EFFECT OF MAIZE PLANTING CONFIGURATION AND BLACKGRAM SEED RATE ON FODDER PRODUCTION UNDER MAIZE-BLACKGRAM INTERCROPPING SYSTEM

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CERTIFICATE

This is to certify that the thesis entitled ***"EFFECT OF MAIZE PLANTING CONFIGURATION AND BLACKGRAM SEED RATE ON FODDER PRODUCTION UNDER MAIZE-BLACKGRAM INTERCROPPING SYSTEM"*** *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 bonafide research work carried out by* ***MD.IBRAHIM****, Registration No:* ***13-05766****, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

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DEDICATED

TO

MY BELOVED

PARENTS

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ABSTRACT

The experiment was conducted at the Agronomy field at Sher-e-Bangla Agricultural University, Dhaka during the period from September to December, 2013 to study the effect of maize planting configuration and blackgram seed rate on fodder production under maize – blackgram intercropping system. The varieties of maize and blackgram used were local savar and BARI mash-3 respectively. The experiment laid out in was a *Randomized Complete Block Design (RCBD) with three (3) replications. Fourteen* treatments *viz*, T_1 = 40×20 cm Maize(sole), T_2 = Black gram sowing @ 40 kg ha^{-1}(sole), T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @ 30 kg ha^{-1}, T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @ 40 kg ha^{-1}, T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @ 50 kg ha^{-1}, T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @ 30 kg ha^{-1}, T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @ 40 kg ha^{-1}, T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @ 50 kg ha^{-1}, T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @ 30 kg ha^{-1}, T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @ 40 kg ha^{-1}, T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @ 50 kg ha^{-1}, T_{12} = Maize sowing at spacing 30×27 cm with Black gram *sowing @ 30 kg ha^{-1}, T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing* @ 40 kg ha^{-1}, T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @ 50 kg ha^{-1} were considered for the present study. Results showed that both the sole maize and blackgram gave the highest per plant values in most of the plant parameters studied. The treatments show appreciable difference in plant height, number of leaves $plant^{-1}$,number of branches $plant^{-1}$, fodder weight $plant^{-1}$ and dry weight of blackgram and maize due to the varying seed rate and row arrangements. Among the intercropping treatments '40×20 cm apart accommodated spacing' showed higher per plant maize fodder yield 172.70 g . But significantly higher fodder yield and dry weight of maize per hectare was found in sole maize. The sole maize showed significantly the highest values of fodder yield 20.16 t ha^{-1}.The sole blackgram showed significantly the highest values of fodder yield 2.02 t ha^{-1}. *The benefit cost ratio (BCR) was found to be the highest (1.77) in the treatment T1.* However, the intercropping treatments showed inconsistent results in respect of growth, fodder attributes.

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LIST OF ACRONYMS

AEZ	=	*Agro-Ecological Zone*
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
LAI	=	Leaf area index
ppm	=	Parts per million
et al.	=	And others
N	=	Nitrogen
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
G	=	gram (s)
Kg	=	Kilogram
µg	=	Micro gram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
HI	=	*Harvest Index*
No.	=	Number
WUE	=	Water use efficiency
Wt.	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
mm	=	millimeter
Max	=	Maximum
Min	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
T	=	Ton
viz.	=	Videlicet (namely)

CHAPTER I

INTRODUCTION

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INTRODUCTION

As an agricultural country, most of the people of Bangladesh live on agriculture. Bangladesh is also an over populated country but the area of land is limited with small farm holdings. Increasing agricultural production per unit area of land is becoming most important step to cope with the present population growth in Bangladesh. In recent years, multiple cropping has been gaining importance as a means of more crop production in limited land area particularly in the countries with small size farm holdings. This system of farming is already in practice in Bangladesh, India, China, Taiwan, Srilanka, Malaysia, Hongkong, Vietnum, Africa and Latin America (Beet, 1977).

The scope for horizontal expansion of cultivable land 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).

There is a little scope for increasing cultivable area in the world. Therefore, farmers in developing countries have also shown keen interest in intercropping practices to increase crop production vertically to meet their requirements for food, fiber and fodder from the existing area (Bandyopadhyay, 1984).

Though the practice of multiple cropping is becoming popular, yet its advantages are not ensured in all circumstances. The profitability, of course, depends on edaphic and biotic conditions and management practices. In last two or three decades, vigorous investigations of multiple cropping had been done in tropical regions. In most cases the practice was found to be profitable. Various preconditions are necessary for the success of multiple cropping. Some favorable important conditions are proper soil textural property, nutrient status of the soil, climatic conditions of the locality, nature of crops and crop combinations (Dalrymple, 1971).

Three types of crop combinations are generally recognized. Some are competitive, some are supplementary and some are complementary to each other. Usually crops belonging to the same family or types are competitive for nutrients moisture, space and others. But crops of different families, such as cereal and legume are usually complementary in nature, that is, they are mutually benefited by natural symbiosis and fixation of nitrogen in soils. Application of phosphorus sometimes enhances the rate of fixation of nitrogen and utilization of other nutrients by crops (Patwary *et al.*, 1985).

Intercropping is promising production technology which not only ensure efficient utilization of natural resources like light, nutrient, water and space (Ghosh, 2004; but also conserve it by reducing soil erosion and lodging, suppress weed growth thereby helps in yield increment and maintain greater stability in crop yields. Intercropping is a viable agronomic means of risk minimizing farmers' profit and subsistence- oriented, energy efficient and sustainable venture .

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 and summer grain legumes 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.

Black gram (*Vigna mungo* L.) is an erect, fast-growing annual, herbaceous legume reaching 30-100 cm in height. It has a well-developed taproot and its stems are diffusely branched from the base. Black gram may be grown as an intercrop with other tall crops like maize, sorghum, cotton, jute, sugarcane, pigeonpea etc. Beside, Blackgram grown as early kharif-l crops so it can be fitted in kharif-1 maize crop for substantial increase of pulse production.

Vigna mungo is also is grown for forage and hay (Gohi, 1982). Its crop residues are an important feed for livestock in some regions of Bangladesh. Fodder is derived mainly from the leaves and stems, but seeds, pods and pod husks are also used. *Vigna mungo* is usually fed to cattle as a fodder but the plant, the seeds and the by-products are also consumed by other species (Fuller, 2004).

Both maize and black gram is grown for grain as well as fodder in kahrif season. When intercropped, either maize or black gram can be used as fodder production. The harvesting stage as fodder of maize and black gram has been identified to be the knee high (Paradkar and Sharma, 1993). That is maize-black gram intercropping can be practiced for achieving fodder production.

To grow black gram as fodder intercrop, a number of studies has been carried out both at home and abroad due to rapid growth in urbanization during the last decades, the demand of milk and milk product is also increasing day by day. Dairy farm is more connected in the urban area then rural area. Moreover due to the lack of fodder cattle rearing is also halted in the rural area. So this is also incorporate to incorporate fodder crop is the existing cropping systems

Maize crop is normally grown at wider row spacing and inter row space can profitably be utilized for higher returns. Though intercropping is an age-old practice, it has attracted worldwide attention owing to yield advantages. One of the main reasons for higher yield in intercropping is that the component crops are able to use growth resources differently, so that when grown together, they complement each other and make better overall use of growth resources than grown, separately (Willey, 1979). Maize- legumes intercropping system, besides increasing productivity and profitability also improves soil health, conserves soil moisture and increases total out turn. Inclusion of legumes as intercrop with cereals not only supply the additional nutrients to crop plant by converting and fixing atmospheric nitrogen in available form through symbiosis with *rhizobial* strains also conserve the soil. However, several factors like cultivar selection, seeding ratio, planting pattern and competition between mixture components affect the growth of species in intercropping (Singh *et al.*, 2008). Legumes in an intercropping system not only provide nitrogen to the associated crops but also increase the amount of humus in the soil due to decaying crop remains. Legumes as intercrop with maize instead of showing any adverse effect maize increase its yield (Singh and Bajpai, 1991). However, Singh and Singh, 1975 reported that intercrops of legumes interfere with normal growth of maize crop. Legume as an intercrop can increase crop yields and economic benefits of intercropping systems (Mucheru *et al.,* 2010). Maize in association with legumes gives higher total yield and net return (Patra *et al.,* 2000).

Considering the above factors, the present experiment was undertaken to study the following objectives.

i. To study the planting geometry on the fodder yield of maize intercropped with blackgram.
ii. To study the total fodder yield of maize + blackgram under intercropping systems.
iii. To assess the compatibility between maize and blackgram as intercropping combination.

CHAPTER II
REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

An effort has been prepared in this chapter to present a brief review of research on intercropping of pulse crops with maize to obtain better fodder yield. Crop production scientists and farmers are now focusing their attention to increase food production to feed the ever-increasing population. It is an established fact that intercropping system increases water utilization efficiency, shows higher land equivalent ratio and above all gives higher yield (Mengping and Zhangjinsong, 2004). Therefore, the available findings of the effect of row arrangement on the yield of maize as sole or intercropped have been briefly reviewed below.

Choudhary (2014) carried out in sequence to identify suitable planting geometry to accommodate intercrops, screening best legume crops and subsequently best performed row ratio of maize and legume crops were intercropped in third experiment with 1:1, 1:2 and 1:5 row proportions. Sole maize gave the maximum grain yield with 4571.1 kg ha^{-1}, whereas, stover yield was highest with maize-cowpea intercrop at 1:2 row ratios (8013.4 kg ha^{-1}) and 57.1 kg ha^{-1} day^{-1} production efficiency followed by frenchbean and least with blackgram. Competition indices like land equivalent ratio (LER) was highest with 1:2 row ratio of maize-frenchbean (1.66), land equivalent coefficient (0.67). But, highest area time equivalent ratio (ATER) was noticed with 1:2 row ratio of maize blackgram (1.47). Relative crowding coefficient (K) and competition ratio were noticed higher with 1:2 row ratio of maize-cowpea, whereas, cowpea combinations has better crowding coefficient and blackgram combinations registered better competitiveness. Monetary advantage index (MAI) was 6433.2 with 1:2 row ratio of maize-blackgram followed by maize-cowpea and lowest with maize-frenchbean with the trend of 1:2>1:5>1:1 row ratios.

Dhakal (2014) conducted in a local tribal farmer's field of hilly Kavilas VDC of Chitwan, Nepal during the rainy season of 2012 (April to September), on maize intercropping with legumes and non-legumes. 2 Factor Strip Plot Design was used in the experiment with 12 treatments and 3 replications. The treatment comprised of combination of three maize variety of different maturity date [Arun-2 (80-90 DAS), Manakamana- 1(120-130 DAS) and Poshilo makai-1(145-155 DAS)] and four intercrops among which Blackgram, Greengram and Cowpea were leguminous intercrop whereas Millet was non leguminous intercrop. Among the used maize varieties, Poshilo Makai-1, a long duration maize, had significantly higher yield (4.72 t ha^{-1}) which was significantly higher than the yield of both medium and short duration maize variety Mankamana-1 (3.5 t ha¯1) and Arun-2 (2.82 t ha^{-1}) respectively. Similarly among the intercrops, the yield of non-leguminous component Millet (0.83 t ha^{-1}) was found higher over other leguminous components Blackgram (0.26 t ha^{-1}), Greengram (0.27 t ha^{-1}) and Cowpea (0.52 t ha^{-1}). Yield of intercrop was found higher in short duration maize variety but the difference was not found significant. The effect of maize variety and the intercrops along with their combinations were also found significant on the gross return, net return and benefit cost ratio where medium and long duration maize varieties were significantly superior over the short duration maize variety (Arun-2) whereas in case of intercrops, leguminous intercrop Cowpea was found significantly superior over other intercrops. Intercropping of long duration maize variety with any leguminous intercrop was found profitable over non legume intercrops.

Kheroar and Patra (2013) conducted during *Kharif* seasons of 2009 and 2010 on sandy loam soil of West Bengal, India to evaluate the productivity and economic viability of maize + legume intercropping systems in additive as well as in replacement series with different row proportions. Maize *(Zea mays* L.) cv. "Vijay" (composite), green gram (*Vigna radiata* L.) cv. "Samrat", black gram (*Vigna mungo* L.) cv. "Sarada", soybean (*Glycine max* L. Merril) cv. "PK

327"and peanut (*Arachis hypogaea* L.) cv. "JL 24", were tested in monoculture as well as in intercropping situations with 1:1 (additive series) and 1:2 ratios (replacement series). The result indicated that intercropped legumes improved the yield components of maize and offered some bonus yield. The highest maize grain yield (2,916.28 kg ha^{-1}) and maize equivalent yield (4,831.45 kg ha^{-1}) were recorded with maize + green gram (1:1) and maize + peanut (1:1), respectively. The values of all the competition functions were always greater than unity and maize + black gram (1:2) recorded the highest values of land equivalent ratio (1.433), area time equivalent ratio (1.374) and land equivalent coefficient (0.421). Maximum monetary advantage (Rs. 10,579.13) was found with maize + green gam (1:1). Maize + peanut (1:2) combination recorded the highest relative net return (2.01), net return (Rs. 28,523.08), benefit-cost ratio (2.76) ad per day return (Rs. 259.30).

Azim Khan *et al.* (2012) was laid out in a randomized complete block design with three replications, and comprised of five treatments viz, sole mungbean, maize + 1 row of mungbean simultaneously seeded, intercrop maize + 2 rows of mungbean simultaneously seeded, intercrop maize + 1 row of mungbean delay seeded by 3 weeks, intercrop maize + 2 rows of mungbean delay seeded by 3 weeks. The treatments significantly affected nodules $plant^{-1}$, nodule dry weight, pods $plant^{-1}$, number of grains pod^{-1}, thousand grain weight, grain yield and biological yield; though the impact was non-significant on weeds fresh and dry biomass parameters. Highest number of nodules $plant^{-1}$ (9.87), nodules dry weight (2.10 g), number of pods $plant^{-1}$ (17.32), number of grains pod-1 (4.23), thousand grain weight (39.33 g), biological yield (1654 kg ha^{-1}) and grain yield (525 kg ha^{-1}) of mungbean was recorded in plots where sole mungbean was cultivated as compared to intercropping with maize in all combinations. In conclusion, the sole cultivation of mungbean was the most effective intercropping system in terms of yield and yield components of mungbean crop.

Verma *et al.* (2008) was carried out with wheat and lentils grown alone or intercropped in a 4:2 row ratio. The wheat in pure stand was given 80 kg N + 16 kg P + 16 kg K ha^{-1} (100% NPK), while sole lentil received 20 kg N + 16 kg P ha^{-1} (100% NP). Intercrops were given 8 different combinations of fertilizers. Wheat grain yield was 3.29 t ha^{-1} in pure stand and 2.73 - 3.12 t ha^{-1} when intercropped. Lentil seed yield was 1.53 t/ha in pure stand and 0.22 - 0.41 t ha^{-1} when intercropped. The highest wheat-equivalent yield and net returns were obtained when wheat with 100% NPK was intercropped with lentils fertilized with 75% NP.

Mixed or intercropping has been reported to have many advantages for the farmers. It increased the total production; acted as insurance against failure of the principal crop and better utilization of inter space in crops. It also reduced the cost of intercultural operation and increased the fertility of the soil (Oleksy and Szmigiel, 2007).

Many scientists have reported that legume may benefit the associated non-legume crops (Waghmare *et al.*, 2005). Inclusion of legumes in the intercropping system was likely to be beneficial as they could fix atmospheric nitrogen into the soil and help in the utilization of soil moisture from deeper soil layers (Bautista, 2006).

Abubeker *et al.* (2006) conducted a study on the effects of maize-annual forage legume associations on maize and fodder production for 4 years in the sub-humid zone of western Ethiopia. *Lablab purpureus* (lablab) and *Vicia atropurpuria* (vicia) were grown as pure crops or as intercrops in maize at 2 planting dates (simultaneous vs delayed 6 weeks) for 3 consecutive years (1994-1996) and pure maize was planted in all plots in the fourth year (1997). Intercropping significantly reduced grain yield in the 3rd year, but its effect on stover yield was not significant. Among the intercrops, simultaneous planting of lablab significantly reduced grain and stover yield but increased forage dry matter (DM) yield. Lablab resulted in lower grain yield and higher total fodder (maize stover+forage DM) yield than vicia intercropped simultaneously with maize. Delayed planting, however, did not affect grain, stover, forage DM or total fodder yields. Forage yield of lablab was significantly higher than that of *Vicia*, as both a monoculture and an intercrop planted simultaneously with maize. Plots under lablab and *Vicia* monocultures for the previous 3 years produced maize yields comparable with those on fertilized plots. Among intercrops, the residual effects of simultaneously planted lablab were greater than for delayed planting. Grain yields following lablab were greater than following *Vicia* both as a monoculture and as a simultaneously planted intercrop. When planted as a monoculture or simultaneously planted intercrop with maize, lablab appeared superior to *Vicia* in terms of its ability to improve both feed supply and soil fertility.

Sunitha and Raja (2005) conducted a field experiment during the 2002/03 kharif and rabi seasons in Andhra Pradesh, India, to study the effect of planting pattern and fertilizers on the yield of rice, and the residual effects of the treatments on sequential fodder maize. The treatments comprised: 3 planting patterns, namely normal planting (15×15 cm), planting with alleys (0.3-3.0-0.3 m) by adjusting plant population of alleys in the net plots, and planting *Sesbania rostrata* in alleys and in situ incorporation; and 3 fertilizer levels, namely 100% recommended dose of NPK fertilizer (RDF), 75% RDF and 75% RDF + 5 t farmyard manure/ha. The highest number of panicles, panicle length filled grains per panicle, 1000-grain weight and grain yield of rice, and maize fodder yield were obtained with *S. rostrata* planting in alleys and in situ corporation, and 75% RDF + 5 t farmyard manure ha^{-1}.

Muhammad *et al.* (2005) conducted a field trial during kharif 2000 at Barani Agricultural Research Station, Kohat, Pakistan, to determine the most profitable combination of cereal fodders with leguminous ones under the given fertility level of the soil. The treatment combinations were: (T_1) sole sorghum; (T_2); sole millet; (T_3) sole cowpea; (T_4) sole mungbean; (T_5) sorghum + cowpea; (T_6) millet+cowpea; (T_7) sorghum+mungbean; and (T_8) millet+mungbean. Results revealed that sorghum and millet being cereal fodder responded explicitly with legumes fodder, cowpeas and mungbean. Yield ranged from 3538-15 694 kg $ha^{-}1$. The maximum fodder yield was recorded from millet+cowpea, and the lowest yield was observed on sole mung treatment.

Bhatti *et. al.* (2005) conducted a field experiment on a sandy-clay loam soil in Faisalabad, Pakistan for two consecutive years (2001 and 2002) to evaluate the effect of intercrops and planting patterns on the agronomic traits of sesame. The planting patterns comprised 40 cm spaced single rows, 60 cm spaced 2-row strips and 100 cm spaced 4-row strips, while the cropping systems were sesame+mungbean, sesame+mashbean (*Vigna aconitifolia*), sesame+soyabean, sesame+cowpea and sesame alone. The various yield components of sesame such as number of capsules $plant^{-1}$, seed weight $plant^{-1}$, 1000-seed weight and plant height were affected significantly by different intercropping systems and planting patterns. Grain legumes intercropping reduced the seed yield of sesame to a significant level by adversely affecting its yield components. However, the additional harvest of each intercrop more than compensated for the loss in sesame production. Among the intercropping patterns, sesame intercropped with mungbean, mashbean, soyabean and cowpea in the pattern of 100 cm spaced 4-row strips proved to be feasible, easily workable and more productive than sesame monocropping. Among the intercropping systems, sesame+mungbean or sesame+mashbean were found to be superior to all other intercropping systems under study.

Nargis *et al.* (2004) evaluated an experiment on mixed cropping of lentil (100%) and wheat (20, 40, 60 or 80%). It was observed that in lentil, 100% lentil + 40% wheat gave the highest number of branches per plant (3.25), whereas 100% lentil + 60% wheat recorded the greatest plant height (35.70 cm). The highest number of seeds per plant (47) and seed yield (1278 kg ha^{-1}) of lentil were obtained under line sowing. Sole wheat (broadcast) produced the tallest plants (89.15 cm) and the longest spikes (9.84 cm). The highest land equivalent ratio (1.52), monetary advantage (63%) and benefit: cost ratio (1.84) was recorded for intercropping lentil (100%) and wheat (40%).

Gbaraneh and Ikpe (2004) conducted a field experiment in Onne, Nigeria, during the 1998 and 1999 cropping seasons, to study the influence of lablab on maize grain and fodder (stover) yield. Lablab was simultaneously sown in maize on the same day and also under sown in maize at 2, 4, 6 and 8 weeks after maize planting (WAP) while sole maize and sole lablab were used as control. Simultaneous planting reduced maize grain yield by 40-63% relative to the sole maize crop while higher grain yield was obtained when under sowing of lablab was delayed beyond 2 weeks after planting. Unlike maize grain yield, highest lablab dry matter fodder yield was obtained when maize and lablab were simultaneously sown, and declined progressively with delayed under sowing of lablab while maize fodder yield was not affected by time of lablab under sowing. Time of lablab under sowing positively influenced total fodder (maize + lablab) yield. When fed to livestock, rate of digestibility was higher in lablab fodder than the maize fodder, indicating that lablab fodder enhanced the digestibility of lablab-maize forage. Under sowing of lablab in maize not latter than effectively controlled weed infestation in the intercrops than under sowing later.

Xiao *et al.* (2003) conducted an experiment on intercropping of faba bean (*Vicia faba*) and wheat (*Triticum aestivum*) using different nitrogen sources. They found that without any root barrier, the growth of wheat plants were improved resulting in greater biomass production and N uptake. Biomass production and N uptake of faba bean were lowest in the treatment without a root barrier. This suggested that wheat had greater competitiveness than faba bean and that this competition leaded to a higher percentage of N fixations from atmospheric nitrogen. Lakshmi *et al.* (2003) conducted a study at the Cropping System Research Centre, Karaman, Kerala, India, during the summer season 1999-2001, to evaluate the fodder production potential of short duration cereal fodder and cereal legume mixtures in rice fallows. The treatments consisted of three cereal fodders and their combinations with fodder cowpea: (1) fodder maize (*Zea mays*); (2) fodder sorghum (Sorghum); (3) fodder bajra (*Pennisetum glaucum*);

(4) fodder maize + fodder cowpea (*Vigna unguiculata*); (5) fodder sorghum + fodder cowpea; (6) fodder bajra + fodder cowpea. The growth attributes showed significantly higher plant height of cereal in the fodder sorghum, whereas the leaf : stem ratio of fodder maize was maximum. Maize as sole crop gave significantly higher green and dry fodder yield followed by maize+cowpea intercropping in all the years and in the pooled analysis result. The fodder yield of maize in combination with cowpea was lower than that of sole maize.

Kumari *et al.* (2003) conducted a field experiment on the sandy loam soil to evaluate weed management practices in a wheat based intercropping system. The highest land equivalent ratio was obtained in the wheat + chickpea intercropping. Weeding thrice showed higher land equivalent ratio compared to the other weed management systems.

Saini and Kapur (2000) carried out a field experiment for three consecutive years (1996-99) at the Sugarcane Research Station, Jalandhar, Indian Punjab, to investigate the feasibility and profitability of intercropping one or two rows of okra, sathi maize or maize fodder in spring sugarcane. Results reveal that, with the exception of intercropping one row of okra or sathi maize, the treatments depressed cane yield significantly. Intercropping one row of okra in spring sugarcane gave the highest cane yield equivalent (80.6 t ha^{-1}) and net profit of Rs 20 368 t ha^{-1}. The corresponding figures for one and two rows of sathi maize were 57.5 t ha^{-1} and 53.3 t ha^{-1}, and Rs 15571 ha^{-1} and Rs 9321 t ha^{-1}, respectively. Intercropping of maize fodder depressed cane yield by 51.6%, resulting in a net loss of Rs 1197 t ha^{-1} as compared to pure cane.

Channakeshava and Ramaprasanna (2000) conducted a study during kharif 1995 and 1996 in bangalore, Karnataka, India to investigate the effect of plant spacings and fertilizer levels on seed yield and yield components of the African tall fodder maize. Six spacing and three fertilizer levels were tried in randomized block design with three replications. Planting African tall maize at 75 × 45 cm spacing recorded significantly higher seed yield (53.27 q ha^{-1}) compared with all other spacing. While closer spacing of 45 × 30 cm registered the lowest seed yield (25.35 q ha^{-1}). Similarly, the application of 200:100:75 kg NPK per ha caused significantly higher seed yield of 42.5 q ha^{-1} compared with the application of either 100:50:25 or 150:75:50 kg NPK per ha. Spacing and fertilizer level interaction resulted in significant differences in the seed yield in African tall fodder maize. Sowing at 75 × 45 cm wider spacing with 200:100:75 kg NPK per ha resulted in higher seed yield (54.02 q/ha) compared with the other treatment combinations, while closer spacing of 45 × 30 cm with 100:50:25 kg NPK per ha registered significantly less seed yield (54.02 q ha^{-1}) compared with the other treatments.

Ahmed *et al. (2000) also conducted an experiment on maize-mungbean* 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 .

Azim *et al.* (2000) conducted a study to examine the influence of maize (*Zea mays*) and cowpea (*Vigna unguiculata*) intercropping on fodder biomass production and silage characteristics. Maize fodder was cultivated alone and intercropped with cowpea at seed ratio of 85:15 and 70:30. Fodder was harvested at heading stage (35% DM). The data indicated a significant increase in biomass and Crude Protein production of maize intercropped with cowpea at a seed ratio of 70:30 followed by a seed ratio of 85:15 compared with maize alone. However, no difference was observed in the production of total digestible nutrients among the treatments. Four types of silages from (i.)maize alone, (ii)maize and cowpea (85:15), (iii) maize and cowpea (70:30) and maize supplemented with 2.5% urea were prepared. After 60 days of ensiling period, silage samples were analyzed for proximate composition and fermentation characteristics.The Crude Protein and lactic acid values of silages I, II, III and IV were 8.52, 9.82, 14.90 and 13.96% and 9.00, 9.38, 10.86 and 7.43%, respectively. The results suggest that intercropping of maize and cowpea at a seed ratio of 70:30 increases fodder production and results in quality silage.

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.

Polthanee and Changsvi. (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.

Satyanarayana and Veeranna (1998) trialed on red lateritic soil in 1993-95, sugarcane was planted in single or paired rows and intercropped with cowpeas, soyabeans, field beans (*Phaseolus vulgaris*) or maize grown for fodder. The effect of planting method on cane yield was not significant, although yield was 10.1% higher in paired rows. Among intercrops, fodder maize had the greatest adverse effect (25.9%) on cane yield, followed by fodder cowpeas (15.9%) and fodder soyabeans (9.6%). Sugarcane grown alone had the highest net and gross returns. Yields of sugarcane and intercrops are tabulated for both years and all treatments.

Krishna *et al.* (1998) conducted a field experiment during 1991 and 1992 on clay loam soil at Rudrur, Andhra Pradesh, compared sole crops of forage maize cv. African Tall (30 or 45 cm row spacing) with maize intercropped or mixed cropped with cowpeas cv. EC 4216. Fertilizer rates of 0, 60, 120 or 180 kg N ha^{-1} were applied. Green and dry fodder yields were highest when a maize + cowpea mixed crop was sown at 30 cm row spacing. The Percentage crude protein was higher in the intercropping treatments than in pure maize. Fodder yield and percentage crude protein increased linearly with increasing N rate, while crude fibre content decreased with increasing N.

Shehu and Alhassan (1997) made a comparison over 2 years in the savanna zone of Nigeria between maize intercropped at different interrow maize spacings with a legume, *Stylosanthes hamata*, and pure stands of maize and *S. hamata*. Intercropping reduced the yield of maize grain, especially when the distance between maize rows was increased beyond 50 cm. Fodder (maize stover + *S. hamata*) dry matter and crude protein yields were only slightly greater at wide interrow spacing of the maize. The reduction in maize grain dry matter yield with intercropping was greater than the increase in fodder dry matter yield obtained.

Ghosh *et al.*, (1997) conducted at West Bengal to study the performance of wheat and lentil. The crops were grown in pure stands or intercropped under different levels of irrigation. Results revealed that mean wheat grain yield was 2.08 t ha^{-1} without irrigation, 2.99 t ha^{-1} with two irrigations (21 and 65 days after sowing) and 3.40 t ha^{-1} with irrigations at 4 critical growth stages. Lentil yield was 0.68 t ha^{-1} without irrigation, 1.16 t/ha with two irrigations at branching and flowering, and 0.94 t with 4 irrigations.

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 compared in an experiment conducted during 1993-94. The Highest maize equivalent yield (6973 kg ha^{-1}) was obtained from maize + mungbean intercropping, but maize + groundnut combination gave the highest maize equivalent yield (5615 kg ha^{-1}) in 1994-95. Maize + mungbean and maize + groundnut also gave the highest net return (Tk. 50952 ha^{-1} and Tk. 40245 ha^{-1} 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).

Sharanappa and Shivaraj (1995) conducted a field experiment during 1989-90 and 1990-91 at Bangalore, rainy-season. Rice (*Oryza sativa*) was planted after green manure crops *Sesbania rostrata*, sunnhemp (*Crotalaria juncea*) or soyabeans (*Glycine max*) grown as sole crops or as intercrops (1:1) with fodder maize (*Zea mays*), after fodder maize grown alone, or after a fallow. The green manures were incorporated into the soil before rice planting. The *S. rostrata* and sunnhemp green manures improved the soil N, P and K contents under a subsequent rice-sunflower sequence. The biomass yield and the total productivity of rice and sunflowers were highest with *S. rostrata* green manure, followed by sunnhemp green manure. Incorporation of the green manure crops intercropped with maize or sole soyabeans did not improve the yield significantly. The soil organic carbon and available N, P and K contents were improved on inclusion of sunn hemp or *S. rostrata* in the sequence. Biomass yield and economic yield of rice and sunflower were highest with application of 100 kg N ha^{-1}.

Senaratne *et al*. (1995) conducted an experiment on 15 N-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.

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^{-1}, 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^{-1} and that of maize from 2.48 to 3.39 t ha^{-1}. The highest rice-equivalent yield (3.35 t ha^{-1}) and gross return (Rs 14,103 t ha^{-1}) were obtained from maize-paired row (100%) + blackgram rows (44%).

Mahajan (1995) conducted a field experiment in 1990-93 in Himachal Pradesh where barley was grown on plots green manured with cowpeas, *Sesbania cannabina*, *Crotalaria juncea* or *Cyamopsis tetragonoloba* or plots previously left fallow and was given 20, 40 or 60 kg N ha^{-1}. In 1992/93, maize (*Zea mays*)-cowpeas (*Vigna unguiculata*) fodder crop was grown on the manured plots before barley and was given 40, 80 or 120 kg N ha^{-1}. Barley grain yield was highest with *S. cannabina* in 1990/91 (2.09 t ha^{-1}) and *C. juncea* in 1991/92

(3.79 t). In 1992/93 grain yield was not significantly affected by green manures. Grain yield was highest with 60 kg N. Maize-cowpea fodder yield was highest with cowpea green manure (31.52 t ha^{-1}) and increased with up to 80 kg N.

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^{-1}) were sown together with one row of maize (26000 to 90000 plants ha^{-1}) in the intercrops, while pure stand densities were 53000 plants/ha for maize and 333000 plants ha^{-1} 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.

Thiyagarajan (1994) conducted a field experiment in 1987-89 at Coimbatore, Tamil Nadu, where maize cv. Co.1 was intercropped with cowpeas cv. Co.4, soybeans cv. Co.1 or maize cv. Co.1 grown for fodder. Maize seed quality was generally not affected by intercropping with the legumes. Soybeans and cowpeas seed quality were lower from intercropping than sole cropping in terms of seed recovery, germination, 100-seed weight producing less vigorous seedlings. Soybean seed quality was significantly decreased when intercropped with fodder maize.

Sunitha and Sreekantan (1994) conducted a field experiment in 1988/89 at Vellayani, Kerala where cowpeas cv. C-152 and maize cv. CO-H-2 were grown alone or intercropped. Under intercropping, cowpeas were grown in alternate, paired or triple rows. Both crops received the recommended NPK fertilizer rate, 75 or 50% of this rate. Cowpea seed yield was not significantly affected by intercropping, but maize fodder yields decreased under paired or triple cropping of cowpeas. Maize fodder yields were decreased by decreasing the NPK rate, but cowpea seed yields were unaffected by the NPK rates. Maize fodder yield was highest under intercropping (row ratio 1:1) where both crops received the recommended NPK rate.

Ramachandra *et al.* (1993) conducted a field experiment on sandy loam during the kharif (monsoon) season of 1991/92 at Bangalore, Karnataka. Maize cv. South African Tall was intercropped with cowpeas cv. C-152, Dolichos lablab or *Vigna umbellata*. The legumes were grown for either grain or fodder. Maize/cowpeas (grain) intercrop gave the highest net return followed by sole maize. Maize/*V. umbellata* (fodder) intercrop had the highest CP content of 12.04%. Maize yield was highest in sole crops followed by maize/cowpeas (grain) intercrop.

Paradkar and Sharma (1993) conducted a field experiment on Vertisol in 1988-89 at Chhindwara, Madhya Pradesh where grain maize cv. Chandan Makka 3 and fodder maize cv. Africa Tall were sown in alternate rows or grown alone. Fodder maize was cut at knee-high stage, tasseling and milk stage. Grain yields were decreased in 1988 and 1989 by 19 and 17%, 48 and 42% and 69 and 66% when the fodder maize was cut at the 3 stages, respectively. Fresh fodder yields were decreased by just under 50% with intercropping. The highest monetary return was obtained from the intercrop where the fodder maize was cut at tasseling.

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).

Ali (1993) conducted a field experiments to determine the optimum fertilizer rate and row ratio of wheat and chickpeas in the late-sown irrigated condition. Of the 3 populations tested (2 : 2, 2 : 1 and 3 : 1 row ratios of wheat: chickpeas), the 2 : 2 row ratios allowed more light interception and transmission to the lower canopy and gave significantly higher yield (4.16 t ha^{-1} wheat equivalent) and land equivalent ratio (LER) than the other treatments. Fertilizers rates used were those of the recommended ones (120 kg N + 26.4 kg P + 50 kg K ha^{-1}) in both cases. Ali (1993) conducted a field experiments at Kanaipur, Faridpur and observed that the highest grain and fodder yields, land equivalent ratio and net returns were achieved from intercropping maize with *Vigna radiata*.

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^{-1} from maize + groundnut combination was second only to that from maize monoculture (2.90 t ha^{-1}). An additional 0.81 t ha^{-1} groundnut was obtained from the intercropping which also gave the highest maize equivalent yield (4.22 t ha^{-1}), land equivalent ratio (LER) (1.56), gross margin (Tk. 10900 ha^{-1} 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^{-1}) 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 tk 8502 ha^{-1}, having same benefit cost ratio.

Legumes grown as companion crops were found to be beneficial for the principal crop through nitrogen fixation. Moreover, legumes may help in the utilization of soil moisture from deeper soil layers. In intercropping of maize with cowpeas in both dry and rainy season. Cowpea gave the best result with respect to soil improvement and weed control (Bautista, 1988).

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).

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 producing 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^{-1} 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.

In Madhya pradesh in India a mixture of wheat and gram in proportion of 2:1 was found to give the highest net return than other seed rate ratio (Raheja, 1954). Wheat - chickpea was found to be most efficient with 1 irrigation in respect of land equivalent ratio, relative co-efficient, monetary advantage, relative net return and area time-equivalent ratio (Mondal *et al.*, 1986).

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 producing maximum cost benefit ratio of 1:3.05 in 100% maize + 50% groundnut combination at 60 kg/ha N level.

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 (Bandyopadhya,1984).

Intercropping is practiced traditionally in many parts of Asia, Africa, Latin America, some temperate regions of Australia and the United States. 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).

In an experiment, Gangwar and Kalra (1984) found that maize intercropped with mungbean and fertilized with 120 kg N ha^{-1} gave more yield than the application of 80 kg N ha^{-1}.

Farmers in developing countries have shown keen interest in intercropping practice because of its potentiality for increasing crop production to meet their requirements for food, fiber and fodder from existing area (Bandyopadhyay,1984).

An index of combined yield, LER provides a quantitative evaluation of the yield advantage due to intercropping (Willey, 1979 b).The 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).

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.

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% compared to sole crop of maize. In both the cases, however, It indicated yield reduction of blackgram and cowpea.

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).

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 .

Akanda and Quayyum (1982) got an 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.

Yadav (1981) obtained highest yield of maize at 120 kg N ha^{-1} 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^{-1}. But application of 135 kg N ha^{-1} significantly increased grain yield compared with 65 or 100 N ha^{-1}. The highest total yield and net return was obtained from maize and groundnut intercropping at the plant population levels of 4.4 x 10^4 maize and 16.6 x 10^4 groundnut plants per hectare with 120 kg N ha^{-1} than 30 kg N ha^{-1} (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} + 1,11,111 blackgram plants ha^{-1} with 20 kg N ha^{-1} instead of 120 kg N ha^{-1}.

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).

The intercropping experiment on wheat, gram, lentil and mustard showed that the combinations of wheat with mustard and with gram were quite compatible producing 19 and 11 percent, respectively more yield than those under monocrops (Razzaque,1980).

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.

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^{-1} in an intercropping systems of maize and legumes. They also reported that the application of 80 kg N ha^{-1} was economically viable.

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.

The maize yield increased by intercropping 103 percent with cowpeas, 16 to 82 percent with mung, 16 to 42 percent with groundnut and 25 to 68 percent with beans (Gunasema *et al.*, 1979). It was indicated that yields of all legumes decreased in the intercropping system.

Intercropping is an age old practice and it has been recognized as a very common practice throughout the developing tropics (Willey, 1979). It makes better use of sunlight, land and water. It may have some beneficial effects on pest and disease problems. In almost all cases, it gives higher total production;

monetary returns and greater resources use efficiently and increase the land productivity by almost 60 percent (IRRI, 1973).

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.

The benefit of cereal-legumes intercropping systems also could be 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%.

De *et al.* (1978) showed that the total productivity per unit land area could be increased in maize, sorghum and pearl millet when these crops were interplanted with short-duration legumes like mugnbean 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.

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

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).

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field at Sher-e-Bangla Agricultural University, Dhaka during the period from September to December, 2013. 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 September to December, of 2013.

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 experiment comprised the following fourteen treatments including control:

T_1 = 40×20 cm Maize (sole)

T_2 = Black gram sowing @ 40 kg ha^{-1}(sole)

T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @ 30 kg ha^{-1}

T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @ 40 kg ha^{-1}

T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @ 50 kg ha^{-1}

T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @ 30 kg ha^{-1}

T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @ 40 kg ha^{-1}

T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @ 50 kg ha^{-1}

T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @ 30 kg ha^{-1}

T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}

T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}

T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}

T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}

T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

3.5 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. There were 42 unit plots altogether in the experiment. The size of each unit plot was 2m × 1.5m. . The treatments were assigned in plot at random.

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 September 1, 2013 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 out

Lay out of the experiment following RCBD was done on September 7, 2013.

3.6.3 Seed sowing

Maize and Blackgram seeds were sown in line and broadcast on September 10 , 2013. 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. Black gram seeds were sown at 5 cm depth in broadcasting at required seed rate. The varieties of maize and Black gram used were local savar and BARI mash-3, respectively. Irrigation was applied in the furrows for the better germination of the seeds.

3.6.4 Gap filling

Black gram and maize seed germinated four and five days after sowing (DAS), respectively. Gap filling was done on September 30, 2013 (20 DAS).

3.6.5 Weeding

Weeding was done manually on October 10, 2013 (30 DAS) both in sole and intercropped treatments.

3.6.6 Application of fertilizer

Maize and blackgram plants received a uniform application of 250, 200, 250, 220and 15 kg ha^{-1} of Urea, TSP, MOP, Gypsum, and Boric acid, respectively. re. Half amount of urea and full quantity of TSP, MOP, Gypsum, and Boric acid were mixed with soil of maize and Black gram 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. Additional fertilizer was not applied for Blackgram as intercrop.

3.7 Data recorded at harvest

3.7.1 Crop characters

For determining the crop characters 3 plants each of black gram and maize from each plot were collected. The following data were recorded from the sampled plants.

Data for Maize

i) Plant height (cm)

ii) Fodder weight plant^{-1} (g)

iii) Fodder weight ha^{-1} (kg)

iv) Dry weight plant^{-1} (g)

Data for Black gram

i) Plant height (cm)

ii) Number of leaves plant^{-1}

iii) Number of branches plant^{-1}

iv) Fodder weight plant^{-1} (g)

v) Fodder weight kg ha^{-1}

vi) Dry weight plant^{-1} (g)

i. Plant height (cm) of maize and blackgram

Plant height of maize was measured in centimeter (cm) by a meter scale at 30, 60 and 90 days after sowing (DAS) and blackgram was at 20,40,and 60 (DAS)from the point of attachment of the leaves to the ground level up to the tip of the longest leaf.

ii. Number of leaves per plant of maize and blackgram

Number of leaves of maize three randomly selected plants were counted at 30, 60 and 90 DAS and blackgram at 20,40 and 60 DAS . All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. The average number of leaves of five plants gave number of leaves per plant.

iii. Number of branches per plant blackgram

Number of branches per plant was counted from each selected plant sample and then averaged at 20, 40, and 60 days after sowing (DAS).

iv. Fodder weight per plant (g) of maize and blackgram

Five randomly selected plants 90 DAS were detached from root by a sharp knife and average fodder weight of plant was recorded in gram(g).

v. Fodder yield per hectare maize and blackgram

The yield of fodder per hectare was calculated in ton by converting the total yield of fodder per plot.

vi. Dry weight of plant of maize and blackgram

Five plants were of maize collected randomly from each plot at 30, 60 and 90 DASand blackgram at 20,40 and 60 DAS. The plants were oven dried 24 hours at 70° C and the dry weight of plant was determined by using the following formula:

$$\text{Dry weight of plant} = \frac{\text{Dry weight (g)}}{\text{Number of plants}}$$

vii. Total fodder yield per hectare

The yield of fodder maize with blackgram per hectare was calculated in ton by converting the total fodder wt. per plot.

3.8 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of organic manure and plant spacing. All input cost included the cost for lease of land and interests of running capital in computing the cost of production. The interests were calculated @ 15% in simple rate. The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ration} = \frac{\text{Gross return per hectate (TK)}}{\text{Total cost of production per hectare (TK)}}$$

3.9 Statistical analysis

The collected data plot were analyzed with the computer-based software MSTAT -C computer program and mean separation was done by Least Significant Difference (LSD) test at 5% levels of probability(Gomez and Gomez,1984) .

CHAPTER IV
RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The results obtained from present study for different crop characteristics, yields and other analyses have been presented and discussed in this chapter.

4.1 Maize

4.1.1 Plant height

The height of maize was greatly affected by different treatments (Table1) at different days after sowing (DAS) under the present study. It was observed that the sole treatment (T_1) showed the tallest plant (105.3, 142.2and 156.2 cm at 30 and 60 and 90 DAS, respectively). But in intercropped treatmentsT_3 showed tallest plant (104.3, 138.2 and 143.7 cm at 30, 60 and at harvest, respectively). On the other hand the height of maize in treatment $T_{13}$was the shortest (85.67, 88.07and 121.00 cm at 30, 60 DAS and at harvest, respectively).

Table1. Performance of maize-blackgram intercropping on plant height of (maize) at different day after sowing (DAS)

Treatments	Plant height (cm)					
	30 DAS		60 DAS		90 DAS	
T_1	105.30	a	142.20	a	156.20	a
T_2	-	-	-	-	-	-
T_3	104.30	ab	138.30	a	143.70	b
T_4	93.00	b-d	137.20	a	139.00	b
T_5	99.00	a-c	121.00	ab	135.50	b
T_6	100.00	a-c	120.00	ab	137.50	b
T_7	102.70	ab	138.00	a	138.70	b
T_8	99.00	a-c	122.70	ab	134.00	b
T_9	99.67	a-c	121.80	ab	142.20	b
T_{10}	88.67	cd	116.20	ab	134.30	b
T_{11}	94.67	a-d	127.30	a	137.00	b
T_{12}	93.33	a-d	123.80	a	141.70	b
T_{13}	85.67	d	88.07	b	121.00	c
T_{14}	100.00	a-c	126.00	a	137.30	b
LSD $_{(0.05)}$	10.35		30.93		9.86	
CV(%)	6.31		14.70		4.23	

Means with uncommon letters within a column are significantly different at 5% level of significance

T_1 = 40×20 cm Maize (sole)
T_2 = Black gram sowing @40 kgha^{-1}(sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = *Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}*
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

4.1.2 Fodder weight plant^{-1} (g)

Fodder weight plant^{-1}under the present study was significantly influenced by different treatments. Maize fodder weight ranged from 52.67-172.70 g plant^{-1}(Figure 1). The highest fodder weight was shown by T_1. But in intercropped treatments T_3 showed the highest fodder weight plant^{-1}(142.70 g). On the other hand the lowest fodder weight plant^{-1}of maize was in treatment T_{13}.

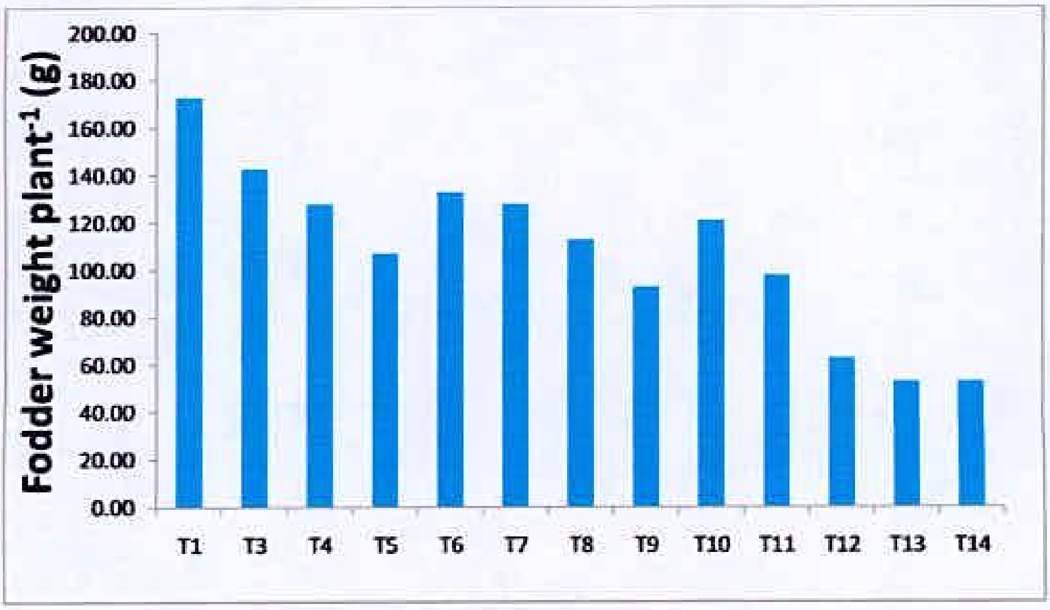

Figure1: Effect of maize-blackgram intercropping on the plant fodder weight (g plant^{-1}) of maize at harvest. (LSD $_{(0.05)}$=1.40)

T_1 = 40×20 cm Maize (sole)
T_2 = Black gram sowing @40 kgha-1 (sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

4.1.3 Fodder weight t ha^{-1}

Maize fodder weight ha^{-1} ranged from 6.14-20.16tha^{-1} (Figure 2). In intercropping maize fodder weight ha^{-1} decreased drastically from 33-56% due to using paired rows of maize to incorporate blackgram. The highest fodder weight was obtained from T_1 (sole maize). Among the intercropping treatments, T_3, T_6, and T_7 showed comparatively higher weight t ha^{-1} but those view lower than sole maize.Significantly the lowest fodder weight was found in T_{13}.

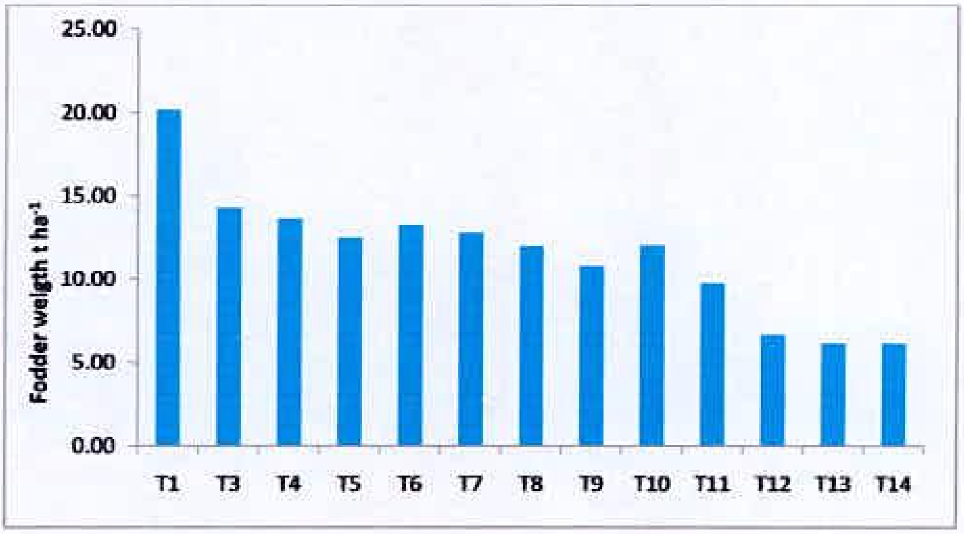

Figure 2: Effect of maize-blackgram intercropping on the fodder weight at harvest (t ha^{-1}) of maize (LSD $_{(0.05)}$=0.16)

T_1 = *40×20 cm Maize (sole)*
T_2 = Black gram sowing @40 kgha^{-1} (sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

4.1.4 Dry weight plant^{-1} (g)

Dry weight plant^{-1}(g) was significantly influenced by different treatments (Table 2) at different days after sowing (DAS). The sole treatment of maize (T_1) showed the highest dry weight plant^{-1} (11.10, 83.15 and 120.5 g at 30, 60 DAS and 90 DAS, respectively). But among the intercropped treatments T_3 showed the highest dry weight plant^{-1} (9.99, 26.44 and 43.83 g at 30, 60 and 90 DAS, respectively).On the other hand the lowest dry weight plant^{-1}of maize was found in treatment T_{13} (5.84, 20.09 and 26.88g at 30, 60 DAS and 90 DAS, respectively).

Table 2. Performance of maize – blackgram intercropping on dry weight plant^{-1} of maize at different days after sowing (DAS)

Treatments	Dry weight plant^{-1}		
	30 DAS	60 DAS	90 DAS
T_1	11.10 a	83.15 a	120.50 a
T_2	- -	- -	-
T_3	9.99 ab	26.44 fg	43.83 ef
T_4	7.33 cd	38.00 c-e	60.33 cd
T_5	6.14 d	39.73 cd	60.83 cd
T_6	7.87 b-d	49.27 b	59.53 cd
T_7	8.14 b-d	43.57 bc	75.00 b
T_8	6.98 cd	31.33 d-f	38.87 fg
T_9	7.12 cd	37.00 c-e	39.50 fg
T_{10}	9.13 a-c	38.09 c-e	55.10 de
T_{11}	8.27 b-d	29.63 ef	49.33 d-f
T_{12}	5.88 d	48.20 b	30.73 gh
T_{13}	5.84 d	20.09 g	26.88 h
T_{14}	6.21 d	34.34 d-f	67.67 bc
$LSD_{(0.05)}$	2.13	8.02	10.89
CV(%)	6.42	11.92	11.54

Means with uncommon letters within a column are significantly different at 5% level of significance

T_1 = 40×20 cm Maize (sole)
T_2 = Black gram sowing @40 kgha^{-1} (sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

4.2 Blackgram

4.2.1 Plant height

Plant height of blackgram was significantly affected by different treatments (Table 3) at different days after sowing (DAS) under the present study. The sole treatment (T_2) showed the tallest plant (44.67, 46.67 and 51.33 cm at 20, 40 DAS and 60 respectively). But in intercropping system T_6 showed the tallest plant (44.00, 45.67 and 49.00 cm)..On the other hand the lowest plant height of blackgram was observed in treatment T_7 (38, 39.33 and 42.00 cm at 20, 40 and 60 DAS respectively).Blackgram plants showed a tendency to increase plant height in intercropping situations which could be as a result of competition for sunlight and shedding effect of maize plants (Karim *et al.* 1990)

Table 3. Performance of maize – blackgram intercropping on plant height of Blackgram at different days after sowing (DAS)

Treatments	Plant height		
	20 DAS	40 DAS	60 DAS
T_1	-	-	-
T_2	44.67 a	46.67 a	51.33 a
T_3	42.67 a-c	41.67 ab	43.43 cd
T_4	43.77 ab	41.67 ab	46.22 b-d
T_5	43.00 a-c	39.53 ab	46.33 b-d
T_6	44.00 ab	45.67 a	49.00 ab
T_7	38.00 f	39.33 b	42.00 d
T_8	41.22 b-e	44.00 a	45.67 b-d
T_9	40.44 c-f	45.00 a	46.33 b-d
T_{10}	40.00 c-f	40.67 ab	47.55 a-c
T_{11}	39.05 d-f	44.00 a	44.89 b-d
T_{12}	38.89 d-f	42.00 ab	43.33 cd
T_{13}	41.67 a-d	44.00 a	47.00 a-c
T_{14}	38.31 ef	12.34 a	47.33 a-c
$LSD_{(0.05)}$	2.768	4.227	3.96
CV (%)	8.67	7.36	5.08

Means with uncommon letters within a column are significantly different at 5% level of significance

T_1 = 40×20 cm Maize (sole)
T_2 = Black gram sowing @40 kgha^{-1} (sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = *Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}*
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

4.2.2 Number of leaf plant^{-1}

Number of leaf plant^{-1} was significantly affected by different treatments (Table 4). The sole treatment of blackgram (T_2) showed the highest number of leaf plant^{-1} (8, 7.33 and 9.00 at 20, 40, 60 DAS, respectively) and it was statistically identical with intercropped treatment T_{13} which resulted 7.00, 7.00 and 7.33 at 20, 40, 60 DAS respectively. On the other hand the lowest number of leaf plant^{-1} (5.33, 5.47 and 5.67 cm^2 at 20, 40, 60 DAS and at harvest respectively) was recorded in treatment T_7. The results obtained from all other treatments showed intermediate results.

Table 4. Performance of maize – blackgram intercropping on number of leaf plant(blackgram) at different days after sowing (DAS)

Treatments	Number of leaf per plant		
	20 DAS	40 DAS	60 DAS
T_1	-	-	-
T_2	8.00 a	7.33 a	9.00 a
T_3	6.67 ab	6.33 a-c	6.33 bc
T_4	6.50 ab	6.00 a-c	7.33 b
T_5	5.67 b	6.00 a-c	5.67 c
T_6	6.33 ab	6.67 a-c	6.67 bc
T_7	5.33 b	5.47 c	5.67 c
T_8	6.00 b	7.00 ab	7.00 bc
T_9	5.83 b	7.00 ab	7.33 b
T_{10}	6.00 b	5.67 bc	7.00 bc
T_{11}	6.00 b	6.67 a-c	6.67 bc
T_{12}	6.33 ab	6.67 a-c	6.67 bc
T_{13}	7.00 ab	7.00 ab	7.33 b
T_{14}	6.00 b	6.00 a-c	6.67 bc
LSD $_{(0.05)}$	1.58	1.42	1.37
CV(%)	9.90	13.05	6.68

Means with uncommon letters within a column are significantly different at 5% **level of significance**

T_1 = 40×20 cm Maize (sole)
T_2 = Black gram sowing @40 kgha^{-1} (sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

4.2.3Number of branches plant^{-1}

Number of branches plant^{-1} of blackgram was significantly affected by different treatments (Table 5) .The sole treatment (T_2) showed the highest number of branches plant^{-1} (2.87, 3.33 and 4.67 at 00 at 20, 40, 60 DAS, respectively). But in intercropping system T_3 showed the highest number of branches plant^{-1}(2.67, 3.00 and 4.00at 20, 40, 60 DAS, respectively).On the other hand the lowest number of branches plant^{-1}(1.67, 2.00 and 2.67 at 20, 40, 60 DAS, respectively) was recorded in treatment T_7.

Table 5. Performance of maize – blackgram intercropping on number of Branches plant^{-1}(blackgram) at different days after sowing (DAS)

Treatments	Number of branch plant^{-1}		
	20 DAS	40 DAS	60 DAS
T_1			
T_2	2.87 a	3.33 a	4.67 a
T_3	2.67 a	3.00 ab	4.00 ab
T_4	2.67 a	2.33 bc	3.67 ab
T_5	1.67 b	2.33 bc	3.33 ab
T_6	2.00 ab	2.67 a-c	4.00 ab
T_7	1.67 b	2.00 c	2.67 b
T_8	2.33 ab	2.87 a-c	3.33 ab
T_9	2.00 ab	2.67 a-c	3.67 ab
T_{10}	1.67 b	2.33 bc	3.67 ab
T_{11}	2.00 ab	2.33 bc	3.33 ab
T_{12}	2.33 ab	2.33 bc	3.00 b
T_{13}	2.33 ab	2.67 a-c	3.67 ab
T_{14}	2.67 a	2.67 ac	3.67 ab
LSD(0.05)	0.64	0.69	1.31
CV(%)	6.74	8.62	11.98

Means with uncommon letters within a column are significantly different at5% level of significance

T_1 = 40×20 cm Maize (sole)
T_2 = Black gram sowing @40 kgha^{-1} (sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

4.2.4 Fodder weight plant^{-1}(g)

Blackgram weight ranged from 34.09-46.66 g plant. The trend of blackgram per plant^{-1} weight (fodder weight) although was found to be inconsistent, significantly the highest per plant weight was obtained from T_2 (Blackgram sole). On the other hand the lowest fodder weight plant^{-1} (34.09g) was recorded in treatment T_{14}.(Figure 3)

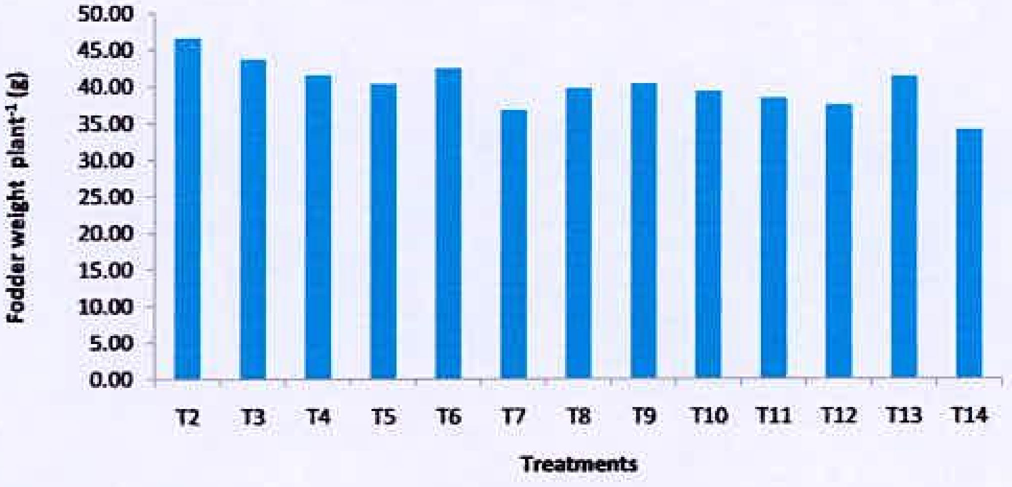

Figure 3: Effect of different in maize-blackgram intercropping on the fodder weight plant^{-1}of blackgram. ($LSD_{(0.05)}$=0.20)

Means with uncommon letters within a column are significantly different at 5% level of significance

T_1 = 40×20 cm Maize (sole)
T_2 = Black gram sowing @40 kgha^{-1} (sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

4.2.5 Fodder weight (t ha^{-1})

The highest fodder weight (2.02 t ha^{-1}) of blackgram was obtained in the sole plot (T_2) (Figure 4). Intercropping decreased the fodder yield (15-73%). Among the intercropping treatments T_8 showed significantly the higher fodder yield. Appreciably the population density did not have significant effect on the blackgram fodder yield, instead the competition free environment probably helped to gain the highest fodder weight of the sole blackgram.

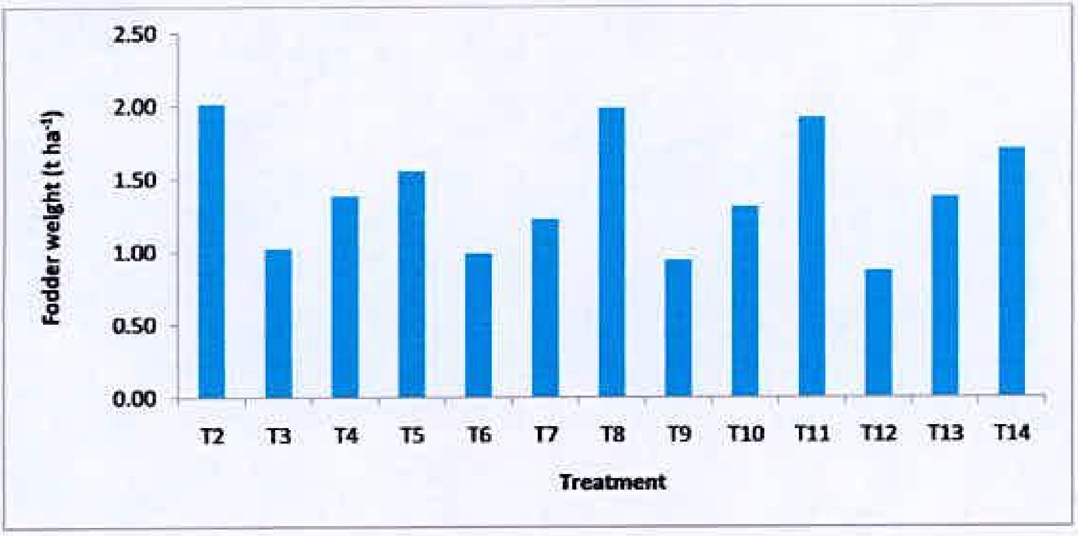

Figure 4: Effect of maize-blackgram intercropping on the weight (t ha^{-1}) of blackgram (LSD($0._{05}$)=0.18)

T_1 = 40×20 cm Maize (sole)
T_2 = Black gram sowing @40 kgha^{-1}(sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

4.2.6 Dry weight plant^{-1}(g)

Under the present study dry weight plant^{-1} (g) was significantly influenced by different treatments (Table 6) based on different Seed rate at different days after sowing (DAS). It was observed that the sole treatment of blackgram (T_2) gave the highest dry weight plant^{-1} (2.85, 5.42 and 5.50 g at 20, 40 DAS and 60 DAS respectively). On the other hand the lowest dry weight of blackgram (1.34, 2.63 and 4.00 g at 20, 40, 60 DAS, respectively) was in treatment T_7. The results obtained from all other treatments were significantly different compared to the highest and lowest dry weight plant^{-1}.

Table 6. Performance of maize – blackgram intercropping on dry weightplant^{-1}of blackgram under different Seed rate at Different days after sowing (DAS)

Treatments	20 DAS	40 DAS	60 DAS
T_1			
T_2	2.85 a	5.42 a	5.50 a
T_3	1.98 bc	3.73 c	4.83 ab
T_4	1.97 bc	4.27 bc	4.33 ab
T_5	1.72 cd	4.45 a-c	5.03 ab
T_6	1.93 bc	4.40 bc	4.70 ab
T_7	1.34 d	2.63 d	4.00 b
T_8	2.19 bc	4.30 bc	5.23 ab
T_9	2.13 bc	4.90 ab	4.50 ab
T_{10}	1.85 c	3.97 bc	4.67 ab
T_{11}	2.04 bc	4.00 bc	5.27 ab
T_{12}	2.05 bc	4.27 bc	5.43 a
T_{13}	2.00 bc	3.97 bc	5.20 ab
T_{14}	2.35 b	4.53 a-c	5.33 ab
$LSD_{(0.05)}$	0.41	0.92	1.21
CV(%)	11.78	12.96	14.58

Means with uncommon letters within a column are significantly different at 5% level of significance

T_1 = 40×20 cm Maize (sole)
T_2 = Black gram sowing @40 kgha^{-1}(sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

4.3 Total Fodder weight (t ha^{-1})

The highest total fodder weight (20.16 t ha^{-1}) of maize was obtained in the sole plot (T_1) (Figure 5). Among the intercropping treatments T_3 showed significantly the higher fodder yield. The lowest total fodder weight (2.02 t ha^{-1}) of blackgram was obtained in the sole plot (T_2).

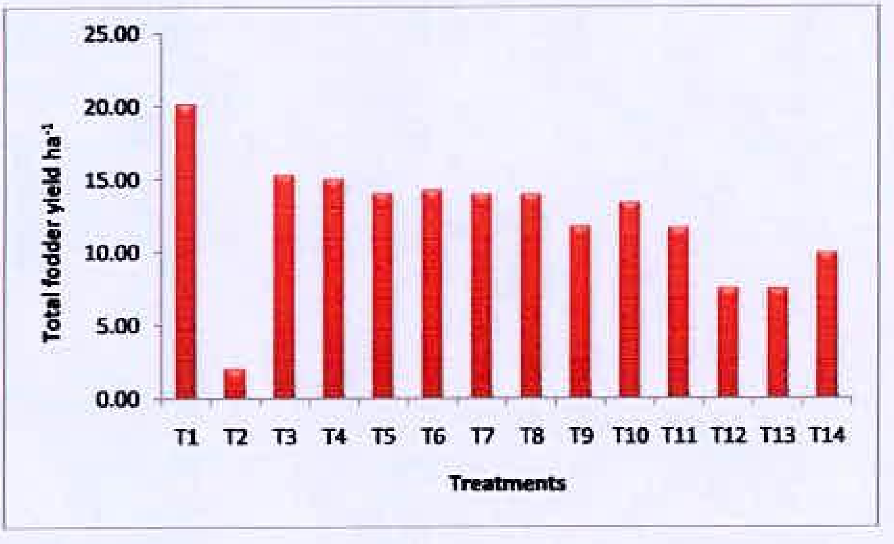

Figure 5: Effect of in maize-blackgram intercropping on the weight (t ha^{-1}) of maize with blackgram (LSD(0.05)=0.19)

4.4 Cost and return analysis

The cost and return analysis were done and have been presented in table 8. Materials (1A), non materials (1B) and over head costs were recorded for all the treatments of unit plot and calculated on per hectare basis the price of maize and blackgram fodder at the local market rate were considered.

The total cost of production ranges between Tk. 66750 and 73812 per hectare among the different treatment combinations. The variation was due to different cost of different seed rate. The highest cost of production Tk. 73812 per ha was involved in the treatment T_5, T_8, T_{11} and T_{14}, while the lowest cost of production Tk. 66750 per ha was involved in the treatment T_2 (Appendix IV). Gross return from the different treatment combinations range between Tk 16160.00 and Tk. 120960.00 per ha.

Among the different treatment combinations T_1 gave the highest net return Tk. 72870.00 per ha while the lowest net return Tk. (-) 52863.00 was obtained from the treatment T_2.

The benefit cost ratio (BCR) was found to be the highest (1.77) in the treatment T_1. Thus it was apparent that although T_1 treatment gave the highest fodder yield of maize (20.16 t ha^{-1}) and the highest gross return (Tk. 52710.00).

Table 7. Cost and return of maize and blackgram due to maize-blackgram intercropping

Treatments	Fodder weight of Maize (t ha^{-1})	Fodder weight of Blackgram (t ha^{-1})	Gross return (Tk ha^{-1})	Total cost of production (Tk ha^{-1})	Net return (Tk ha^{-1})	Benefit cost ratio (BCR)
T_1	20.16	0.00	120960	68250	52710	1.77
T_2	0.00	2.02	16128	66750	-50547	0.24
T_3	14.27	1.02	93780	71075	22492.5	1.30
T_4	13.62	1.38	92792	72700	20492	1.28
T_5	12.48	1.56	87320	73812	14007.5	1.19
T_6	13.27	0.99	87534.4	71587	16246.9	1.23
T_7	12.77	1.23	86428	72700	14128	1.20
T_8	12.02	1.98	87992	73312	14679.5	1.10
T_9	10.81	0.94	72380	71587.	1092.5	1.02
T_{10}	12.07	1.31	82900	72700	10600	1.14
T_{11}	9.77	1.92	73962	73812	649.5	1.01
T_{12}	6.68	0.87	47090.4	71587	-24197	0.65
T_{13}	6.14	1.38	47880	72700	-24420	0.65
T_{14}	6.14	1.71	50504	73812	-22809	0.68

Price of Fodder Maize Tk. 6@ kg, Price of Fodder blackgram Tk. 8@ kg

T_1 = 40×20 cm Maize (sole)
T_2 = Black gram sowing @40 kgha^{-1} (sole)
T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @30 kg ha^{-1}
T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @40 kg ha^{-1}
T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @50 kg ha^{-1}
T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @30 kg ha^{-1}
T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @40 kg ha^{-1}
T_8 = *Maize sowing at spacing 50×16 cm with Black gram sowing @50 kg ha^{-1}*
T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @30 kg ha^{-1}
T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @40 kg ha^{-1}
T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @50 kg ha^{-1}
T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @30 kg ha^{-1}
T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @40 kg ha^{-1}
T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @50 kg ha^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

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The experiment was conducted at the Agronomy field at Sher-e-Bangla Agricultural University, Dhaka during the period from September to December, 2013 to effect of maize planting configuration and blackgram seed rate on fodder production under maize blackgram intercropping system. The varieties of maize and blackgram used were local savar and BARI mash-3 respectively. The experiment was conducted in a Randomized Complete Block Design (RCBD) with 3 replications. Fourteen treatments *viz,* T_1 = 40×20 cm Maize (sole), T_2 = Black gram sowing @ 40 kg ha^{-1} (sole), T_3 = Maize sowing at spacing 60×13 cm with Black gram sowing @ 30 kg ha^{-1}, T_4 = Maize sowing at spacing 60×13 cm with Black gram sowing @ 40 kg ha^{-1}, T_5 = Maize sowing at spacing 60×13 cm with Black gram sowing @ 50 kg ha^{-1}, T_6 = Maize sowing at spacing 50×16 cm with Black gram sowing @ 30 kg ha^{-1}, T_7 = Maize sowing at spacing 50×16 cm with Black gram sowing @ 40 kg ha^{-1}, T_8 = Maize sowing at spacing 50×16 cm with Black gram sowing @ 50 kg ha^{-1}, T_9 = Maize sowing at spacing 40×20 cm with Black gram sowing @ 30 kg ha^{-1}, T_{10} = Maize sowing at spacing 40×20 cm with Black gram sowing @ 40 kg ha^{-1}, T_{11} = Maize sowing at spacing 40×20 cm with Black gram sowing @ 50 kg ha^{-1}, T_{12} = Maize sowing at spacing 30×27 cm with Black gram sowing @ 30 kg ha^{-1}, T_{13} = Maize sowing at spacing 30×27 cm with Black gram sowing @ 40 kg ha^{-1}, T_{14} = Maize sowing at spacing 30×27 cm with Black gram sowing @ 50 kg ha^{-1} were considered for the present study.

The growth contributing characters of maize were significantly influenced by intercropping blackgram with maize. The sole treatment (T_1) showed the tallest plant (105.3, 142.2 and 156.2 cm at 30 and 60 and 90 DAS, respectively). The highest value of different parameters like number of leaves plant^{-1}(6.53, 7.27 and 9.45 at 30, 60 DAS and 90 DAS), fodder weight plant^{-1} (172.70 g), dry weight pant^{-1} (11.10, 83.15 and 120.5 g at 30, 60 DAS and 90 DAS, respectively) were obtained in sole maize (T_1) treatment. The highest fodder weight (20.16 t ha^{-1}) was obtained from T_1 (sole maize). But in the intercropping treatments the highest plant height (105.3, 142.2 and 156.7 cm at 30, 60 and at harvest, respectively), number of leaves plant^{-1} (6.33, 7.17 and 6.78 at 30, 60 and 90 DAS, respectively), fodder weight plant^{-1} (142.70 g), dry weight pant^{-1} (9.99, 26.44 and 43.83 g at 30, 60 and 90 DAS, respectively), and fodder weight ha^{-1} (14.27 t ha^{-1}) were obtained in the treatment T_3. On the other hand the lowest plant height (85.67, 88.07and 121.00 cm at 30, 60 DAS and at harvest respectively), number of leaves plant^{-1} (5.33, 5.83 and 5.67 at 30, 60 DAS and 90 DAS), fodder weight plant^{-1} (52.67g) fodder weight ha^{-1} (6.14 t) and dry weight/pant (5.84, 20.09 and 26.88 g at 30, 60 DAS and 90 DAS, respectively) were obtained in treatment T_{13}.

The growth contributing characters of blackgram were significantly influenced by intercropping blackgram with maize. The highest values of different parameters likes tallest plant (44.67, 46.67 and 51.33 cm at 20, 40 DAS and 60 respectively), number of leaf plant^{-1} (8, 7.33 and 9.00 at 20, 40, 60 DAS, respectively), number of branches plant^{-1} (2.87, 3.33 and 4.67 at 20, 40, 60 DAS, respectively), fodder weight plant^{-1} (46.66 g), fodder weight ha^{-1} (2.02 t), dry weight pant^{-1} (2.85, 5.42 and 5.50 g at 20, 40 and 60 DAS respectively) were obtained in sole blackgram treatment. But in the intercropping treatments the highest results of plant height (38, 39.33 and 42.00 cm at 20, 40 and 60 DAS respectively) in T_4. But in intercropping system T_3 showed the highest number of branches/plant (2.67, 3.00 and 4.00 at 20, 40, 60 DAS, respectively). On the other hand the lowest results of plant height (38, 39.33 and 42.00 cm at 20, 40 and 60 DAS respectively), number of leaf plant^{-1} (5.33, 5.47 and 5.67 cm^2 at 20, 40, 60 DAS and at harvest respectively), number of branches plant^{-1} (1.67, 2.00 and 2.67 at 20, 40, 60 DAS, respectively) were obtain from T_7 treatment. On the other hand the lowest fodder weight plant^{-1} (34.09g) was recorded in treatment T_{14}. On the other hand the lowest fodder weight ha^{-1} (0.87t ha^{-1}) was recorded in treatment $T_{12.}$ On the other hand the lowest dry weight of blackgram (1.34, 2.63 and 4.00 g at 20, 40, 60 DAS, respectively) was in treatment T_7.

The benefit cost ratio (BCR) was found to be the highest (1.77) in the treatment T_1. Thus it was apparent that although T_1 treatment gave the highest fodder yield of maize (20.16 t ha^{-1}) and the highest gross return (Tk. 52710.00).

From the findings of the present investigation the following conclusion can be drawn: Mention the row arrangement system offered the highest land utilization compared to sole one.

Recommendation

Further study may be needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.

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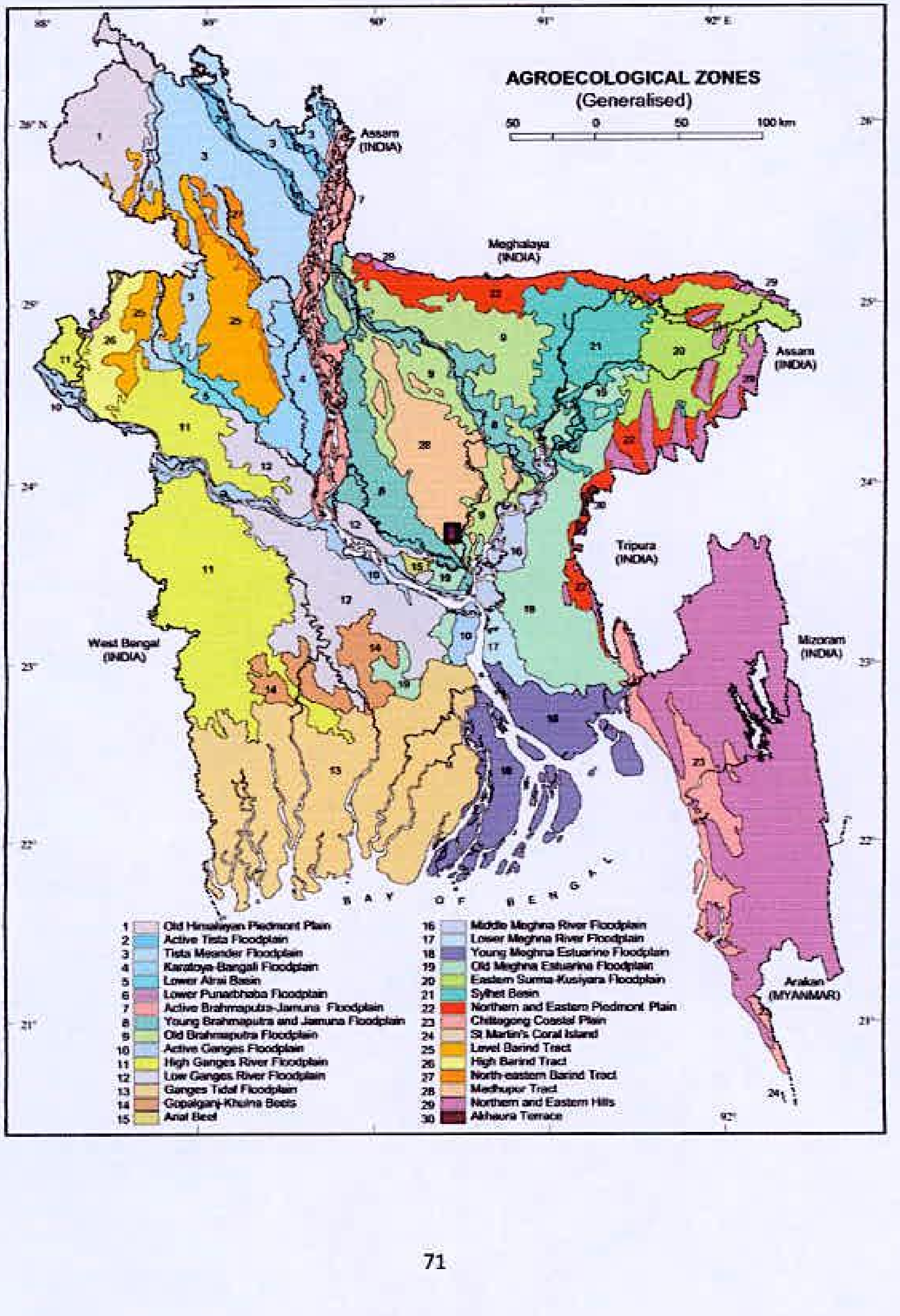
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from September to December, 2013

Month (2013)	*Air temperature (°C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
September	*31.8*	24.4	75.5	*56.5*
October	30.5	19.4	65.5	23.4
November	28.8	16.0	61.5	16.00
December	25.4	13.5	60	15.00

* Monthly average,

* Source: mini weather station in Sher-e-Bangla Agricultural University, Dhaka-1207.

Appendix III .Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source:Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Appendix IV. Production cost of maize and blackgram per hectare

(A)Material cost (Tk.)

Treatments	maize Seed (kg ha^{-1})	Blackgram seed (kg ha^{-1})	Fertilizer tk	Sub total 1 (A)
T_1	5000	0	12500	17500
T_2	0	4000	12500	16500
T_3	5000	3000	12500	20500
T_4	5000	4000	12500	21500
T_5	5000	5000	12500	22500
T_6	5000	3000	12500	20500
T_7	5000	4000	12500	21500
T_8	5000	5000	12500	22500
T_9	5000	3000	12500	20500
T10	5000	4000	12500	21500
T_{11}	5000	5000	12500	22500
T_{12}	5000	3000	12500	20500
T_{13}	5000	4000	12500	21500
T_{14}	5000	5000	12500	22500

Appendix IV. Contd

B) Non-material cost (Tk. / ha)

Treatments	Land preparation Tk ha^{-1}	Seed sowing Tk ha^{-1}	Intercultural operation Tk ha^{-1}	Harvesting Tk ha^{-1}	Sub total	Total input cost 1 (A) + 1 (B)
T_1	9000	3000	2000	2500	16500	34000
T_2	9000	3000	2000	2000	16000	32500
T_3	9000	3000	2000	2500	16500	37000
T_4	9000	3000	2000	2500	16500	38000
T_5	9000	3000	2000	2500	16500	39000
T_6	9000	3000	2000	2500	16500	37000
T_7	9000	3000	2000	2500	16500	38000
T_8	9000	3000	2000	2500	16500	39000
T_9	9000	3000	2000	2500	16500	37000
T_{10}	9000	3000	2000	2500	16500	38000
T_{11}	9000	3000	2000	2500	16500	39000
T_{12}	9000	3000	2000	2500	16500	37000
T_{13}	9000	3000	2000	2500	16500	38000
T_{14}	9000	3000	2000	2500	16500	39000

Appendix IV. Contd.

(C) Overhead cost and total cost of production (Tk.)

Treatments	Cost of lease of land	Miscellaneous cost (5% of input cost)	Interest on running capital for 6 months (15% of the total input cost)	Total	Total cost of production (input cost + interest on running capital, Tk/ha)
T_1	30000	1700	2550	34250	68250
T_2	30000	1630	2445	34075	66750
T_3	30000	1835	2752.5	34587.5	72700
T_4	30000	1880	2820	34700	73812
T_5	30000	1925	2887.5	34812.5	71587
T_6	30000	1835	2752.5	34587.5	72700
T_7	30000	1880	2820	34700	73812
T_8	30000	1925	2887.5	34812.5	73312
T_9	30000	1835	2752.5	34587.5	71587
T_{10}	30000	1880	2820	34700	72700
T_{11}	30000	1925	2887.5	34812.5	73812
T_{12}	30000	1835	2752.5	34587.5	71587.
T_{13}	30000	1880	2820	34700	72700
T_{14}	30000	1925	2887.5	34812.5	73812