EFFECT OF FERTILIZER DOSE AND BLACKGRAM HARVEST TIME ON FODDER YIELDS UNDER MAIZE-BLACKGRAM INTERCROPPING SYSTEM

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Fertilizer Dose and Blackgram Harvest Time on Fodder Yields 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. Rabiul Islam Shamim**, Registration number: **08-02679** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

Dated: 22.02.2016
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TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted at the Agronomy field laboratory of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October 2013 to January 2014 to find out the effect of fertilizer dose and blackgram harvest time on fodder yields under maize-blackgram intercropping system. Maize (local variety) was used as the main fodder crop and blackgram variety BARI Mash-3 as an intercrop. The experiment consisted 14 treatment as combination of recommended fertilizer and 20% more than recommended fertilizer with different harvesting time of blackgram which are $T_1 = F_RH_{40}$, $T_2 = F_RH_{50}$, $T_3 = F_RH_{60}$, $T_4 = F_RH_{70}$, $T_5 = F_RH_{80}$, $T_6 = F_RH_{90}$, $T_7 = F_{R+20\%}H_{40}$, $T_8 = F_{R+20\%}H_{50}$, $T_9 = F_{R+20\%}H_{60}$, $T_{10} = F_{R+20\%}H_{70}$, $T_{11} = F_{R+20\%}H_{80}$, $T_{12} = F_{R+20\%}H_{90}$, T_{13} = Sole maize and T_{14} = Sole blackgram. Here, F_R: Recommended dose of fertilizer (Cowdung: 10 t ha^{-1}; Urea: 350 kg ha^{-1}; TSP: 250 kg ha^{-1}; MoP: 200 kg ha^{-1}; Zypsum: 170 kg ha^{-1} and Zinc sulphate: 15 kg ha^{-1}), $F_{R+20\%}$: More than 20% fertilizer of recommended dose, H_{40}: Blackgram harvest at 40 DAS, H_{50}: Blackgram harvest at 50 DAS, H_{60}: Blackgram harvest at 60 DAS, H_{70}: Blackgram harvest at 70 DAS, H_{80}: Blackgram harvest at 80 DAS and H_{90}: Blackgram harvest at 90 DAS. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Significant difference among the treatments was observed for fodder yield and yield contributing charcters of maize and blackgram. The minimum light intensity (131.94 Lx) was observed from the late harvested blackgram plots. The longest plants were obtained from sole maize. The highest maize fodder yields (25.53 t ha^{-1}) was obtained from T_{13} treatment, whereas the lowest (20.73 t ha^{-1}) from T_7 treatment. The highest blackgram fodder yields (9.89 t ha^{-1}) were obtained from T_{14} treatment. The highest (1.86) land equivalent ratio (LER) was recorded from T_{12} treatment and the lowest (1.00) from the sole crop both maize and blackgram. The highest equivalent yield (EY) of fodder maize (35.06 t ha^{-1}) was recorded from T_{12} treatment. The highest EY of fodder blackgram (28.05 t ha^{-1}) was recorded from T_{12} treatment. The study revealed that application of recommended fertilizer + 20% more than recommended fertilizer and harvest at 90 DAS would be optimum for achieving higher fodder yield under maize-blackgram intercropping system.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Bangladesh is an agricultural based country. The important and crucial role played by livestock in the traditional and subsistence rural agro-economy of Bangladesh cannot be overlooked. Livestock contributes 2.79% of the Gross Domestic Products (GDP) and 13.7% of the agricultural GDP of Bangladesh (BBS, 2012). Moreover, Livestock by-products namely hides and skins, leather and leather products are important export items of the country and contribute about 13% total foreign exchange earning of the country. Shortage of animal feed is the major constraint of animal production and is likely, in turn, to increase the predisposition of animal disease and mortality.

In Bangladesh, unfortunately, about 90% of the ruminants diet consists of low quality roughage i.e., rice straw and moreover, the amount available is far less than the requirement (Jackson, 1981). Virtually Bangladesh has no arable land for feed and fodder production exclusively for animals. At present, cattle, buffaloes, sheep and goats subsist mainly on rice straws, weeds, roadside and fallow land grazing and tree leaves with limited supplementation of cereal bran and oilcakes (Moog, 1990). Rice straw is the major cattle feed in Bangladesh lacking both in energy and protein. In addition high fiber content and lignin disfavor ruminants digestibility consequently it cannot even maintain animal's productive performance (Wongsrikeao and Wanapat, 1985). Tareque (1985) reported that out of total 29 million tons of roughages available for ruminants, rice straw contributes around 23.27 million tons (81.0%) and green forages only 1.6 million tones (5.6%). As a result growth rate or milk production of the animal consuming rice straw alone are generally low and often only about 10% of the genetic potentiality of the animal (Leng, 1995). On a straw-based diet, supplementation of small amount of green grass is often recommended for optimization of rumen environment (Preston and Leng, 1987) or even to meet the maintenance requirement of animal (Ranjhan and Singh, 1993).

Maize (*Zea mays L.)* is one of the important crops of the world and grown primarily for grain, secondarily for fodder and then raw materials for industries. Its fodder can safely be fed at all stages of growth without any danger of oxalic acid or prussic acid (Dahmardeh *et al.,* 2009). So, there is ample scope for expansion of maize areas in Bangladesh (Islam and Kaul, 1986). But there is problem in increasing the cropping area for maize to grow as fodder as it has to compete with a number of crops in dry season. The production of fodder maize can be increased in cropping system in combination of a leguminous fodder crop.

Blackgram (*Vigna mungo* L.) is a grain legume widely cultivated in Asian countries. Green plants can also be used as animal feed and its residues can be used as green manure. Being a short duration crop it fits well into the intensive cropping system and the crop is potentially useful in improving cropping pattern (Ahmed *et al*., 1998). An important feature of the blackgram plant is the ability to establish a symbiotic partnership with specific bacteria, setting up the biological N_2-fixation process in root nodules by *rhizobia* that may supply plants needs for N (Mandal *et al*., 2009; Mahmood and Athar, 2008).

Maize grown in association with pulse produced 144% high maize equivalent yield than that of sole cropped maize and the combination also produced higher land equivalent ratio, and gross and net returns, and was more remunerative than sole crop maize (Singh *et al*., 2000). Tsubo and Walker (2003) reported that mixed/intercropping is a technique for small farmers and intercropping systems of maize with legumes were superior to sole crops. Cereal-legume intercropping plays an important role in subsistence food production in both developed and developing countries, especially in situations of inadequate water resources (Tsubo *et al.,* 2005). Intercropped legumes fix most of their nitrogen from the atmosphere and not compete with maize for nitrogen resources (Vesterager *et al.,* 2008; Adu-Gyamfi *et al.,* 2007). The goal of diversified agricultural production systems is to reach production stability through improved crop protection and increased productivity and profitability offered by many intercropping systems (Banik and Sharma, 2009).

While intercropping maize-blackgram, there may be deficit of soil nutrients due to increased competition. To overcome the deficit in nutrient supply it is suggested to increase soil fertility through using optimum fertilizer dose under intercropping system for sustainable production (Dambreville *et al*., 2008). However, there is very limited information available on the optimum doses of fertilizers and manure in intercropping system.

Intercropping is advocated due to its benefits for yield increase, conserving soil, control of weeds, control blackgram root parasite infections and high quality fodder (Chen *et al*., 2004). Maize based intercropping system with legume plants viz., blackgram helps in improving soil health as well as yield of main crop (Beedy *et al*., 2010). Maize-blackgram intercrops yielded more and were associated with less risk than their rotations (Kamanga *et al*., 2010). Maize in association with different legumes gives higher total yield and net return (Patra *et al*., 2000). Practicing intercropping of maize with blackgram, farmers can obtain fodder maize and blackgram fodder at the same time from the same land. Harvesting time of blackgram also influences fodder yield and optimum time harvested blackgram produced highest fodder yield with maintaining optimum quality (Kamanga *et al*., 2010). Higher land equivalent ratio (LER) values are obtained with intercropping (Sarno *et al*., 1998). Insurance against total crop failure under aberrant weather conditions or pest epidemics are the most important advantages of intercropping system (Dey and Singh, 1981). Considering the present context the study was designed with the following objectives:

- To observe growth of fodder maize and blackgram with varying fertilizer dose and harvest time of blackgram under intercropping;
- To find out the level of fertilizer requirement of fodder maize intercropped with blackgram under varying harvest time of blackgram;
- To increase the potential fodder yield of fodder maize and blackgram under varying fertilizer and blackgram harvest time.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Intercropping is defined as the growth of two or more crops in proximity in the same field during a growing season to promote positive interaction between them. Among different cropping systems, intercropping system was found to be a better practice for increased growth, yield and development. Production potentiality may also be denoted in terms of yield advantage, resource expense advantage or resource expense efficiency. But very few research works related to intercropping including blackgram in maize for fodder production have so far been carried out in Bangladesh. Literature pertaining to production potential of maize oriented intercropping with blackgram and other pulses and also other crops as related to growth factors were reviewed. As ample information on these crops and their intercrops related to the growth factors were not available, relevant literatures on other crops were also cited in this chapter under the following headings:

2.1. Intercropping Systems

Intercropping is a crop intensification practice in which two or more crops are inter planted on the field such that their growth cycle overlaps. Higher yield in terms of total biomass and grain production per unit area in a given season without the use of costly inputs under intercropping system is attributed to better use of growth resources namely, light, moisture and nutrients (Sivakumar and Virmani, 1980; Lakhani, 1976). Rao and Willey (1980) stated that the crop mixtures would also stabilize returns over seasons as they provide more than one commodity and can act as buffer against frequent price changes in any one of the component crops. Price fluctuations are quite common in countries like Bangladesh, where 65% of agricultural produce comes from rainfed agriculture. It is a technique of crop intensification in both time and space wherein the competition between crops may occur during a part or whole of crop growth period. It has been a common practice followed by the farmers of India, Africa, Srilanka, West Indies and Bangladesh.

2.2 Advantages of Intercropping

The main advantage of intercropping is the more efficient utilization of the available resources and the increased productivity compared with each sole crop of the mixture (Mucheru-Muna *et al.,* 2010; Launay *et al*., 2009; Carrubba *et al.,* 2008; Agegnehu *et al.,* 2008; Andersen *et al.,* 2007; Dhima *et al.,* 2007; Ofosu-Anim and Limbani, 2007; Muoneke *et al.,* 2007; Zhang and Li, 2003; Szumigalski and Van Acker, 2005; Hauggaard-Nielsen *et al*., 2001).

Intercropping controls soil erosion by preventing rain drops from hitting the bare soil where they tend to seal surface pores, prevent water from entering the soil and increase surface erosion. In maize-cowpea intercropping, cowpea acts as the best cover crop and reduces soil erosion (Kariaga, 2004). Reddy and Reddi (2007) mentioned that taller crops act as wind barrier for short crops. In legume and nonlegume intercropping, yield of non - legume increases in intercropping as compared with monocropping (Brintha and Seran, 2008). Pal and Shehu (2001) found that all legume crops contributed to yield and N uptake of maize either intercropped with legume or grown after legume as a sole crop. Intercropping serves as an insurance against total crop failure in uncertain weather condition, increasing total productivity, equitable and judicial use of land resources and farming inputs including labour (Barik *et al.*, 1998). Intercropping can provide better lodging resistance for some crops highly susceptible to lodging (Assefa and Ledin, 2001).

Intercropping is one way of introducing more biodiversity into agro ecosystems and results from intercropping studies indicate that increased crop diversity may increase the number of ecosystem services provided. Higher species richness may be associated with nutrient cycling characteristics that often can regulate soil fertility (Russell, 2002), limit nutrient leaching losses (Hauggaard-Nielsen *et al*., 2003), and significantly reduce the negative impacts of pests (Bannon and Cooke, 1998; Fininsa, 1996; Boudreau and Mundt, 1992) also including that of weeds (Hauggaard-Nielsen *et al*., 2001; Liebman and Dyck, 1993).

2.3 Maize-Legume Intercropping

Intercropping maize with cowpea has been reported to increase light interception in the intercrops, reduce water evaporation, and improve conservation of the soil moisture compared with maize alone (Ghanbari *et al*., 2010). It was reported that intercropping maize with legumes considerably reduced weed density in the intercrop compared with maize pure stand due to decrease in the available light for weeds in the maize-legume intercrops, which led to a reduction of weed density compared with sole crops (Bilalis *et al.*, 2010). Maize-french bean gave high maize equivalent yield over sole maize yield (Hugar and Palled, 2008). Among legume-cereal intercropping system, the combination of maize+pigeonpea was considered to be highly suitable with a minimum competition for nutrients, while legume + legume intercropping system, pigeonpea + groundnut system was the most efficient one in terms of resource use-efficiency (Ghosh, 2007).

Regularly intercropped pigeon pea or cowpea can help to maintain maize yield to some extent when maize is grown without mineral fertilizer on sandy soils in sub-humid zones (Waddington *et al*., 2007). Maize-legume intercropping systems are able to lessen amount of nutrients taken from the soil in comparison to a maize monocrop (Tsubo *et al.*, 2005). Higher crop productivity and resource use efficiency was observed in maize-bean intercropping systems than respective sole cropping according to Tsubo and Walker (2003). West and Griffith (1992) observed maize yield was increased by 26% in maize-soybean strip intercropping. Maize-cowpea intercropping increases the amount of nitrogen, phosphorous and potassium contents compared to mono crop of maize (Dahmardeh *et al.*, 2010).

Tsubo and Walker (2003) reported that mixed/intercropping is a technique for small farmers and intercropping systems of maize with legumes were superior to sole crops. Maize-cowpea intercropping suppresses weeds and insures against total crop failure when one crop fails (Mongi *et al.*, 1976). Cereal-legume intercropping plays an important role in subsistence food production in both developed and developing countries, especially in situations of inadequate water resources (Tsubo *et al.*, 2005).

2.4 Effect of Intercrops on Growth, Yield and Yield Components

Intercropping of maize with urdbean significantly increased the grain yield of maize compared to sole maize grown both in normal row planting and paired row planting (Shivay *et al.,* 2001). Singh *et al.* (2000) observed that intercropping of maize with vegetable pea and lentil increased the dry matter accumulation and yield attributes *viz.,* length and girth of cob. The grain yield of maize increased to the extent of 2.32 to 7.5 per cent over sole cropping when it was intercropped with grain legumes (soybean, urdbean, cowpea and groundnut). In addition, there was bonus yield from legume component (Rana *et al.,* 2001). In Venezuela, Marin *et al.* (1998) revealed that there was no adverse effect of intercropping on the leaf area development or biomass accumulation in maize. Whereas, these characteristics were reduced in intercropped *Phaseolus vulgaris*, which behaves as a poor competitator.

Gollar and Patil (1997) in maize based cropping system observed that maize grain yields with cowpea, French bean, soybean and sunflower were 3421, 4544, 4024 and 2260 kg ha^{-1}, respectively, under staggered sowing and 4181, 4935, 4539 and 3019 kg ha^{-1}, respectively, under simultaneous sowing. Intercropping of maize with French bean recorded significantly higher maize yield than the sole crop (4491 kg ha^{-1}). Barik and Tiwari (1996) noticed that, in intercropping of maize with cowpea, the height of maize plant did not differ significantly at different growth stages compared to sole cropping.

In Brazil, maize grain yields were comparable in the monocrop and intercropping systems in 2:2 row proportion with frenchbean, but the yields decreased significantly when intercropped with other crops and yields were the lowest under 2:3 row proportion (Raposo *et al.,* 1995). Decreased yield of maize due to intercropping of legumes namely cowpea, clusterbean, sunhemp and dhiancha has been observed by Gangwar and Sharma (1994). Intercropping of maize with cowpea significantly affected the yield of cowpea, which decreased from an average of 0.48 tonnes to 0.23 t ha^{-1} as maize population increased from 20,000 to 80,000 plants ha^{-1} (Cardoso *et al.,* 1994).

Reddy and Reddi (1981) observed higher grain yield of maize when intercropped with groundnut and greengram but the grain yield of maize was significantly reduced by the intercrop of cowpea in all the three spacings (60 × 30, 75 × 24 and 90 × 20 cm) because of its quick early vegetative growth. Kanakeri (1991) recorded observations on maize intercropped with legumes (green gram, black gram, soybean and cowpea) in 1:1 and 1:2 row ratios at Dharwad. No significant differences in maize growth, yield parameters and yield were obtained compared to sole maize.

The highest yield of maize (22 q ha^{-1}) was recorded in maize + soybean at 45 cm/30 cm in 2:2 row ratio followed by 16.7 q ha^{-1} in an additional row of soybean in between two rows of normal sown maize (Arya and Saini, 1989). Intercropping of maize with black gram, soybean, pigeon pea and cluster bean at 50 kg N ha^{-1} increased the maize grain yield by 0.34 to 0.56 t ha^{-1} compared with maize grain yield in pure stand at 50 kg N ha^{-1} (Singh and Kaushik, 1987). Maize and cowpea mixture grown for fodder purpose recorded higher leaf area index and light interception for maize in mixture over sole (Fawusi and Wanki, 1982).

Field experiments were conducted by Tripathi and Lawande (2008) in Pune, Maharashtra, India, to evaluate the performance of different intercrops, i.e. onion, garlic, potato and cabbage, with sugarcane in 4 different planting and irrigation systems. The highest yield of sugarcane was recorded in pair row planting with sprinkler irrigation. Among the various intercrops, the highest yield of sugarcane was recorded when intercropped with garlic, followed by potato and cabbage and onion. The highest water saving was recorded in the sugarcane-potato combination under drip irrigation system. The highest net profit was obtained with sugarcane-cabbage combination under sprinkler irrigation. The yield of garlic was lower under cropping than the average yield level of sole garlic. This was because of late planting of garlic to match with the planting of sugarcane. But if the water savings was considered, the sugarcane-cabbage and sugarcane-onion combinations in pair row planting and drip irrigation were the best combinations.

Ylmaz *et al*. (2008) carried out an experiment with alternate planting combinations of maize (*Zea mays*) with common bean (*Phaseolus vulgaris*) or cowpea (*Vigna sinensis* [*V. unguiculata*]) were compared with the solitary planting of each crop in Turkey. The treatments consisted of sole planting of maize (71,500 plants ha^{-1}), common bean (285,750 plants ha^{-1}) and cowpea (285,750 plants ha^{-1}), and 6 maize-legume intercropping series (50:50, 67:50 and 100:50 proportions with one- or 2-row planting patterns). The planting patterns were evaluated based on several intercropping indices, such as land equivalent ratio, relative crowding coefficient, actual yield loss, monetary advantage index, and intercropping index. Compared to solitary planting, the maize-cowpea and maize-common bean intercropping systems at a 67:50% proportion (plant density) was superior in terms of yield, land use efficiency and economics, regardless of the planting pattern.

A field experiment was conducted by Marer *et al*. (2007) during kharif season at Main Agricultural Research Station, Dharwad (Karnataka) to study the feasibility and adaptability of intercropping of maize and pigeonpea in 1:1, 2:1, 2:2, 3:1 and 4:2 row proportions with 50 and 100% pigeonpea population levels. Sole crop of maize and pigeonpea recorded significantly higher grain yield (6,337 and 1,090 kg ha^{-1}, respectively). Among intercropping systems, intercropping of maize and pigeonpea at 4:2 row ratio with 50% pigeonpea population resulted in maximum maize equivalent yield (8,076 kg ha^{-1}), net returns (Rs. 30,492 ha^{-1}) and B:C ratio (2.75) over other intercropping systems and sole crops.

Patel *et al*. (2007) conducted a field experiment in Gujarat, India, during wet season to select the best wet season crops for intercropping (1:1 and 1:2 row ratios) with castor bean (*Ricinus communis*) to increase net returns and land equivalent ratio. The highest castor bean seed yield (752 kg ha^{-1}) was obtained in sole crop of castor bean. Intercropping reduced castor bean yield. The maximum reduction (40%) in yield was recorded when castor bean was intercropped with moth bean at 1:1 row ratio, while the minimum reduction on seed yield was recorded when castor bean was intercropped with cowpea at 1:2 row ratio

(1.68%). Castor bean + green gram and castor bean + cowpea intercropping increased castor bean equivalent yield compared with castor bean equivalent yields of the sole crops. Intercropping of all the crops increased the land equivalent ratio compared with sole crops. The highest land equivalent ratio (48%) was recorded in the castor bean + cowpea (1:2) intercropping.

A field experiment was conducted by Tripathi *et al.* (2007) at JNKVV-Zonal Agricultural Research Station, Tikamgarh during rainy seasons under rainfed condition. On the basis of three years mean, results revealed that the highest sesame grain equivalent yield, net return and B:C ratio were recorded with sole sesame as compared to sole clusterbean and sole blackgram. The intercropping of sesame + blackgram at 3:1 row ratio will remain in 2nd position in respect of sesame grain equivalent yield, net return and benefit cost ratio.

A field experiment was conducted by Srivastava and Verma (2007) during the winter seasons in Uttar Pradesh, India, to evaluate the effect of various row ratios, mustard cultivar and fertilizer rates on the growth, phenological events and yield of component crops in wheat + mustard intercropping. Treatments comprised: 8:1, 5:1 and 2:1 row ratios; Sanjucta Asesh and Vardan mustard cultivars; and 33.33%, 66.67% and 100% recommended dose of NPK (90:45:45 kg NPK ha^{-1}). To achieve higher growth and yields of mustard along with efficient resource utilization, application of 100% recommended dose of fertilizer to both the component crops was imperative.

Singh (2007) carried out a field experiment in Kashmir, India, during the rainy (kharif) season to study the response of sunflower (*Helianthus annuus*), French bean (*Phaseolus vulgaris*) intercropping to different row ratios (1:1 and 2:2) and nitrogen levels (0, 40, 80 and 120 kg ha^{-1}) under rainfed conditions. Intercropping reduced the values of growth parameters, yield attributes and seed yield of both sunflower and French bean compared with their sole crops. Both the intercropping recorded significantly higher sunflower-equivalent yield (SEY), net income and benefit : cost ratio than their sole stands. Intercropping of sunflower + French bean under 2:2 row ratio recorded significantly higher SEY (1231 kg ha^{-1}), land-equivalent ratio (1.25), net income (Rs. 13138 ha^{-1}) and benefit : cost ratio (1.95), and also indicated a modest competitive ratio (2.10 : 0.48), followed by sunflower + French bean in 1:1 ratio.

A field experiment was conducted by Dutta and Bandyopadhyay (2007) during the rainy seasons (kharif) under typical rainfed upland conditions at Jhargram, West Bengal, India, to study the groundnut (*Arachis hypogaea* cv. JL 24) + pigeon pea (*Cajanus cajan* cv. UPAS 120) intercrop management under various plant densities and fertilizer levels. The treatment comprised 2 sole stands of groundnut and pigeon pea and 12 stands of intercropping groundnut and pigeon pea in 4:2 row ratio under different plant density and fertilizer dose. Based on the results of 2 years, the highest pod yield of groundnut (1322 kg ha^{-1}) and pigeon pea (985 kg ha^{-1}) was recorded under their sole treatment. The best performing treatment was groundnut (with 100% plant density and 100% recommended dose of fertilizer) + pigeon pea (with 75% plant density and 50% of recommended fertilizer) intercropping system which gave the highest groundnut-equivalent yield (1410 kg ha^{-1}), net return (Rs. 18418 ha^{-1}), benefit : cost ratio (1.88), land-equivalent ratio (1.18), relative crowding coefficient (2.67) and monetary advantage (Rs. 4301 ha^{-1}).

Howlader (2006) reported that the highest land equivalent ratio of 1.09 was obtained from the 4:1 row ratio of wheat: bush bean at maturity stage but 1.44 was obtained from the 3:2 row ratio of wheat: bush bean at vegetative stage. He found that highest wheat equivalent yield was 5.095 t ha^{-1} at maturity stage and 4.734 t ha^{-1} at vegetative stage obtained from the 3:2 row ratio of wheat bush bean.

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

A field experiment was conducted by Ahlawat *et al*. (2005) at New Delhi, India to evaluate the productivity of chickpea (*Cicer arietinum*) based intercropping systems. The yield of chickpea was adversely affected by intercropping with Indian mustard (*Brassica juncea*), barley (*Hordeum vulgare*) and linseed (*Linum usitatissimum*). However, the magnitude of reduction was relatively higher with intercropiing with Indian mustard. Further, the yield of chickpea increased as the proportion of chickpea increased in the mixture from 2:1 to 4:1, whereas the reverse trend was observed in the yield of intercrops. Sole Indian mustard recorded the highest total productivity in terms of chickpea equivalent yield (CEY), followed by chickpea + Indian mustard (2:1), chickpea + linseed in various row proportions and sole chickpea recorded similar CEY, which was markedly lower than sole barley and linseed and chickpea intercropped with Indian mustard and barley in various proportions, except chickpea + barley in 4:1 row proportion. Among various intercropping systems, chickpea + barley, especially in 2:1 and 3:1 row proportions, showed yield advantages in terms of land equivalent ratio (LER), while all the sole intercrops and chickpea-based intercropping systems, except chickpea + linseed (4:1) recorded higher income equivalent ratio over sole chickpea.

An experiment was conducted by Dua *et al*. (2005) at Shimla, Himachal Pradesh, India to evaluate different row ratios and cropping geometry in potato (*Solanum tuberosum*) + French bean (*Phaseolus vulgaris*) intercropping system. The potato was a dominant species when it was sown in lesser proportion than French bean, whereas French bean dominated potato in intercropping when its proportion was equal or less than that of potato. All the intercropping treatments showed yield advantage over sole cropping. Based on land-equivalent ratio (1.4975) and compensation ratio, the maximum advantage from the intercropping of potato +

French bean was obtained when planted in 2:2 row ratio with 100% population density of each crop.

Thakur *et al*. (2004) conducted a field experiment in Chhindwara, Madhya Pradesh, India, to select the most compatible intercrop with sunflower under varying row proportions for increased and economical productivity. The treatments comprised: 50 cm sole sunflower; 25 cm sole chickpea; 25 cm sole pea; 25 cm sole linseed; 25 cm sole niger; sunflower + chickpea (1:1 and 1:2); sunflower + pea (1:1 and 1:2); sunflower + linseed (1:1 and 1:2); sunflower + niger (1:1 and 1:2). Sunflower + chickpea (1:1) gave the maximum plant height (100 cm) of wheat and land equivalent ratio (1.27). Sunflower + linseed (1:1) gave the highest head size (12.5 cm) and grain yield (1525 kg ha^{-1}) of sunflower. Sunflower + niger (1:1) had the highest number of seeds per head (279) and relative crowding coefficient (3.33). Sunflower + pea (1:1) and (1:2) and sunflower + linseed (1:2) gave the highest seed chaffiness (9.2%), sunflower equivalent yield (1101 kg ha^{-1}) and stem girth (5.0 cm), respectively.

An experiment was conducted in Pusa, Bihar, India by Haidar *et al*. (2004) to study the effect of toria (*Brassica campestris* var. toria cv. TS-17) or yellow mustard (*B. campestris* var. sarson cv. Rajendra sarson-I) intercropping, one and sown in two rows, with sugarcane on crop yield. Intercropping of 2 rows of yellow sarson with sugarcane recorded the highest reduction (23.7%) in nematode population followed by sugarcane + one row of yellow mustard at harvest of intercrops. This sequence showed prolonged effect of toxicity as evidenced by 12% reduction in nematode population from initial density level at the time of harvest of sugarcane. Sugarcane + yellow mustard intercropping system exhibited the highest cane equivalent yield.

Abdur *et al*. (2004) conducted an experiment in Pakistan to study the effect of legume intercropping on the growth of sorghum. The treatments comprised single row (60 cm apart), double row (30/90 cm) and triple row strip (30/120 cm) planting of sorghum (cv. PARC-SS-II), with and without mungbean (cv. MN-92) and guar (cv. DK-3). The planting pattern had a significant effect on the maturity of sorghum. The double row strips took maximum number of days (104.4) to maturity. The interaction between planting patterns and legume intercropping with regards to maturity of sorghum was not significant in both years. Legume intercropping significantly decreased the number of grains per panicle compared to sole sorghum. Sole sorghum produced the maximum number of grains per panicle compared to sorghum grown in association with mungbean and guar. The interaction between planting pattern and legume intercropping was also not significant. Sorghum grain yield was significantly affected by planting pattern in both years where the highest yield was obtained from double row strips. Legume intercropping also significantly affected sorghum grain yield.

Mengping and Zhangjinsong (2004) observed that the intercropping system was an established fact that the system increased water utilization efficiency, shows higher land equivalent ratio and above all gives higher yield.

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) were recorded for intercropping lentil (100%) and wheat (40%).

Cheng *et al.* (2003) reported that when higher nitrogen was applied under wheat + blackgram intercropping system, 1000-seed weight was greater than mono cropped wheat.

Kumari and Prasad (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.

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.

A field investigation was carried out by Chakravorty and Mrinalinee (2002) during summer season to evaluate the yield and economics of intercropping maize cv. Vijoy with pulses (green gram cv. ML 56, black gram cv. T-9) and cowpea cv. Local under rainfed conditions in Jorhat, Assam, India. Among intercropping system, paired rows of maize and black gram proved superior to all other treatments with respect to growth and yield attributing characters, grain yield of maize (26.89 q ha^{-1}) and grain yield of black gram (3.82 q ha^{-1}). Paired rows of maize and cowpea found to be the best with respect to maize equivalent yield (45.03 q ha^{-1}) net return (Rs. 14,952) and monetary advantage (Rs. 5380.77). Between 2 methods of planting, paired row planting was found to be better than alternate row planting in respect to yield attributing characters, yield, maize equivalent yield and economic indices.

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

Ashok *et al*. (2001) evaluated an experiment at New Delhi. They found that number of tillers per plant of wheat was not significantly affected by wheat based intercropping system.

Oleksy and Szmigiel (2001) reported that 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.

Qiujie *et al.* (1999) conducted an experiment where wheat and groundnuts were relay cropped or sequentially cropped and given 2 rates each of N and P fertilizer, alone or in combination. Average wheat and groundnut yields were increased by 27.7 and 14.3%, respectively, compared with sequential cropping. Both individual and combined applications of N and P significantly increased yield, and yield stability was greatest with combined application in the relay intercropping system.

Rahman (1999) reported that intercropping of grasspea with wheat was sustainable over sole crop.

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

Dwivedi *et al.* (1998) found that all intercropping systems had higher total yield and net returns than pure stands.

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

Sarma and Sarma (1998) conducted a field study in rabi season (winter). Wheat, lentils and peas were grown alone or intercropped as 1:1 or 2:2 rows between wheat and each of the other crops. Wheat yield was 3.0 - 3.1 t ha^{-1} when grown alone and 2.6 - 20.8 t ha^{-1} when intercropped. Wheat-equivalent yield was highest from sole Rajmash, because of the higher economic value of this crop. Wheat-equivalent yield was higher in intercropping systems than in sole wheat, with the best results given by intercropping with Rajmash.

Sarno *et al.* (1998) reported that higher equivalent yields were obtained with intercropping treatment of wheat-field pea. The land equivalent ratio (LER) values were found to be greater.

Nazir *et al*. (1997) reported that biological efficiency (yield) and economics of wheat-based intercropping were introduced as the intercropping systems of wheat + fenugreek, wheat + lentils, wheat + chickpeas, wheat + linseed, wheat + barley and sole crop wheat in Pakistan. In monetary terms, both the wheat-fenugreek and wheat-lentil intercropping systems proved to be more beneficial than the other cropping systems, including mono cropped wheat. They also reported that all the intercropping systems gave substantially higher total yield equivalent than that of sole crop.

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

Verma and Mallick (1997) carried out a field trial in winter seasons 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}, while sole lentil received 20 kg N + 16 kg P ha^{-1}. Intercrops were given 8 different combinations of fertilizers.

Wheat grain yield was 3.29 t ha^{-1} in pure stand and 2.73 - 3.12 t ha^{-1} when intercropped. Lentil seed yield was 1.53 t ha^{-1} in pure stand and 0.22 - 0.41 t ha^{-1} when intercropped. The highest wheat-equivalent yield and net returns were obtained when wheat was intercropped with lentils fertilized with 80 kg N + 16 kg P + 16 kg K ha^{-1}.

Singh (1996) conducted an experiment where wheat and gram were grown in pure stands or in 1:1, 1: 2, 2:1 or 2:2 row ratios and given 0, 25, 50 or 75 kg N ha^{-1}. Yields of both crops were highest in pure stands. Wheat equivalent yield was highest when wheat was grown alone and in the 2:1 wheat: gram intercrop. Land equivalent ratios were always more than one in most intercropping treatments.

Hosamani *et al.* (1995) published the results of a field experiment with wheat which was intercropped with *Cicer arietinum* (chickpea), safflower or *Brassica juncea* in wheat: oilseeds row ratios of 3:1, 4:2 or 5:1. Mean wheat grain yields at the 3 row rations were 1.78, 1.50 and 1.91 t ha^{-1}, respectively. Wheat/safflower intercrop gave the highest wheat equivalent yield (3.07 t) and the highest net returns.

Haymes *et al*. (1994) compared wheat yield under sole cropping which was not severely depressed by intercropping with bean. It was found that wheat yield was significantly higher in alternate and within row spacing than in block spacing. Wheat yields increased with increasing density, and were decreased by increasing bean density. Weed biomass was significantly lower in all intercrop patters compared with sole cropping. In the block spacing the highest LER was obtained with wheat at 100% of the recommended sowing rate.

Varshney (1994) conducted an experiment during rabi season. Chickpeas and wheat were grown as sole crop or intercrop. Both crops only received the recommended NP fertilizer rate. Result showed that the sole wheat gave the highest chickpea equivalent yield. Application of the recommended fertilizer rate to wheat gave higher yields than application to both the crops.

Ali (1993) conducted a field experiment to determine the optimum fertilizer rate and row ratio of wheat and chickpeas in the late-sown under irrigated condition. Of the 3 populations tested (2:2, 2:1 and 3:1 row rations 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.

Ardesana *et al.* (1993) stated that in recent years, many scientists are engaged to improve intercropping system for long time to achieve higher yield benefit. Among different cropping systems, intercropping system was found to be a better practice for increased growth, yield and development. In Bangladesh, pulse crops are generally grown without fertilizer or manure. However, it was found that the yield of pulse could be increased substantially by using fertilizers. Pulses, although fix nitrogen from atmosphere, it was also evident that nitrogen application became helpful to increase the yield, although there were controversies regarding the nitrogen. The pattern of N-fixation or utilization of other plant nutrients may have extra significance while practicing intercropping.

Atar *et al*. (1992) conducted a field experiment at New Delhi with wheat base intercropping system. It was observed that intercropping system ensured highest water use efficiency.

Dahatonde *et al*. (1992) conducted a field experiment during the winter season; wheat was intercropped with French bean. Row ratios were 6:3 or 4:2 and the crops were given recommended fertilizers (100 kg N + 50 kg P + 50 kg ha^{-1} for wheat and 90 kg N + 50 kg P ha^{-1} for French bean). French bean grown alone produced the highest equivalent yield of 4.01 t ha^{-1} and the highest net returns. The best intercropping treatment producing a wheat equivalent yield of 3.60 t ha^{-1} was with 4:2 wheat/French bean intercrop.

Goldmon (1992) studied winter wheat relay cropped with soyabean. Results showed that sole wheat yielded slightly more than intercropped wheat. The land equivalent ratio was 1.18 with the wheat component comprising over 80% of the total. Among the intercropped treatments, soyabean grown in narrow row spacing and those with an indeterminate growth habit had better light interception.

Pandey *et al.* (1992) tested increasing N and P application rates (up to 40 kg ha^{-1} of each) and found that yields of wheat and *Cicer arietinum* grown as either intercrop or mixed crop were increased.

Hiremath *et al*. (1990) carried out a field trial in the rabi season on black clay soils. Wheat and soyabean were grown alone or intercropped in 12 different row ratios ranging from 1:1 to 4:3. The highest land equivalent ratio (1.33) was obtained from intercropping wheat and soyabean in a 1:2 row ratio, and the highest gross returns from a 3:1 row ratio.

Bautista (1988) observed that 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 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. The author also reported that 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.

Mondal *et al.* (1986) reported that 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.

Bandyopadhyay (1984) reported that 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, fibre and fodder from existing area.

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

Hashem (1983) experimented to determine the profitability of intercropping systems; agronomically feasible technology may not always be accepted if it is economically viable. It is claimed that in almost all cases intercropping gave more monetary return than the sole crops.

Khan (1983) reported that the ratio of seed rate of crops in mixed or intercropping has got direct effect on the production and yield. Fertilizer application in the practice of mixed or intercropping is another important factor that affects the yield and production of the crops. The seed rate ratio or plant population is an important consideration in mixed intercropping practices. The best combination of seedling ratio for wheat and chickpea was found to be 50:100.

Islam *et al.* (1982) estimated that 80 per cent N fertilizer may be saved in a maize + blackgram intercropping. He found highest LER values (1.55) when maize was intercropped with black gram at 44,444 maize plants ha^{-1} and 1, 11, 111 black gram plants ha^{-1} with 20 kg N ha^{-1} instead of 120 kg N ha^{-1}. Miah (1982) obtained similar results where wheat and gram combination at 50:100 or 50:50 seed rate ratios gave more than 50% increased production over monoculture.

Bhuiyan (1981) investigated mixed cropping of gram with wheat under different proportion of normal seed rates. The highest LER of 1.47 was obtained at 100:75 seed rate ratio.

2.5 Effect of Fertilizers and Manure on Fodder Production

Plant growth is often affected by poor soil condition, Osmotic pressure and nutritional imbalance in rooting zone (Totamat and Singh, 1981). Nitrogen fertilizer application significantly increased green forage production. Robinson (1991) also working with *Penniselkum typhoid* and *Lutium multiflorum* at six levels of nitrogen fertilizer (0-800 kg/ha) observed that forage yields increased as nitrogen applications increased. Manahar *et al.* (1992) studied the influence of different levels of N (30, 60 or 90 kg N/ha) and P (25 or 50 kg P_2O_5/ha) on the green fodder yield of pear millet fodder and stated the increasing N and P fertilizer resulting in increase or green fodder yields.

Khandaker and Islam (1998) conducted an experiment on yield and quality of fodder maize with different levels of nitrogen (0, 21, 42 and 63 kg N/-ha) and observed that application of 63 kg N/ha resulted in significantly higher ($P < 0.01$) yield of green fodder (41.05 t/ha). Maize *(Zea mays)* forage when harvested under different stages of maturity (6, 7, 8 and 9 weeks after sowing) a progressive increase in forage yield upto 8 weeks but significant < 0.01) increase was observed upto 7 weeks of age was observed.

Shahjalal *et al.* (1996) conducted an experiment with maize and oat forage under two different levels (50 or 100 kg/ha) of N fertilizer and observed that the oat forage gave significantly ($P < 0.05$ to $P < 0.01$) higher yields of green mass (61.5 t/ha vs 48.9 t/ha). Ramamurthy and Shivashankar (1996) stated that phosphorus fertilizer application of maize fodder sown on a sandy loam soil. An increase in 8% of fresh yields was observed due to residual response to 56.25 kg P205/ha compared with the application of 37.50 kg P_2O_5/ha.

Chen *et al.* (1994) observed in pop corn *(Zea mays)* given 0, 150, 300 or a 400 kg N/ha the highest yield of 5175 kg/ha was given by 300 kg N. Increasing N rate increased leaf length, thickness and width. Razende *et al.* (1994) also concluded that number of leaves increased with increasing N rate.

Gonet and Stadejek (1992) conducted an experiment in various parts of Poland with maize as green forage. They grew at about 300,000 plants/ha in rows 35 cm apart and given 0-180 kg N/ha before sowing and found that optimum rate ranged from 100 kg/ha on rye complex soil to 130 kg N on wheat complex soil. Average dry matter (DM) yields increased from 9.22 t/ha without N fertilizer to 14.72 t/ha with 180 kg N/ha.

Okajma *et al.* (1983) reported that dry matter (DM) yield of maize increased with increasing N rate. They also reported that grain yield increased from 0.91 t/ha with no N to 10.09 g with 200 kg N/ha. Choubey *et al.* (1999) conducted an experiment with different N levels at the rate of 20, 40, 60 and 80 kg N/ha on para grass and observed that application of 60 kg N/ha reported in significantly highest green forage had DM yield over rest of the N levels except 80 kg/ha. Stout *et al.* (2001) conducted an experiment on orchard grass with using different doses of N fertilizer at the rate of 0, 22.4, 44.8 and 89.6 kg/ha and observed that dry matter yields increased with the increased of N fertilizer.

Awasthi *et al.* (1993) carried out an experiment by applying nitrogen fertilizer to wheat and maize at the rate of 0, 20, 40 and 60 kg N/ha. Significantly higher value of plant height, leaf area index, dry matter production and spikes/m^2 were observed in 60 kg N/ha then other doses.

Dhiman *et al.* (1982) stated that plant height increase with increase in N upto 120 kg/ha, while in the subsequent year, increased upto 180 kg N/ha. Hammam (1995) applied 0, 36 and 250 kg N/ha for maize production and observed that increasing nitrogen levels increased the plant height. But, Dijk (1996) observed that application of over 60 kg N/ha in row decreased growth rate of crop particularly on clay soils.

Chapter III

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted to find out the effect of blackgram harvest time on fodder yield potentials of maize-blackgram intercropping system under varying dose of fertilizers. A brief description of the experimental site, soil, climate, experimental design, treatments, cultural operations, data collection and analysis of different parameters for both fodder maize and blackgram have been presented under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted in Rabi season during the period from October 2013 to January 2014.

3.1.2 Location of the experimental site

The experiment was carried out at the experimental field of Agronomy Department, Sher-e-Bangla Agricultural University, Dhaka-1207. The experimental field was located at $90^0$22´ E longitude and $23^0$41´ N latitude at an altitude of 8.6 meters above the sea level. The experimental site was located under the agro-ecological region 28.

3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February and the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al.*, 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh Meteorological Department, Sher-e-Bangla Nagar, Dhaka and details has been presented in Appendix I.

3.1.4 Soil characteristics of the experimental plot

The soil belonged to "The Modhupur Tract", AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.8 and had organic matter 1.34%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details have been presented in Appendix II.

3.2 Experimental details

3.2.1 Planting materials

3.2.1.1 Description of maize cultivars

Seeds of maize (local variety) were used as a main fodder crop for the study and it was collected from local market.

3.2.1.2 Description of blackgram

Seeds of blackgram variety BARI Mash-3 were used as a fodder intercrop for the study and the seeds of this variety were collected from Bangladesh Agricultural Development Corporation (BADC).

3.2.2 Treatment of the experiment

The experiment consisted 14 treatment as combination of two fertilizer dose (recommended fertilizers and 20% more than recommended fertilizers) with different harvesting time of blackgram at different days after sowing (DAS) which are presented below:

$T_1 = F_RH_{40}$ (Recommended fertilizers and harvest at 40 DAS)

$T_2 = F_RH_{50}$ (Recommended fertilizers and harvest at 50 DAS)

$T_3 = F_RH_{60}$ (Recommended fertilizers and harvest at 60 DAS)

$T_4 = F_RH_{70}$ (Recommended fertilizers and harvest at 70 DAS)

$T_5 = F_RH_{80}$ (Recommended fertilizers and harvest at 80 DAS)

$T_6 = F_RH_{90}$ (Recommended fertilizers and harvest at 90 DAS)

$T_7 = F_{R+20\%}H_{40}$ (20% more than recommended fertilizers and harvest at 40 DAS)

$T_8 = F_{R+20\%}H_{50}$ (20% more than recommended fertilizers and harvest at 50 DAS)

$T_9 = F_{R+20\%}H_{60}$ (20% more than recommended fertilizers and harvest at 60 DAS)

$T_{10} = F_{R+20\%}H_{70}$ (20% more than recommended fertilizers and harvest at 70 DAS)

$T_{11} = F_{R+20\%}H_{80}$ (20% more than recommended fertilizers and harvest at 80 DAS)

$T_{12} = F_{R+20\%}H_{90}$ (20% more than recommended fertilizers and harvest at 90 DAS)

T_{13} = Sole maize

T_{14} = Sole blackgram

F_R: Recommended dose of fertilizer (Cowdung: 10 t ha^{-1}; Urea: 350 kg ha^{-1}; TSP: 250 kg ha^{-1}; MoP: 200 kg ha^{-1}; Zypsum: 170 kg ha^{-1} and Zinc sulphate: 15 kg ha^{-1})

3.2.3 Experimental design and layout

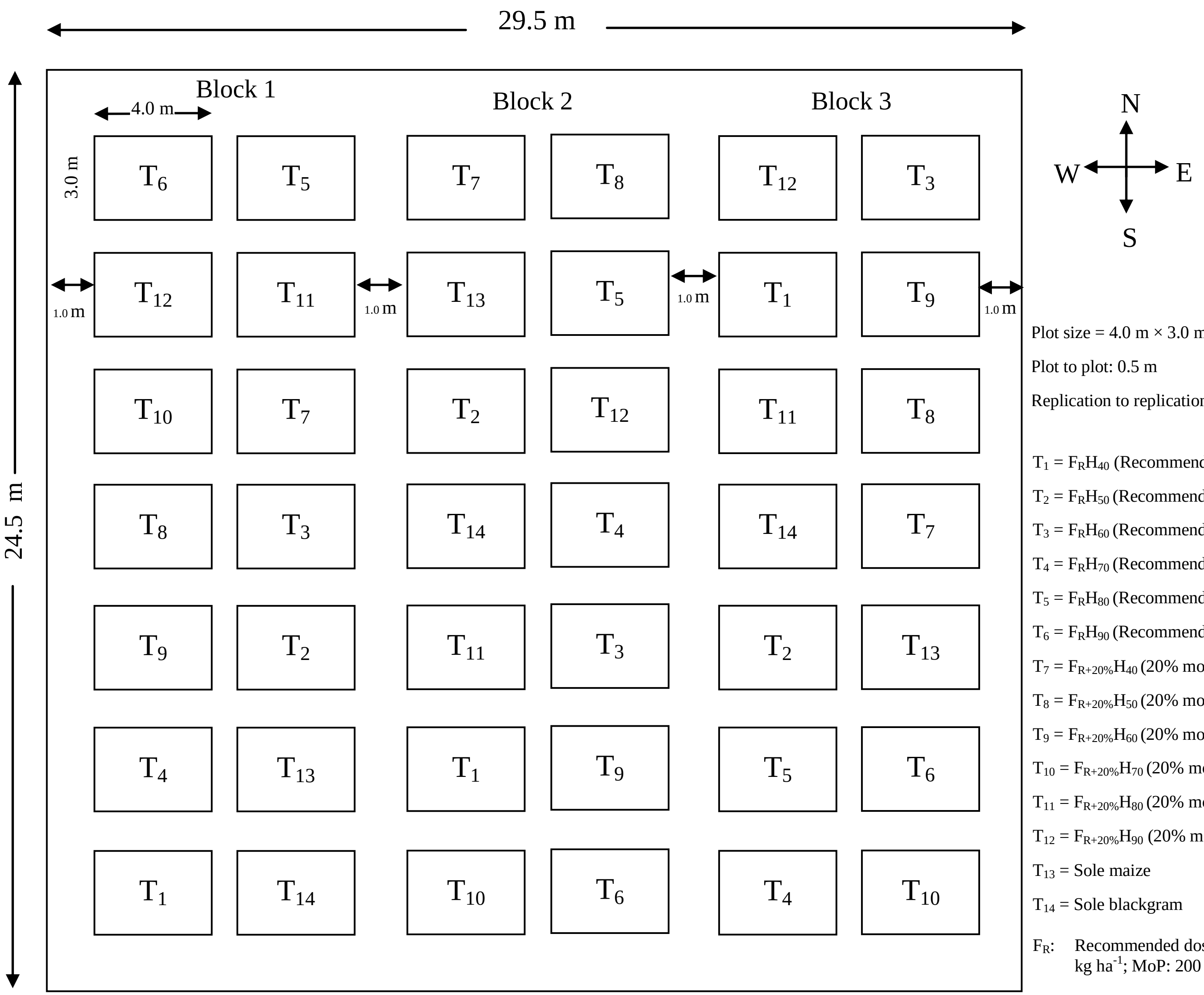
The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experimental unit was divided into three blocks each of which representing a replication. Each block was divided into 14 plots in which 14 treatments were applied at random. So, the total number of unit plots in the entire experimental plot was 42. Size of each unit plot was 4.0 m × 3.0 m = 12.0 m^2. The distance maintained between two plots was 0.5 m and between blocks it was 1 m. Layout of the experiment presented in Figure 1.

3.3 Growing of crops

The particular of the cultural operations carried out during the experimentation are presented below:

3.3.1 Land preparation

The experimental field was first opened on October 27, 2013 with the help of a power tiller and prepared by three successive ploughings and cross-ploughings. Each ploughing was followed by laddering to have a desirable fine tilth. The visible larger clods were hammered to break into small pieces. All kinds of weeds and residues of previous crop were removed from the field. Individual plots were cleaned and finally leveled with the help of wooden plank.



Plot size = 4.0 m × 3.0 m

Plot to plot: 0.5 m

Replication to replication: 1.0 m

$T_1 = F_RH_{40}$ (Recommended fertilizers and harvest at 40 DAS)

$T_2 = F_RH_{50}$ (Recommended fertilizers and harvest at 50 DAS)

$T_3 = F_RH_{60}$ (Recommended fertilizers and harvest at 60 DAS)

$T_4 = F_RH_{70}$ (Recommended fertilizers and harvest at 70 DAS)

$T_5 = F_RH_{80}$ (Recommended fertilizers and harvest at 80 DAS)

$T_6 = F_RH_{90}$ (Recommended fertilizers and harvest at 90 DAS)

$T_7 = F_{R+20\%}H_{40}$ (20% more than recommended fertilizers and harvest at 40 DAS)

$T_8 = F_{R+20\%}H_{50}$ (20% more than recommended fertilizers and harvest at 50 DAS)

$T_9 = F_{R+20\%}H_{60}$ (20% more than recommended fertilizers and harvest at 60 DAS)

$T_{10} = F_{R+20\%}H_{70}$ (20% more than recommended fertilizers and harvest at 70 DAS)

$T_{11} = F_{R+20\%}H_{80}$ (20% more than recommended fertilizers and harvest at 80 DAS)

$T_{12} = F_{R+20\%}H_{90}$ (20% more than recommended fertilizers and harvest at 90 DAS)

T_{13} = Sole maize

T_{14} = Sole blackgram

F_R: Recommended dose of fertilizer (Cowdung: 10 t ha^{-1}; Urea: 350 kg ha^{-1}; TSP: 250 kg ha^{-1}; MoP: 200 kg ha^{-1}; Zypsum: 170 kg ha^{-1} and Zinc sulphate: 15 kg ha^{-1})

Figure 1. Field layout of the experimental plot

3.3.2 Fertilizers and manure application

The sources of N, P_2O_5, K_2O, S and Zn as urea, TSP, MoP, Zypsum and Zinc sulphate were applied, respectively as per the recommended dose of maize cultivation and following treatments. The entire amounts of TSP, Zypsum and Zinc sulphate were applied during the final land preparation and mixed well with the soil. Urea was applied in ½ as basal during final land preparation and rest ½ at 40 days after seeds sowing as per the mentioned below. Well-rotten cowdung 10 t/ha also applied during final land preparation and mixed well the soil of the experimental plot. The following amount of manures and fertilizers were used which shown in Table 1 recommended by BARI (2011).

Table 1. Recommended fertilizers and manure applied for the experimental field

Manures and Fertilizers	Dose/ha	Application	
		Final land preparation	1st installment
Cowdung	10 tons	10 ton	--
Urea	350 kg	175 kg	175 kg
TSP	250 kg	250 kg	--
MoP	200 kg	200 kg	--
Zypsum	170 kg	170 kg	--
Zinc sulphate	15 kg	15 kg	--

3.3.3 Sowing of seeds

The maize seeds were planted in lines each having a line to line distance of 75 cm and plant to plant distance of 25 cm having 2 seeds/hole under direct planting in the well prepared plot on 10 November 2013.

The blackgram seeds were sown at the same days on November 10, 2013. Seeds were sown continuous by in a shallow furrow in between maize lines and after sow, seeds were covered with soil and slightly pressed by hand.

3.3.4 Intercultural operations

3.3.4.1 Irrigation

The experimental plot was irrigated two times based on the field situation. The first irrigation was done at 25 DAS and second was applied at 45 DAS of maize or blackgram. Proper drainage system was maintained to remove the excess amount of water from the plot.

3.3.4.2 Pest management

In the whole period of experimentation, no sever infestation of diseases and pest were found. Special attention were undertaken to protect the crop from the attack of parrots, pigeons and other birds.

3.4 Harvesting and sampling

The fodder crop blackgram was harvested at 40, 50, 60, 70, 80 and 90 DAS and the maize fodder was harvested 90 DAS. Samples were collected from different places of each plot in the centre. The selected sample plants were then tagged and carefully carried to the Agronomy field laboratory in order to collect data.

3.5 Data recording

The following data were recorded during the study period:

3.5.1 Data of soil moisture and light intensity of the field

1. Soil moisture
2. Light intensity

3.5.2 Data of fodder maize

1. Plant height (cm)
2. Leaves plant^{-1}
3. Length of leaf (cm)
4. Breadth of leaf (cm)
5. Leaf area plant^{-1} (cm^2)
6. Fodder yield (t ha^{-1})
7. Relative yield

3.5.3 Data of fodder blackgram

1. Plant height (cm)
2. Branches plant^{-1}
3. Leaves plant^{-1}
4. Length of leaf (cm)
5. Breadth of leaf (cm)
6. Leaf area plant^{-1} (cm^2)
7. Fodder yield (t ha^{-1})
8. Relative yield of fodder blackgram

3.5.4 Data of land equivalent ratio and equivalent yield

1. Land equivalent ratio (LER)
2. Equivalent yield (EY)

3.6 Procedure of data collection

3.6.1 Data of soil moisture and light intensity

Soil moisture (%)

The fresh weight of soil was recorded from each unit plot. The weight of the soil was recorded immediately after harvest of blackgram. After recording the fresh weight of the soil it was dried well in sun and then dried in an oven at 65^{0}C for 72 hours, until constant weight was achieved. It was recorded at 40, 50, 60, 70, 80 and 90 DAS. The recorded weight, after oven drying, was the dry weight of soil. Soil moisture was calculated following the formula on dry weight basis -

$$\text{Soil moisture (\%)} = \frac{\text{Initial weight – Oven dry weight}}{\text{Oven dry weight}} \times 100$$

Light intensity (Lx)

Light intensity was measured at each plot as per treatment of harvesting time. It was measured using Lutron Luxmeter Model Lx-101 and expressed in Lx. Light intensity was measured at maize height at the top most position of foliage and also as the base, middle and upper level foliage height as per blackgram at harvesting time.

3.6.2 Data of fodder maize

Plant height (cm)

The height of maize was recorded in centimeter (cm) at 90 DAS during harvest from five randomly selected plants in each plot. The height was measured from soil surface to tip of the plant and mean height was recorded.

Leaves plant^{-1} (No.)

The total number of leaves plant^{-1} of maize was counted. Data were recorded as the average of five plants selected at random from the inner rows of each plot at 90 DAS during harvesting time of fodder maize.

Length of leaf (cm)

The distance from the base of the lamina to the tip of leaf was considered length of leaf. It was measured with a meter scale and was recorded in centimeter (cm). Data were recorded as the average of five plants selected at random from the inner rows of each plot at 90 DAS during harvesting time of fodder maize.

Breadth of leaf (cm)

The distance vertically from the one side to another side to the middle of leaf was considered breadth of leaf. It was measured with a meter scale and was recorded in centimeter (cm). Data were recorded as the average of five plants selected at random from the inner rows of each plot at 90 DAS during harvesting time of fodder maize.

Leaf area (cm^2)

Leaf area (LA) was determined from plant samples by using an automatic leaf area meter (Model LI-3100, Li-COR, Lincoln, NE, USA) immediately after removal of leaves from plants to avoid rolling and shrinkage. Leaf area was recorded as the average of five leaves selected at random from the plant of inner rows of each plot at 90 DAS during harvesting time of fodder maize.

Fodder yield (t ha^{-1})

The maize fodder yield ha^{-1} was measured by converted fodder yield plot^{-1} into yield ha^{-1} and was expressed in ton.

Relative yield

Relative yield was measured dividing intercropped fodder yield of maize by the sole crop yield of fodder maize. Relative yield was calculated by using the following formula-

$$\text{Relative fodder yield of maize} = \frac{\text{Fodder yield of the intercropped maize}}{\text{Fodder yield of the sole maize}}$$

3.6.2 Data of fodder blackgram

Plant height (cm)

The height of blackgram was recorded in centimeter (cm) as per harvest time in each plot from five randomly selected plants in each plot. The height was measured from soil surface to tip of the plant and mean height was recorded.

Branches plant^{-1} (No.)

The total number of branches plant^{-1} of blackgram was counted. Data were recorded as the average of five plants selected at random from the inner rows of each plot as per treatment of harvesting time of blackgram.

Leaves plant^{-1} (No.)

The total number of leaves plant^{-1} of blackgram was counted. Data were recorded as the average of five plants selected at random from the inner rows of each plot as per treatment of harvesting time of blackgram.

Length of leaf (cm)

The distance from the base of the lamina to the tip of leaf was considered length of leaf. It was measured with a meter scale and was recorded in centimeter (cm). Data were recorded as the average of five plants selected at random from the inner rows of each plot as per treatment of harvesting time of blackgram.

Breadth of leaf (cm)

The distance vertically from the one side to another side to the middle of leaf was considered breadth of leaf. It was measured with a meter scale and was recorded in centimeter (cm). Data were recorded as the average of five plants selected at random from the inner rows of each plot.

Leaf area (cm^2)

Leaf area (LA) was determined from plant samples by using an automatic leaf area meter (Model LI-3100, Li-COR, Lincoln, NE, USA) immediately after removal of leaves from plants to avoid rolling and shrinkage. Leaf area was recorded as the average of five leaves selected at random from the plant of inner rows of each plot as per treatment of harvesting time of blackgram.

Fodder yield (t ha^{-1})

The blackgram fodder yield ha^{-1} was measured by converted fodder blackgram yield $plot^{-1}$ into yield ha^{-1} and was expressed in ton.

Relative yield

Relative yield was measured dividing intercropped yield of blackgram by the sole crop yield of blackgram. Relative fodder yield was calculated by using the following formula -

$$\text{Relative fodder yield of blackgram} = \frac{\text{Fodder yield of the intercropped blackgram}}{\text{Fodder yield of the sole blackgram}}$$

3.6.4 Data of land equivalent ratio and equivalent yield

3.6.4.1 Land equivalent ratio

In order to compare the difference among the treatments, land equivalent ratio (LER) was calculated. LER value was computed from the fresh fodder yield according to the following formula-

$$\text{LER} = \frac{\text{Fodder yield of the intercropped Maize}}{\text{Fodder yield of the sole maize}} + \frac{\text{Fodder yield of intercrop blackgram}}{\text{Fodder yield of sole balckgram}}$$

LER in its simplest form has been defined as the relative area of the sole crop that would be required to produce the yield achieved by intercropping.

3.6.4.2 Equivalent yield (t ha^{-1})

In the intercropping system, equivalent yields were used as criteria for evaluating the productivity. Fodder maize equivalent was calculated and it was computed by converting the fodder yield of blackgram into the yield of main crop fodder maize on the basis of prevailing market prices using the following formula -

$$\text{Maize equivalent yield} = Y_M + \frac{Y_B \times P_B}{P_M}$$

Where,

Y_M = Fodder yield of maize (t ha^{-1})

Y_B = Fodder yield of blackgram (t ha^{-1})

P_B = Market price of fodder blackgram (Tk. 5 kg^{-1})

P_M = Market price of fodder maize (Tk. 4 kg^{-1})

Similarly,

$$\text{Blackgram equivalent yield} = Y_B + \frac{Y_M \times P_M}{P_B}$$

Where,

Y_B = Fodder yield of blackgram (t ha^{-1})

Y_M = Fodder yield of maize (t ha^{-1})

P_M = Market price of maize fodder (Tk. 4 kg^{-1})

P_B = Market price of blackgram fodder (Tk. 5 kg^{-1})

3.7 Statistical analysis

The collected data were complied and analyzed to find out the statistical significance among the level of factors. The collected data were analyzed by MSTAT–C software. The means for all recorded data were calculated and the analyses of variance of all characters were performed. The mean differences were evaluated by Duncan’s Multiple Range Test (DMRT) at 0.01 or 0.05 level of probability (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of fertilizer dose and blackgram harvest time on fodder yields under maize-blackgram intercropping system. The analyses of variance (ANOVA) of the recorded parameter are presented in Appendix III-VI. The results have been presented and possible interpretations are given under the following headings:

4.1 Soil moisture and light intensity

4.1.1 Soil moisture (%)

Soil moisture of maize-blackgram intercropped field showed significant variation due to different treatments at 40, 50, 60, 70, 80 and 90 days after sowing (DAS) (Appendix III). The maximum soil moisture (34.78%, 33.87%, 35.86%, 35.97%, 36.54% and 37.13%, respectively) was recorded from T_{12} ($F_{R+20\%}H_{90}$) at 40, 50, 60, 70, 80 and 90 DAS which was however, statistically similar with other treatments except T_{13} (sole maize) followed by T_{14} (sole blackgram) and the minimum (30.22%, 29.34%, 30.11%, 30.34%, 30.54% and 30.61%, respectively) from T_{14} treatment (Table 2). Result showed that intercropped plot preserved maximum soil moisture upto harvest than the sole cropped plot. In the intercropped plot more soil moisture was preserved possibly due to restriction of direct falling of sunlight on the soil. On the other hand, it also prevented soil moisture evaporation from the field by covering surface soil. Moreover, legumes might have helped in the utilization of moisture from deeper soil layers (Bautista, 1988). Similar results also reported by Manisha *et al*. (2007), Dutta and Bandyopadhyay (2007) and Ahlawat *et al.* (2005) from intercropped field in their earlier study. Results obtained showed that there was no marked difference in soil moisture due to intercropping and higher fertilizer application. However, relatively higher soil moisture was obtained in intercropped and highly fertilized plots which may be attributed to the denser foliage in these plots.

Table 2. Effect of fertilizer dose and time of harvesting of blackgram on soil moisture content under maize-blackgram intercropping system

Treatments	Soil moisture (%) at different days after sowing					
	40	50	60	70	80	90
T_1	34.05 ab	30.84 a-c	30.67 c	30.86 b	31.05 b	30.89 b
T_2	34.11 ab	33.62 ab	31.77 bc	31.27 b	31.46 b	31.13 b
T_3	34.46 a	33.84 a	35.71 ab	32.04 b	32.13 b	31.89 b
T_4	34.49 a	33.35 ab	35.50 ab	35.54 a	32.85 b	32.55 b
T_5	34.36 a	33.50 ab	35.20 ab	35.92 a	36.34 a	32.89 b
T_6	34.23 a	33.47 ab	35.68 ab	35.84 a	36.43 a	36.98 b
T_7	34.64 a	31.22 a-c	31.03 c	31.15 b	31.24 b	30.95 a
T_8	34.45 a	33.46 ab	32.56 a-c	31.46 b	31.78 b	31.68 b
T_9	34.66 a	33.45 ab	35.63 ab	32.86 ab	32.34 b	32.05 b
T_{10}	34.56 a	33.64 ab	35.91 a	35.44 a	33.07 b	32.67 b
T_{11}	34.63 a	33.65 ab	35.84 a	35.69 a	36.53 a	33.05 b
T_{12}	34.78 a	33.87 a	35.86 a	35.97 a	36.54 a	37.13 a
T_{13}	31.43 bc	30.04 bc	30.44 c	30.67 b	30.74 b	30.82 b
T_{14}	30.22 c	29.34 c	30.11 c	30.34 b	30.54 b	30.61 b
$S\bar{x}$	0.885	1.084	1.205	1.071	0.928	0.950
Significance level	0.05	0.05	0.01	0.01	0.01	0.01
CV(%)	4.52	5.75	6.19	5.58	4.86	5.06

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

$T_1 = F_RH_{40}$ $T_2 = F_RH_{50}$

$T_3 = F_RH_{60}$ $T_4 = F_RH_{70}$

$T_5 = F_RH_{80}$ $T_6 = F_RH_{90}$

$T_7 = F_{R+20\%}H_{40}$ $T_8 = F_{R+20\%}H_{50}$

$T_9 = F_{R+20\%}H_{60}$ $T_{10} = F_{R+20\%}H_{70}$

$T_{11} = F_{R+20\%}H_{80}$ $T_{12} = F_{R+20\%}H_{90}$

T_{13} = Sole maize T_{14} = Sole blackgram

F_R: Recommended dose of fertilizer (Cowdung: 10 t ha^{-1}; Urea: 350 kg ha^{-1}; TSP: 250 kg ha^{-1}; MoP: 200 kg ha^{-1}; Zypsum: 170 kg ha^{-1} and Zinc sulphate: 15 kg ha^{-1})

$F_{R+20\%}$: More than 20% fertilizer of recommended dose

H_{40}: Blackgram harvest at 40 DAS H_{50}: Blackgram harvest at 50 DAS

H_{60}: Blackgram harvest at 60 DAS H_{70}: Blackgram harvest at 70 DAS

H_{80}: Blackgram harvest at 80 DAS H_{90}: Blackgram harvest at 90 DAS

4.1.2 Light intensity (Lx)

Statistically significant variation was recorded for light intensity of the maize and blackgram intercropped field in the context of fodder blackgram plant but regarding maize plot it was statistically non-significant (Appendix IV). In case of maize, light intensity varied from 131.94 to 133.22 Lx. The minimum light intensity (131.94 Lx) was observed from T_5 (F_RH_{80}) and T_{14} (Sole blackgram), whereas the maximum light intensity (133.22 Lx) from T_6 (F_RH_{90}) treatment. In case of blackgram, the maximum light intensity (86.42 Lx, 99.97 Lx and 133.11 Lx) was recorded from T_{14} (sole blackgram) at the point of basement, middle and upper of the plant, respectively, while the minimum light intensity (67.88 Lx, 76.57 Lx and 93.12 Lx) was found from T_3 (F_RH_{60}) at the same position which was statistically similar with the other treatments of the experiment. The results indicated that the intercropped plots showed low light intensities. This was because of the higher plant population stands and denser canopies as compared with the sole ones. Such results were also reported by Xiao *et al.* (2008).

4.2 Yield contributing characters and fodder yield of maize

4.2.1 Plant height (cm)

Plant height of maize varied significantly due to different treatments under the trial (Appendix V). The longest plant (119.81 cm) was obtained from T_{12} ($F_{R+20\%}H_{90}$) treatment which was however, statistically similar (117.10 cm, 116.87 cm, 114.82 cm, 113.80 cm, 113.26 cm, 112.56 cm, 111.67 cm and 110.88 cm) to T_{13} (Sole maize), T_6 (F_RH_{90}), T_{11} ($F_{R+20\%}H_{80}$), T_5 (F_RH_{80}), T_{10} ($F_{R+20\%}H_{70}$), T_4 (F_RH_{70}), T_9 ($F_{R+20\%}H_{60}$) and T_3 (F_RH_{60}) treatments, respectively. The shortest plant was obtained from (105.51 cm) from T_7 ($F_{R+20\%}H_{40}$) treatment which was statistically similar (105.52 cm, 108.45 cm and 109.24 cm) with T_1 (F_RH_{40}), T_2 (F_RH_{50}) and T_8 ($F_{R+20\%}H_{50}$) treatments, respectively (Table 4). Intercropped probably creates a competition between the plant species for light receiving and nutrient absorption that leads to the vegetative growth and the ultimate results is the longest plant. Plant height of sole blackgram was highly and significantly greater than those of intercropped ones which may be attributed to the 'no competition' among the plants (Nargis *et al.*, 2004).

Table 3. Effect of fertilizer dose and time of harvesting of blackgram on light intensity under maize-blackgram intercropping system

Treatments	Light intensity (candle light)			
	Maize canopy	Blackgram canopy position		
		Base	Middle	Upper
T_1	133.04	68.13 b	77.16 b	94.67 b
T_2	132.72	69.13 b	76.87 b	93.78 b
T_3	131.99	67.88 b	76.57 b	93.12 b
T_4	132.32	68.25 b	78.07 b	94.13 b
T_5	131.94	68.66 b	76.47 b	95.24 b
T_6	133.22	69.34 b	75.86 b	95.19 b
T_7	132.58	67.92 b	77.15 b	95.17 b
T_8	132.87	68.46 b	77.23 b	94.23 b
T_9	133.13	69.09 b	77.36 b	95.04 b
T_{10}	133.06	69.04 b	77.26 b	93.88 b
T_{11}	132.34	67.96 b	77.22 b	94.47 b
T_{12}	132.55	68.47 b	76.98 b	94.08 b
T_{13}	132.51	68.03 b	78.45 b	94.56 b
T_{14}	131.94	86.42 a	99.97 a	133.11 a
$S\bar{x}$	NS	1.375	1.757	2.695
Significance level	--	0.01	0.01	0.01
CV(%)	4.12	3.41	5.86	4.80

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability, NS = Not significant

$T_1 = F_RH_{40}$ $T_2 = F_RH_{50}$

$T_3 = F_RH_{60}$ $T_4 = F_RH_{70}$

$T_5 = F_RH_{80}$ $T_6 = F_RH_{90}$

$T_7 = F_{R+20\%}H_{40}$ $T_8 = F_{R+20\%}H_{50}$

$T_9 = F_{R+20\%}H_{60}$ $T_{10} = F_{R+20\%}H_{70}$

$T_{11} = F_{R+20\%}H_{80}$ $T_{12} = F_{R+20\%}H_{90}$

T_{13} = Sole maize T_{14} = Sole blackgram

F_R: Recommended dose of fertilizer (Cowdung: 10 t ha^{-1}; Urea: 350 kg ha^{-1}; TSP: 250 kg ha^{-1}; MoP: 200 kg ha^{-1}; Zypsum: 170 kg ha^{-1} and Zinc sulphate: 15 kg ha^{-1})

$F_{R+20\%}$: More than 20% fertilizer of recommended dose

H_{40}: Blackgram harvest at 40 DAS H_{50}: Blackgram harvest at 50 DAS

H_{60}: Blackgram harvest at 60 DAS H_{70}: Blackgram harvest at 70 DAS

H_{80}: Blackgram harvest at 80 DAS H_{90}: Blackgram harvest at 90 DAS

Table 4. Effect of fertilizer dose and time of harvesting of blackgram on fodder yield attributes and yield of maize under maize-blackgram intercropping system

Treatments	Plant height (cm)	Leaves plant^{-1} (No.)	Length of leaf (cm)	Breadth of leaf (cm)	Fodder yield (t ha^{-1})	Relative yield
T_1	105.52 c	11.40 cd	66.93 c	4.43 bc	21.00 b	0.83 b
T_2	108.45 bc	11.67 b-d	67.67 c	4.43 bc	21.57 b	0.85 b
T_3	110.88 a-c	11.73 b-d	69.13 a-c	4.50 bc	21.43 b	0.85 b
T_4	112.56 a-c	11.87 a-d	70.04 a-c	4.57 ab	22.20 b	0.88 b
T_5	113.80 a-c	12.00 a-c	71.02 a-c	4.63 ab	22.93 b	0.91 ab
T_6	116.87 ab	12.13 a-c	73.55 ab	4.73 ab	22.97 b	0.91 ab
T_7	105.51 c	10.87 d	67.05 c	4.15 c	20.73 b	0.82 b
T_8	109.24 bc	11.67 b-d	68.14 bc	4.47 bc	21.27 b	0.84 b
T_9	111.67 a-c	11.73 b-d	69.33 a-c	4.53 ab	21.73 b	0.86 b
T_{10}	113.26 a-c	11.87 a-d	70.67 a-c	4.60 ab	22.50 b	0.89 b
T_{11}	114.82 a-c	12.07 a-c	71.88 a-c	4.61 ab	22.33 b	0.88 b
T_{12}	119.81 a	12.53 ab	74.23 a	4.89 a	23.40 ab	0.92 ab
T_{13}	117.10 ab	12.80 a	74.57 a	4.67 ab	25.53 a	1.00 a
$S\bar{x}$	2.760	0.311	1.737	0.109	0.794	0.031
Significance level	0.05	0.05	0.05	0.05	0.05	0.05
CV(%)	4.26	6.53	4.28	5.15	6.17	6.15

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

$T_1 = F_R H_{40}$ $T_2 = F_R H_{50}$

$T_3 = F_R H_{60}$ $T_4 = F_R H_{70}$

$T_5 = F_R H_{80}$ $T_6 = F_R H_{90}$

$T_7 = F_{R+20\%} H_{40}$ $T_8 = F_{R+20\%} H_{50}$

$T_9 = F_{R+20\%} H_{60}$ $T_{10} = F_{R+20\%} H_{70}$

$T_{11} = F_{R+20\%} H_{80}$ $T_{12} = F_{R+20\%} H_{90}$

T_{13} = Sole maize T_{14} = Sole blackgram

F_R: Recommended dose of fertilizer (Cowdung: 10 t ha^{-1}; Urea: 350 kg ha^{-1}; TSP: 250 kg ha^{-1}; MoP: 200 kg ha^{-1}; Zypsum: 170 kg ha^{-1} and Zinc sulphate: 15 kg ha^{-1})

$F_{R+20\%}$: More than 20% fertilizer of recommended dose

H_{40}: Blackgram harvest at 40 DAS H_{50}: Blackgram harvest at 50 DAS

H_{60}: Blackgram harvest at 60 DAS H_{70}: Blackgram harvest at 70 DAS

H_{80}: Blackgram harvest at 80 DAS H_{90}: Blackgram harvest at 90 DAS

4.2.2 Leaves plant^{-1} (No.)

Significant variation due to different treatments was recorded in respect of leaves plant^{-1} of maize (Appendix V). The maximum number of leaves plant^{-1} (12.80) was obtained from T_{13} treatment which was statistically similar (12.53, 12.13, 12.07, 12.00 and 11.87) to T_{12}, T_6, T_{11}, T_5, T_{10} and T_4 treatments, while the minimum number (10.87) from T_7 treatment and it was statistically identical (11.40) with T_1 treatment (Table 4). Tsubo and Walker (2003) reported that intercropping were superior in terms of leaves plant^{-1}.

4.2.3 Length of leaf (cm)

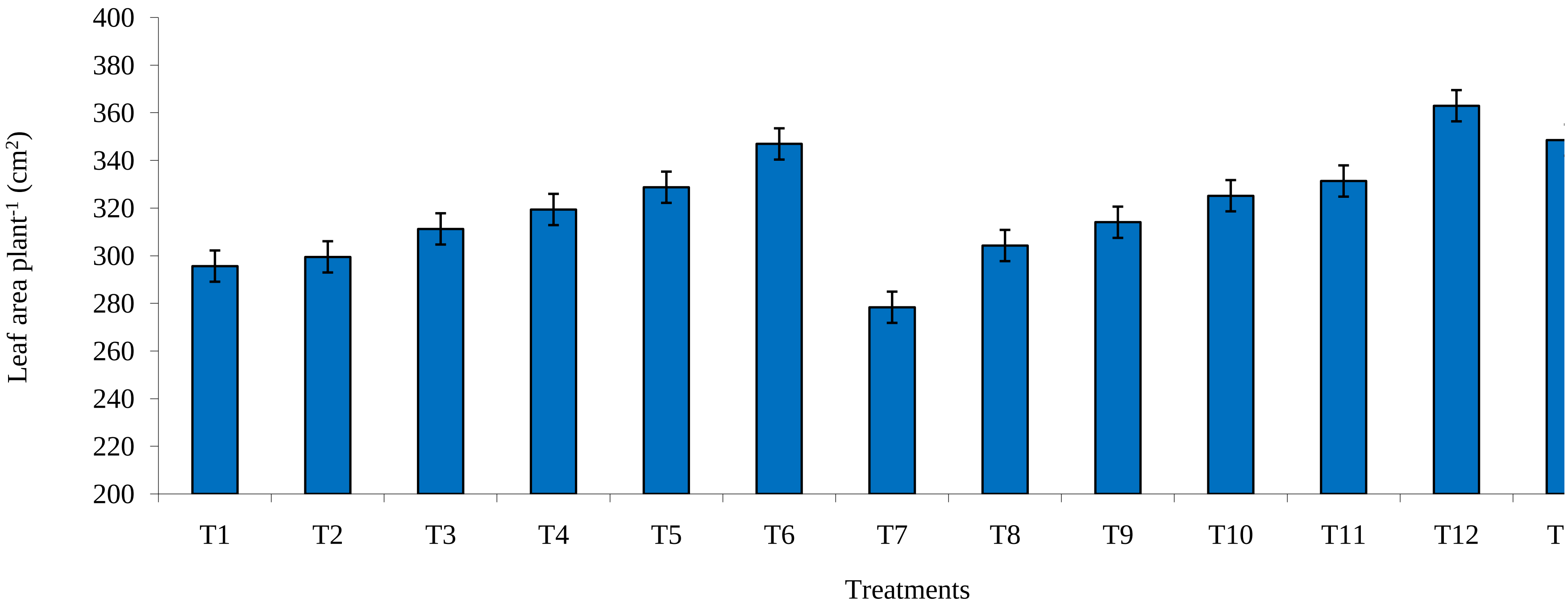
Length of maize leaf showed significant variation due to different treatments (Appendix V). The longest leaf (74.57 cm) was obtained from T_{13} treatment which was statistically similar (74.23 cm, 73.55 cm, 71.88 cm, 71.02 cm, 70.67 cm, 70.04 cm 69.33 cm and 69.13 cm) to T_{12}, T_6, T_{11}, T_5, T_{10}, T_4, T_9 and T_3 treatments, respectively. The shortest leaf (66.93 cm) was recorded from T_1 treatment which was statistically similar and with T_7 (67.05 cm) and T_2 (67.67 cm) treatment (Table 4). Nargis *et al.* (2004) observed the longest leaf with intercropping condition.

4.2.4 Breadth of leaf (cm)

Different treatments showed statistically significant variation in terms of breadth of leaf of maize (Appendix V). The highest breadth of leaf (4.89 cm) was obtained from T_{12} treatment which was statistically similar (4.73 cm, 4.67 cm, 4.63 cm, 4.61 cm, 4.60 cm, 4.57 cm and 4.53 cm) to T_6, T_{13}, T_5, T_{11}, T_{10}, T_4 and T_9 treatments, respectively. The lowest breadth of leaf (4.15 cm) was recorded from T_7 treatment and which was statistically identical with T_1 (4.43 cm) and T_2 (4.69 cm) treatments (Table 4). Tsubo and Walker (2003) reported that intercropping were superior to sole crops in terms of breadth of leaf.

4.2.5 Leaf area plant^{-1} (cm^2)

Leaf area of maize varied significantly due to different treatments (Appendix V). The highest leaf area (362.95 cm^2) was obtained from T_{12} treatment and it was statistically identical with T_{13} (348.51 cm^2) and T_6 (346.91 cm^2) treatments. The lowest leaf area (278.34 cm^2) was recorded from T_7 treatment which was statistically similar with T_1 (295.62 cm^2) and T_2 (299.50 cm^2) treatments (Figure 2). Bilalis *et al.* (2010) recorded the highest leaf area for intercropping condition.



$T_1 = F_RH_{40}$ $T_2 = F_RH_{50}$ $T_3 = F_RH_{60}$ $T_4 = F_RH_{70}$ $T_5 = F_RH_{80}$ $T_6 = F_RH_{90}$ $T_7 = F_{R+20\%}H_{40}$
$T_8 = F_{R+20\%}H_{50}$ $T_9 = F_{R+20\%}H_{60}$ $T_{10} = F_{R+20\%}H_{70}$ $T_{11} = F_{R+20\%}H_{80}$ $T_{12} = F_{R+20\%}H_{90}$ T_{13} = Sole maize

F_R: Recommended dose of fertilizer
$F_{R+20\%}$: More than 20% fertilizer of recommended dose
H_{40}: Blackgram harvest at 40 DAS
H_{50}: Blackgram harvest at 50 DAS
H_{60}: Blackgram harvest at 60 DAS
H_{70}: Blackgram harvest at 70 DAS
H_{80}: Blackgram harvest at 80 DAS
H_{90}: Blackgram harvest at 90 DAS

Figure 2. Effect of fertilizer dose and harvesting time of blackgram on leaf area plant^{-1} of maize under maize-blackgram intercropping system. (Vertical bar represents SE values)

4.2.6 Fodder yield (t ha^{-1})

Different treatments varied significantly due to fodder yield of maize (Appendix V). The highest fodder yield (25.53 t ha^{-1}) was obtained from T_{13} treatment which was statistically similar to T_{12} (23.40 t ha^{-1}) treatment. Among the intercropping system, T_{12} ($F_{R+20\%}H_{90}$) treatment produced the maximum fodder yield of maize mainly due to cumulative effects of tallest plant, leaf size and number. The lowest fodder yield (20.73 t ha^{-1}) was recorded from T_7 treatment which was statistically similar with rest of the treatments (Table 4). Intercropped pigeon pea or cowpea can help to maintain maize yield when maize is grown without mineral fertilizer on sandy soils in sub-humid zones (Waddington *et al*., 2007).

4.2.7 Relative yield

Relative yield of maize showed statistically significant variation due to different treatments (Appendix V). The highest relative yield (1.00) was obtained from T_{13} treatment which was statistically similar to T_{12} (0.92), T_5 (0.91) and T_6 (0.91) treatments. The lowest relative yield (0.81) was recorded from T_7 which was statistically similar with other rest of the treatments (Table 4). Tsubo and Walker (2003) reported that intercropping were superior to sole crops in context of relative yield.

Among the intercropping systems, T_{12} treatment had significantly higher fodder yield and relative yield values although maize plants in this plot had competition for longer time. But those plots had high dose of fertilizers which probably compensated competition loss from blackgram to some extent.

4.3 Yield contributing characters and fodder yield of blackgram

4.3.1 Plant height (cm)

Plant height of blackgram showed statistically significant variation due to different treatments (Appendix VI). The longest plant (58.47 cm) was obtained from T_{14} treatment which was statistically similar (57.33 cm, 56.86 cm, 55.14 cm and 54.04 cm) to T_{12}, T_6, T_{11} and T_5 treatments, respectively and the shortest plant (33.77 cm) from T_1 treatment and it was statistically identical (35.45 cm) with T_7 (Table 5). Ghosh *et al.* (2006) reported that intercropping helped in improving the soil physical environment, increasing soil microbial activity and restoring organic matter and also had smothering effect on weed, increased plant growth as well as plant height.

4.3.2 Branches plant^{-1} (No.)

Significant variation was recorded for number of branches plant^{-1} of blackgram due to different treatments (Appendix VI). The maximum number of branches plant^{-1} (5.20) was obtained from T_{14} treatment which was followed (4.80) by T_{12} treatment and the minimum number of branches plant^{-1} (1.80) was recorded from T_1 treatment which was statistically similar (2.00) with T_7 treatment (Figure 3).

4.3.3 Leaves plant^{-1} (No.)

Different treatments varied significantly in terms of number of leaves plant^{-1} of blackgram (Appendix VI). The maximum number of leaves plant^{-1} (22.20) was obtained from T_{14} treatment which was statistically similar (21.40 and 20.20) to T_{12} and T_6 treatments, respectively. The minimum number of leaves plant^{-1} (10.00) was recorded from T_1 treatment which was statistically similar (10.80) with T_7 treatment (Table 5).

Table 5. Effect of fertilizer dose and harvesting time of blackgram on fodder yield attributes and yield of blackgram under maize-blackgram intercropping system

Treatments	Plant height (cm)	Leaves plant^{-1} (No.)	Length of leaf (cm)	Breadth of leaf (cm)	Fodder yield (t ha^{-1})	Relative yield
T_1	33.77 h	10.00 h	4.25 f	4.33 f	6.10 g	0.62 h
T_2	42.45 g	13.20 g	4.86 e	4.69 ef	6.94 f	0.70 fg
T_3	46.13 e-g	15.20 fg	5.32 d	4.94 c-e	7.36 f	0.74 ef
T_4	51.05 c-e	16.60 ef	6.04 c	5.22 b-d	8.10 de	0.82 c-e
T_5	54.04 a-d	18.80 cd	6.82 b	5.39 a-c	8.77 b-d	0.89 bc
T_6	56.86 ab	20.20 a-c	7.08 ab	5.58 ab	9.16 b	0.93 ab
T_7	35.45 h	10.80 h	4.37 f	4.58 ef	6.20 g	0.63 gh
T_8	43.68 fg	13.60 g	5.04 de	4.86 de	7.03 f	0.71 f
T_9	48.35 d-f	15.80 ef	5.45 d	5.04 cde	7.50 ef	0.76 d-f
T_{10}	52.47 b-d	17.50 de	6.22 c	5.28 a-d	8.25 cd	0.83 cd
T_{11}	55.14 a-c	19.60 b-d	6.94 ab	5.45 a-c	8.91 bc	0.90 bc
T_{12}	57.33 ab	21.40 ab	7.15 ab	5.65 ab	9.33 ab	0.94 ab
T_{14}	58.47 a	22.20 a	7.29 a	5.78 a	9.89 a	1.00 a
$S\bar{x}$	1.801	0.703	0.141	0.158	0.224	0.023
Significance level	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	6.39	7.37	4.12	5.33	4.87	4.87

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

$T_1 = F_RH_{40}$ $T_2 = F_RH_{50}$

$T_3 = F_RH_{60}$ $T_4 = F_RH_{70}$

$T_5 = F_RH_{80}$ $T_6 = F_RH_{90}$

$T_7 = F_{R+20\%}H_{40}$ $T_8 = F_{R+20\%}H_{50}$

$T_9 = F_{R+20\%}H_{60}$ $T_{10} = F_{R+20\%}H_{70}$

$T_{11} = F_{R+20\%}H_{80}$ $T_{12} = F_{R+20\%}H_{90}$

T_{13} = Sole maize T_{14} = Sole blackgram

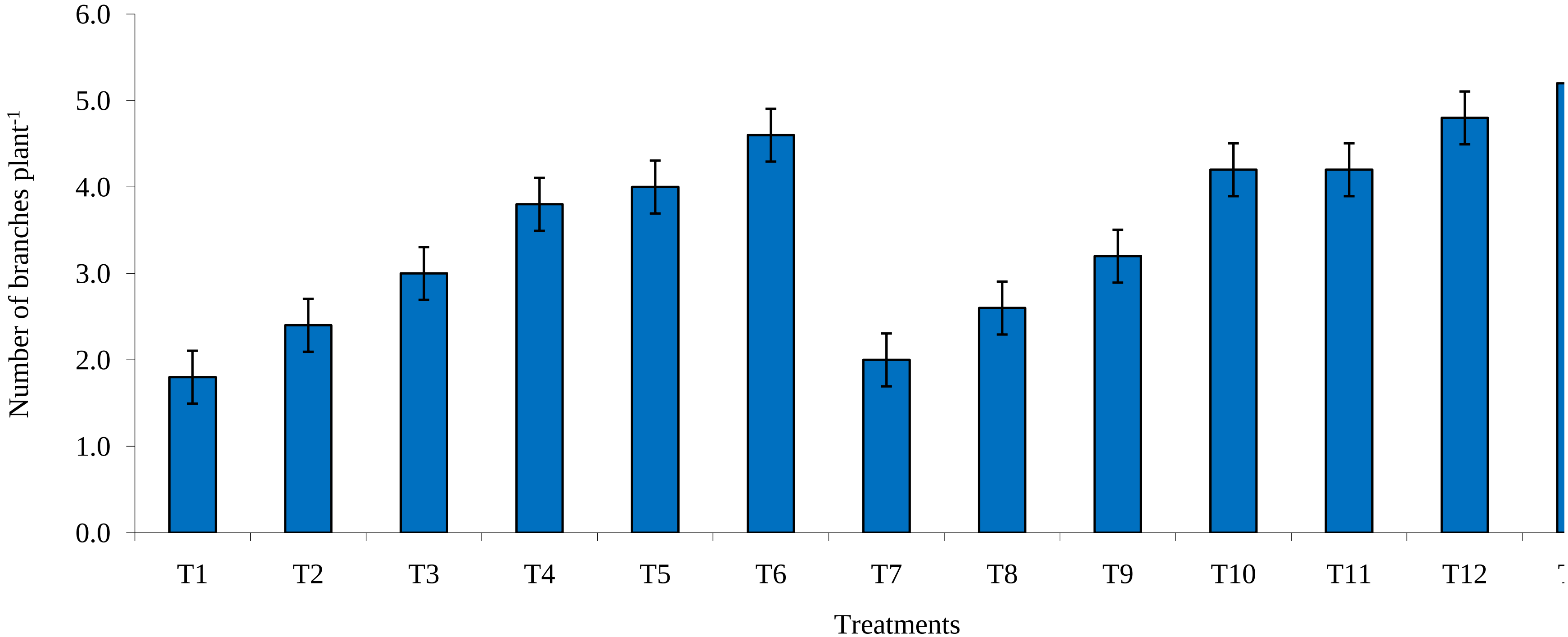
F_R: Recommended dose of fertilizer (Cowdung: 10 t ha^{-1}; Urea: 350 kg ha^{-1}; TSP: 250 kg ha^{-1}; MoP: 200 kg ha^{-1}; Zypsum: 170 kg ha^{-1} and Zinc sulphate: 15 kg ha^{-1})

$F_{R+20\%}$: More than 20% fertilizer of recommended dose

H_{40}: Blackgram harvest at 40 DAS H_{50}: Blackgram harvest at 50 DAS

H_{60}: Blackgram harvest at 60 DAS H_{70}: Blackgram harvest at 70 DAS

H_{80}: Blackgram harvest at 80 DAS H_{90}: Blackgram harvest at 90 DAS



$T_1 = F_RH_{40}$ $T_2 = F_RH_{50}$ $T_3 = F_RH_{60}$ $T_4 = F_RH_{70}$ $T_5 = F_RH_{80}$ $T_6 = F_RH_{90}$ $T_7 = F_{R+20\%}H_{40}$

$T_8 = F_{R+20\%}H_{50}$ $T_9 = F_{R+20\%}H_{60}$ $T_{10} = F_{R+20\%}H_{70}$ $T_{11} = F_{R+20\%}H_{80}$ $T_{12} = F_{R+20\%}H_{90}$ T_{14} = Sole blackgram

F_R: Recommended dose of fertilizer

$F_{R+20\%}$: More than 20% fertilizer of recommended dose

H_{40}: Blackgram harvest at 40 DAS

H_{50}: Blackgram harvest at 50 DAS

H_{60}: Blackgram harvest at 60 DAS

H_{70}: Blackgram harvest at 70 DAS

H_{80}: Blackgram harvest at 80 DAS

H_{90}: Blackgram harvest at 90 DAS

Figure 3. Effect of fertilizer dose and harvesting time of blackgram on number of branches plant^{-1} of blackgram under maize-blackgram intercropping system. (Vertical bar represents SE values)

4.3.4 Length of leaf (cm)

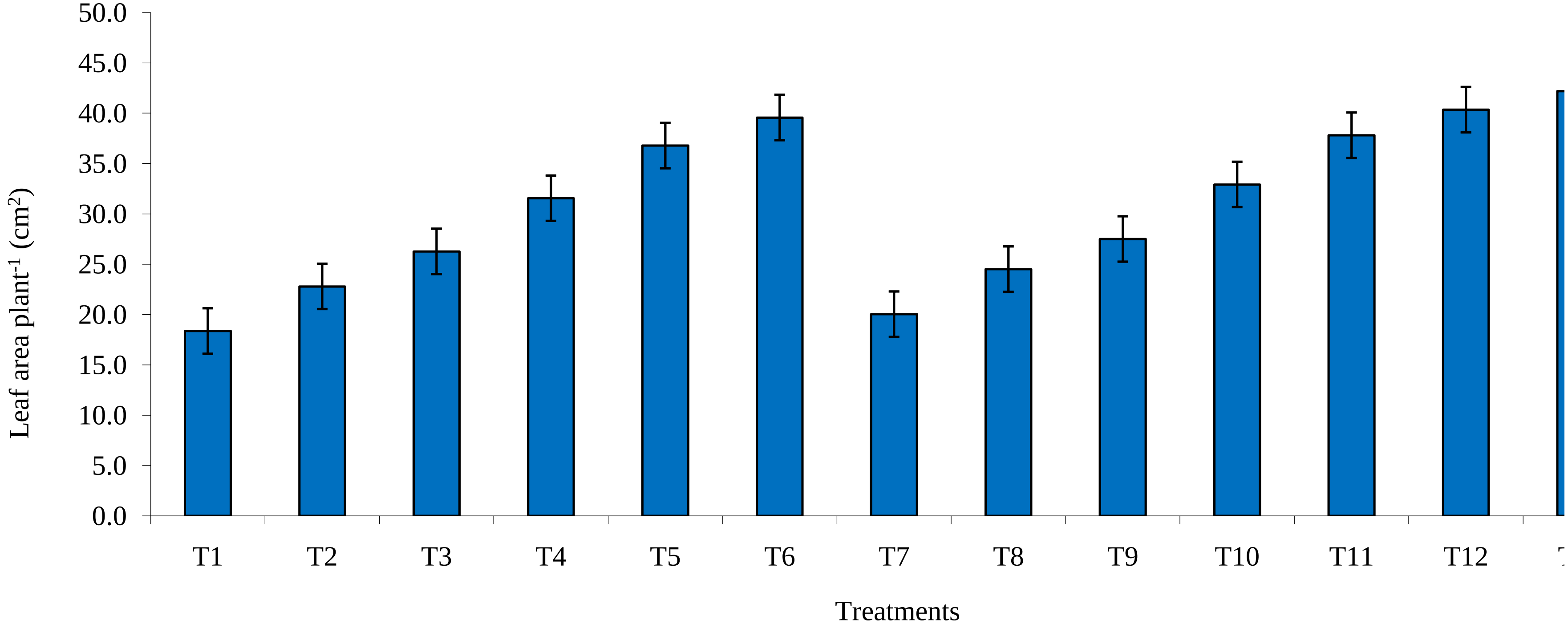
Significant variation was recorded for length of leaf of blackgram due to different treatments (Appendix VI). The longest leaf (7.29 cm) was obtained from T_{14} treatment which was statistically similar (7.15 cm and 7.08 cm) to T_{12} and T_6 treatments, respectively. The shortest leaf (4.25 cm) was recorded from T_1 which was statistically similar (4.37 cm) with T_7 treatment (Table 5).

4.3.5 Breadth of leaf (cm)

Breadth of leaf of blackgram varied significantly due to different treatments (Appendix VI). The highest breadth of leaf (5.78 cm) was obtained from T_{14} treatment which was statistically similar (5.65 cm, 5.58 cm, 5.45 cm, 5.39 cm and 5.28 cm) to T_{12}, T_6, T_{11} and T_{10} treatments, respectively. The lowest breadth of leaf (4.33 cm) was recorded from T_1 treatment and it was statistically similar (4.58 cm and 4.69 cm) with T_7 and T_2 treatments, respectively (Table 5).

4.3.6 Leaf area plant^{-1} (cm^2)

Different treatments varied significantly in terms of leaf area plant^{-1} of blackgram (Appendix VI). The highest leaf area (42.18 cm^2) was obtained from T_{14} treatment which was statistically similar (40.35 cm^2 and 39.57 cm^2) to T_{12} and T_6 treatments, respectively. The lowest leaf area (18.36 cm^2) was found from T_1 which was statistically similar (20.03 cm^2) with T_7 treatment (Figure 4). Maize and cowpea mixture grown for fodder purpose recorded higher leaf area over sole (Fawusi and Wanki, 1982).



$T_1 = F_R H_{40}$ $T_2 = F_R H_{50}$ $T_3 = F_R H_{60}$ $T_4 = F_R H_{70}$ $T_5 = F_R H_{80}$ $T_6 = F_R H_{90}$ $T_7 = F_{R+20\%} H_{40}$

$T_8 = F_{R+20\%} H_{50}$ $T_9 = F_{R+20\%} H_{60}$ $T_{10} = F_{R+20\%} H_{70}$ $T_{11} = F_{R+20\%} H_{80}$ $T_{12} = F_{R+20\%} H_{90}$ T_{14} = Sole blackgram

F_R: Recommended dose of fertilizer

$F_{R+20\%}$: More than 20% fertilizer of recommended dose

H_{40}: Blackgram harvest at 40 DAS

H_{50}: Blackgram harvest at 50 DAS

H_{60}: Blackgram harvest at 60 DAS

H_{70}: Blackgram harvest at 70 DAS

H_{80}: Blackgram harvest at 80 DAS

H_{90}: Blackgram harvest at 90 DAS

Figure 4. Effect of fertilizer dose and harvesting time of blackgram on leaf area plant^{-1} of blackgram under maize-blackgram intercropping system. (Vertical bar represents SE values)

4.3.7 Fodder yield (t ha^{-1})

Different treatments varied significantly in terms of fodder yield of blackgram (Appendix VI). The highest fodder yield (9.89 t ha^{-1}) was obtained from T_{14} which was statistically similar (9.33 t ha^{-1}) to T_{12} treatment. The lowest fodder yield (6.10 t ha^{-1}) was obtained from T_1 treatment which was statistically similar (7.03 t ha^{-1}) with T_7 treatment (Table 5). Mengping and Zhangjinsong (2004) observed that the intercropping system was an established fact that the system increased water utilization efficiency, and above all gives higher yield. Among intercropping system, T_{12} treatment had higher fodder yield. This was obvious as these plants experienced longer time to grow which facilitated them to accumulate more dry matter. Moreover, plants in this treatment at reproductive stage accompanied with filled pods in them which contributed higher fodder weight values. This also helped this treatment to acquire higher relative yield.

4.3.8 Relative yield

Significant variation was recorded in terms of relative yield of blackgram due to different treatments (Appendix VI). The highest relative yield (1.00) was obtained from T_{14} treatment which was statistically similar (0.94 and 0.93) to T_{12} and T_6 treatments, respectively. The lowest relative yield (0.62) was recorded from T_1 treatment which was statistically similar (0.63) with T_7 treatment (Table 5). Tsubo and Walker (2003) reported that intercropping systems of maize with legumes were superior to sole crops in context of relative yield.

4.4 Data on land equivalent ratio and equivalent yield

4.4.1 Land equivalent ratio

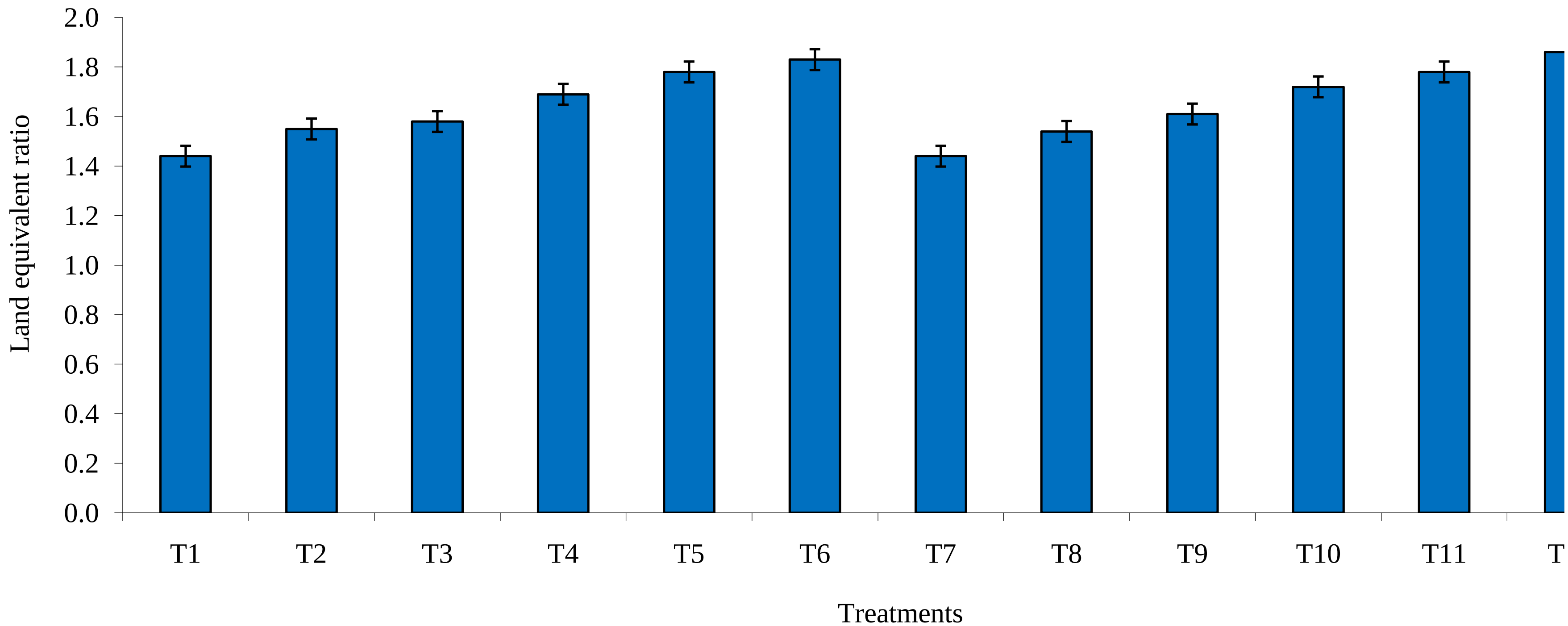
Land equivalent ratio (LER) for maize and blackgram intercropping showed significant variation due to different treatments (Figure 5). The highest LER (1.86) was recorded from T_{12} treatment which was statistically similar (1.83) with T_6 treatment and the lowest (1.00) from the sole crop both maize and blackgram. It revealed that intercropping was highly productive than the sole crop cultivation. Intercropping is also considered as a well recognized practice for better land use system along with substantial yield advantages compared to sole cropping. These advantages may be especially important because they are achieved not by means of costly inputs but also by the simple expedient of growing crops together. Mengping and Zhangjinsong (2004) observed that the intercropping system was an established fact that the system increased water utilization efficiency, shows higher land equivalent ratio and above all gives higher yield.

4.4.2 Equivalent yield (t ha^{-1})

Equivalent yield (EY) of maize showed significant variation due to different treatments (Figure 6). The highest EY of fodder maize (35.06 t ha^{-1}) was recorded from T_{12} treatment which was statistically similar (34.42 t ha^{-1}) with T_6 treatment the lowest EY of fodder maize (25.53 t ha^{-1}) was recorded from the sole crop of blackgram.

Equivalent yield (EY) of blackgram showed significant variation due to different treatments (Figure 6). The highest EY of fodder blackgram (28.05 t ha^{-1}) was recorded from T_{12} treatment which was statistically similar (27.54 t ha^{-1}) with T_6 treatment and the lowest (9.89 t ha^{-1}) was recorded from the sole crop of maize.

It revealed that intercropping was highly productive than the sole crop cultivation. Intercropping is also considered as a well recognized practice for better land use system along with substantial yield advantages. Dwivedi *et al.* (1998) found that all intercropping systems had higher total yield.



$T_1 = F_R H_{40}$ $T_2 = F_R H_{50}$ $T_3 = F_R H_{60}$ $T_4 = F_R H_{70}$ $T_5 = F_R H_{80}$ $T_6 = F_R H_{90}$ $T_7 = F_{R+20\%} H_{40}$
$T_8 = F_{R+20\%} H_{50}$ $T_9 = F_{R+20\%} H_{60}$ $T_{10} = F_{R+20\%} H_{70}$ $T_{11} = F_{R+20\%} H_{80}$ $T_{12} = F_{R+20\%} H_{90}$

F_R: Recommended dose of fertilizer

$F_{R+20\%}$: More than 20% fertilizer of recommended dose

H_{40}: Blackgram harvest at 40 DAS

H_{50}: Blackgram harvest at 50 DAS

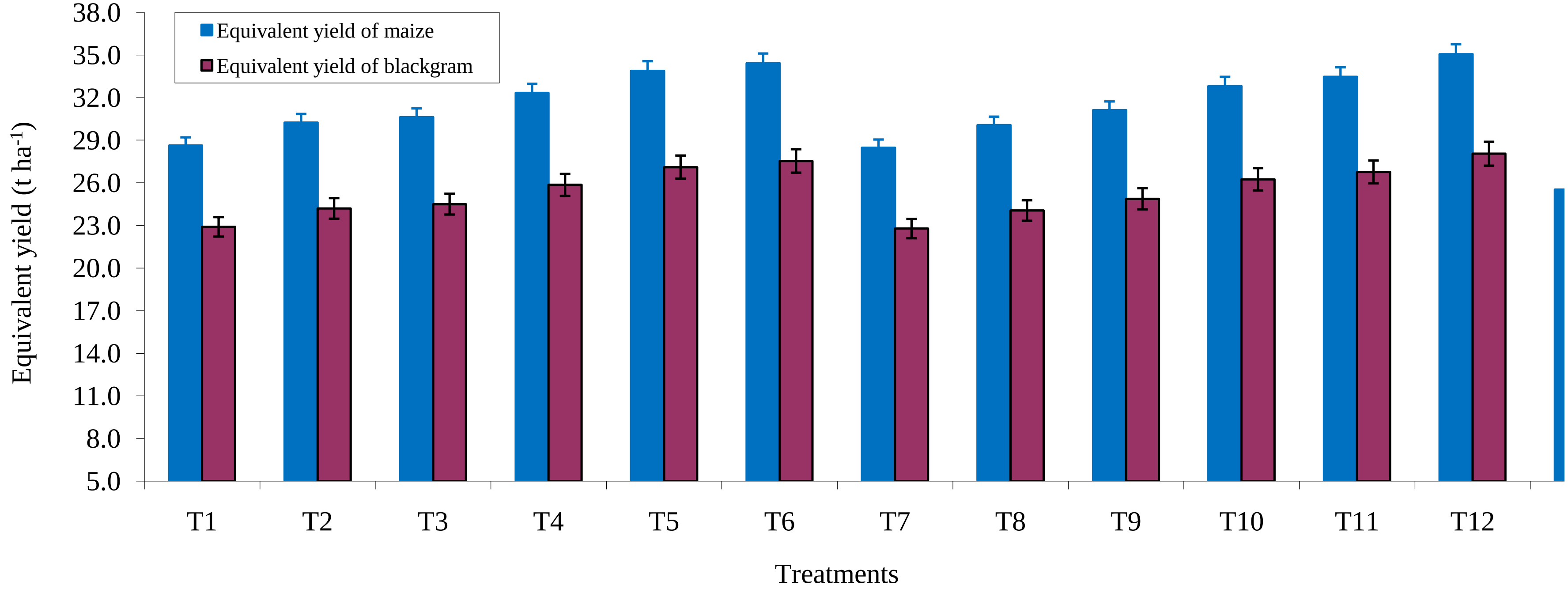
H_{60}: Blackgram harvest at 60 DAS

H_{70}: Blackgram harvest at 70 DAS

H_{80}: Blackgram harvest at 80 DAS

H_{90}: Blackgram harvest at 90 DAS

Figure 5. Effect of fertilizer dose and harvesting time of blackgram on land equivalent ratio under maize-blackgram intercropping system. (Vertical bar represents SE values)



$T_1 = F_RH_{40}$ $T_2 = F_RH_{50}$ $T_3 = F_RH_{60}$ $T_4 = F_RH_{70}$ $T_5 = F_RH_{80}$ $T_6 = F_RH_{90}$ $T_7 = F_{R+20\%}H_{40}$
$T_8 = F_{R+20\%}H_{50}$ $T_9 = F_{R+20\%}H_{60}$ $T_{10} = F_{R+20\%}H_{70}$ $T_{11} = F_{R+20\%}H_{80}$ $T_{12} = F_{R+20\%}H_{90}$ Sole maize and sole blackgram

F_R: Recommended dose of fertilizer

$F_{R+20\%}$: More than 20% fertilizer of recommended dose

H_{40}: Blackgram harvest at 40 DAS

H_{50}: Blackgram harvest at 50 DAS

H_{60}: Blackgram harvest at 60 DAS

H_{70}: Blackgram harvest at 70 DAS

H_{80}: Blackgram harvest at 80 DAS

H_{90}: Blackgram harvest at 90 DAS

Figure 6. Effect of fertilizer dose and harvesting time of blackgram on equivalent yield under maize-blackgram intercropping system. (Vertical bar represents SE values)

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Agronomy Department, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October 2013 to January 2014 in Robi season to find out the effect of fertilizer dose and blackgram harvest time on fodder yields under maize-blackgram intercropping system. Maize (local variety) was used as the main fodder crop and blackgram variety BARI Mash-3 as an intercrop. The experiment consisted 14 treatment as combination of recommended fertilizer and 20% more than recommended fertilizer with different harvesting time of blackgram which are $T_1 = F_RH_{40}$, $T_2 = F_RH_{50}$, $T_3 = F_RH_{60}$, $T_4 = F_RH_{70}$, $T_5 = F_RH_{80}$, $T_6 = F_RH_{90}$, $T_7 = F_{R+20\%}H_{40}$, $T_8 = F_{R+20\%}H_{50}$, $T_9 = F_{R+20\%}H_{60}$, $T_{10} = F_{R+20\%}H_{70}$, $T_{11} = F_{R+20\%}H_{80}$, $T_{12} = F_{R+20\%}H_{90}$, T_{13} = Sole maize and T_{14} = Sole blackgram. Here, F_R: Recommended dose of fertilizer (Cowdung: 10 t ha^{-1}; Urea: 350 kg ha^{-1}; TSP: 250 kg ha^{-1}; MoP: 200 kg ha^{-1}; Zypsum: 170 kg ha^{-1} and Zinc sulphate: 15 kg ha^{-1}), $F_{R+20\%}$: More than 20% fertilizer of recommended dose, H_{40}: Blackgram harvest at 40 DAS, H_{50}: Blackgram harvest at 50 DAS, H_{60}: Blackgram harvest at 60 DAS, H_{70}: Blackgram harvest at 70 DAS, H_{80}: Blackgram harvest at 80 DAS and H_{90}: Blackgram harvest at 90 DAS. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

The maximum soil moisture (34.78%, 33.87%, 35.86%, 35.97%, 36.54% and 37.13%, respectively) was recorded from T_{12} ($F_{R+20\%}H_{90}$) at 40, 50, 60, 70, 80 and 90 DAS. The minimum soil moisture (30.22%, 29.34%, 30.11%, 30.34%, 30.54% and 30.61%, respectively) was found from T_{14} treatment. In case of maize, the minimum light intensity (131.94 Lx) was observed from T_5 treatment and the maximum (133.22 Lx) from T_6 treatment. In case of blackgram, the maximum light intensity (86.42 Lx, 99.97 Lx and 133.11 Lx) was recorded from T_{14} treatment at the point of basement, middle and upper of the plant, respectively, while the minimum light intensity (67.88 Lx, 76.57 Lx and 93.12 Lx) was found from T_3 treatment.

In case of maize, the longest plant (119.81 cm) was obtained from T_{12} treatment and the shortest plant (105.51 cm) was recorded from T_7 treatment. The maximum number of leaves plant^{-1} (12.80) was obtained from T_{13} treatment, while the minimum number (10.87) was recorded from T_7 treatment. The longest leaf (74.57 cm) was obtained from T_{13} treatment and the shortest (66.93 cm) from T_1 treatment. The highest breadth of leaf (4.89 cm) was obtained from T_{12} treatment, whereas the lowest breadth of leaf (4.15 cm) was recorded from T_7 treatment. The highest leaf area plant^{-1} (362.95 cm^2) was obtained from T_{12} treatment and the lowest (278.34 cm^2) was recorded from T_7 treatment. The highest fodder yield (25.53 t ha^{-1}) was obtained from T_{13} treatment and the lowest (20.73 t ha^{-1}) from T_7 treatment. The highest relative yield (1.00) was obtained from T_{13} treatment and the lowest (0.81) from T_7 treatment.

In case of blackgram, the longest plant (58.47 cm) was obtained from T_{14} treatment and the shortest plant (33.77 cm) was recorded from T_1 treatment. The maximum number of branches plant^{-1} (5.20) and leaves plant^{-1} (22.20) were obtained from T_{14} treatment, whereas the minimum number of branches plant^{-1} (1.80) and leaves plant^{-1} (10.00) were recorded from T_1 treatment. The longest leaf (7.29 cm) was obtained from T_{14} treatment and the shortest leaf (4.25 cm) was recorded from T_1 treatment. The highest breadth of leaf (5.78 cm) and leaf area plant^{-1} (42.18 cm^2) were obtained from T_{14} treatment and the lowest breadth of leaf (4.33 cm) and leaf area plant^{-1} (18.36 cm^2) were recorded from T_1 treatment. The highest fodder yield (9.89 t ha^{-1}) was obtained from T_{14} treatment and the lowest (6.10 t ha^{-1}) from T_1 treatment. The highest relative yield (1.00) was obtained from T_{14} treatment and the lowest (0.62) from T_1 treatment.

The highest LER (1.86) was recorded from T_{12} treatment and the lowest (1.00) from the sole crop both maize and blackgram. The highest equivalent yield (EY) of fodder maize (35.06 t ha^{-1}) was recorded from T_{12} treatment and the lowest

(25.53 t ha^{-1}) from the sole crop of blackgram. The highest EY of fodder blackgram (28.05 t ha^{-1}) was recorded from T_{12} treatment and the lowest (9.89 t ha^{-1}) from the sole crop of maize.

It may be concluded that treatment T_{12} [$F_{R+20\%}H_{90}$ (20% more than recommended fertilizers and harvest at 90 DAS)] is superior in consideration of fodder yield potentials of maize-blackgram intercropping system.

Recommendation

Considering the results of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of regional adaptability;
2. Another legume crop, further fertilizer dose increased may be included in the future study.

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Appendices

APPENDICES

Appendix I. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from October, 2013 to January, 2014

Month	*Air temperature (^{o}C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
October, 2103	23.4	15.6	72	00
November, 2013	25.8	16.0	78	00
December, 2013	22.4	13.5	74	00
January, 2014	25.2	12.8	69	00

* Monthly average,

* Source: Bangladesh Meteorological Department

Appendix II. Characteristics of the soil of experimental field

A. Physical properties of the soils of the experimental field

Soil properties	Analytical data
Sand (%)	29.04
Silt (%)	41.80
Clay (%)	29.16

B. Chemical properties of the soils of the experimental field

Soil properties	Analytical value
pH	5.8
Organic matter (%)	1.34
Total N (%)	0.08
Available P (ppm)	31.15
Exchangeable K (meq/100 g)	0.18
Exchangeable Ca (meq/100 g)	0.12
Exchangeable Mg (meq/100 g)	--
Avalable S (ppm)	0.02
Zinc (ppm)	--
Boron (ppm)	--

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

Appendix III. Analysis of variance of the data on soil moisture content in the field as influenced by maize-blackgram intercropping under different blackgram harvesting time and varying dose of fertilizers

Source of variation	Degrees of freedom	Mean square					
		Soil moisture (%) at					
		40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS
Replication	2	0.397	0.051	0.083	7.086	0.164	0.565
Treatment	13	5.499*	7.409*	17.572**	16.437**	16.371**	13.013**
Error	26	2.351	3.524	4.356	3.438	2.583	2.709

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on light intensity in the field as influenced by maize-blackgram intercropping under different blackgram harvesting time and varying dose of fertilizers

Source of variation	Degrees of freedom	Mean square			
		Light intensity (candle light)			
		Maize canopy	Blackgram canopy position		
			Base	Middle	Upper
Replication	2	16.955	4.387	4.326	1.936
Treatment	13	0.592	69.659**	112.979**	321.791**
Error	26	17.082	5.675	9.266	21.793

** Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on fodder yield contributing characters and yield of maize as influenced by maize-blackgram intercropping under different blackgram harvesting time and varying dose of fertilizers

Source of variation	Degrees of freedom	Mean square						
		Plant height (cm)	Leaves plant^{-1} (No.)	Length of leaf (cm)	Breadth of leaf (cm)	Leaf area (cm^2)	Fodder yield (t ha^{-1})	Relative yield
Replication	2	10.940	0.019	0.586	0.017	145.708	0.827	0.001
Treatment	12	57.121*	0.694*	20.814*	0.093*	1680.506**	4.844*	0.007*
Error	24	22.856	0.289	9.054	0.036	195.044	1.892	0.003

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on fodder yield contributing characters and yield of blackgram as influenced by maize-blackgram intercropping under different blackgram harvesting time and varying dose of fertilizers

Source of variation	Degrees of freedom	Mean square							
		Plant height (cm)	Branches plant^{-1} (No.)	Leaves plant^{-1} (No.)	Length of leaf (cm)	Breadth of leaf (cm)	Leaf area (cm^2)	Fodder yield (t ha^{-1})	Relative yield
Replication	2	1.892	0.003	1.039	0.044	0.031	3.568	0.107	0.001
Treatment	12	198.838**	3.651**	45.577**	3.585**	0.590**	198.373**	4.433**	0.045**
Error	24	9.734	0.036	1.484	0.059	0.075	5.259	0.150	0.002

** Significant at 0.01 level of probability;