EFFICACY OF INTEGRATED NITROGEN AND IRRIGATION MANAGEMENT ON THE YIELD AND YIELD ATTRIBUTES OF BLACKGRAM

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BY

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Dedicated to

My

Parents & Teachers who laid the foundation of my success

Contents

Contents

Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

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

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ABSTRACT

An experiment was carried out at Sher-e-Bangla Agricultural University farm; Dhaka to investigate the efficacy of integrated nitrogen and irrigation managements on the yield attributes and yields of blackgram cv. BARI mash-3 (*Vigna mungo* L.) cv. BARI mash-3 during the period from March 2006 to May 2006. The trial comprised of ten treatments such as T_1= No fertilizer and no irrigation (control), T_2 = 20 kg N ha^{-1} as basal, T_3 = 20 kg N ha^{-1} as basal with one irrigation at first flowering stage, T_4 = 30 kg N ha^{-1} as basal, T_5 = 30 kg N ha^{-1} as basal with one irrigation at first flowering stage, T_6 = 40 kg N ha^{-1} as basal, T_7 = 40 kg N ha^{-1} as basal with one irrigation at first flowering stage, T_8 = 10 kg N ha^{-1} as basal and split 10 kg N ha^{-1} with one irrigation at first flowering stage, T_9 = 15 kg N ha^{-1} as basal and split 15 kg N ha^{-1} with one irrigation at first flowering stage and T_{10} = 20 kg N ha^{-1} as basal and split 20 kg N ha^{-1} with one irrigation at first flowering stage. Result revealed that nitrogen and irrigation influenced significantly on most of the growth, yield parameters and yield of blackgram. Plant height, number of branches per plant, number of leaves per plant, seeds per pod, leaf dry weight and stem dry weight increased significantly with 40 kg N ha^{-1} as basal with one irrigation at first flowering stage (35 DAS).This greater dry matter eventually supported the plant to produce more number of branches and pods per plant, which resulted in maximum seed yield per plant (10.45 g) or per hectare (1.86 ton). A functional positive relationship was observed among number of branches per plant, 1000-seed weight, pods per plant, and seeds per pod with seed yield.

CHAPTER 1

INTRODUCTION

Pulses or grain legumes which are a vital source of protein, calories, minerals and some vitamins. Pulses occupy an area of about 0.3 million ha (2.34% of the total cropped area) and contribute about 1.07 t ha^{-1} of the total grain production of the country (Ahmed *et al.* 1985).A large number of pulses are grown in Bangladesh of which grass pea, lentil, mung bean, blackgram, chickpea, fieldpea and cowpea are important. Pulse protein is rich in amino acids like isoleucine, leucine, lysine, valine etc. FAO (1999) recommends a minimum pulse intake of 80 g/head/day whereas; it is only 14.19 g in Bangladesh (BBS, 2006). This is because of the fact that production of the pulses is not adequate to meet the national demand.

Among the pulse crops, blackgram (*Vigna mungo*.) is one of the main edible pulse crops of Bangladesh. It ranks fourth among the pulses with an area of about 82000 ha (BBS, 2006). As an excellent source of plant protein it is cultivated extensively in the tropics and subtropics. Blackgram grain contains 59% carbohydrates, 24% protein, 10% moisture, 4% mineral and 3% vitamins (Khan, 1981; Kaul, 1982). The green plants can also be used as animal feed and its residues have manual value. The crop is potentially useful in improving cropping pattern The yield of blackgram is very poor as compared to many other legume crops (Wahhab *et al*.,1981). It can also fix atmospheric nitrogen through the symbiotic relationship between the host blackgram roots and soil bacteria and thus improves soil fertility. Slow rate of dry matter accumulation during pre-flowering phase, leaf senescence during the period of pod development and low partitioning efficiency of assimilates to grain are identified as the main physiological constraints for increasing yield. That is why blackgram is highly responsive to nitrogen. It plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the acreage and production of blackgram is steadily declining (BBS, 2006).

The average yield of Blackgram is 0.7 t ha^{-1}(BBS, 2006). There are many reasons of lower yield of blackgram. Nitrogen and irrigation management in kharif-1 season are one of them. For the pulse crops, nitrogen is most useful because it is the main component of protein. The management of fertilizer greatly affects the growth, development and yield of this crop. Pulses although fix nitrogen from the atmosphere, there is evident that application of nitrogenous fertilizers at flowering stage becomes helpful in increasing the yield (Patel *et al.,* 1984, Ardeshana *et al.,* 1993).

Blackgram is a rain fed crop in most countries, grown either during the wet season or on the residual soil moisture. Blackgram responses favorably to added water resulting in higher yields, especially when irrigation is given at the time of flowering (Lawn, 1978 ; Miah and Carangal, 1981). In summer cultivation when temperature is high, relative humidity is low and evapo-transpiration is greater, then 3-4 irrigations may be needed to obtain higher yields of blackgram (Sing and Sing, 1979 ; Lal and Yadav, 1981). Irrigation during flowering stage helps for retention of flowers and pod development.

Since the process of nodulation and nitrogen fixation is inhibited at higher levels of fertilizer nitrogen in the soil (Lawn and Brun, 1974) but there is a demand of nitrogen of the crop at post flowering period.

In Bangladesh some studies have been conducted to find out the seed yield of blackgram with optimum nitrogen dose and irrigation level. More studies are needed in respect of irrigation and nitrogen management for Blackgram. Considering the above facts, the present study was undertaken with following objectives:

1) To observe the optimum dose of nitrogen in blackgram cultivation
2) To determine the irrigation level for the optimum yield of blackgram
3) To determine the time of application of nitrogen fertilizer and irrigation in blackgram for achieving maximum yield

CHAPTER 2

REVIEW OF LITERATURE

Blackgram is an important pulse crop in Bangladesh. In Bangladesh blackgram is generally grown without fertilizer and irrigation. However there are evidences that the yield of blackgram can be increased substantially by the use of fertilizers and irrigation. There are also controversies regarding the rates of nitrogen and time of irrigation application (Patel *et al.,* 1984; Ardeshana *et al,.* 1993).

Information on fertilizer and irrigation management of pulse related to the study are reviewed and presented in the following heads.

2.1 Efficacy of integrated fertilizers on blackgram.

2.1.1 Plant height

Saini and Thakur (1996) stated that nitrogen at 30 and 40 kg ha^{-1} significantly increased the plant height of blackgram compared with no N.

Jamro *et al*. (1990) observed that application of 90 kg N ha^{-1} is significantly increased the plant height of blackgram.

Yein *et al.* (1981) conducted a field experiment on nitrogen in combination with phosphorus fertilizer to blackgram. They revealed that application of 40 kg N ha^{-1} increased plant height.

Asaduzzaman (2006) found that plant height of mungbean was significantly increased by the application of nitrogen fertilizer at 30 kg ha^{-1}.

Akhtaruzzaman (1998) conducted a field experiment on mungbean where plant height increased almost linearly up to 40 kg N ha^{-1} although response of 30 and 40 kg N ha^{-1} was identical.

Suhartatik (1991) in a study observed that increased application of NPK fertilizers significantly increased the plant height of mungbean.

Hamid (1988) conducted a field experiment to investigate the effect of nitrogen and carbon on the growth and yield performance of mungbean (*Vigna radiata* L. wilczek). He found that the plant height of mungbean cv. Mubarik was found to be increased with nitrogen at 40 kg ha^{-1}.

Trung and Yoshida (1983) conducted a field trial on mungbean in nutrient-rich soil, involving 0-100 ppm N as treatments. They observed that maximum plant height at all the stages of plant growth were obtained by the application of 25 ppm N.

2.1.2 Number of leaves

Asaduzzaman (2006) reported that different levels of nitrogen showed significantly increased number of leaves per plant of mungbean up to level of 30 kg N ha^{-1}.

Srivastava and Verma (1982) showed that N application at the rate of 15kg ha^{-1} increased the number of green leaves in greengram plants.

2.1.3 Total dry matter

Leelavathi *et al* (1991) reported that different levels of nitrogen showed significantly increased dry matter production of blackgram up to 60 kg N ha^{-1}.

Yakadri *et al.* (2002) studied the effect of nitrogen (40 and 60 kg ha^{-1}) on crop growth and yield of greengram (cv. ML-267). Application of nitrogen at 20 kg ha^{-1} resulted in the significant increase in leaf area ratios indicating better partitioning of leaf dry matter.

Chowdhury and Rosario (1992) studied the effect of 0, 30, 60 or 90 kg N ha^{-1} levels on the rate of growth and yield performance of mungbean at los Banos, Philippines in 1988. They observed that N above the rate of 30 kg N ha^{-1} reduced the dry matter yield.

Agbenin *et al.* (1991) carried out a field experiment under glass house condition and found that nitrogen application significantly increased the dry matter yield of mungbean..

Raju and Verma (1984) carried out a field experiment during summer season of 1979 and 1980 to study the response of mungbean var. Pusa baishaki to varying levels of nitrogen (15, 30, 45 and 60 kg N ha^{-1}) in the presence and absence of seed inoculation with *Rhizobium.* They found that maximum dry matter weight per plant was obtained by the application of 60 kg N ha^{-1} inoculated with *Rhizobium.*

2.1.4 Number of Pods

Mosamma uttma Kulsum (2003) reported that different levels of nitrogen showed significantly increased pods per plant of blackgram up to N 60 kg ha^{-1}.

Singh *et al*. (1993) reported increased pod yield greengram up to N 20kg ha^{-1} and P 40 kg ha^{-1}.

Jamro *et al* (1990) reported that application of 90 kg N ha^{-1} to blackgram resulted in appreciable improvement in the number of pods per plant.

Srinivas *et al.* (2002) examined the effect of nitrogen (0, 20, 40 and 60 kg ha^{-1}) and P (0, 25, 50 and 75 kg ha^{-1}) on the growth and seed yield of mungbean. They observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg/ha followed by a decrease with further increase in N.

Sarkar and Banik (1991) reported that application of 10 kg N ha^{-1} to mungbean resulted in appreciable improvement in the number of pods per plant.

In an experiment, Yein *et al.* (1981) applied nitrogen and phosphorus fertilizers to mungbean and reported that combined application of nitrogen and phosphorus fertilizers increased the number of pods per plant. The rate of nitrogen and phosphorus was 50 kg and 75 kg per hectare, respectively.

Patel and Parmar (1986) conducted an experiment to evaluate the response of greengram with varying levels of nitrogen and phosphorus. They observed that increasing N application to rainfed mungbean (cv. Gujrat-1) from 0 to 50 kg N ha^{-1} increased the number of pods per plant.

Tank *et al.* (1992) reported that mungbean fertilized with 20 kg N ha^{-1} along with 75 kg P_2O_5 ha^{-1} significantly increased the number of pods per plant.

In trials, on clay soils during the summer season Patel *et al.* (1984) observed the effect of N levels (0, 10, 20 and 30 kg N ha^{-1}) and that of the P (0, 10, 20, 40, 60 and 80 kg P_2O_5 ha^{-1}) on the growth and seed yield of mungbean. It was found that application of 30 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} significantly increased the number of pods per plant.

2.1.5 Number of seeds per pod

Malik *et al.* (2003) investigated the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and P (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98 during 2001. It was found that number of seeds per pod was significantly affected by varying levels of nitrogen and phosphorus.

2.1.6 1000-seed weight

Patel and Patel (1991) found that application of nitrogen, phosphorus and potassium fertilizers resulted in significant increases in 1000 seed weight of blackgram.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen levels on the yield and yield components of mungbean at the agronomic research station, Farooqabad in Pakistan during the year of 2000 and 2001. They revealed that with the application of NPK at the rate of 50-50-0 kg/ha significantly affected the 1000 grain weight.

Quah and Jafar (1994) noted that 1000 seed weight of mungbean increased significantly with 40 kg N ha^{-1}.

Yadav (1990). observed that application of 40 kg P_2O_5 ha^{-1} along with 20 kg N ha^{-1} significantly increased the 1000 seed weight of mungbean.

A field experiment was conducted by Sarkar and Banik (1991) to evaluate the effect of varying rates of N on mungbean. Results revealed that application of 10 kg N ha^{-1} resulted in the appreciable improvement in different yield attributes along with 1000 seed weight over control.

2.1.7 Seed Yield

Saini and Thakur (1996) stated that application of 30 kg N/ha significantly increased the grain yield /plant blackgram.

Bhalu *et al.* (1995) observed that seed yield of blackgram increased with up to 20 kg N and 40 kg P_2O_5.

Yadav *et al*. (1994) reported that higher seed yield of blackgram with 20 kg N ha^{-1}, 40 kg P ha^{-1} and 40 kg K ha^{-1}.

Singh *et al*. (1993) reported increased seed yield of blackgram with N 20 kg ha^{-1} and P 40 kg ha^{-1}.

Leelavathi *et al* (1991) reported that different levels of nitrogen showed significant difference in dry matter production of blackgram up to a certain level of 60 kg N ha^{-1}.

Upadhayay *et al*.(1991) reported that N application markedly increased the seed yield of blackgram in nitrogen deficient sandy loam soil

Vidhate *et al.* (1986) explored the response of blackgram to nitrogen fertilization. They observed that an increase in the dose of N fertilizer increased the grain yield. Higher percent of grain yield increased when equal dose of 25 kg N ha^{-1} applied at sowing and at flowering.

Mozumdar *et al*. (2003) conducted an experiment to study the effect of different nitrogen levels viz. 0, 20, 40, 60 and 80 kg N ha^{-1} on Binamoog-2 and they observed that increase of nitrogen fertilizer increased seed yield up to 40 kg N ha^{-1} and that was 1607 kg ha^{-1}.

Raju and Verma (1984) reported that application of 15-60 kg N ha^{1} significantly increased seed yields of mungbean.

Karle and Pawar (1998) examined the effect of varying levels of N and P fertilizers on summer mungbean. They reported that mungbean produced higher seed yield with the application of 15 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}.

Patil *et al*. (1984) showed that increased in the dose of nitrogen from 20 to 40 $kgha^{-1}$ at flowering improved grain yield from 39 to 89 percent over control. It is interesting to note that half dose of 20 kg/ha of nitrogen applied at sowing and remaining at the time of flowering gave higher yield than the application of 40 kg N/ha as basal in mungbean.

Pongkao and Inthong (1988) applied N at the rate of 0-60 kg ha^{-1} on mungbean and reported that application of 15 kg N ha^{-1} was found to be superior giving 23% higher seed yield over the control.

A field experiment conducted by Sarkar and Banik (1991) to study the effect of N in combination with P on the yield of mungbean. Results showed that application of N along with P significantly increased the seed yield of mungbean. The maximum seed yield was obtained with the combination of 20 kg N and 60 kg P_2O_5 ha^{-1}.

Ardeshana *et al.* (1993) conducted a field experiment on clay soil during the rainy season of 1990 to study the response of mungbean to nitrogen. They observed that seed yield increased with the application of nitrogen fertilizer up to 20 kg N ha^{-1} in combination with phosphorus fertilizer up to 40 kg P_2O_5 ha^{-1}.

Bachchhav *et al.* (1994) conducted a field experiment during the summer season with greengram cv. Phule-M. They observed that among nitrogen fertilizers rates (0-45 kg N ha^{-1}) seed yield increased with 30 kg N ha^{-1}.

Kaneria and Patel (1995) conducted a field experiment on a Vartisol in Gujarat, India with mungbean cv. K 581 using 0 or 20 kg N ha^{-1} levels. They found that application of 20 kg N ha^{-1} significantly increased the seed yield.

In a field experiment conducted by Satyanarayanamma *et al.* (1996), five mungbean cultivars were sprayed with 2% urea at pre-flowering, flowering, pod development or at all the combinations or at combination of two of three growth stages. They reported that spraying urea at flowering and pod development stages produced the highest seed yield.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75, and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg ha^{-1} resulted with maximum seed yield (1112.96 kg ha^{-1}).

Rajender *et al*. (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-

111 and T44.They observed grain yield increased with increasing N rates up to 20 kg ha^{-1}.

Results from field experiments conducted by Mahadkar and Saraf (1988) during summer season mungbean showed that the application of N with P and K at 20,2,5 kg ha^{-1} gave higher seed yield.

2.1.8 Harvest Index

Mozumdar *et al.* (2003) conducted a field experiment at the Bangladesh Agricultural University, Mymensingh. They tested five levels of nitrogen (0, 20, 40, 60 and 80 kg ha^{-1}) and two varieties of summer mungbean viz., Binamoog-2 and Kanti. The results revealed that nitrogen application had negative affect on the harvest index in both the varieties.

2.2. Efficacy of irrigation

Nandan and Prasad (1998) reported that grain yield and net returns were higher with 3 irrigations than with 1 and 2 irrigations in blackgram (Tripurari and Yadav, 1990).

Eck and Musick (1979) reported that yield reductions from stress initiated at early boot stage resulted from both reduced seed size and seed numbers of sorghum.

Pandey *et al.* (1984) reported that mungbean is more susceptible to water deficits than many grain legumes. Water stress affects canopy development and overall growth process but there are varietals differences in stress tolerance.

Petersen (1989) reported that water stress reduced pods per plant and mean seed weight in *Phaseolus vulgaris* and pods per plant and seeds per pod in *P. acutifolius*. Similar results were reported by Lopes *et al.*, (1988).

Sadasivam *et al.* (1988) reported that stress during vegetative phase reduce grain yield through reducing plant size, limiting root growth and number of pods and harvest index in mungbean. Decreased grain yield due to water stress was also reported in soybean (Rajput *et al.*, 1991), green grain and blackgram (Tripurari and Yadav, 1990), fababean (Khade *et al.*, 1990).

Hamid *et al.* (1990) reported a drastic yield reduction in mungbean due to water stress. The yield loss was primarily caused by the reduction of canopy development, inhibition of photosynthetic rate and lower dry matter production.

Mazumdar and Roy (1992) reported that the higher grain with irrigation in summer sesame. Similar result was found in soybean (Rajput *et al.* 1991) pea (Rahman *et al.*, 2000), greengram (Pal and Jana, 1991), gram (Javiya *et al.*, 1989).

Turk *et al.* (1980) demonstrated the response of cowpea to intensities of drought at different stages of growth and reported that yields were not reduced by drought imposed during the vegetative stage; while drought occurred during flowering stage substantial yield reduction was obvious. Variation in yields resulted from difference in number of pods/m^2 and small seed size.

Dubtez and Mahalle (1969) found that water stress reduced yield of bushbean by 53%, 71% and 35% when the stress occurred during preflowering, flowering and pod formation periods, respectively.

Fieldpeas were most sensitive to water stress during flowering and early pod filling stage of soyabean (Hsiao and Acevedo, 1974; Lewis *et al.*, 1974, Hiler *et al.*, 1972).

Cselotel (1980) reported that a regular water supply particularly during flowering and pod formation was necessary for high yield and good quality of snap beans. Higher number of dry pods per plant, increased seed weight and seed yield per hectare was found when irrigation was done weekly (Haque, 1988) Sankar (1992) reported similar results in peas and greengram.

Pannu and Singh (1988) observed the total dry matter as well as grain yields was affected by moisture stress in mungbean.

Khade *et al*. (1990) found highest number of pods plant^{-1}, seeds pod^{-1} and seed yield with 3 irrigations in *Vicia sp.*
Viera *et al.* (1991) reported a yield reduction of 35 to 40% when drought stress was imposed during seed filling.

Siowit and Kramer (1997) observed that in soybean, the maximum reduction in yield due to moisture stress occured during bean filling stage. Drastic yield reduction was also reported in mungbean due to water stress (Sadasivam *et al.*, 1988*;* Hamid *et al.*, (1990*).* The yield loss was primarily caused by the reduction of canopy development, inhibition of photosynthetic rate and lower dry matter production

Salter and Goode (1967) stated that the extent of yield reduction from water deficits depends not only on the magnitude of the deficit but also on the stage of growth of bushbean. Yield and dry matter production were reduced in all growth stress by water deficits. They further reported that when the deficit was removed the growth rate did not immediately return to normal but required several days to recover.

Biswas (2001) reported that irrigation frequency exerted a remarkable impact on yield of fieldbean. Application of 3 irrigations increased pod yield about 19% and 13% and seed yield about 53% and 30% over 1 and 2 irrigations respectively. He also reported higher number of pods/plant, seeds/pod and pod length with higher frequency of irrigation.

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Sher-e-Bangla Agricultural University farm , Dhaka, during the period of March to May, 2006 in the kharif -1 season to study the efficacy of integrated nitrogen and irrigation managements on the yield attributes and yield of blackgram (cv. BARI mash- 3). Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Experimental site

The experimental field was located at 23^0 77´ W latitude and 90^0 33´ E longitude at an altitude of 9 meter above the mean sea level. Appendix-II.

3.2 Soil

The soil belongs to the Agro-Ecological Zone – Modhupur Tract (AEZ 28). The land topography is medium high and soil texture is silty clay with pH 5.6. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-I.

3.3 Climate

The climate of the experimental area was sub tropical. The rainfall was heavy during Kharif season and low rainfall in Rabi season. The atmospheric temperatures were higher in Kharif season. The weather conditions during experimentation such as monthly total rainfall (mm), mean temperature (^{0}C), sunshine hours and humidity (%) are presented in Appendix III.

3.4 Planting material

The variety of blackgram used for the present study was BARI mash-3. The required seeds for the experiment were collected from the pulse Research centre of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The seeds were healthy, well matured and free from mixture of other seeds, weed seeds and extraneous materials. Before sowing, the seeds were tested for germination in the laboratory and the percentage of germination was found to be over 90%. The important characteristic of this variety is mentioned below:

3.4.1 BARI Mash-3 (Hemanta)

The plant height of this varity ranges from 40-45 cm . Leaves are dark green. The variety is resistant to *Cercospora* leaf spot and yellow mosaic virus. Maximum seed yield is 1.1-1.4 ton/ ha. Seeds contain 23.9% protein and 46.8% carbohydrate.

3.5 Land preparation

The land was irrigated and first opened with the tractor drawn disc plough. Ploughed soil was then brought into desirable fine tilth by 4 operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 20 February and 28 February 2006, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before planting and the basal dose of fertilizers was incorporated thoroughly.

3.6 Fertilizer application

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium respectively. Nitrogen was applied in the experiment as per treatment. P_2O_5 and K_2O were applied as basal dose at the rate of 48 and 33 kg per hectare respectively following BARI recommendation.

3.7 Treatments of the experiment

The treatments were tested as follows**:**

T_1 = No fertilizer and no irrigation (Control)

T_2 = 20 kg nitrogen/ha as basal without irrigation

T_3 = 20 kg nitrogen/ha as basal with one irrigation at first flowering stage

T_4 = 30 kg nitrogen/ha as basal without irrigation

T_5 = 30 kg nitrogen/ha as basal with one irrigation at first flowering stage

T_6 = 40 kg nitrogen/ha as basal without irrigation

T_7 = 40 kg nitrogen/ha as basal with one irrigation at first flowering stage

T_8 = 10 kg nitrogen/ha as basal and split 10 kg nitrogen/ha with one irrigation at first flowering stage

T_9 = 15 kg nitrogen/ha as basal and split 15 kg nitrogen/ha with one irrigation at first flowering stage

T_{10} = 20 kg nitrogen/ha as basal and split 20 kg nitrogen/ha with one irrigation at first flowering stage

3.8 Experimental design and lay out

The experiment was laid out in a Randomized complete block design with three replication (RCBD). Each replication had 10 unit plots in which the treatment combination were assigned at random. The size of each plot was 3m×2m. The blocks and unit plots were separated by 1.5m and 1m, respectively. The intra block and plot spaces were used as irrigation and drainage channels. A layout of the experiment has been shown in Appendix IV.

3.9 Germination test

Three layers of filter paper were placed on Petridishes. Each petridish contained 100 seeds. Germination percentage was calculated by using the following formula.

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds taken for germination}} \times 100$$

3.10 Sowing of seeds in the field

Seeds were sown on the furrow on 9th March, 2006 and the furrows were covered by soils soon after seeding. Seeds were treated with Bavistin before sowing the seeds to control the seed borne disease. The seeds were sown continuously in 30cm apart rows at about 2-3 cm depth in afternoon and covered with soil.

3.11 Germination of seeds

Seed germination occurred from 6th days after sowing. On the 7th day the percentage of germination was more than 85% and on the 9th day nearly all baby plants came out of the soil.

3.12 Intercultural operations

3.12.1 Thinning and weeding

Thinning and weeding were done at 20 days after sowing (DAS) when the plant attained at a height of about 10 cm. Plant to plant distance was maintained at 6-7 cm. Second weeding was done at 35 DAS when the plants attained about 15-20 cm height.

3.12.2 Irrigation

Irrigation was done as per treatments.

3.12.3 Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) and virus vectors (jassid) attacked the young plants and at latter stage of growth pod borer (*Maruca testulalis*) attacked the plant. Dimacron 50EC was sprayed at the rate of 1litre/ha to control this insects.

3.12 Crop sampling and data collection

Ten plants were selected randomly from each plot and were uprooted for data recording. The data of plant height, number of branches, number of flowers, and leaves per plant were recorded from sampled plants at an interval of fifteen days which was started from 25 DAS.

3.13 Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown to black in color**.** The matured pods were collected by hand picking from a pre demarcated area of .9 m^2 at the center of each plot.

3.14 Data collection

The following data were recorded

i. Plant height (cm)
ii. Number of leaves per plant
iii. Number of branches per plant
iv. Leaves dry weight (g)
v. Stem dry weight (g)
vi. Reproductive dry weight(g)
vii. Above ground dry matter production per plant (g)

viii. Number of pods per plant
ix. Number of seeds per pod
x. 1000- seed weight (g)
xi. Seed yield (g/ plant)
xii. Seed yield (t/ha)
xiii. Harvest index (%)

3.15 Procedure of data collection

3.15.1 Plant height (cm)

The height of the selected plant was measured from the ground level to the top of the plants and the mean height was expressed in cm.

3.15.2 Number of leaves per plant

The leaves (trifoliate) were counted from ten sample plants. The average number of leaves per plant was determined.

3.15.3 Number of branches/plant

The branches were counted from ten plants. The average number of branches/plant was determined.

3.15.4 Leaf dry weight

Ten plants were randomly selected from each treatment and leaves are separated from each plant then leaves were dried separately in an oven for 72 hours at 80^0C and weight was taken carefully. This procedure was done from 25 DAS to 85 DAS at 15 days interval.

3.15.5 Stem dry weight

Stems were separated from ten plants of each treatment. These stems were dried separately in oven for 72 hours dry was taken carefully. This procedure was done from 25 DAS to 85 DAS at 15 days interval

3.15.6 Reproductive parts dry weight

Reproductive parts (flowers and pods) dry weight of ten plants of the each treatment was measured from 40 DAS to 85 DAS.

3.15.7 Above ground plant parts dry weight

The sum of the plant parts (leaves dry weight, stem dry weight and reproductive parts dry weight) constituted the above ground dry weight

3.15.8 Number of pods per plant

The number of pod from ten randomly selected plants from each plot was determined at the time of harvest to find out the number of pods/plant.

3.15.9 Number of seeds per pods

Ten pods were taken randomly from each treatment and the seeds were separated and counted. Then the average seed number per pod was calculated.

3.15.10 Weight of 1000-seed (g)

1000-seed were counted from each plot and weight was taken on an electrical balance and data were recorded.

3.15.11 Seed yield (t ha^{-1})

Plants of selected 0.9m^2 from each plot were harvested at complete maturity. The seeds of each pod were separated from the plants manually and were dried in the sun to a constant weight. Seed weight was recorded plot wise and yields were then converted to t ha^{-1} basis.

3.15.12 Harvest index (%)

Harvest index was calculated with the following formula.

$$\text{Harvest Index (\%)} = \frac{\text{Grain Yield (t/ha)}}{\text{Biological Yield (t/ha)}} \times 100$$

3.15.13 Analysis of data

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C. The means were separated following least significance deference (LSD) test at 0.05 level of significance.

CHAPTER 4

RESULTS AND DISCUSSION

Present study was undertaken to investigate the efficacy of integrated nitrogen and irrigation on different yield and yield attributes of blackgram. The results of the experiment have been presented and discussed in this chapter.

4.1 Plant height (cm)

The results showed that the effect of irrigation and nitrogen fertilizer on plant height was significant at 40DAS to 85 DAS (Fig. 1). Plant height rapidly increased from 25 DAS to 40 DAS thereafter a slower rate of increase in plant height was recorded up to harvest. At early growth stage (25 DAS) no significant variation in plant height was observed due to treatment variation. The highest plant height was produced in 40 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_7). The lowest plant height was found in each growth stage where the crop was grown without fertilizer & irrigation (control). Both nitrogen and irrigation probably promoted cell division or cell elongation of blackgram plants, thus increased plant height. Saini and Thakur (1996) found similar results and Yein *et al.* (1981) found increased plant height of blackgram with nitrogen application. Haque (1988) also observed increased plant height in bushbean due to application of irrigation at weekly intervals. An increased plant height due to application of irrigation was also reported in fieldpea (Yadav *et al.,* 1994

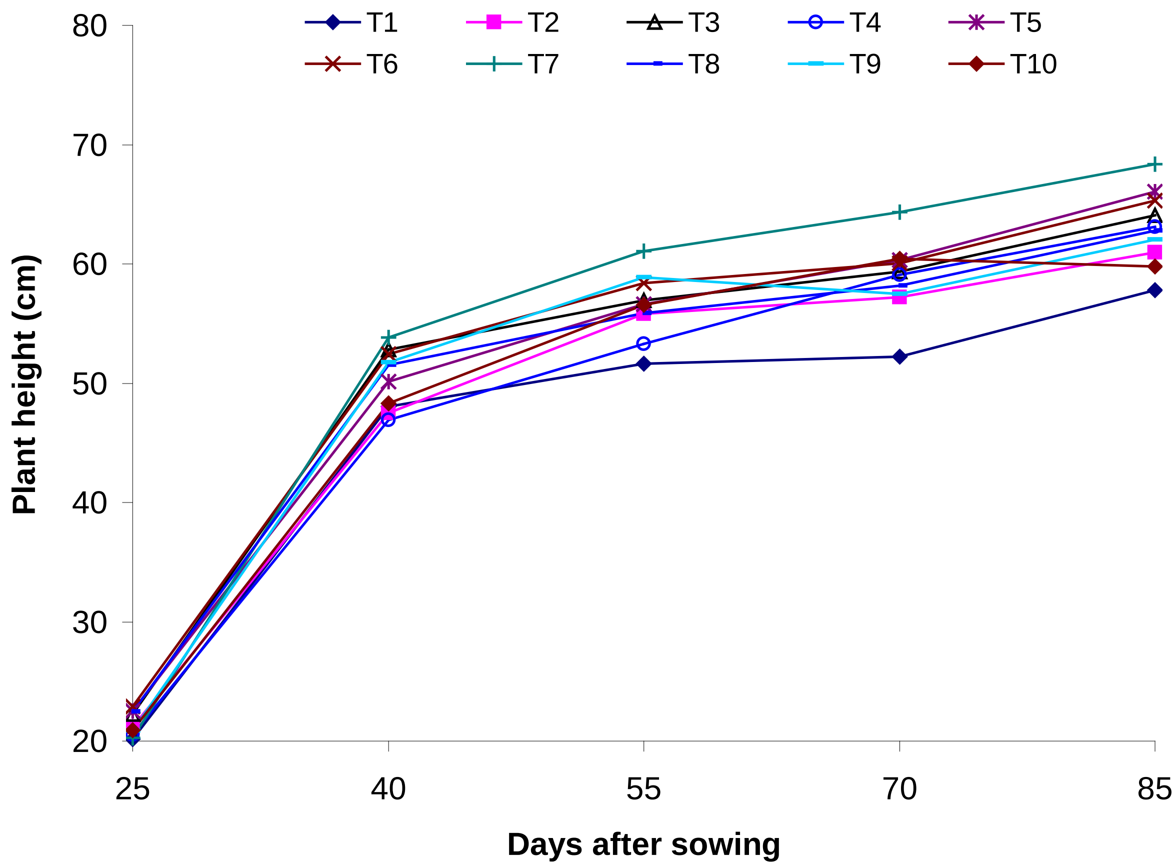

Fig.1 Plant height of blackgram as influenced by nitrogen and irrigation (LSD $_{0.05}$ =3.813, 4.751, 4.562 and 4.583 at 40, 55, 70 and 85 DAS respectively)

4.2 Number of branches per plant

Number of branches was significantly increased by nitrogen and irrigation from 40 DAS to 85 DAS (Fig.2). The maximum number of branches per plant was produced in 40 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_7). The second highest number of branches per plant was observed from the treatment of 30 kg N ha^{-1} as basal + one irrigation (T_5). Plants in control plot showed lower number of branches from 40 to 85 days after sowing. The other treatments gave similar number of branches per plant at different growth stages. Similar results were noticed in bushbean by Wein *et al.*, 1997 and in fieldpea by Ferdous, 2001.

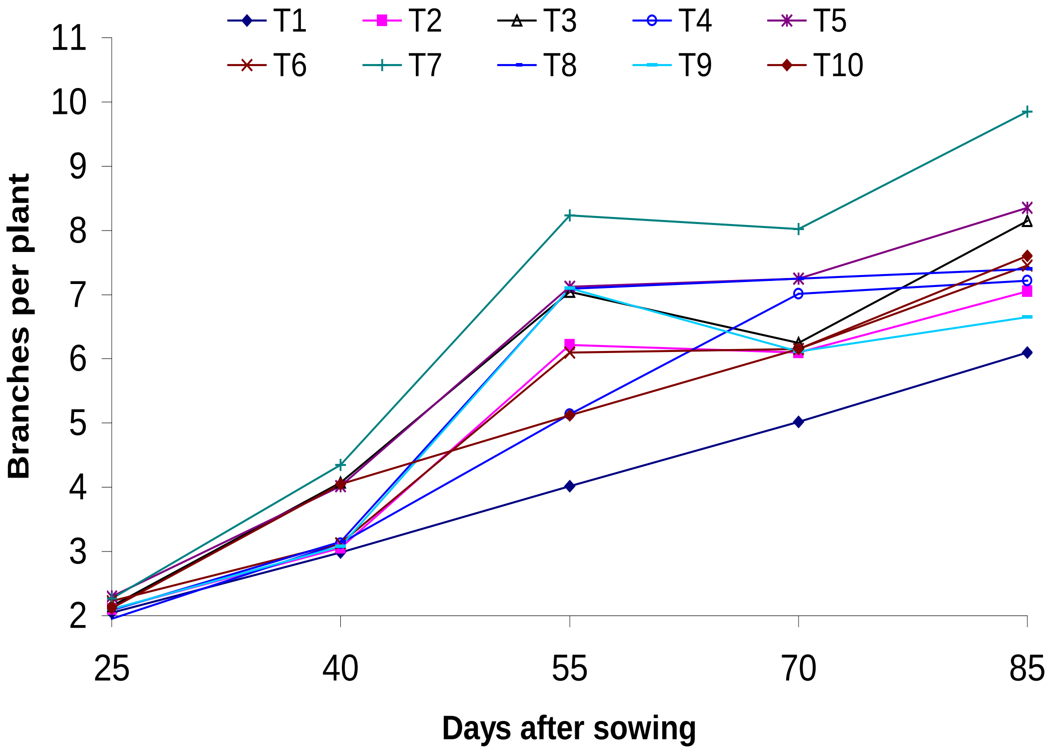

Fig. 2 Number of branches per plant of blackgram as influenced by nitrogen and irrigation (LSD $_{0.05}$ = 0.242, 0.491, 0.637 and 0.789 at 40, 55, 70 and 85 DAS respectively)

4.3 Number of leaves per plant

Numbers of leaves per plant increased significantly from 40 DAS and continued up to 70 DAS (Fig.3). Treatment T_7 (40 kg N ha^{-1} as basal and one irrigation at first flowering stage) resulted in maximum leaves per plant in each growth stage which some treatments were similar with (T_7) than other treatments. Treatment 30 Kg N ha^{-1} as basal + one irrigation at first flowering stage (T_5) gave second highest number of leaves per plant at 55 and 70 DAS. The lowest number of leaves per plant was recorded when plant grown without fertilizer and irrigation (control). Srivastava and Verma (1982) showed that N application at a rate of 15 kg ha^{-1} increased the number of green leaves, in mungbean plant

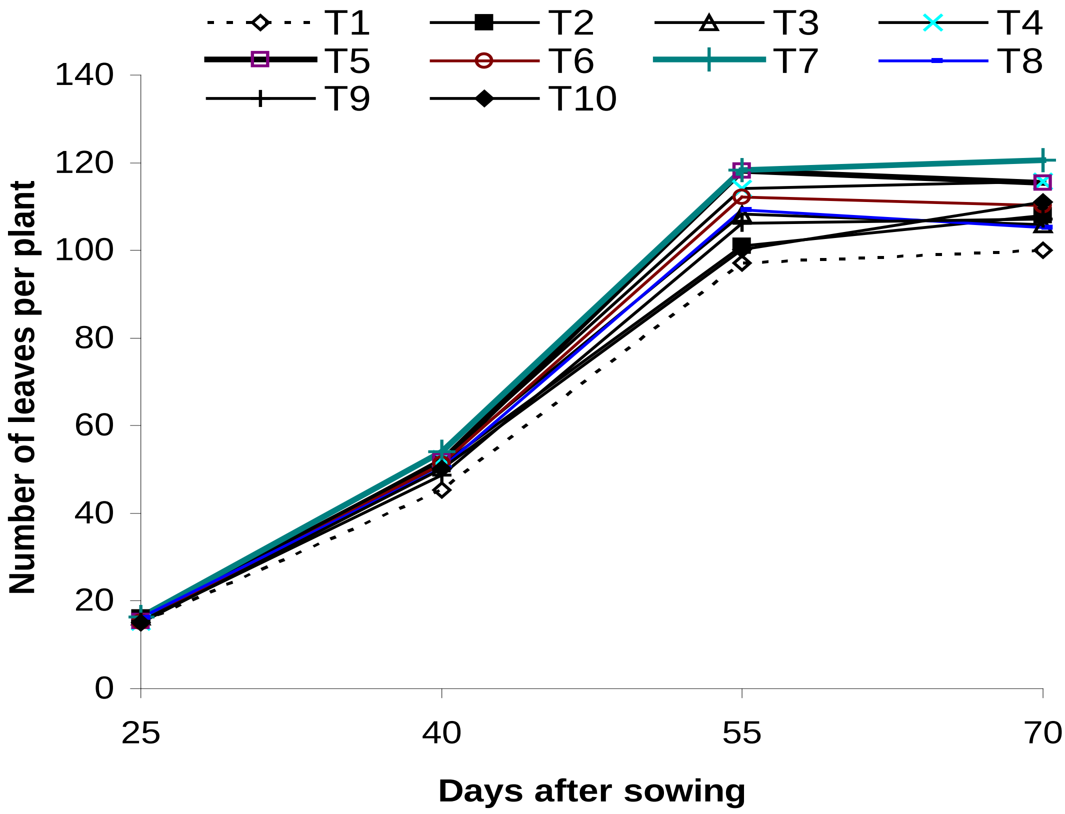

Fig. 3 Number of leaves per plant of blackgram as influenced by nitrogen and irrigation (LSD $_{0.05}$ = 1.45, 3.236, 10.46, 10.02 and 410.57 at 25, 40, 55, 70 and 85 DAS respectively)

4.5 Leaf dry weight (g/plant)

Leaf dry matter was increased significantly between 25 to 85 DAS (Fig.5). Treatment 40 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_7) and 30 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_5) were found superior to other treatments in accumulation of dry matter in leaf at each growth stage. Plants grown without fertilizer and irrigation had minimum leaf dry weight at each growth stage. Reduction in leaf dry matter due to water stress in different legumes was also reported earlier in blackgram (Sadasivam *et al.*, 1988) and soybean (Siowit and Kramer, 1977) which might be attributed to reduced leaf size.

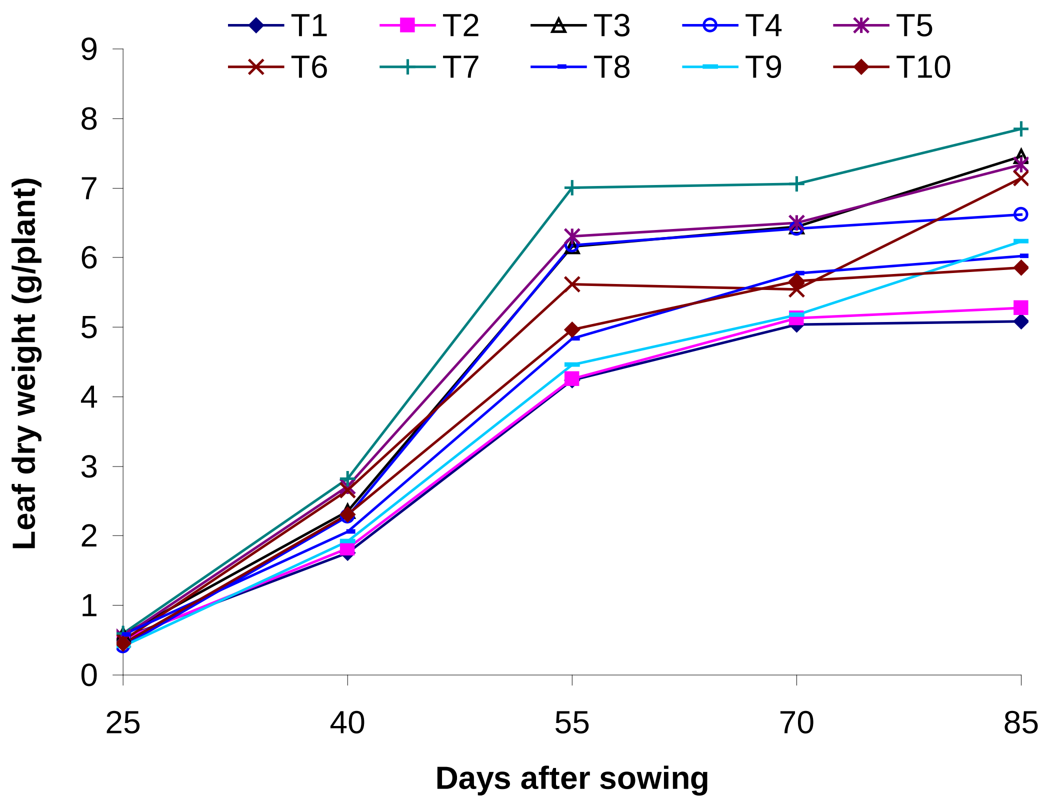

Fig. 5 Leaf dry weight of blackgram as influenced by nitrogen and irrigation (LSD $_{0.05}$ = 0.0171, 0.367, 0.457, 0.437 and 0.413 at 25, 40, 55, 70 and 85 DAS respectively)

4.6 Stem dry weight

Stem dry matter was significantly increased from 25 DAS (Fig.6) and increased sharply at 55 DAS and it continued up to harvest. The highest dry weight of stem was observed in treatment 40 kg N ha^{-1}as basal + one irrigation at first flowering stage (T_7) and 30 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_5) at each growth stage. Control treatments gave minimum stem dry matter in different crop growth stages. Reduction in stem dry matter in cowpea (Wein *et al.*, 1997) and shoot dry matter in soybean (Siowit and Kramer, 1997) due to water stress was also reported elsewhere.

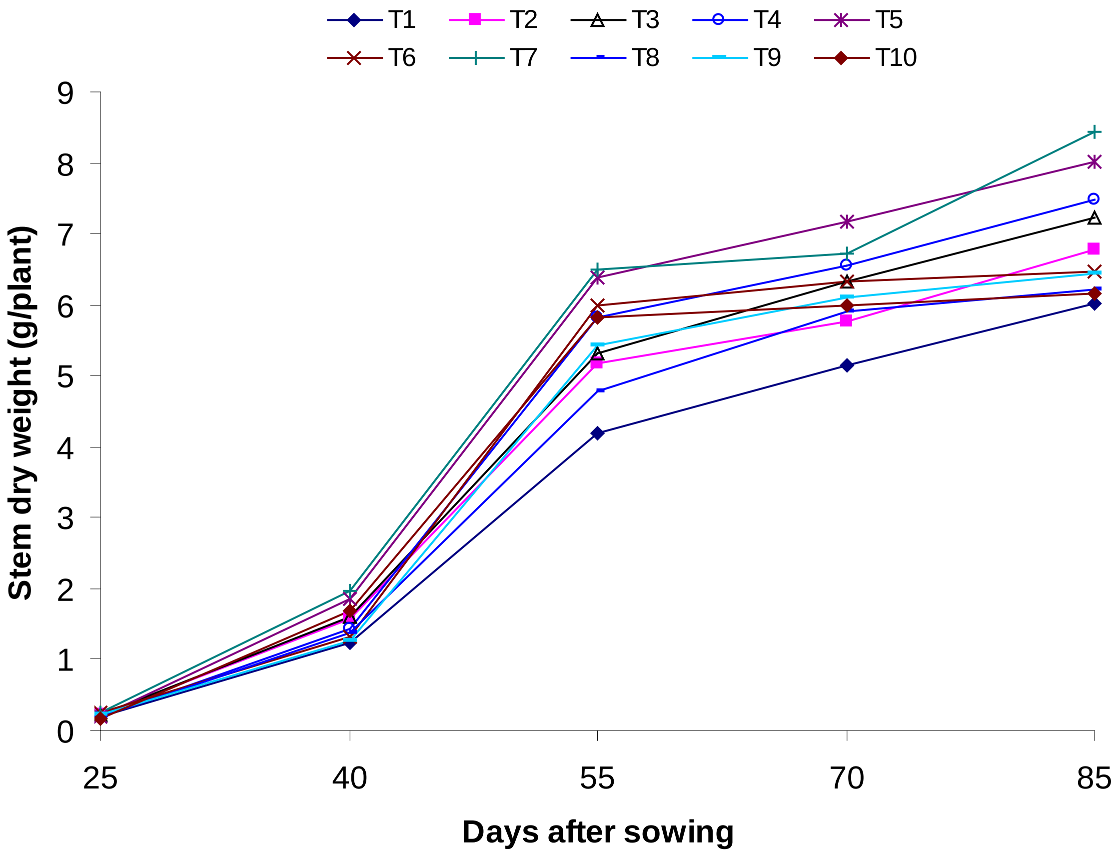

Fig. 6 Stem dry weight of blackgram as influenced by nitrogen and irrigation ($LSD_{0.05}$ = 0.0171, 0.1329, 0.391, 0.347 and 0.5118 at 25, 40, 55, 70 and 85 DAS respectively)

4.7 Dry weight of reproductive organs

Nitrogen and irrigation application showed significant variation in reproductive organ of blackgram. Dry weight of reproductive organ increased slowly at the beginning and then exponentially, which continued up to maturity (Fig.7). It was observed that the treatment variation significantly influenced reproductive dry weights from 40 DAS to 85 DAS. Sharp increase in dry weight of reproductive organ might be the resultant of remobilization of reserves from vegetative parts as well as translocation of assimilates towards the grains. The highest dry weight of reproductive organ observed in the treatment 40 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_7). The lowest dry weight of reproductive organ was found in control. Available reports indicated that legume plants produce less photosynthetic under water stress condition (Hamid *et al.*, 1990, in mungbean Siowit and Kramer, 1997 in soybean and Keneth and Hall, 1980 in cowpea).

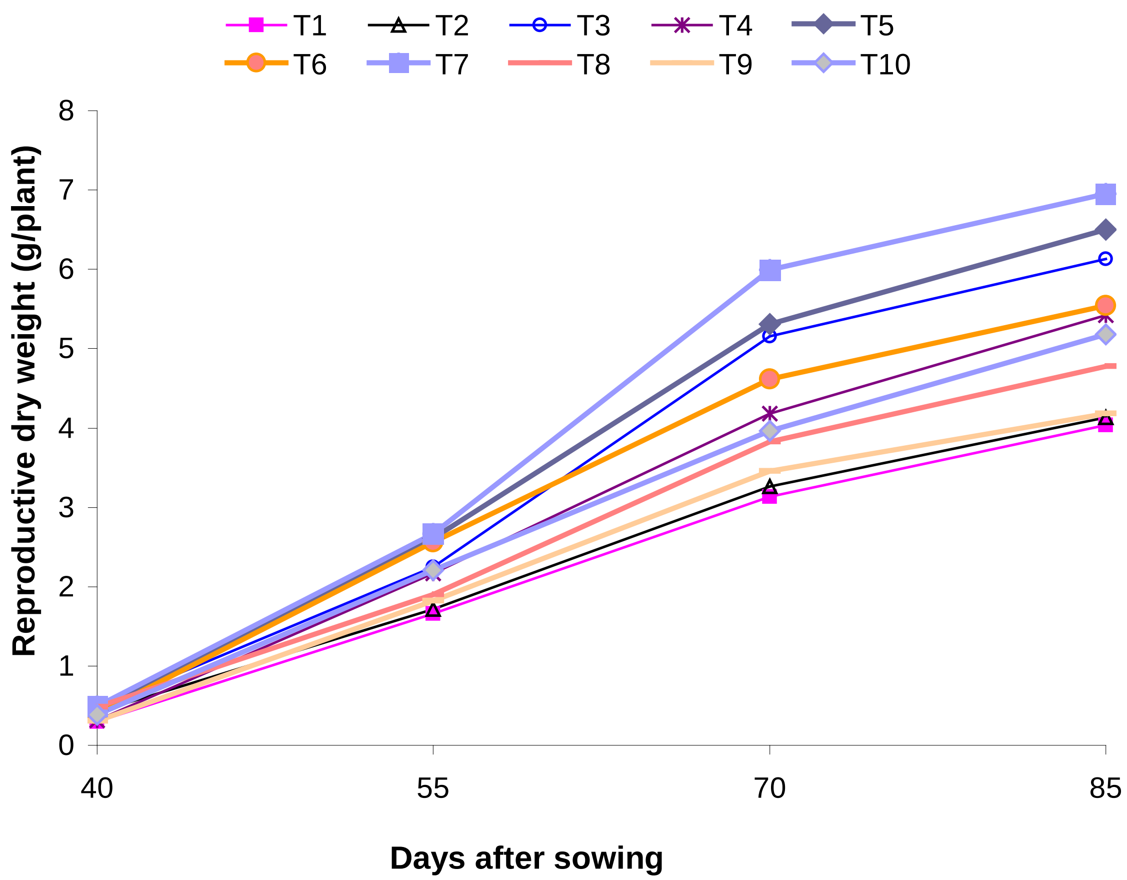

Fig.7 Reproductive dry weight of blackgram as influenced by nitrogen and irrigation (LSD $_{0.05}$ = 0.215, 0.313, 0.351, 0.462 and 0.383 at 25, 40, 55, 70 and 85 DAS respectively)

4.8 Above ground dry weight (g/plant)

Above ground dry weight of blackgram increased significantly from 25 DAS to 85 DAS (Fig. 8). Treatment 40 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_7) had greater influence on plant producing maximum above ground dry weight and that was noticed after 40 DAS total maturity. These variations in above ground dry matter production was greater compared to other treatments. The maximum above ground dry matter (23.56 g) was found at harvest (85 DAS). Control treatment produced minimum above ground dry matter in each growth stage. Lower dry weight in control plot might be due to internal nutrient and moisture stresses of plant, which caused reduction in both cell division and cell elongation and reduced carbohydrate synthesis and hence the growth was minimal (Karmer, 1988). The increase in dry matter due to higher number of irrigation was also recorded by Nandan and Prasad (1998).

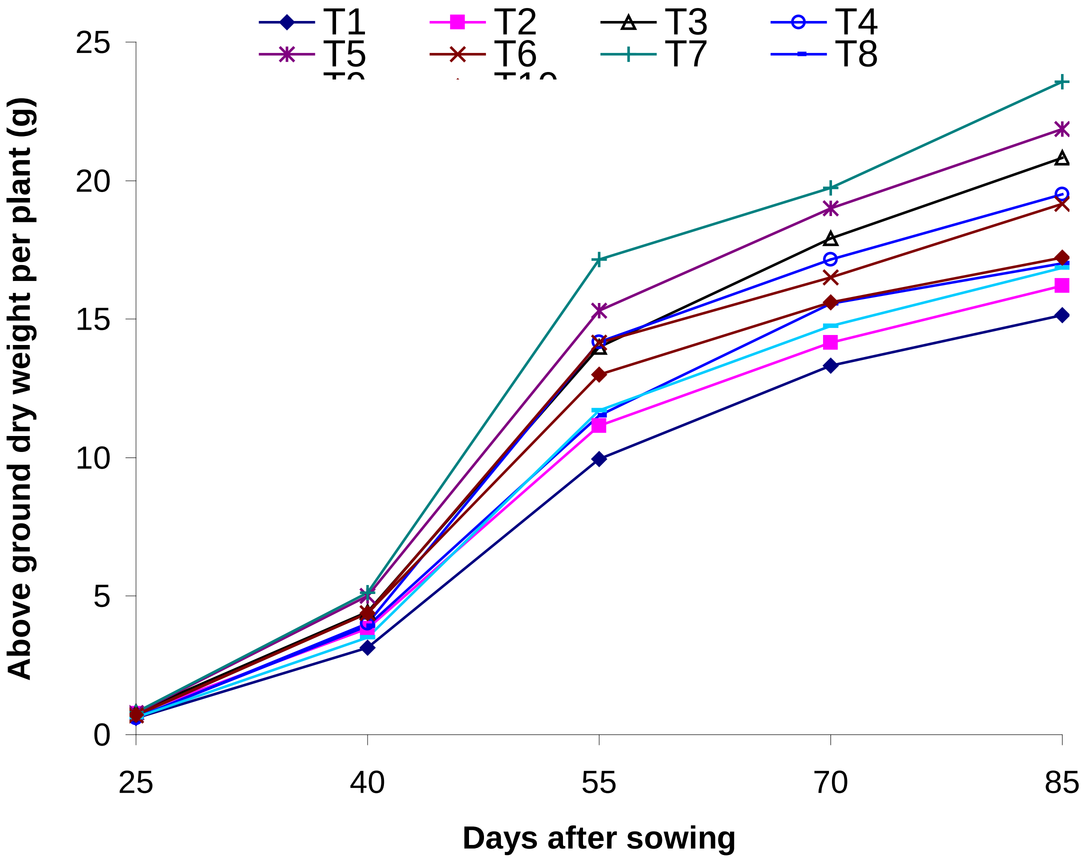

Fig. 8 Above ground dry weight of blackgram as influenced by nitrogen and irrigation (LSD $_{0.05}$ =0.546 0.486, 0.572, 0.451 and 0.514 at 25, 40, 55, 70 and 85 DAS respectively)

4.9 Yield contributing characters

Results of yield contributing characters have been presented in Table 1.

4.9.1 Number of pods per plant

Both nitrogen and irrigation significantly influenced the number pods per plant. Treatment of 40 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_7), 30 kg N^{-1} ha as basal + one irrigation at first flowering stage (T_5) and 20 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_3) gave significantly highest number of pods per plant. No nitrogen and no irrigation produced lower number of pods per plant. Probably optimum nitrogen and soil moisture restricted flower and pod dropping, which might have contributed to more pods per plant as reported by Biswas (2001) in fieldbean. The reduced number of pods per plant due to water stress was also reported earlier in fieldbean (Petersen, 1989 and Lopes *et al.*,1988).

4.9.2 Number of seeds per pod

The number of seeds per pod was significantly affected by nitrogen and irrigation application. Number of seeds per pod of blackgram ranged from 6.20 to 7.93 due to the treatment variation. However, the highest number of seed per pod was recorded from treatment T_7 (40 kg N ha^{-1} as basal + one irrigation at first flowering stage) that similar with T_7 and the lowest with T_1 (control). This finding was partly supported by Singh *et al.* (1993) who stated that application of nitrogen increased the number of seeds per pod.

4.9.3 1000 seed weight

The 1000 seed weight varied from 40.20g to 46.58 g (Table-1). Treatment of 40 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_7) produced heavier seed that similar with T_{10}, T_9, $T_{6,}$ T_5 and T_3 and lighter in T_1 (control).

Singh *et al*., (1993) in blackgram and greengram and Roy *et al*., (1995) in sesame also got the highest seed weight with moderate nitrogen level.

Table 1 Efficacy of integrated nitrogen and irrigation on yield contributing characters of blackgram.

Treatments	**Number of pods/plant**	**Number of seeds/pod**	**1000 seed weight (g)**
T_1	46.10	6.20	40.20
T_2	47.90	6.87	42.35
T_3	68.65	7.50	43.80
T_4	61.08	7.33	41.02
T_5	71.08	7.43	43.80
T_6	63.95	7.27	44.15
T_7	73.10	7.93	46.58
T_8	53.85	7.17	42.75
T_9	62.10	6.85	44.20
T_{10}	63.7	7.02	45.90
LSD $_{(0.05)}$	**5.593**	**0.454**	**3.039**
CV (%)	5.33	3.70	4.07

4.10 Yield

4.10.1 Seed yield (g/plant)

Seed yield per plant was significantly affected by nitrogen and irrigation. The highest seed yield per plant (10.45g) was observed in T_7 (40 kg N ha^{-1} as basal + one irrigation at first flowering stage) (Table 2). T_5 produced 9.76g seed per plant and the treatment 20 kg N ha^{-1} as basal + one irrigation at first flowering stage (T_3) produced 9.50g seed per plant and they were statistically similar. The lowest yield per plant was recorded from control and that was 6.97 g/plant. The seed yield obtained from T_7 was 10.45% more over control. T_7 produced the highest yield due to maximum production of crop characters like plant height, branches per plant, leaves per plant, leaf dry weight, stem dry weight, total dry matter and pods per plant and seeds per pod. Similar results were observed in snap bean by Haque (1988) in Frenchbean by Sing (1990) and in pea by Verma *et al*., (1998).

4.10.2 Seed yield (t/ha)

Seed yield per hectare was significantly affected by nitrogen and irrigation (Table 2). The highest seed yield (1.86 t/ha) was observed in T_7 (40 kg N ha^{-1} as basal + one irrigation at first flowering stage), which was statistically similar to T_5 (30 kg N ha^{-1} as basal + one irrigation at first flowering stage) and T_3 (20 kg N ha^{-1} as basal + one irrigation at first flowering stage). The lowest yield (1.24 t/ha) was observed from the control treatment. Treatment of 40 kg N ha^{-1} as basal + one irrigation at first flowering stage probably influenced plant to have good production of dry matter in early stage and that eventually raised and partitioned to the reproductive units. The irrigation also helped optimum seed development. These findings agreed well with Bachchhav *et al*. (1994) who found that application of 40 kg N ha^{-1} resulted with highest seed yield. Similar result was also found in bushbean (Ahlawat and Sharma, 1998) and in pea (Ferdous, 2001).

Table 2 Efficacy of integrated nitrogen and irrigation on the yield of blackgram

Treatments	Yield (g/plant)	Yield (t/ha)
T_1	6.96	1.24
T_2	7.34	1.31
T_3	9.50	1.69
T_4	8.96	1.59
T_5	9.76	1.74
T_6	8.29	1.47
T_7	10.45	1.86
T_8	7.41	1.32
T_9	7.69	1.37
T_{10}	8.50	1.51
LSD $_{(0.05)}$	**0.5315**	**0.1799**
CV (%)	3.64	6.88

4.11 Harvest Index (HI)

Both nitrogen and irrigation effect on harvest index was highly significant (Table 3). Higher HI might be beneficial in obtaining higher economic yield. A significant increase in HI was found in blackgram due to application of nitrogen and irrigation. The highest HI of 36.74% was observed in treatment 20 kg N/ha as basal and split 20 Kg N h^{-1} + one irrigation at first flowering stage (T_{10}) that similar with T_7,T_1,T_3 and $T_{2.}$ It was due to the increased dry matter accumulation, better root development resulting from higher partitioning of dry matter towards the production of economic yield. The lowest HI was observed at 30 kg N ha^{-1} as basal (T_4) and that was 30.03. Similar results were recorded in bushbean (Islam, 2001), in mungbean (Akhtaruzzaman, 1998) and in sesame (Roy *et al*, 1995).

Table 3 Efficacy of integrated nitrogen and irrigation on harvest index of blackgram

Treatments	**Harvest Index (%)**
T_1	35.21
T_2	34.40
T_3	34.66
T_4	30.03
T_5	33.23
T_6	33.65
T_7	35.77
T_8	31.95
T_9	31.36
T_{10}	36.74
LSD $_{(0.05)}$	**2.819**
CV (%)	4.88

4.12 Correlation and Regression Analyses

Correlation analysis showed that seed yield was positively correlated with branches per plant, pods per plant and 1000 seed weight & this was significant (Table 4).

The relationship between branches per plant, pods per plant, seeds per pod, seed yield were strongly positive, linear and significant (R^2=0.8034, R^2=0.8308 and R^2=0.7744 . respectively) (Figs.9, 10 and 11).

Table 4 Correlation among the yield contributing characters and yield of blackgram

Parameters	Branches/plant	Pods/plant	Seeds/pod	1000-seed weight (g)	Seed yield
Branches/plant	1.000	0.824**	0.724**	0.486**	0.905**
Pods/plant		1.000	0.778**	0.522**	0.769**
Seeds/pod			1.000	0.344NS	0.636
1000 seeds weight				1.000	0.445**
Seed yield					1.000

** Significant at 0.01 level.

* Significant at 0.05 level.

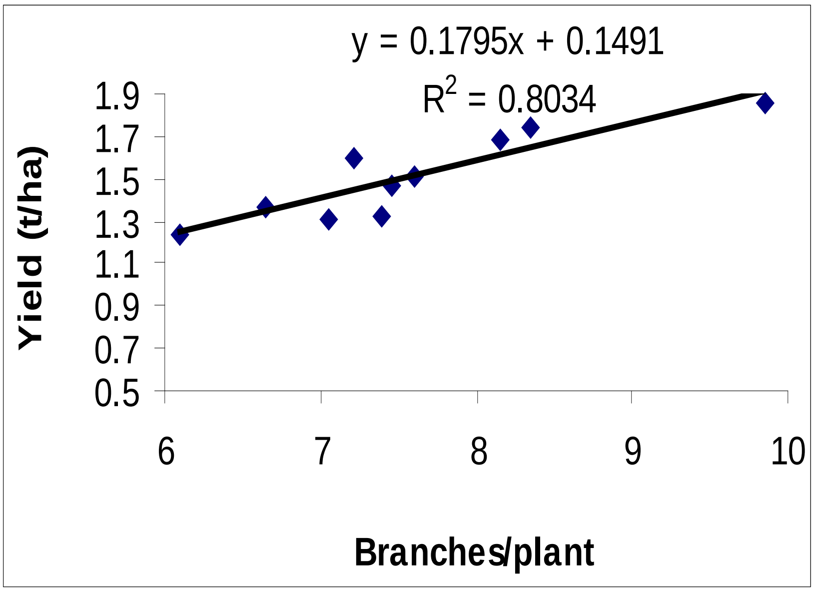

Fig. 9 Relationship between branches / plant and yield of blackgram

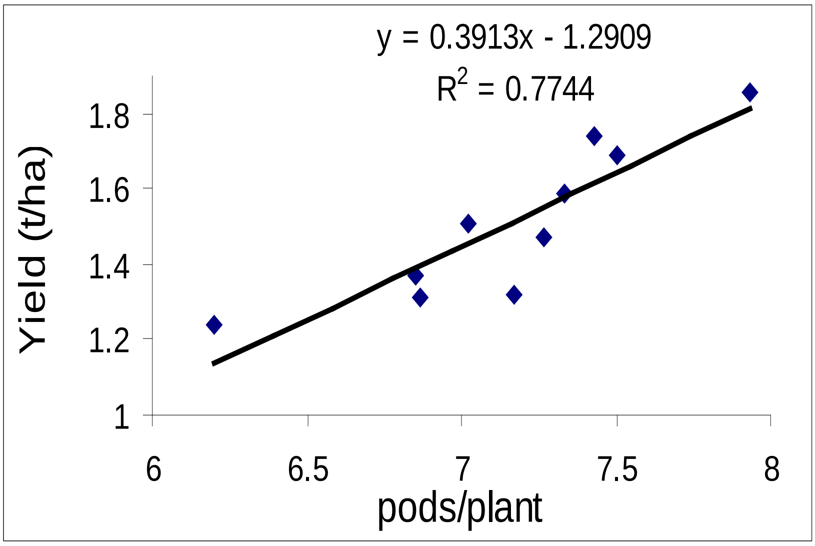

Fig. 10 Relationship between pods per plant and yield of blackgram

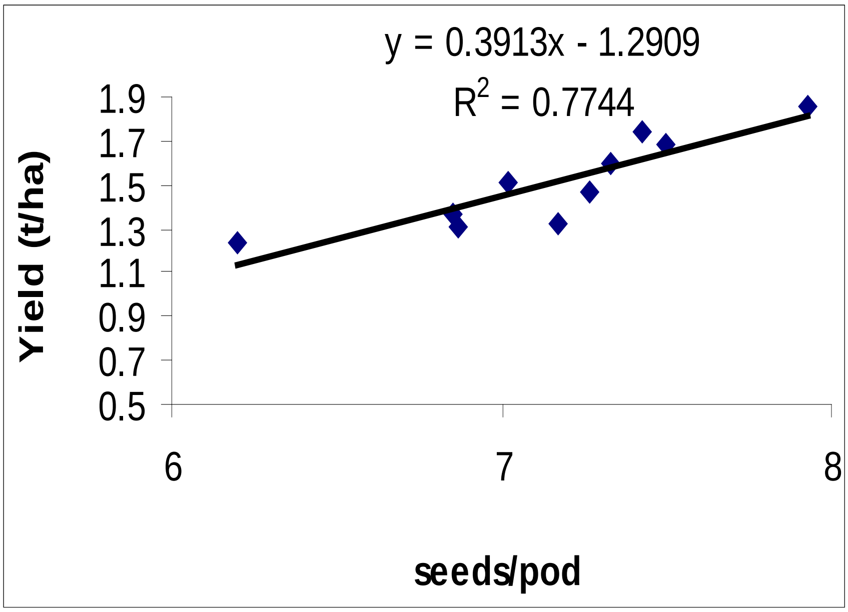

Fig. 11 Relationship between seeds/pod and yield of blackgram

CHAPTER 5

SUMMARY

The present experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka to study the efficacy of integrated nitrogen and irrigation management on the yield and yield attributes of blackgram (*Vigna mungo*) cv. BARI mash-3 during the period from March 2006 to May 2006. The trial comprised of ten treatments such as T_1= control, T_2=20 kg N ha^{-1} as basal, T_3=20 kg N ha^{-1} as basal with one irrigation at first flowering stage, T_4 =30 kg N ha^{-1} as basal, T_5=30 kg N ha^{-1} as basal with one irrigation at first flowering stage, T_6=40 kg N ha^{-1} as basal, T_7=40 kg N ha^{-1} as basal with one irrigation at first flowering stage, T_8=10 kg N ha^{-1} as basal and split 10 kg N ha^{-1} with one irrigation at first flowering stage, T_9=15 kg N ha^{-1} as basal and split 15 kg N ha^{-1} with one irrigation at first flowering stage and T_{10}=20 kg N ha^{-1} as basal and split 20 kg N ha^{-1} with one irrigation at first flowering stage.

The experiment was laid out in randomized complete block design (RCBD) with three replications. The size of unit plot was 3m x 2m.The land was fertilized with Triple Super Phosphate @ 100 kg and Murate of Potash 67 kg per hectare Nitrogen fertilizer was given following treatments. Blackgram cv. BARI mash-3 were sown on 9th March, 2006 and harvested on 18 May, 2006. Data on different growth and yield attributes were recorded and analyzed statistically following LSD test at 5% level.

The highest plant height were observed in each growth stage was found in T_7, which was significant while the lowest was found in $T_{1.}$ Plant height rapidly increased up to 40 DAS thereafter a slower rate of growth was noticed.

Nitrogen and irrigation application influenced the number of branches per plant in all treatments except control. Branches per plant were highest with T_7 in each sampling except 55 DAS and lowest with control. Number of branches per plant increased sharply from 40 DAS and continued up to 70 and after that no significant improvement was noticed at 85 DAS.

The highest number of leaves per plant was produced in T_7 and the lowest in control. Irrespective of treatment difference, number of leaves increased from 25 DAS to 55 DAS and thereafter leveled off.

Leaf dry matter was increased significantly from 25 DAS and then it rapidly increased up to 55 DAS and continued until harvest. T_7 was found superior to other treatments in accumulation of dry matter in leaf and T_1 was inferior.

The highest stem dry weight was produced in T_7 and the lowest in control. The increment continued until harvest at a slow rate. The second highest dry weights of stem were observed in T_5 at each growth stage and the lowest in control. Nitrogen and irrigation application showed significant variation in reproductive organ of blackgram. The maximum dry weight of reproductive organ was observed in T_7 followed by T_3 and T_5 and the lowest in control. The rest of the treatments were statistically more or less similar.

The above ground dry matter was significantly increased from 40 DAS to 85 DAS. Treatment T_7 showed the influence in producing greater above ground dry matter in all growth stages. Control treatment significantly gave minimum above ground dry matter throughout the life cycle of the plant. T_7, T_5 and T_3 gave significantly highest number of pods per plant, which were statistically similar while control gave the lowest.

The number of seeds per pod was significantly affected by nitrogen and irrigation. The highest number of seeds per pod was recorded from treatment T_7 The highest 1000 seed weight was recorded from treatment T_7 and the lowest was from the control.

The highest seed yield per plant and the total seed yield were observed in T_7 that was 10.45 g/plant and 1.86 t/ha respectively. The lowest yields were recorded from the control, which were 6.97 g/plant and 1.24 t/ha respectively.

The highest harvest index was observed in T_{10} and the lowest in T_4.The relation between branches per plant, pods per plant, seeds per pod, and seed yield were positive and linear.

CONCLUSION

Reviewing the results of the present study, it may be concluded that blackgram plant has a great demand of nitrogen nutrition during its reproductive development and it is optimized with irrigation. Application of nitrogen (Basal 40 kg/ha with one irrigation during first flowering stage) seems to be optimum for satisfactory growth characters, yield and yield attributes and of blackgram. The yield increment is the resultant effect of greater production of dry matter which optimally partitioned to the economic part (seed) blackgram.

This was a one year experimental observation. This trial could be tested for couple of years in different agro ecological zone of Bangladesh for precise recommendation.

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APPENDICES

Appendix I. The mechanical and chemical characteristics of soil (0-15cm)of the experimental site as observed prior to experimentation

Mechanical composition:

Particle size constitution

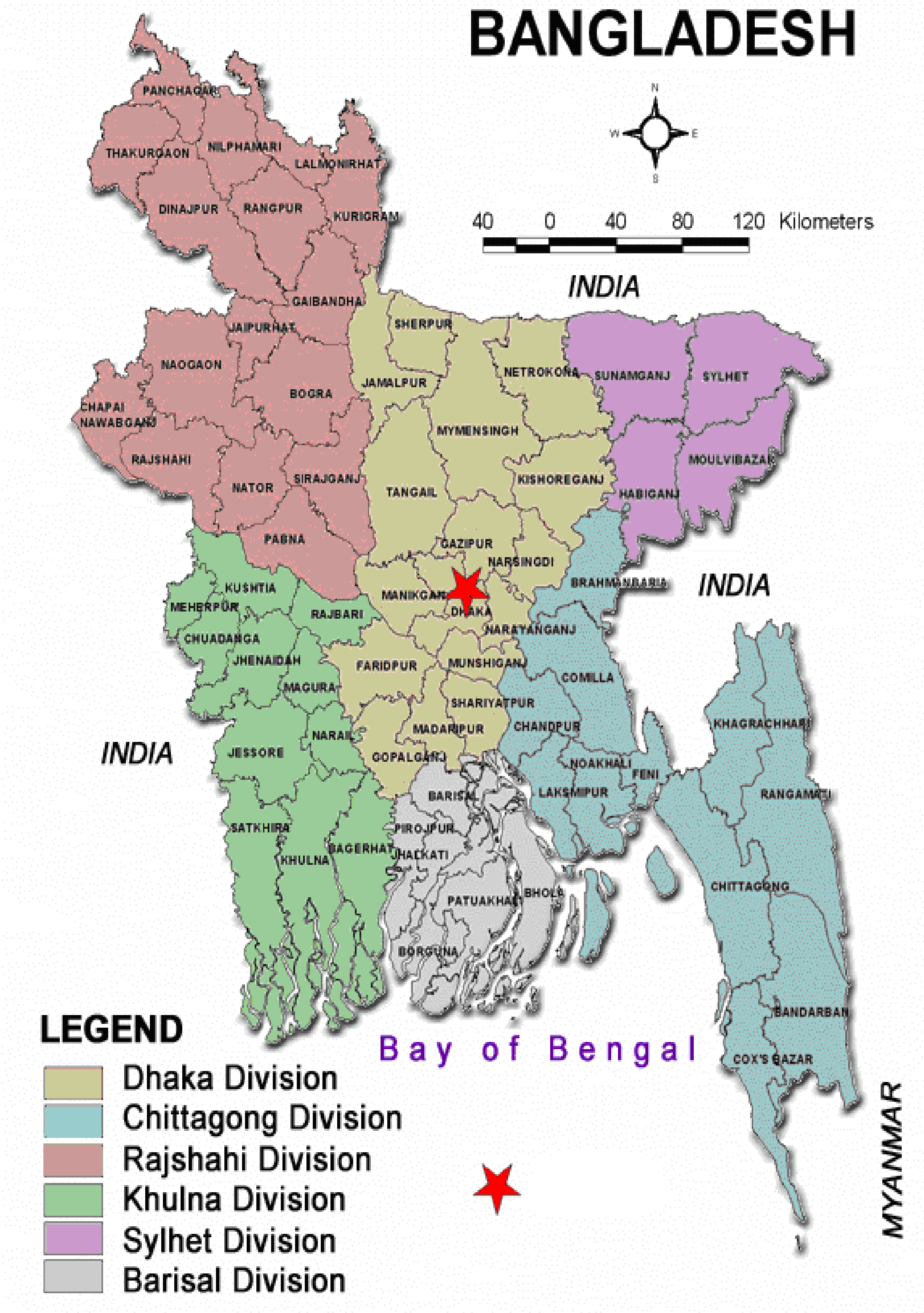
Sand	:	26%
Silt	:	45%
Clay	:	29%
Texture	:	Silty clay
pH	:	5.6

Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.07
Phosphorus	22.08 µg/g soil
Sulphur	25.98 µg/g soil
Magnesium	1.00 meq/100 g soil
Boron	0.48 µg/g soil
Copper	3.54 µg/g soil
Zinc	3.32 µg/g soil

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

Appendix II. Experimental location on the map of Agro-ecological Zones of Bangladesh


BANGLADESH
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INDIA
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MYANMAR
Bay of Bengal
PANCHAGAR
THAKURGAON
NILPHAMARI
LALMONIRHAT
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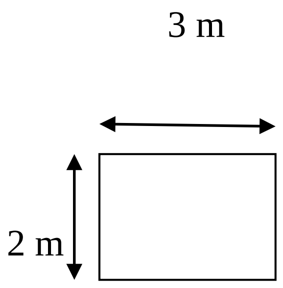
RANGPUR
KURIGRAM
GAIBANDHA
JAIPURHAT
NAOGAON
BOGRA
CHAPAI NAWABGANJ
RAJSHAHI
NATOR
SIRAJGANJ
PABNA
SHERPUR
JAMALPUR
NETROKONA
MYMENSINGH
KISHOREGANJ
TANGAIL
GAZIPUR
NARSINGDI
MANIKGANJ
DHAKA
NARAYANGANJ
MUNSHIGANJ
FARIDPUR
SHARIYATPUR
MADARIPUR
GOPALGANJ
RAJBARI
SUNAMGANJ
SYLHET
MOULVIBAZAR
HABIGANJ
BRAHMANBARIA
COMILLA
CHANDPUR
NOAKHALI
FENI
LAKSMIPUR
KHAGRACHHARI
RANGAMATI
CHITTAGONG
BANDARBAN
COX'S BAZAR
KUSHTIA
MEHERPUR
CHUADANGA
JHENAIDAH
MAGURA
NARAIL
JESSORE
SATKHIRA
KHULNA
BAGERHAT
BARISAL
PIROJPUR
JHALKATI
PATUAKHALI
BHOLA
BORGUNA
LEGEND
Dhaka Division
Chittagong Division
Rajshahi Division
Khulna Division
Sylhet Division
Barisal Division

Appendix III. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from February 2006 to May 2006.

Year	Month	Air temperature (^{0}C)			Relative humidity (%)	Rainfall (mm)	Sunshine (h)
		Maximum	Minimum	Mean			
2006	February	21.26	19.43	20.34	51.27	0	148
	March	36.2	22	29.1	46.13	0	155
	April	33.74	23.81	28.77	61.4	185	253
	May	32.5	24.95	28.72	64.27	180	96

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

APPENDIX –IV. Experimental layout



Plot size: 3 m×2 m
Between Plot: 1m
Between replication: 1.5 m