was conducted at the Agronomy field at Sher-e-Bangla Agricultural University, Dhaka during the period from March to June 2006 to study the effect of row arrangement and nitrogen on the yield of maize intercropped with mungbean. The experiment was conducted in a Randomized Complete Block Design (RCBD) with 3 replications. The treatments were T_1=Sole maize normal row (MNR) with 120 kg N/ha,T_2 = Sole maize paired row (MPR) with 120 kg N/ha, T_3 = MNR + 2 mungbean rows with 120 kg N/ha, T_4 = MNR + 2 mungbean rows with 60 kg N/ha, T_5 = MPR + 5 mungbean rows with 120 kg N/ha, T_6 = MPR + 5 mungbean rows with 60 kg N/ha, T_7 = Sole mungbean with 30 kg N/ha. In all the treatments, the recommended plant population of maize (55,555 plants/ha) was maintained. Recommend plant population of mungbean (3,33,333 plants/ha) in sole situation and (2,22,222 plants/ha) in intercropped treatments were maintained. Maximum grain yield of maize (4283.00 kg/ha) and mungbean (1,087.00 kg/ha) were obtained in T_1 and T_7, respectively. Highest maize equivalent yield (6002.00 kg/ha) was found in T_5 and the lowest (3623.30 kg/ha) in T_7. Land equivalent ratio (LER) varied from 22 to 53% in the different treatments. Highest LER (1.53) was found in T_5 which also gave maximum net return (Tk39000.00/ha) with benefit cost ratio (BCR) (2.60). Lower LER (1.22) was recorded T_4.

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ACRONYMS

AEZ	=	Agro- Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BARI		Bangladesh Agricultural Research Institute
cm	=	Centi-meter
cv.	=	Cultivar (s)
CV (%)	=	Percentage of Coefficient of Variance
^{0}C	=	Degree Centigrade
DAS		Days After Sowing
et al.	=	And others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	gram (s)
HI	=	Harvest Index
hr	=	hour(s)
kg	=	kilogram (s)
LSD		Least Significant Difference
m	=	Meter
mm	=	Millimeter
MP	=	Muriate of Potash
m^2	=	meter squares
N	=	Nitrogen
No.	=	Number
NS	=	Non significant
RH	=	Relative Humidity
SAU	=	Sher-e- Bangla Agricultural University
t ha^{-1}	=	Tons per hectare
TSP	=	Triple Super Phosphate
UNDP	=	United Nations Development Program
var.	=	Variety
%	=	Percent

Chapter 1

Introduction

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Chapter 1
INTRODUCTION

There is a little scope for increasing cultivable area in the world. Therefore, farmers in developing countries have shown keen interest in intercropping practices to increase crop production vertically to meet their requirements for food, fibre and fodder from the existing area (Bandyopadhyay, 1984). The scope for horizontal expansion in Bangladesh is almost out of question. Crop production scientists and farmers are now focusing their attention to increase food production to feed the ever-increasing population. Intercropping is not only a means of augmentation of crop production and monetary return over space and time but also provides insurance against total crop failures and / or provides better avenues of employment for the rural folk (Bandyopadhyay, 1984). The various methods of vertical development of food production, intercropping as a form of multiple cropping can play an important role in increasing crop productivity per unit area per unit time. Intercropping is an age-old practice and has been recognized as a very common practice throughout the developing tropics (Willey, 1979 a). The main philosophical basis for grater stability of yield in mixed and intercropping is that if one crop fails or grows poorly due to various biotic and abiotic stresses, another component crop can compensate, and such compensation can not occur when the crops are grown separately. Besides, this practice proved to be more suitable for efficient utilization of natural resources such as soil moisture, nutrients, solar energy etc. than the conventional systems (Fisher, 1977). Moreover, growing two or more crops together may make the best use of space, solar radiation and nutrients in the soil due to their differential growth habit (Trenbath, 1974). Intercropping makes better use of sunlight, land and water. In almost all cases, it gives higher total production, monetary returns and greater resource use efficiency and increases the land productivity.

Maize (*Zea mays* L.) is a cereal crop gradually assuming increasing importance in Bangladesh due to its high yield potentiality and versatile use. The agro-climatic condition of Bangladesh is favorable for its cultivation round the year. As a food it can be consumed directly as a green cobs, roasted cobs or popped grain, flour, sattu and its stalk can be used as cattle feed. As a commercial crop, maize is used for manufacturing starch, corn flakes, alcohol etc. (Thakur, 1980). It has been found that this crop can very well be fitted in cropping pattern under partially irrigated high land conditions (BARI, 1982). However, it competes with broadcast aus in kharif season and other upland crops in rabi season. To popularize maize and avoid competition with other crops, intercropping is a good technique where farmers may produce maize with other crops (pulses, vegetables etc.) simultaneously.

Mungbean (*Vigna radiata* (L.) Wilczek.) is one of the major pulse crops in Bangladesh. It is a crop of the tropics and sub-tropics and requires a warm temperature regime. Mungbean may be grown as an intercrop with other tall crops like maize, sorghum, cotton, jute, sugarcane, pigeonpea etc. Beside, mungbean grown as early kharif-I crops so it can be fitted in kharif-I maize crop for substantial increase of pulse production.

The intensification of crop production can be done through intercropping systems where two or more crops are grown simultaneously in the same land at the same time (Zandstra, 1979). In the tropical and sub-tropical regions, cereal-legumes intercropping are the most popular practices because of its many additional advantages (Okigbo and Greenland, 1979; Willey, 1979 a, Karim *et al.* 1990; Akkteruzzaman and Quayyum, 1991; Torofder *et al.* 1992). Intercropping becomes most productive and economical when both the crops differ with genetic make up, photosynthetic pathway, growth habit, growth duration and demand of different growth resources (Fukai and Trenbath, 1993). Intercrop productivity also depends on the light availability within the canopy of component crops (Ross, 1981; Isoda *et al*., 1992; Takahashi and Nakaseko, 1993). In an intercropping system, light distribution within the canopy is governed by plant type, leaf orientation, plant density and planting arrangement of component crops. Since solar radiation provides the energy for photosynthesis, the amount of light intercepted by the canopy determines the biomass and crop productivity. 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. Despite many advantages of cereal-legumes intercropping systems all crop combination are not equally profitable (Mandal and Mahapatra, 1990; Shah *et al*., 1991). Economical viability of intercropping system depends on many factors such as production potential of component crops, cost of production and market prices of the commodities.

In cereal-legumes intercropping systems, legumes are considered as nitrogen economy and favored the yield of component crop. However, the extent of biological nitrogen fixation of different kinds of legumes are not generally same in a particularly environment and often varied with the change of crop environments. The quantity of nitrogen fixed by the legumes component in cereal-legume intercropping systems depends on species, morphology and the competitive abilities of the component crops (Ofori and Stern, 1987). Therefore, the quantity of nitrogen saved by different kinds of legumes also determines the economics of cereal-legume intercropping systems.

Instead of uniform row of maize, paired row planting of maize is an advantageous management which ultimately improves the gross return by accordingly different legume crops between the wider spaces of paired maize rows. Singh (1979) observed that sorghum gave 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 the soil nutrients and solar radiation. Karim *et al.* (1990) reported the monetary advantage from groundnut cultivation between paired rows of maize.

The present study was undertaken with the following objectives:

i. To study the row arrangement on the yield of maize (kharif-I) intercropped with mungbean.

ii. To find out the nitrogen dose on the yield of maize (kharif-I) and mungbean intercropping system.

iii. To study the performance of maize and mungbean intercropping system.

iv. To evaluate the economic performance of intercropping maize with mungbean as sole and intercrop combination.

v. To find out the suitable planting system for maize-mungbean intercropping system.

Chapter 2

Review of Literature

Chapter 2

REVIEW OF LITERATURE

Crop production scientists and farmers are now focusing their attention to increase food production to feed the ever-increasing population. Intercropping is a form of multiple cropping can play an important role in increasing crop productivity per unit area per unit time. Therefore, the available findings of the effect of row and nitrogen managements on the yield of maize as sole or intercropped have been briefly reviewed below:

Ahmed *et al.* (2000 a) conducted a field experiment on maize-mungbean intercropping to assess the yield advantage from the viewpoint of growth process in Japan, during June-October 1999. Three maize densities (75 x 50, 75 x 30, 75 x 15 cm^2) intercropped with one row of mungbean did not affect the maize yield, but the yields of mungbean were greatly affected. The maximum and minimum yields of mungbean were obtained in sole mungbean and mungbean intercropped with a high-density maize plot, respectively. Land equivalent ratios (LER) were higher than 1.0 in all intercropping plots where highest LER (1.79) was observed in the low-density of maize plot.

Ahmed *et al.* (2000 b) also conducted an experiment on maize-mung bean intercropping to find out suitable mungbean cultivars (Kanti and BARI-mung-5) and its sowing systems in intercropping and to analyze the yield improvement from the viewpoint of growth process with the consideration of canopy structure and light interception. Maize yield did not differ significantly due to intercropping. In sole crop situation of mungbean, the variety BARI-mung-5 showed higher yield than Kanti but in intercropping situation, BARI-mung-5 yield was reduced more than Kanti. The yield reduction of BARI-mung-5 was 73% and that of Kanti was 35-44%. There was no significant difference between the yield of 1 row and 2 rows sowing systems of mung bean in intercrop treatments for both of the mungbean cultivars. Land equivalent ratio (LER) of plots of maize intercropped with both cultivars was evident. The highest LER (1.58) was observed in intercropped with mungbean variety Kanti.

Polthanee *et al.* (1999) conducted an experiment on mungbeans cv. Chainat 36 where mungbean sown 50, 65 or 80 days after emergence of maize cv. Suwan 5 in a relay cropping system. Grain yield and yield components of maize were not significantly affected by relay sowing dates, with yield range 2113-2131 kg/ha. Mungbean yield was 630 kg/ha in pure stand, but in relay cropping systems yield was only 232 and 68 kg/ha when it was sown 50 and 80 DAE. Land equivalent ratio of relay cropping ranged from 1.11 to 1.36 when mungbean sown 80 and 50 days after maize emergence. In economic evaluation, the relay cropping treatments gave 7 to 24% monetary advantage over the sole maize cropping.

Patra *et al.* (1999) observed the increased number of cobs per plant due to temporal complementary in maize-legume association. He 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 and its early vigour might be reduced the yield of intercrops. Singh *et al.* (1988) 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. Patra *et al.* (1990) also 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.

Quayyum *et al.* (1999) conducted an experiment on crop weed competition in maize sole and maize + blackgram intercropping system. The highest maize equivalent yield, gross return, net return and benefit cost ratio were recorded from one hand weeding 42 DAS (days after sowing) and earthing up 21 DAS. But in maize sole situation, two hand weedings 21 and 42 DAS with earthing up DAS showed higher benefit cost ratio than the other treatments.

Nag *et al.* (1996) reported that monoculture of maize, cowpea, khesari, mungbean, groundnut and maize intercropped with legumes (cowpea, khesari, mungbean and groundnut) in paired rows were compares in an experiment conducted during 1993-94, highest maize equivalent yield (6973 kg/ha) was obtained from maize + mungbean Intercropping, but maize + groundnut combination gave the highest maize equivalent yield (5615 kg/ha) in 1994-95. Maize + mungbean and maize + groundnut also gave the highest net return (Tk. 50952/ha and Tk. 40245/ha.) during 1993-94 and 94-95, respectively. But 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).

Senaratne *et al.* (1995) conducted an experiment on 15N-labelled soil, maize intercropped with cowpea (*Vigna unguiculata*), mungbean (*Vigna radiata*) and groundnuts (*Arachis hypogea*). Intercropped groundnuts fixed the highest amount of N from the atmosphere (552 mg plant^{-1}), deriving 85% of its N from the atmosphere. Intercropped cowpea and mungbean fixed 161 and 197 mg N plant^{-1}, obtaining 81% and 78% of their N content from the atmosphere, respectively. The proportion of N derived by maize from the associated legume varied from 7 to 11% for *V. radiata*, 11 to 20% for *V. unguiculata* and 12 to 26% for groundnuts, which amounted to about 19-22, 20-45 and 33-60 mg N maize plant^{-1}, respectively. The high N fixation potential of intercropped groundnuts and their relatively low harvest index for N appeared to contribute to the greater beneficial effect on the associated crop.

Hirota *et al.* (1995) conducted a field experiment on maize and mungbean cv. Kanti as pure stands and intercropped at different plant densities. Two rows of mungbean (266 x 10^3 plants/ha) were sown together with one row of maize (26000 to 90000 plants/ha) in the intercrops, while pure stand densities were 53000 plants/ha for maize and 333000 plants/ha for mungbean. The grain yield of maize in monoculture was about 484 g/m^2 and 158-219 g/ m^2 when intercropped. Seed yield of mungbean was 72 g/m^2 in pure stand, 68 g/m^2 at the lowest density of maize when intercropped, and 20-21 g/m^2 in the other intercropping treatments. Land equivalent ratio (LER) was highest (1.39) at the lowest maize density where as other plots was <1.0.

Quayyum and Maniruzzaman (1995) carried out an experiment to evaluate the intercropping of maize (*Zea mays* L.) and rice (*oryza sativa* L.) with blackgram (*Phaseolus mungo* L.). Aus rice (BR 21), maize (Barnali) and blackgram (Barimash) as sole crops and blackgram as intercrop or strip crop with rice and maize. Aus rice yield varied from 1.43 to 2.23 t/ha, depending on the treatments. Reduction in yield of rice under inter or strip cropping with blackgram was almost proportional to the land area. Blackgram yield ranged from 0.33 to 0.79 t/ha and that of maize from 2.48 to 3.39 t/ha. The highest rice-equivalent yield (3.35 t/ha) and grass return (Rs 14,103/ha) were obtained from maize-paired row (100%) + blackgram rows (44%).

Torofder et al. (1992) conducted an experiment to determine the effect of intercropping maize with different legumes (mungbean, soybean, cowpea, blackgram and groundnut). Maize yield of 2.60 t/ha from maize + groundnut combination was second only to that from maize monoculture (2.90 t/ha). An additional 0.81 t/ha groundnut was obtained from the said intercropping which also gave the highest maize equivalent yield (4.22 t/ha), land equivalent ratio (LER) (1.56), gross margin (Tk. 10900 /ha and benefit cost ratio (2.06)

Karim *et al.* (1990) conducted an experiment to study the effect of planting system maize with rows of groundnut grown as mono and / intercrop. Maximum grain yield of maize (2.96 t/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 was found in uniform 3 or paired 6 rows of groundnut. Both the former and the latter combination gave higher LER (1.44) and net return of Tk. 8719 and 8502 /ha, having same benefit cost ratio.

The magnitude yield of advantage of intercropping system could be determined by the use of LER value (Ofori and Stern, 1987). The concept of land equivalent ratio 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).

Akanda and Quayyum (1982) got a LER value of 1.72 in a maize and groundnut combination. The land equivalent ratio is the most frequently used index to determine the effectiveness of intercropping relative to growing crops separately (Willey, 1985). Intercropping corn with legume mixture (mungbean, soybean and groundnut) increased LER by 30 to 60% over monoculture crops (IRRI, 1974). 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.

Land equivalent ratio (LER) is a good measure for evaluating land productivity, in physical terms of a sole crop vs intercrop (Chowdhury, 1979). When two or more dissimilar crops are grown in the same filed at the same time, LER measures the crop productivity of a unit land area sown to a crop mixture *vis-a-vis* the crop productivity of sole components of the mixture grown on an equivalent land area (Mead and Willey, 1980; Shaner *et al.* 1982).

An index of combined yield, LER provides a quantitative evaluation of the yield advantage due to intercropping (Willey, 1979 b). LER could be used either as an index of biological efficiency to evaluate the effects of various agronomic variables (fertility levels, density level and spacing, comparison of cultivar performance, relative time of sowing and crop combinations) on an intercropping system in a locality or as an index of productivity across geographical location to compare a variety of intercropping systems (Chetty and Readdy, 1984).

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". The LER is the sum of the fractions of the yield of the intercrops relative to their sole crop yields (Andrwes and Kassam, 1976). At IRRI (1974) it was found that a corn + legume mixture increased LER from 1.3 to 1.6 over a monoculture corn. In this experiment it was found that corn + mungbean mixture increased land productivity by 50 percent whereas green soybean and groundnut with corn increased land productivity by 60 percent.

Dhingra *et al.* (1991) conducted an intercropping experiment with maize and mungbean under different planting patterns and row orientation where higher maize yield was obtained from intercropping system. This increase in maize yield was attributed to the complementary effect of mungbean in terms of biological nitrogen fixation. No differences in growth and yield attributes indicated any adverse effect of intercropping of mungbean on the growth and yield of maize. Singh (1978) and Reddy and Reddy (1981) also did not observe any adverse effect on maize yield due to intercropping with legumes. Additional yield of mungbean ranging from 250-350 kg ha^{-1} was obtained in different planting pattern, depending upon the number of mungbean rows and solar radition penetration in different planting patterns. Higher productivity and income in intercropping systems also depends on their planting density and geometry (Shivarum and Shivashankar, 1992). Singh *et al.* (1986) conducted an intercropping experiment with maize, soyabean and blackgram under varying population and nitrogen levels and concluded that yields of the mixed stand with maize at 50,000 plants ha^{-1} were higher than maize at 37500 or 75000 plants ha^{-1}.

Quayyum *et al.* (1987) conducted an experiment on 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. This was 22% higher than the yield of sole crop of maize. Two combined, maize + chicpea, yield gave the highest net return of Taka 12803.00 /ha and highest LER of 1.35 indicating that the mixture was 35% more efficient in terms of land utilization than a sole crop of maize.

Cereal-legume intercropping has been advocated by many authors (Akanda and Quayyum, 1982; Hashem and Maniruzzaman, 1986; Akhtaruzzaman and Quayyum, 1991, Akthtaruzzaman *et al.*, 1993). In cereal-legume intercropping system, yield reduction of legumes has been reported in almost all cases. It is likely that legume plants suffer from shade underneath tall maize plants and could not achieve its yield potential whereas maize yields were usually less affected than legume yields. 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).

Intercropping is practiced traditionally in many parts of Asia, Africa, Latin America, some temperate regions of Australia and the United States (Searle *et al.*, 1981; Allen and Obura, 1983; Chui and Shibles, 1984). Inter or mixed cropping is also widely practiced by the farmers of Bangladesh. There are many established and speculated advantages for intercropping systems such as higher grain yields, greater land use efficiency and improvement of soil fertility by the component legume crops (Willey 1979 b, Andrew and Kassam, 1976).

Hashem and Maniruzzaman (1986) reported that almost all cases intercropping gave higher monetary return than the sole crop. Rahman *et al.* (1982) found higher monetary return in a maize + mungbean combination. Akanda and Quayyum (1982) found maize + groundnut combination produced maximum cost benefit ratio of 1:3.05 in 100% maize + 50% groundnut combination at 60 kg/ha N level.

Different nutritional demands of the two dissimilar crops grown together may create competition problems in meeting the nutrient needs of the crops grown simultaneously. However, in such intercropping mixture where legume and cereal are grown in association the rate of nitrogen fertilizer to be used is a mute question. In an experiment of cotton + legume (mungbean and groundnut) intercrops, Giri and Upadhyay (1980) showed that yield of seed cotton and monetary return per hectare were increased significantly with every higher level of nitrogen. Kalra and Gangwar (1980) reported that total productivity increased by 29 to 37.5 percent with the application of nitrogen @ 80-120 kg/ha as compared with 40 kg/ha in an intercropping systems of maize and legumes. They also reported that the application of 80 kg N/ha was economically viable.

In an experiment, Gangwar and Kalra (1984) found that maize intercropped with mungbean and fertilized with 120 kg N/ha gave more yield than the application of 80 kg N/ha.

Yadav (1981) obtained highest yield of maize at 120 kg N/ha in maize + pigeonpea intercrop. Pigeonpea as an intercrop did not increase the yield of maize at any level of nitrogen. It was concluded by Rajasejaran *et al.* (1983) that maximum economic return was obtained by growing maize with blackgram or onion with 100 kg N/ha. But application of 135 kg N/ha significantly increased grain yield compared with 65 or 100 N/ha. The highest total yield and net return was obtained from maize and groundnut intercropping at the plant population levels of 4.4×10^4 maize and 16.6×10^4 groundnut plants per hectare with 120 kg N/ha than 30 kg N/ha (Quayyum *et al.* 1985). The main advantage for the use of legumes in intercropping and mixed cropping is as the saving of N-fertilizer (Threnbath, 1974). Hashem (1983) indicated that 40 percent N may be saved in a maize + cowpea intercropping system. Islam (1982) estimated that 80 percent nitrogen fertilizers might be saved in maize + blackgram intercropping. He found highest LER value (1.55) when maize was intercropping with blackgram at 44,444 maize plants/ha + 1,11,111 blackgram plants/ha with 20 kg N/ha instead of 120 kg N/ha.

The maize yield increased by intercropping were 103 percent with cowpeas, 16 to 82 percent with mung, 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.

The effect of each crop component should be taken into consideration to determine the plant type for intercropping. The cereal crops possess erectophilic leaf architecture where as legume are phanophilic. Most of the solar energy is harvested by a few leaves of a legume where as cereals absorbs solar energy through the canopy as a whole. Cereals are least affected by shortage of solar energy in a cereal-legume intercropping system, as they are generally taller in nature, but cereals having initial faster growth rate which has a shading effect on the legumes exaggerate competitive disadvantage of legumes. Cereals in most cases thus become the dominant crop and the dominated crops give less than their expected yield (Bandaypadhyay, 1984)

Hashem (1983) reported that maize yield was reduced in intercropping with cowpea by 19% at 100% maize + 50% cowpea combination but the total yield advantage increased by 25% compare to sole crop of maize. In both the cases, however, they indicated yield reduction of blackgram and cowpea.

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, the technique of "paired row" planting has been developed to harness the maximum advantage from an intercropping system (Singh, 1983).

Mainruzzaman *et al.* (1981) reported several cereal-legume intercrop combinations like wheat + lentil/chickpea, maize + blackgram and maize + groundnut etc. Some of these combinations resulted in increased productivity.

Maize-blackgram and maize + cowpea were reported to be good intercrop combinations by Islam (1982) and Hashem (1983), respectively.

Average increase of total grain production ranged from 29.5 to 92.5 percent as a result of maize + legumes (blackgram, greengram and cowpea) intercropping (Kalra and Gangwar, 1980) system. Islam (1982) found 19 and 16 percent yield reduction of maize than a sole maize in maize + blackgram intercropping systems at population levels of 44, 444 maize plants per hectare and 1,11,111 blackgram plants per hectare. But total yield advantage increased by 47 and 55 percent respectively.

Rathore *et al.* (1980) observed in maize + blackgram intercropping system that paired plating of maize 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.

The yield advantage of intercropping is the best utilization of the environmental resources for growth and development of the crops' components (Willey, 1979 a; Singh, 1981); other possible ways of improving crop productivity may be through better weed control, pest and disease reduction (Moody and Shetty, 1979).

De *et al.* (1978) shown the total productivity per unit land area can be increased in maize, sorghum and pearl millet when these crops were interplanted with short-duration legumes like mugbean and soybean. They obtained additional yield of 620 and 120 kg per hectare when maize was intercropped with mungbean and soybean, respectively compared to a sole maize crop.

The benefit cereal-legumes intercropping systems also controlled by the quantity of N_2 fixed by component legume crops. The quantity of N_2 fixed by the legumes component in cereal legume intercropping depends on the species, morphology, and density of legume in the mixture, the type of management and the competition abilities of the component crops. Wahua and Miller (1978) reported that, shading by the cereal, reduce both the seed yields and the N_2 fixation potential of the companion legumes. In a sorghum-soybean intercropping system, a tall variety of sorghum reduced soybean yield by 75% and N_2 fixation at the early pod filling stage by 99%.

Enyi (1973) conducted an experiment in kharif season and he observed that rapid growth of weed leads to severe crop weed competition, which drastically reduced the growth and economic yield of crops. On the other hand intercropping reduces weed growth through competition. He showed that the cost required for weeding could be reduced in an intercropped mixture. Experiments on weed management that have been conducted in an intercropping system indicate that many factors including the specific component crops, crop cultivars, plant population, spatial arrangement and soil fertility determine the weed competitive ability of intercrops (Moody and Shetty, 1979). The biomass of weed growing in association in a corn + mungbean intercrop was found to be low or generally lower than found in sole crops (Bantilan and Harwood, 1973; Bantilan *et al.* (1974). In cotton/mungbean or cowpea intercropping system, De (1974) observed that fast initial growth of the legume crop keeps the weeds under control. Bantilan *et al.* (1974) found that mungbean was superior to groundnut or sweet potato in suppressing weeds when these crops were intercropped with corn. The superiority of mungbean to groundnut appeared to be due to the more rapid early growth of the mungbean and its fast leaf canopy build up.

A proper combination of crops is important for the success of intercropping systems, when two crops are to be grown together. It is imperative that the peak period of growth of the two crops species should not coincide. Crops of varying maturity duration need to be chosen so that quick maturing crops completes its life cycle before the grand period of growth of the other crop starts. However, the yields of both the crops are reduced when grown as mixed or intercropped, compared with when the crops are grown alone but in most cases combined yields per unit area from mixed or intercropping are higher (Saxena, 1972).

Saxena (1972) reported that crops of varying maturity durations need to be chosen so that a quick maturing crop completes its life cycle before the grand period of growth of the other crop starts. Intercropping legumes with non-legumes has been a traditional practice of the farmers of tropical and sub-tropical areas where 'low level equilibrium' farming exists and difficulties arise from shortage of available capital, unfavourable price relationships, unsophisticated markets, uncertain and unevenly distributed rain and a rudimentary infrastructure (Bhatnagar and Davies, 1979).

Willey and Osiru (1972) obtained better yield advantage of maize and bean mixtures through more efficient utilization of light by tall maize and short bean. Giri and De (1978) found that the total productivity and land equivalent ratio can be increased when tall and initially slow-growing crops like pigeonpea were interplanted with quick maturing crops like mung or blackgram.

Andrews (1972) indicated that this practice provides scope for better utilization of labour, ensures crop productivity, increases farm income and improves nutritional quality of diet for the farm family. The major objectives of intercropping are (i) to produce an additional crop without affecting much the yield of base crop, (ii) to obtain higher total economic returns, (iii) to optimize the use of natural resources including light water and nutrients and (iv) to stabilize the yield of crops (Rahman *et al.* 1982).

Chapter 3

Materials and Methods

Chapter 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field at Sher-e-Bangla Agricultural University, Dhaka during the period from March to June, 2006. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout experimental design, intercultural operations, data recording and their analysis.

3.1 Site description

The experiment was conducted in the Sher-e-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28 (Appendix I) during the Kharif-I season of 2006.

3.2 Climate and weather

The experimental area was under the sub-tropical climate that characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the Rabi season (October-March). The weather data during the study period of the experimental site is shown in Appendix II.

3.3 Soil

The farm belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. The land was above sea level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field for soil analysis with the cooperation of Soil Resources and Development Institute (SRDI), Dhaka. The physiochemical properties of the soil are presented in Appendix III. From the initial soil analysis it was found that the quantity of total N (%), available P (ppm) and exchangeable K (meq/100 g soil) were below the critical level.

3.4 Experimental treatments

The following seven treatments were tested:

T_1 = Sole maize normal row (MNR) with 120 kg N/ha
T_2 = Sole maize paired row (MPR) with 120 kg N/ha
T_3 = MNR + 2 mungbean rows with 120 kg N/ha
T_4 = MNR + 2 mungbean rows with 60 kg N/ha
T_5 = MPR + 5 mungbean rows with 120 kg N/ha
T_6 = MPR + 5 mungbean rows with 60 kg N/ha
T_7 = Sole mungbean with 30 kg N/ha

3.5 Experimental design

The experiment was conducted in a Randomized Complete Block Design (RCBD) with 3 replications. The plan of layout and other details are given in Appendix IV and V.

3.6 Cultural operations

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

3.6.1 Land preparation

The land was opened on February 27, 2006 by a tractor-drawn disc plough followed by harrowing. Power tiller was used to obtain a good tilth. The land was leveled by ladder and weeds were collected and removed.

3.6.2 Lay of out plan

Lay out of the experiment following RCBD was done on February 28, 2006.

3.6.3 Seed and sowing

Maize and mungbean seeds were sown in line on March 1, 2006. V- shaped furrows about 10 cm deep was made at appropriate distances by a small manually drawn furrow opener. Two to three seeds of maize per hill were dibbled at 5 cm depth of the furrows maintaining a hill distance of 25 cm. Mungbean seeds were sown at 5 cm depth in solid lines at required seed rate. The varieties of maize and mungbean used were Barnali and BARImung-5, respectively. Irrigation was applied in the furrows for the better germination of the seeds.

3.6.4 Gap filling and thinning

Mungbean and maize seed germinated four and five days after sowing (DAS), respectively. Gap filling was done on March 12, 2006 (11 DAS). Thinning of excess maize and mungbean plants were done at 20 DAS to keep one plant per hill of maize and 10 cm between plants in a mungbean row.

3.6.5 Plant population and planting system

In all the treatments the recommended plant population of maize (55,555 plants per hectare) was maintained. Recommended plant population of mungbean (3,33,333 plants per hectare) in sole plot was maintained by sowing the seeds 30 cm apart between and plant to plant distance as 10 cm. Maize was sown in two row orientation like uniform row (UR) and paired row (PP) systems. In UR method normal spacing (75cm x 25 cm) was followed. In PR method, two maize rows were sown at 37.5 cm distance and two paired rows were separated by a distance of 150 cm. Plant to plant distance for maize was 25 cm in both the methods. In UR method, two rows of mungbean were sown between the maize rows while in PR method five rows of mungbean were between the two pairs of maize rows.

3.6.6 Weeding

Weeding was done manually on March 22, 2006 (21 DAS) both in sole and intercropped treatments.

3.6.7 Plant protection

Adequate plant protection measures were taken for better establishment of the plants. Vitavax-200 at the rate of 2g per kg seed was used before seed sowing for seed treatment. Diazinon 60 EC at the rate of 2.5 ml per litre, Sumitheon at the rate of 2 ml per litre water at 15 and 35 DAS were applied to prevent mungbean plants from the attach of caterpillar, pod borer etc. Mild infestation of mosaic virus was noticed in mungbean and maize was free from any disease. Earthing-up was practiced against lodging of maize plants.

3.6.8 Application of fertilizer

Maize plants received a uniform application of 216-120-144-7 kg/ha of TSP, MP, Gypsum, and Boric acid, respectively. Maize treatments as sole and intercropped were given nitrogen fertilizer as per treatments. Sole mungbean received 30 kg nitrogen per hectare. Half amount of urea and full quantity of TSP, MP, Gypsum, and Boric acid were mixed with soil of maize and mungbean treatments at the time of sowing. The remaining quantity of urea was applied in maize rows in two equal splits at 25 and 45 DAS as side dressing. The sole mungbean received 30 kg N/ha as basal application. Additional fertilizer was not applied for mungbean as intercrop.

3.7 Data recorded at harvest

3.7.1 Crop characters

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

Data for Maize

i) Plant height (cm)

ii) No. of cobs per plant

iii) Cob length (cm)

vi) No. of grains per cob

v) 1000- grain weight (g)

vi) Grain yield (kg/ha)

vii) Stover weight (kg/ha)

Data for Mungbean

i) Plant height (cm)

ii) No. of pods per plant

iii) Length of pod (cm)

iv) No. of seeds per pod

v) 1000-seed weight (g)

vi) Seed yield (kg/ha)

3.7.2 Grain yield

An area of 13.5 m^2 (4.5m x 3m) was harvested from both sole and intercropped treatments of mungbean and maize. The harvested area included six maize rows in sole and intercrop, 15 mungbean rows in sole and 10 in intercrop treatment. Mungbean was harvested in two times at 64 and 79 DAS. Maize was harvested at 99 DAS. 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 and mungbean were recorded. Maize stover was dried and per plot weight was recorded. The grain yield of maize and mungbean and stover yield of maize from each plot were converted into per hectare yield.

3.7.3 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.

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

Where,

Ym =Yield of maize (kg/ha)

Yi =Yield of intercrop mungbean (kg/ha)

Pi = Price of intercrop mungbean (Tk/ha)

Pm = Price of maize (Tk/ha).

3.8 Harvest index of maize

Harvest index of maize was calculated by following formula:

$$HI\,(\%) = \frac{\text{Economic yield}}{\text{Biological yield (excluding root)}} \times 100$$

3.9 Relative Yield

Relative yield is the ratio between yield of component crops and yield of sole crop.

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

3.10 Land equivalent ratio (LER)

LER was calculated by the following formula as given by Willey (1979 b).

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

Where,

Yml = Yield of maize when intercropped with legume

Ym = Yield of sole maize

Ylm = Yield of legume when intercropped with maize

Yl = Yield of sole legume

3.11 Economics

The total man hours used for the different field operations including harvesting and threshing were recorded on the basis of fix area and time requirement that finally 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 and mungbean grains.

3.12 Benefit cost ratio (BCR)

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

$$BCR = \frac{\text{Gross return (Tk/ha)}}{\text{Cost of cultivation (Tk/ha)}}$$

3.13 Statistical analysis

The data of each plot were analyzed with the computer-based software MStatC and mean separation was done following Least Significant Difference (LSD) test.

Chapter 4

Results and Discussion

Chapter 4

RESULTS AND DISCUSSION

4.1 Crop characters of maize

4.1.1 Plant height

The height of maize was not significantly affected by different treatments (Table1). The taller plant was 242 cm in treatment T_1 (Sole maize NR with 120 kg N) which was closely followed by treatment T_2 (Sole maize PR with 120 kg N). The height of maize in treatment T_3 (Maize NR + Two rows of mungbean with 120 kg N) was 228 cm. The Lowest plant height was observed in treatment T_6 (Maize PR + Five rows of mungbean with 60 kg N) that was 218 cm. Overall, higher plant height was observed with higher dose of N.

4.1.2 Cob length

Cob length was significantly affected by different treatments (Table1). The higher cob length (20.64 cm) was observed in T_1 but statistically identical to T_2 treatment. The length of cob was higher in 120 kg N/ha applied plot of sole maize. Intercrop situation resulted in minimum cob length. The length was significantly lower when maize and mungbean were intercropped with 60 kg N/ha.

4.1.3 Number of grains per cob

The number of grains per cob was significantly influenced by different treatments (Table 1). The significantly highest number of grains per cob (400) was obtained in T_1. Sole maize planting dominated over paired row maize planting in respect of production of grains per cob. Intercropped situation resulted insignificant lower number of grains per cob even with higher or lower nitrogen level. There was no significant different in grains/cob in sole (PR) and intercropped situation. On an average grain/cob was lower with 60 kg N/ha

4.1.4 1000-grain weight

There was no significant variation observed in 1000-grain weight in different treatments (Table1). However, higher 1000-grain weight (238.00g) was that obtained from T_1 followed by T_2. Neither nitrogen levels nor row arrangement in sole or intercropped situation influenced this parameter. Both the sole situation scheme slightly higher grain weight intercropped situation.

4.1.5 Grain yield of maize per hectare

(Different planting systems and nitrogen levels influenced significantly the production of grain yield of maize (Table1). Maximum grain yield (4283.00 kg/ha) was obtained from the sole maize in UR planting system with 120 kg N/ha in T_1 followed by the T_2 where maize was grown as sole crop in PR planting system with same N level. It indicates that the plant population of maize per hectare remains the same in the different maize row management, which gave similar grain yield.) These results were in conformity with the findings of De *et al.* (1978), Mohta and De (1980) and Akhtaruzzaman (1987). Treatment T_5 (maize as paired rows intercropped with 5 mungbean lines with 120 kg N/ha) also produced statistically similar grain yield to those of T_1 and T_2 treatment. It is evident from grain yield point of view, PR maize with mungbean rows intercropping situation did not reduce the grain yield substantially. In intercropping situations where mungbean was accommodated either in uniform row or paired rows of maize gave lower yield of maize with lower dose of nitrogen (60 kg N/ha). This result was in agreement with the findings of Akanda and Quayyum (1982), Gangwar and Kalra (1984) and Akhtaruzzaman (1987). In general, grain yield of maize reduced in intercropping situation compared to the sole maize regardless of N dose.

4.1.6 Stover yield of maize per hectare

Stover yield of maize was significantly affected by the treatments (Table 1). Maximum stover yield (5255.000kg/ha) was obtained from T_1 and was followed by T_5, T_2, T_3 and T_7. The minimum stover yield (4610.00 kg/ha) was obtained from T_4 and followed by T_7 and T_3. Likewise grain of maize, T_5 also proved effective management to produce stover yield which was at par with sole maize stover production. Stover yield in intercrop situation was not reduced as in the case of grain yield regardless of the amount of nitrogen applied.

4.1.7 Harvest index of maize

Harvest index of maize was affected by different treatments (Table 1). The maximum harvest index (0.45) was observed in UR sole maize with 120 kg N/ha and followed by paired maize row system fertilized with 120 kg N/ha. Inter crop situation with higher or lower rate of nitrogen showed lower harvest index (0.39 to 0.42)

Table 1. Effect of row arrangement and nitrogen on the grain yield and crop characters of **maize** as sole and intercropped with mungbean

Treatments	Plant height (cm)	Cob length (cm)	No. of grains/ Cob	1000-grain wt /(g)	Grain yield (kg/ha)	Stover Yield (kg/ha)	Harvest Index (%)
T_1	241	20.64	400.30	238.00	4283.00	5255.00	45
T_2	239	19.16	346.00	236.00	4140.00	5010.00	44
T_3	228	18.47	333.00	231.30	3604.00	4936.00	42
T_4	225	16.96	310.00	229.0	3116.00	4610.00	40
T_5	227	18.40	348.70	231.00	3751.00	5089.00	43
T_6	218	16.52	308.30	230.00	3160.00	4885.00	39
LSD (0.05)	NS	1.986	36.26	NS	610.70	396.70	0.018
CV (%)	4.32	5.95	5.83	7.03	9.00	4.39	5.16

T_1 = Sole maize normal row (MNR) with 120 kg N/ha

T_2 = Sole maize paired row (MPR) with 120 kg N/ha

T_3 = MNR + 2 mungbean rows with 120 kg N/ha

T_4 = MNR + 2 mungbean rows with 60 kg N/ha

T_5 = MPR + 5 mungbean rows with 120 kg N/ha

T_6 = MPR + 5 mungbean rows with 60 kg N/ha

4.2 Crop characters of Mungbean

4.2.1 Plant height

Plant height of mungbean was not significantly affected by the different treatments (Table 2). The higher plant height (84.67 cm) was found in T_3 where NR maize was intercropped with two rows of mungbean at 120 kg/ha and the lower plant height (76.00 cm) was recorded in sole mungbean (T_7). Mungbean plants showed a tendency to increase plant height in intercropping situations could be as a result of competition for sunlight and shedding effect of maize plants (Karim et al. 1990)

4.2.2 Number of pods per plant

Number of pods per plant was significantly influenced by the various treatments (Table 2). Higher number of pods per plant (18.83) was obtained in T_7 which was followed by T_5. The lower number of pod (15.93) was recorded in T_4 but statistically at par to T_6 and T_3. In T_5, the maize plants probably did not compete with mungbean plants for nitrogen requirement as the plants were given 120 kg N/ha. Thus mungbean plants gave similar pod production that of sole mungbean treatment (T_7). Where as in intercrop situation with lower nitrogen level (60 kg N/ha), mungbean plants probably had greater competition with maize plants for nitrogen requirement thus producing minimum pods/plant. These results were also evident in T_6 and T_4 as maize intercropping systems were given lower rate of nitrogen (60 kg/ha).

4.2.3 Pod length

Pod length of mungbean was significantly affected by the different treatments (Table 2). The maximum pod length (7.66 cm) was obtained in treatment T_7 which was statistically indicated to T_5 and T_6. The lowest pod length (6.16cm) was in treatment T_4. Paired row planting system of maize and sole mungbean (T_5, T_6 and T_7) gave comparatively higher length of pod than the uniform planting systems of maize (T_3 and T_4). It is inferred that mungbean in the sole and paired row maize planting systems have more exposure to sunlight which longer pod length.

4.2.4 Number of seeds per pod

Number of seeds per pod was significantly influenced by the different treatments (Table 2). Higher number of seeds per pod (7.45) was recorded in T_7 which followed by T_5, T_6, T_3. The lower number of seeds per pod was found in treatment T_4 which followed by T_3 and T_6. It was evident that the number of seeds per pod varied with pod length and longer pods had higher number of seeds per pod.

4.2.5 1000-seed weight

No significant influence of treatments was observed in 1000-seed weight (Table 2). However, the highest 1000-grain weight (27.25g) was recorded in treatment T_6 and the lowest weight (25.36g) was found in T_5. Seed weight did not follow any definite trend.

4.2.6 Seed yield of mungbean (kg/ha)

Grain yield of mungbean was significantly varied as affected by different treatments (Table 2). The highest grain yield (1087.00 kg/ha) was obtained from treatment T_7 and it was significantly different from other treatments. This yield difference was mainly due to the higher plant population of mungbean in sole plot. The number of plants per hectare was 3,33,333 in sole mungbean plot whereas the number of plants in the intercrop treatments was 2,22,222 (about 67% lower than the sole population). Beside this, the maximum yield was obtained due to the integrated effect of higher number of pods/ plant, bigger pod length and number of seeds per pod. The second highest yield (675.30 kg/ha) was obtained from the treatment T_5 and followed by T_3 and T_6. In intercropping situation, inter or intra-specific competition for light, water and nutrients appeared to have greater effect on mungbean, which reduced yield attributes and yield of mungbean. Reduced yield of intercropped also been reported by Gunasema *et al.* (1979). Though planting systems of maize did not have any significant difference on mungbean grain yield under intercropped situation but it appears that mungbean grain yield was slightly more in PR planting than uniform row planting system with same nitrogen level.

Table 2. Effect of row arrangement and nitrogen on the seed yield and crop characters of **mungbean** as sole and intercropped with maize

Treatments	Plant height (cm)	No. of pods/plant	Pod length (cm)	No. of seeds/pod	1000-seed wt (g)	Seed yield (kg/ha)
T_3	84.67	17.00	6.66	6.43	26.45	605.00
T_4	81.21	15.93	6.16	5.80	26.06	540.70
T_5	83.00	18.00	7.31	7.19	25.36	675.30
T_6	80.00	16.00	7.15	6.43	27.25	601.00
T_7	76.00	18.83	7.66	7.45	25.68	1087.00
LSD (0.05)	NS	1.333	0.895	1.053	NS	104.20
CV (%)	5.31	4.31	6.80	8.39	7.74	7.89

T_3 = MNR + 2 mungbean rows with 120 kg N/ha

T_4 = MNR + 2 mungbean rows with 60 kg N/ha

T_5 = MPR + 5 mungbean rows with 120 kg N/ha

T_6 = MPR + 5 mungbean rows with 60 kg N/ha

T_7 = Sole mungbean with 30 kg N/h

4.3 Evaluation of intercropping system

Total land productivity is a basic consideration in evaluating intercropping system where land holdings are very meager. For this purpose, relative yields, maize equivalent yield, land equivalent ratio (LER), net monetary return per hectare and benefit cost ratio could be the better indicators of the different row management of crops. These were computed and presented in Table 3 and 4 and illustrated under different heads.

4.3.1 Relative yield

In all the intercrop treatments, relative yield of maize was reduced (Table 3). The extent of yield reduction was more observed in intercropping treatments where NR and PR maize rows were intercropped with mungbean and gave a lower nitrogen dose. However, PR Maize + Mungbean planting showed better relative yield of maize than NR Maize + Mungbean system. The similar trend of relative yields of mungbean was obtained in intercropping situation as it was observed in maize relative yields of intercropping situation. Relative yield of mungbean in intercropping situation were lower than that of sole mungbean. The PR maize + mungbean system also showed better relative yield of mungbean than NR maize + mungbean system. In intercrop treatments the yield reduction in maize and mungbean might be due to inter and intra plant component competition or antagonistic relationship between maize and mungbean. This result was in conformity with Rahman and Shamsuddin (1981), Hoque *et al.* (1980) and Hashem (1983).

4.3.2 Maize equivalent yield

Higher maize equivalent yields were recorded for all the intercropping treatments than the grain yields recorded in sole maize (Table 3). The highest maize equivalent (6002.00 kg/ha) was obtained from PR maize intercropped with mungbean with 120 kg N/ha (T_5). The next higher maize equivalent yield

(5620.60) was obtained from NR maize intercropped with mungbean at120 kg N/ha (T_3). Lower nitrogen level for PR or NR intercropped system had lower values of maize equivalent yield which indicates the growth of mainly maize crops were reduced due to shortage of nitrogen in their life cycle. In intercrop situation, the maize equivalent yields were higher due to 2.78 times greater market price of mungbean grain than maize grain price. The lowest equivalent yield (3623.30 kg/ha) was from the sole mungbean.

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 is expressed as LER. Table 3 showed that a yield advantage was obtained from all the intercropping treatments. Intercropping maize with mungbean at different planting systems with different nitrogen levels gave LER advantages ranging from 22 to 53% with slightly yield loss of maize. Maximum LER (1.53) was obtained from PR maize intercropped with mungbean at 120 kg N/ha (T_5). Which means that by intercropping maize and mungbean in paired row planting system with 120 kg N/ha could produce 3751 kg of maize and 675.30 kg of mungbean from one hectares of land instead of growing them separately in 1.53 hectares of land to obtain the same total yield. In other words, by intercropping maize with mungbean the land use efficiency was increased by 50%. The higher LER in intercrop treatments also indicates that the mungbean could be intercropped with maize for higher production and better utilization of resources. Similar result also had been reported from maize + mungbean intercropping by Ahmed et al. (2000 b); Polthanee and Changsri (1999); Kalra and Gangwar (1980).

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

Treatments	Maize		Mungbean		Maize equivalent yield (kg/ha	LER
	Grain yield (kg/ha)	Relative yield	Seed yield (kg/ha)	Relative yield		
T_1	4283.00	1.00	-------	-------	4283.00	1.00
T_2	4140.00	1.00	--------	-------	4140.00	1.00
T_3	3604.00	0.84	605.00	0.56	5620.60	1.40
T_4	3116.00	0.73	540.70	0.50	4916.00	1.23
T_5	3751.00	0.88	675.30	0.62	6002.00	1.50
T_6	3160.00	0.74	601.00	0.55	5163.30	1.29
T_7	--------	-------	1087.00	1.00	3623.30	1.00

T_1 = Sole maize normal row (MNR) with 120 kg N/ha

T_2 = Sole maize paired row (MPR) with 120 kg N/ha

T_3 = MNR + 2 mungbean rows with 120 kg N/ha

T_4 = MNR + 2 mungbean rows with 60 kg N/ha

T_5 = MPR + 5 mungbean rows with 120 kg N/ha

T_6 = MPR + 5 mungbean rows with 60 kg N/ha

T_7 = Sole mungbean with 30 kg N/ha

4.4 Economical profitability

4.4.1 Gross return

Total gross return (Tk101283.00/ha) was the highest in PR maize intercropped with mungbean at 120 kg N/ha (T_5) followed by 95122.00 Tk/ha in NR maize intercropped with mungbean with 120 kg N/ha (T_3). Both the sole crop of maize failure to show higher gross return than intercropped situation. This was due to additional benefit from mungbean without hampering the grain yield of maize. Though mungbean price is higher but failure to show higher gross return in sole situation.

4.4.2 Total variable cost

The highest total cost of cultivation (Tk 39000.00/ha) was found in treatment T_5 followed by (Tk 37000.00/ha) in T_3. The higher cost was involved in treatment T_5 due to planting system and higher dose of nitrogen. The lowest total cost of cultivation (Tk 22000.00 /ha) was recorded from sole mungbean (Table 4).

4.4.3 Net return

The highest net return over variable cost was Tk 62283.00/ha recorded from T_5 though higher cost was involved. The second highest return Tk 58122.00/ha was in T_3. The lowest net return was Tk 32350.00/ha obtained from sole mungbean (Table 4). PR maize + 5 mungbean rows at 120 kg N/ha resulted in additional net return as 16287.00 Tk over UR maize cultivation. On the other hand, if maize and mungbean were cultivated individually in two hectares, the additional net return from their intercrop in one-hectare system was Tk 23111.00/ha. So from monetary point of view, the T_5 was the best row management of maize + mungbean intercrop system. All the intercropping system showed higher net return than sole maize with uniform or paired row system.

4.4.4 Benefit cost ratio (BCR)

The highest BCR (2.60) was obtained from T_5. The second highest BCR 2.57 was in T_3. The lowest BCR was 2.28 obtained from T_2 (Table 4). Monetary advantages were also obtained by Kalra and Gangwar(1980), Rahman *et al.* (1982), Akanda and Quayyum (1982), Bandyopaydhya (1984) and Akhtaruzzaman (1987)) from intercrop combinations of different crops. It is noted that MPR + 5 rows of mungbean with 60 kg N/ha showed lower BCR than sole mungbean and sole maize in paired rows. Sole mungbean also showed similar BCR to sole maize in uniform row and higher than paired row maize which might be due to lower cost of cultivation of munbean.

Table 4. Economic analyses of different treatments

Treatments	Grain yield (kg/ha)		Gross return (Tk/ha)			Total cost of cultivation (Tk/ha)	Net Return (Tk/ha)	BCR
	Maize (1)	Mungbean (2)	Maize (3)	Mungbea (4)	Total 5=(3+4)	(6)	7=(5-6)	8=(5/6)
T_1	4283.00	-------	77094	------	77094	31100	45994	2.47
T_2	4140.00	-------	74520	-------	74520	32700	41820	2.28
T_3	3604.00	605.00	64872	30250	95122	37000	58122	2.57
T_4	3116.00	540.70	56088	27035	83123	36000	52530	2.30
T_5	3751.00	675.30	67518	33765	101283	39000	62283	2.60
T_6	3160.00	601.00	56880	30050	86930	37500	49430	2.31
T_7.	------	1087.00	-----	54350	54350	22000	32350	2.47

T_1 = Sole maize normal row (MNR) with 120 kg N/ha

T_2 = Sole maize paired row (MPR) with 120 kg N/ha

T_3 = MNR + 2 mungbean rows with 120 kg N/ha

T_4 = MNR + 2 mungbean rows with 60 kg N/ha

T_5 = MPR + 5 mungbean rows with 120 kg N/ha

T_6 = MPR + 5 mungbean rows with 60 kg N/ha

T_7 = Sole mungbean with 30 kg N/ha

Market prices:
Maize = Tk18/kg Labour cost @ Tk.70 day^{-1}
Mungbean = Tk50/kg

Chapter 5

Summary and Conclusion

Chapter 5

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field at Sher-e-Bangla Agricultural University, Dhaka during the period from March to June, 2006 to study the effect of row arrangement and nitrogen on the yield of maize intercropped with mungbean. The experiment was conducted in a Randomized Complete Block Design (RCBD) with 3 replications. Seven treatments viz, T_1 = Sole maize normal row (MNR) with 120 kg N/ha, T_2 = Sole maize paired row (MPR) with 120 kg N/ha, T_3 = MNR + 2 mungbean rows with 120 kg N/ha, T_4 = MNR + 2 mungbean rows with 60 kg N/ha, T_5 = MPR + 5 mungbean rows with 120 kg N/ha, T_6 = MPR + 5 mungbean rows with 60 kg N/ha, T_7 = Sole mungbean with 30 kg N/ha

The seeds were sown in rows on March 1, 2006. Maize was planted in two different planting systems namely normal row (NR) and paired row (PR). In intercrop situation of NR method normal spacing (75cm x 25cm) was followed and two rows of mungbean were sown between the maize rows. In PR method two maize rows were sown at 37.5 cm distance and two such pairs of maize rows were separated by 150 cm. Normal plant to plant distances (25 cm) were maintained in both the methods. Recommended plant population of maize (55,555 plants/ha) and mungbean (3,33,333 plants/ha) were maintained in sole crop treatments. Intercropped mungbean population was just two third (about 67%) of the recommended monoculture population. The varieties of maize and mungbean used were Barnali and BARImung-5, respectively.

Maize plants received a uniform application of 216-120-144-7 kg/ha of TSP, MP, Gypsum, and Boric acid respectively. Maize as sole and intercropped treatments were given nitrogen fertilizer following treatments. Mungbean received 30 kg nitrogen per hectare in sole crop. Half amount of urea and full quantity of TSP, MP, Gypsum, and Boric acid were mixed with soil before sown of maize and mungbean. The remaining quantity of urea was applied equally in maize rows as side dressing at 25 and 45 DAS. Studies at harvest were made on plant height, yield components, grain and stover yields in each treatment.

Results of the experiment revealed that the grain yield of maize significantly affected by different treatments. Higher maize yield was obtained in T_1 (4283.00 kg/ha) where maize was grown as sole with 120 N kg/ha under NR system and followed by T_2 (4140.00 kg/ha) where maize was grown as a sole crop with same level of nitrogen. In intercrop situation, maximum maize grain yield (3751.00 kg/ha) was found in T_5. The lowest maize yield (3116.00 kg/ha) was obtained in T_4. Grain yield of maize was significantly affected by the higher rate of nitrogen both in PR and UR planting methods. The yield difference between treatments was mainly due to variation in number of grains per cob and also cob length.

Seed yield of mungbean was significantly affected by different treatments. Significantly highest seed yield (1,087.00 kg/ha) was obtained from the sole mungbean (T_7). Among the intercropped situation, higher seed yield mungbean was obtained from treatment T_5 and the lowest yield (540.70 kg/ha) was found in T_4. The differences in yield of mungbean in sole and intercrop situations were mainly due to variation in plant population. The yield difference of mungbean in intercrop assumed to be due to inter or intra-specific competition for light, water, nutrients and so on, which reduced the number of pods per plant and number of grains per pod. Among the yield components of mungbean pod length and number of grains per pod were found responsible for variations in yield.

The intercropping systems were evaluated on the basis of relative yield, maize equivalent yield, land equivalent ratio (LER), net monetary returns per hectare and BCR. Relative yield of maize and mungbean revealed that both the components crops in intercropped situation have slight adverse effect on their individual yield but their combined yield was higher. LER varied from 22 to 53% in the different treatments. Highest LER (1.53) was found in T_5 and the lowest (1.22) in T_4. Maximum maize equivalent (6002.00 kg/ha) was found in T_5 and the lowest (3623.30 kg/ha) in T_7. Economic analysis of the different treatments showed that highest gross return (Tk101283.00/ha) and the highest net return (Tk39000.00/ha) and BCR (2.60) were found in T_5. The results of the study showed that all intercrop treatments gave higher maize equivalent than the sole maize. By intercropping maize + five mungbean rows in PR planting method at 120 kg N/ha gave comparatively higher net monetary return compared to that obtained from monoculture of maize and mungbean. However, these results need to be verified further.

From the findings of the present investigation the following conclusion can be drawn:

- All intercropping treatments produced higher maize equivalent than a sole crop of maize. This indicated that higher total grain productivity was possible in intercropped with mungbean by utilizing the same land in same time.
- Paired row (PR) planting system offered the space between the two such pairs of rows for intercropping short duration and early growing crop mungbean can be grown. Wider row space ensured better availability of solar radiation and other natural resources to the short statured companion crop.

- Maize and mungbean intercrop did not reduce nitrogen requirement of maize.
- By intercropping maize + five mungbean rows in paired row (PR) planting methods at 120 kg N/ha could be viable from economic point of view.

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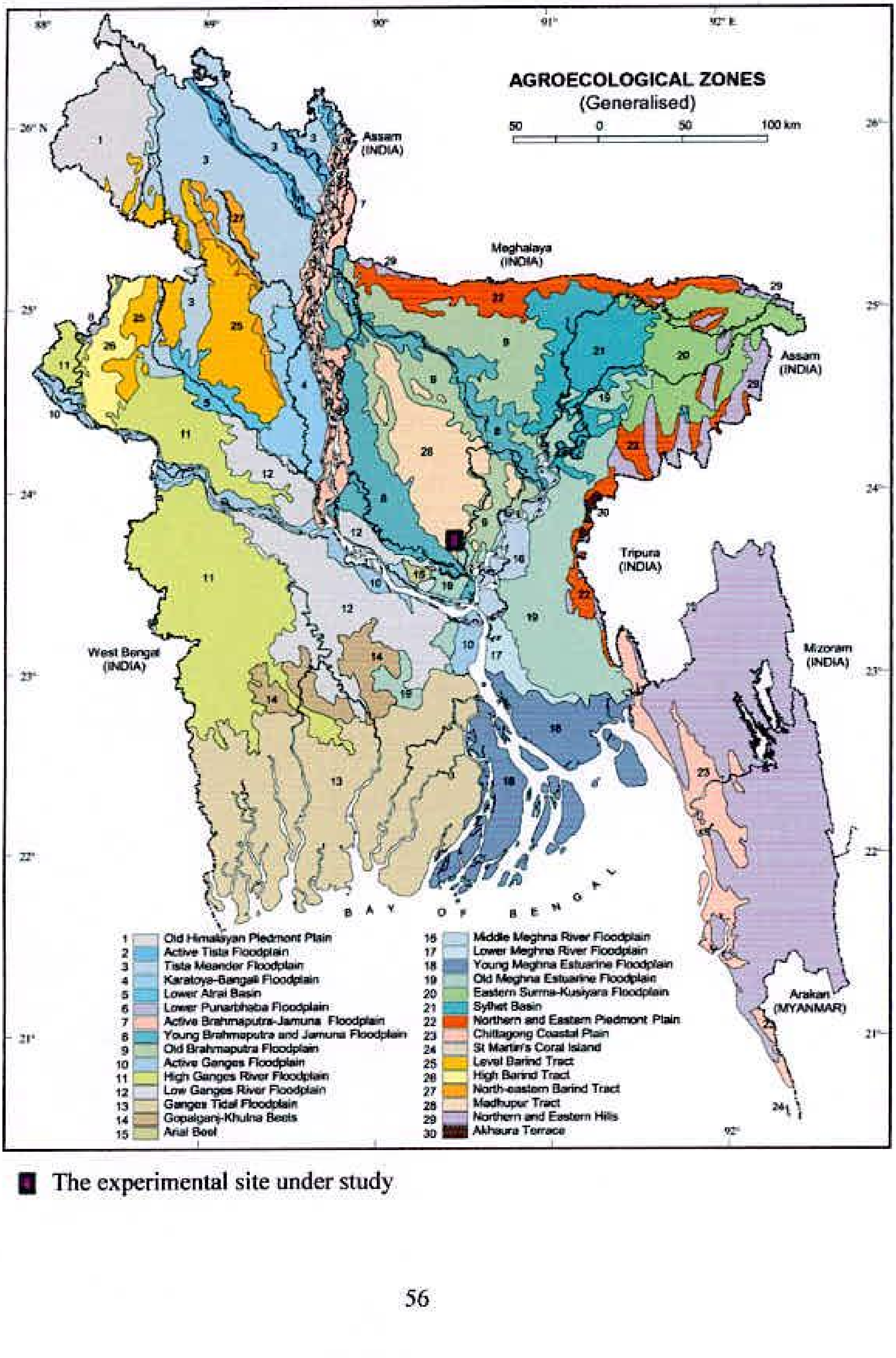
Appendices

APPENDICES

Appendix I. Map showing the experimental site under study



■ The experimental site under study

Appendix II. Monthly average air temperature, relative humidity and total rainfall of the experimental site during the period from January 2006 to July 2006

Month	RH (%)	Max. Temp. (°C)	Min. Temp. (°C)	Rain fall (mm)
January	69.53	25.00	13.46	0
February	51.27	30.00	1943	0
March	46.13	34.00	22.00	0
April	61.4	35.00	23.81	185
May	64.27	35.00	24.95	180
June	66.00	32.50	23.00	181
July	68.00	31.00	22.00	175

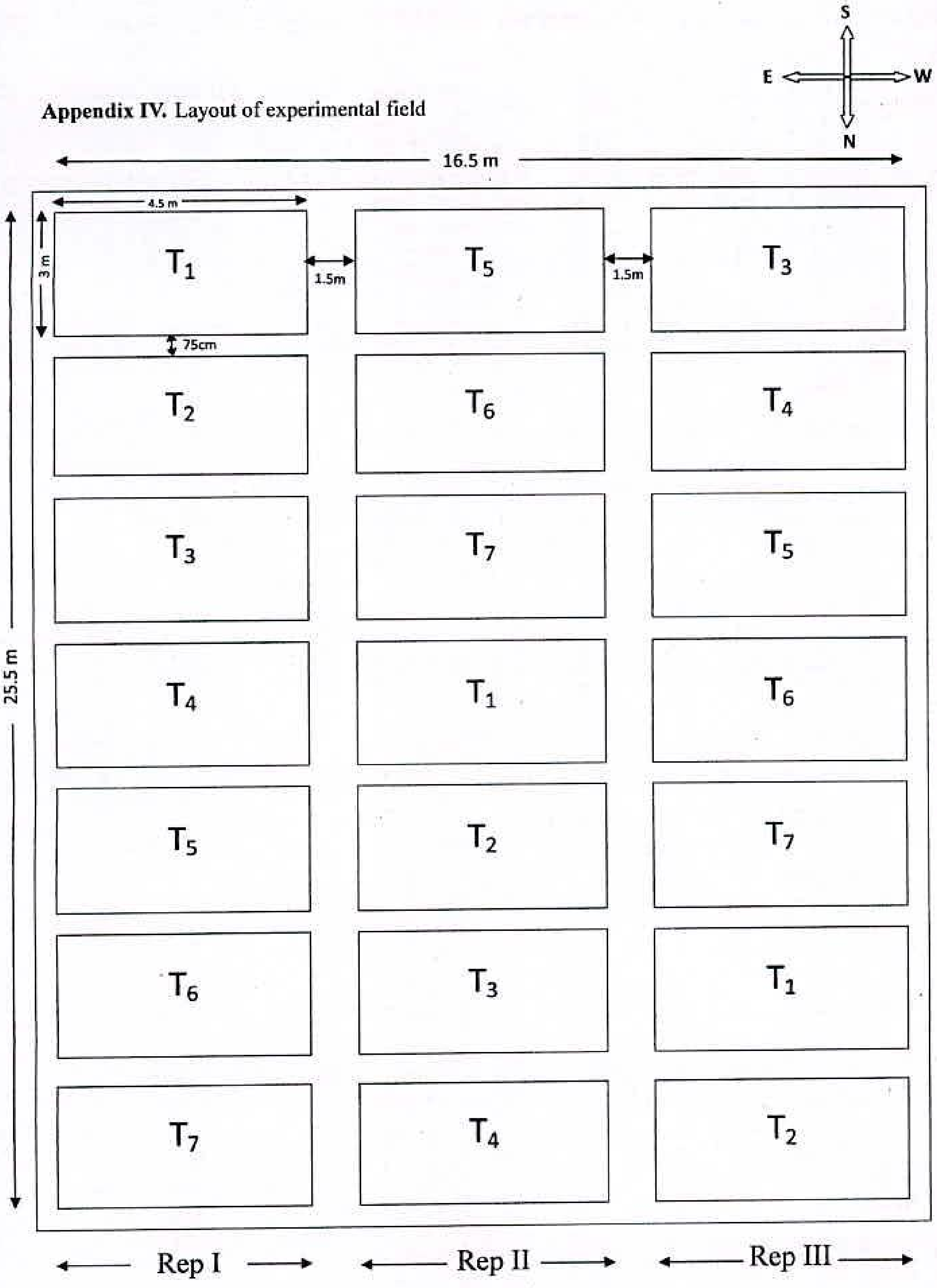
Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Physiochemical properties of the initial soil

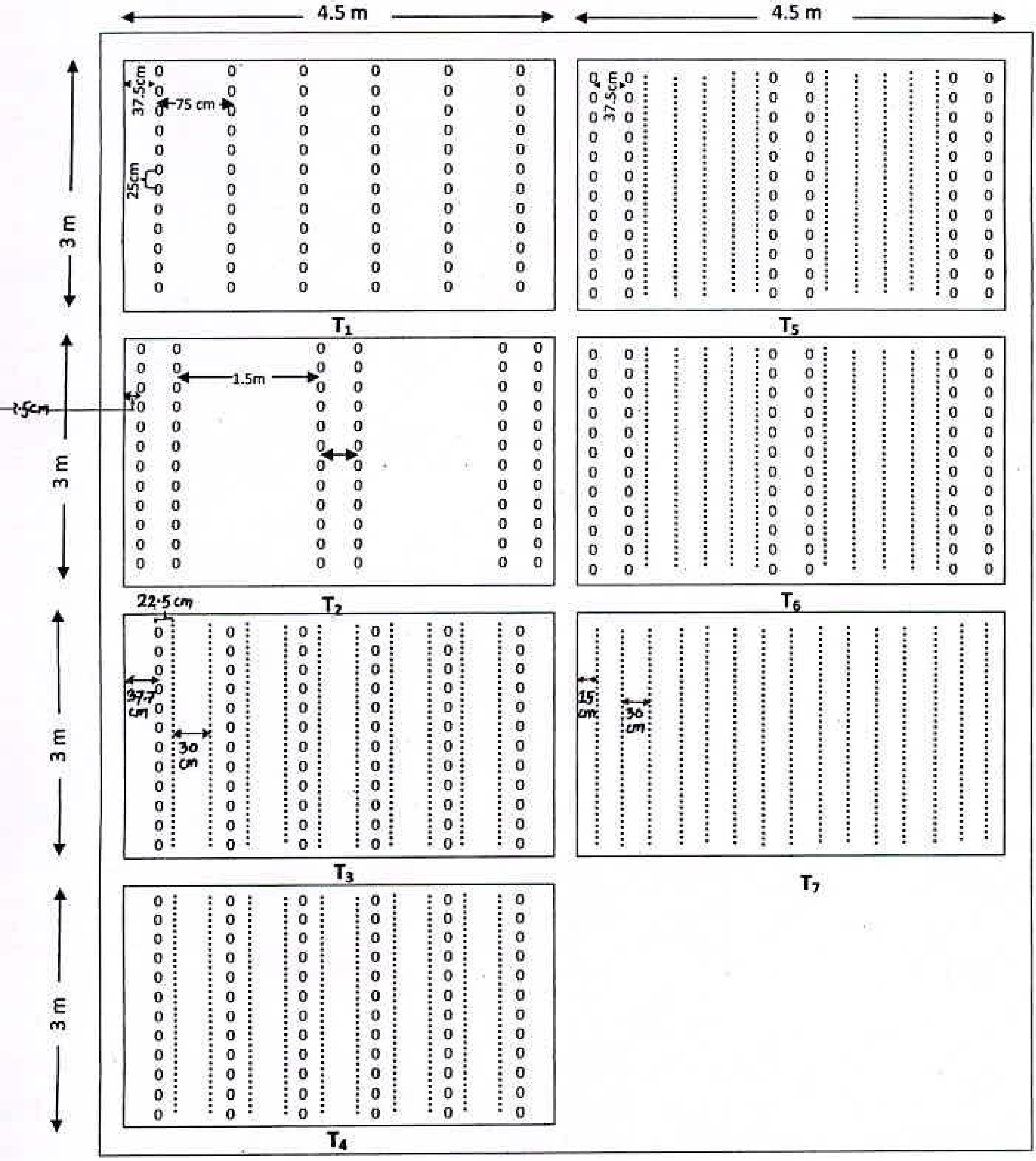
Characteristics	**Value**	**Critical value**
Partical size analysis.		
% Sand	26	.....
% Silt	45	.....
% Clay	29	......
Textural class	silty-clay	......
pH	5.6	acidic
Organic carbon (%)	0.45	......
Organic matter (%)	0.78	......
Total N (%)	0.03	0.12
Available P (ppm)	20.00	27.12
Exchangeable K (me/100 g soil)	0.10	0.12
Available S (ppm)	45	......

Source: Soil Resources Development Institute (SRDI), Dhaka-1207

Appendix IV. Layout of experimental field



Appendix V. Layout of treatments arrangement



000 = Maize row
..... = Mung bean row

Appendix VI. Summary of analysis of variance for different character of maize

Source of variation	Degree of freedom	Mean Sum Squares						
		Plant height (cm)	Cob length (cm)	No. of grain/cob	1000 grain wt(g)	Grain yield (Kg/ha)	Stover Yield (Kg/ha)	Harvest Index (HI)
Treatment	5	0.24ns	6.762**	3391.122**	38.756ns	537983.65*	141115.95ns	0.0022*
Replication	2	0.060*	6.020*	1003.389ns	1462.056*	357431.05ns	176110.05ns	0.0022*
Error	10	0.010	1.192	397.189	267.056	112695.98	47543.12	0.0001
Total	17							

* Significant at 5% level
** Significant at 1% level
ns Not significant

Appendix VII. Summary of analysis of variance for different character of mungbean

Source of variation	Degree of freedom	Mean Sum Squares					
		Plant height (cm)	Number of pods/plant	Pod length (cm)	Number of seed/pod	1000 seed wt (g)	Seed yield (kg/ha)
Treatment	4	32.613^{ns}	4.786**	1.029*	1.320*	1.619ns	146123.43**
Replication	2	33.346^{ns}	9.693**	0.0435^{ns}	0.916^{ns}	11.054^{ns}	8589.067^{ns}
Error	8	18.459	0.501	0.226	0.313	4.099	3064.483
Total	14						

* Significant at 5% level
** Significant at 1% level
ns Not significant

LIST OF PLATES

Plate I. Normal row arranagement of maize

Plate II. Paired row arrangement of maize

Plate III. Intercropping system with normal row of maize + two mungbean rows

Plate IV. Intercropping system with paired row of maize +five mungbean rows