RESPONSE OF CHICKPEA (*Cicer arietinum* L.) TO INTEGRATED NITROGEN AND IRRIGATION MANAGEMENT

BY

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CERTIFICATE

This is to certify that the thesis entitled, **"RESPONSE OF CHICKPEA (*Cicer arietinum* L.) TO INTEGRATED NITROGEN AND IRRIGATION MANAGEMENT"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **Md. Shariful Islam,** Registration No. **27551/00717** under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 26.12.07

Dhaka, Bangladesh

(Prof. Dr. Md. Fazlul Karim)

Supervisor

Dedicated To

My Beloved Parents

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RESPONSE OF CHICKPEA (*Cicer arietinum* L.) TO INTEGRATED NITROGEN AND IRRIGATION MANAGEMENT

ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka to study the response of chickpea (*Cicer arietinum* L.) cv. BARI chhola-5 to integrated nitrogen and irrigation management during the period from November 2006 to March 2007. The trial comprised of ten treatments as T_1 = no fertilizer and no irrigation (control), T_2 = 20 kg N ha^{-1} as basal without irrigation, T_3 = 20 kg N ha^{-1} as basal with one irrigation at flower initiation stage, T_4 = 30 kg N ha^{-1} as basal without irrigation , T_5 = 30 kg N ha^{-1} as basal with one irrigation at flower initiation stage, T_6 = 40 kg N ha^{-1} as basal without irrigation, T_7 = 40 kg N ha^{-1} as basal with one irrigation at flower initiation stage, T_8 = 10 kg N ha^{-1} as basal and 10 kg N ha^{-1} as split with one irrigation at flower initiation stage, T_9 = 15 kg N ha^{-1} as basal and 15 kg N ha^{-1} as split with one irrigation at flower initiation stage and T_{10} = 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} as split with one irrigation at flower initiation stage. N fertilization with irrigation management generally increased yield and yield components on chickpea. An application of 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} as split application with one irrigation at flower initiation stage (55 DAS) of chickpea tended to produce better performance and gave higher yield. Plants grown without nitrogen fertilizer and irrigation (control) gave the lowest yield.

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SOME COMMONLY USED ABBREVIATIONS

Abbreviation		Full Word
AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
BSMRAU	=	Bangabandhu Shake Mujzibur Rahman Agricultural University
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%	=	Percent coefficient of variance
Hr	=	Hour
t	=	ton
DM	=	Dry matter

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Pulses occupy a unique position in the world of agriculture by virtue of their high protein content and capacity for fixing atmospheric nitrogen. Amongst grain legumes, chickpea is unique because of its nutritional quality, which depends on its protein concentration, amino acid makeup and protein digestibility. Chickpea (*Cicer arietinum* L.) as an intercrop play an important role in the cropping pattern in Bangladesh.

Chickpea is a temperate crop though it is well adapted in tropical and sub-tropical conditions (Kay, 1979). In the tropics and sub-tropics, chickpea is normally sown in the post monsoon i.e. during rabi season. In Bangladesh, chickpea is grown on well drained alluvial to clay loam soils having pH ranging from 6.0 to 7.0. It can not be cultivated successfully in poorly drained lowland.

Chickpea is the most important pulse crop in Bangladesh after grasspea and lentil occupying third position in terms of acreage (13765 ha) and production (10,000 M ton) and contributes about 20% of the total pulses. The average yield of chickpea is 726 kg ha^{-1} (BBS, 2006).

The acreage of chickpea cultivation in Bangladesh is decreasing due to less return as compared to other crops and also due to increase in area under boro rice, maize and potato cultivation (BBS, 2004). The increasing gap between production and demand of pulses in Bangladesh has resulted in chronic problem of malnutrition mainly due to protein deficiency.

The increase in area under chickpea is not possible as it will have a direct impact on other major crops. So proper management should be adapted to increase the per hectare yield of chickpea. The average yield of chickpea is very poor in comparison to chickpea producing countries of the world. There are many reasons of lower yield of chickpea of which management of fertilizer is the important one that greatly affects the growth, development and yield of chickpea. It although fix nitrogen from atmosphere, but evident are those that nitrogen application become helpful to increase the yield (Vadavia *et al.*, 1991; Patra *et al.*, 1989; Chaudhari *et al.*, 1998 and Khan *et al.*, 1992). Nitrogen is most useful for pulse crops as a component of protein (BARC, 1997).

Fertilizer management especially with nitrogen, phosphorus and sulpher produced seeds with high level of protein and amino acids in chickpea (Gupta and Singh, 1982).

On the other hand, chickpea is a deep rooted crop that extracts water from deep layers when the surface water is depleted. Still it is grown in rabi season when lack of water becomes a serious restriction to crop production. Rainfall is very limited and unpredictable in this season. None can take the risk of growing crops successfully under rain fed condition. So, irrigation at responsive stage, of the crop becomes necessary to ensure optimum yield of the crop. In areas where irrigation facility exists farmers often misuse water by over irrigation or sometimes under irrigation due to their ignorance on water requirement of specific crops for a particular location. Saraf *et al.* (1990) stated that excess and deficient moisture conditions both are detrimental and reduce yield of chickpea.

Hence, an experiment was carried out to maximize the yield of chickpea with optimum N and irrigation management. Considering the above facts, the present work was conducted with the following objectives:

- to find out the optimum dose of N in chickpea cultivation.
- to determine the irrigation requirement for optimum yield of chickpea.
- to study the importance of application of N fertilizer and irrigation at flower initiation stage of chickpea for maximum yield attributes and yield harvest.

Chapter 2

Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

Chickpea is an important pulse crop in Bangladesh which can contribute largely in the national economy. In Bangladesh, chickpea crop is generally grown without fertilizer and irrigation. However, there are evidences that the yield of chickpea can be increased substantially by using fertilizers and irrigation (Dahiya *et al.,* 1989 and Katare *et al.,* 1984). There are also controversies regarding the rates of N and time of irrigation application in chickpea. Information on fertilizer and irrigation managements of chickpea related to the study are reviewed and presented in the following heads.

2.1 Influence of nitrogen fertilizers

2.1.1 Plant height

Arvadia and Patel (1988) observed stimulatory effect of nitrogen or phosphorus alone at the rate of 25 kg ha^{-1} on the growth of chickpea plants. They also reported appreciable increase in the plant height than those in control plots. Application of phosphorus alone at the rate of 50 kg ha^{-1} did not show any significant effect on plant height over 25 kg P ha^{-1} wheras Patra *et al.* (1989) noticed increased plant height of chickpea over control with 20 kg N along with 40 kg P ha^{-1}.

Rathore and Patel (1991) noticed that application of 18 kg N along with 46 kg P ha^{-1} increased plant height of chickpea over no N application.

Chaudhari *et al.* (1998) found a positive effect of nitrogen at the rate of 20 and 40 kg ha^{-1} on increased in chickpea plant height.

Vadavia *et al.* (1991) noticed that application of 20 kg ha^{-1} N and 40 kg P ha^{-1} increased plant height of chickpea significantly over no N and P application.

Dahiya *et al.* (1993) reported increased in plant height of chickpea using N and P at the rate of 18-27 and 46-69 kg ha^{-1} respectively.

2.1.2 Number of branches $plant^{-1}$

Dahiya *et al.* (1993) reported that application of 18-27 kg N and 46-69 kg P ha^{-1} increased number of branches $plant^{-1}$ in chickpea.

Rathore and Patel (1991) found that the doses of 18 kg N and 46 kg P ha^{-1} were most effective in increasing the number of branches $plant^{-1}$ of chickpea.

Chaudhari *et al.* (1998) found a positive effect of nitrogen at the rate of 20 and 40 kg ha^{-1} on increased in chickpea number of primary and secondary branches $plant^{-1}$.

Vadavia *et al.* (1991) reported that application of 20 kg N ha^{-1} and 40 kg P ha^{-1} increased number of branches $plant^{-1}$ of chickpea.

2.1.3 Number of pods $plant^{-1}$

Patra *et al.* (1989) noticed that number of pods $plant^{-1}$ of chickpea increased over control with 20 kg N along with 40 kg P ha^{-1}.

Rathore and Patel (1991) observed that maximum number of pods $plant^{-1}$ when chickpea was provided with 18 kg N along with 46 kg P ha^{-1}.

Chaudhari *et al.* (1998) found a positive effect of nitrogen at the rate of 20 and 40 kg ha^{-1} on increased in chickpea pods per plant and protein content in seed over control.

Karadavut and Ozdemir (2001) conducted a field trial on *Rhozobium sp*. and nitrogen on chickpea cultivers. They found that *Rhizobium* inoculation and 30 kg N ha^{-1} significantly increased pods $plant^{-1}$.

Vadavia *et al.* (1991) found that number of pods $plant^{-1}$ of chickpea increased following application of 20 kg N ha^{-1} and 40 kg P ha^{-1}.

Bhopal and Singh (1990) conducted an experiment with the semi dwarf gardenpea cv. Lincoln, which received N at the rate of 0, 20, 40 and 60 kg ha^{-1}, P_2O_5 at 0, 30, 60 and 90 kg ha^{-1} and K_2O at 30 kg ha^{-1}. They concluded that increasing N rates up to 40 kg ha^{-1} increased green pod yield. Further addition of nitrogen (60 kg ha^{-1}) tended to decrease the yield.

Khan *et al.* (1992) reported that the application of 20 kg N + 50 kg P_2O_5 ha^{-1} in chickpea produced significantly higher number of pods $plant^{-1}$.

Vijai *et al.* (1990) carried out an experiment with gardenpea cv. Bonneville on N or P. They found that increasing rates of N or P up to 40 kg ha^{-1} significantly increased pod yield.

Negi (1992) carried out an experiment with 4 levels of N (10, 20, 40, 60 kg ha^{-1}) and 3 of P_2O_5 (0, 60, 120, kg ha^{-1}) on vegetable pea. He reported that the application of 20 kg ha^{-1} gave the highest green pod yield. A combination of 20 kg N and 60 kg P_2O_5 ha^{-1} also produced the higher yield (1.72 t ha^{-1}).

2.1.4 Number of seeds pod^{-1}

Patra *et al.* (1989) noticed in chickpea increased number of seeds pod^{-1} over control with 20 kg N along with 40 kg P ha^{-1}.

Rathore and Patel (1991) performed an experiment on chickpea with different levels of nitrogen and phosphorus fertilizers. They reported that application of 18 kg N along with 46 kg P ha^{-1} resulted with significant increase in the chickpea seeds pod^{-1}.

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. They found that number of seeds pod^{-1} was significantly affected by varying levels of nitrogen and phosphorus.

2.1.5 1000-seed weight

Patra *et al.* (1989) reported that when 20 kg N along with 40 kg P ha^{-1} were applied, it increased 1000-seed weight of chickpea over control.

Rathore and Patel (1991) reported that application of 18 kg N ha^{-1} along with 40 kg P ha^{-1} increased 1000-seed weight.

Vadavia *et al.* (1991) found that seed weight increased following application of 20 kg N ha^{-1} and 40 kg P ha^{-1} of chickpea.

2.1.6 Seed yield

Khokar and Warsi (1987) reported maximum seed yield in chickpea with application of 18 kg N ha^{-1}. On the other hand, Patel *et al.* (1989) observed no significant yield variation in chickpea with the application of 15-30 kg N ha^{-1}.

Arvadia and Patel (1988) observed stimulatory effect of nitrogen or phosphorus alone at the rate of 25 kg ha^{-1} on chickpea plants and reported appreciable increased in seed yield than those in control plots. They also found application of phosphorus alone at the rate of 50 kg ha^{-1} showed no additional improvement of that parameter over 25 kg P ha^{-1}.

Dahiya *et al.* (1989) noted an increase in seed yield in chickpea over control with the application of N, P and K at the rate of 20, 40 and 20 kg ha^{-1} respectively.

Patra *et al.* (1989) conducted an experiment on chickpea with different N and P rates. They stated that application of 20 kg N and 40 kg P ha^{-1} increased grain yield of chickpea. Application of 25 kg N +50 kg P ha^{-1} gave the highest yield in the experiment of Javiya *et al.* (1989).

Rathore and Patel (1991) noticed that application of 18 kg N along with 46 kg P ha^{-1} increased seed yield of chickpea by 28.7% over no N application.

Reddy and Ahlawat (1998) noticed that application 18 kg N, 46 kg P and 5.25 kg Zn ha^{-1} increased grain and straw yield of chickpea. They also found increase in nitrogen, phosphorus and zinc uptake by plants leading to increase in protein yield.

Chaudhari *et al.* (1998) conducted a field trial with chickpea grain with different rates of N and P fertilizer. They found a positive effect of nitrogen at the rate of 20 and 40 kg ha^{-1} on the growth and yield of chickpea. Wheras Chaudhari *et al.* (1975) observed chickpea yield as not affected by seed inoculation and application of 25 kg N ha^{-1}.

Vadavia *et al.* (1991) found significant higher seed yield of chickpea following application of 20 kg ha^{-1} N and 40 kg P ha^{-1}. Application of 20 kg N ha^{-1} increased grain yield of chickpea reported by Subba Rao *et al.* (1986).

Shamim and Naimat (1987) reported that application of 10 kg N + 75 kg P_2O_5 ha^{-1} to *Cicer arietinum* cv. C-727 increases seed yields cover uninoculated seed from 583 to 878 kg ha^{-1}.

Tomar and Sharma (1985) obtained highest seed yield in chickpea of two consecutive years with the application of N, P and K at the rate of 20, 40 and 20 kg ha^{-1} respectively over control. Similar result was obtained by Rawal and Yadava (1986) using those fertilizers at the same rate.

Dahiya *et al.* (1993) noticed higher seed yield in chickpea over control while using N and P at rate of 18-27 and 46-69 kg ha^{-1} respectively. Khan *et al.* (1992) also reported that application of N and P increased grain yield of chickpea significantly over no N and P application. The application of 20 kg N + 50 kg P_2O_5 ha^{-1} resulted with significant increase in the chickpea yield.

2.1.7 Straw yield

Vadavia *et al.* (1991) found that application of 20 kg ha^{-1} N and 40 kg P ha^{-1} increased significant straw yield of chickpea. Subba Rao *et al.* (1986) also reported that the rate of 20 kg N ha^{-1} was most effective in increasing straw yield.

2.1.8 Biological yield

Karadavut and Ozdemir (2001) stated the application of *Rhizobium sp.* and 30 kg N ha^{-1} on 3 chickpea cultivars in the winter season of 1995-96 and 1996-97 significantly increased pods $plant^{-1}$.

Khan *et al.* (1992) reported from his study that biological yield of chickpea increased significantly with 20 kg N + 50 kg P_2O_5 ha^{-1}.

2.1.9 Harvest index

Harvest index may be influenced by N fertilization. Chaudhari *et al.* (1998) found that application of 20-40 kg N ha^{-1}significantly influenced harvest index of chickpea.

Islam (2003) found a significant increase in harvest index in bush bean due to application of N. The lowest HI was in control and the maximum was at 36.8 kg N ha^{-1}.

2.2 Influence of irrigation

It is well established that the effects of water stress on growth and yield depend both on the degree of stress and on the stage of growth at which the stress occurs.

Katare *et al.* (1984) reported that seed yields of *Cicer arietinum* with 1, 2, 3, and 4 irrigations were increased by 25, 31, 50 and 51%, respectively.

Watanabe *et al.* (1986) observed in an experiment that *Vigna radita* cv. SPRI and soybeans cv. SJ 4 were irrigated 8 and 12 times. The irrigation treatment increased pod number hill^{-1} and 1000-seed weight.

Giriappa (1971) studied that in lateritic sandy loam soils, two irrigations of 6 cm depth each at flowering and pod development stages were the best for growth, dry matter production, grain yield and grain protein content of lentil.

Petersen (1989) reported that water stress reduced pods plant^{-1} and mean seed weight in *Phaseolus vulgaris* and pods plant^{-1} and seeds pod^{-1} in *Lens culinaris*.

Bhan (1977) found that two or three irrigations given at four to six leaf/branches, flower/pod formation stages showed high yield of lentil.

Siowit and Kramer (1977) observed in soybean that the maximum reduction in yield due to moisture stress during grain 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.

Michael (1985) found that the plant height, branches plant^{-1}, pods plant^{-1} and 1000-grain weight increased significantly with one irrigation and three irrigations reduced the grain yield, 1000-grain weight, grain protein content and nodulation in lentil.

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.

Sadasivam *et al.*, (1988) reported that stress during vegetative phase reduced 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 by Provakar and Suraf (1991) in chickpea and Rajput *et al.* (1991) in soybean.

Lopes *et al.* (1988) reported that moisture deficiency resulted in lower number of leaves, pods plant^{-1}, reduced plant height, root ratio in *Phaseolus vulgaris.* Pannu and Singh (1988) demonstrated the total dry matter as well as grain yields were affected by moisture stress in mungbean.

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.

Rathi *et al.* (1995) found that most critical growth stage for moisture stress in lentil is flowering initiation of followed by pod formation. In case of failure of winter rains, 1 to 2 irrigations are required for enhanced productivity of the crop. The importance of irrigation is increased under late planting of the crop due to poor root developments.

Rajput *et al.* (1991) reported the higher grain yield and yield components of soybean due to irrigation application. Similar result was reported by Rahman *et al.* (2000) in edible pea and Javiya *et al.* (1989) in gram.

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.

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

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

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 the flowering stage substantial yield reduction was obvious. Variation in yields resulted from difference in number of pods m^{-2} and small seed size.

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

Irrigation increased pigeonpea yield by 97% while drought prevails during the reproductive phase which found the major yield-limiting factor (ICRISAT, 1986). Frick and Pinolato (1987) found that the deleterious effects of drought stress imposed at flowering reduced photosynthetic leaf area that affected directly the grain yield of chickpea.

Petersen (1989) reported that water stress reduced pods $plant^{-1}$ and mean seed weight in *Phaseolus vulgaris* and pods $plant^{-1}$, seeds pod^{-1} in *Phaseolus acutifolius.* Similar results were reported by Lopes *et al.* (1988) in lentil.

Khade *et al.* (1990) found highest number of pods $plant^{-1}$, seeds pod^{-1} and seed yield with 3 irrigations in field pea.

Viera *et al.* (1991) reported the yield reduction of 35% when drought stress was imposed during seed filling but found no effect on germination or vigour in soybean seeds.

Nandan and Prasad (1998) reported that grain yield and net returns were higher with 3 irrigations than with 1 and 2 irrigations in frenchbean (Provakar and Suraf, 1991).

Biswas (2001) reported that irrigation frequency exerted a remarkable impact on yield of fieldbean. Application of 3 irrigations increased vegetable 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^{-1} seeds pod^{-1} and pod length with higher frequency of irrigation.

Dumbre and Deshmidkh (1983) studied on gram and reported that presowing irrigation with or without further irrigation, at 45 and 75 days after sowing on yield of gram cv. Phule Gl. Chafa and N-59 in 1980-82. Yield were significantly higher with pre sowing irrigation + irrigation at 45 and 75 days than with presowing irrigation alone.

Singh (1991) studied with chickpea cv. JG 74 in a field experiment and stated that water deficits before flowering decreased canopy development, light interception and dry matter production.

Abdalla (1987) carried out an experiment having different irrigation levels on lentil cv. Giza 9. He reported that increasing the number of irrigations increased the number of pods plant^{-1} and seed yield.

It was noted from reviewing above works that chickpea yield can be increased substantially by the application of nitrogen along with irrigation.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

In this chapter, the details of different materials used and methodology followed during the experimentation have been presented.

3.1 Experimental site

The research work was carried out at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from November, 2006 to March 2007.

3.2 Soil

Initial soil samples from 0-15 cm depth were collected from experimental field. The collected samples were analyzed at Soil Resources Development Institute (SRDI), Dhaka, Bangladesh. The soil was silty clay in texture having 26% sand, 45% silt and 29% clay and the pH was 5.6. The physio-chemical properties of the soil are presented in Appendix I. The experimental site belongs to the Madhupur Tract Agro Ecological Zone (AEZ-28) as shown in Appendix II.

3.3 Climate

The experimental area belongs to subtropical climatic zone which is characterized by moderately high temperature and heavy rainfall in summer and moderately low temperature and scanty rainfall in winter. Meteorological data during the crop growing period are shown in Appendix-III.

3.4 Planting material

The variety of chickpea used in this experiment was the BARI chhola-5. The seeds were collected from the Pulses Research Centre of Bangladesh Agricultural Research Institute (BARI). 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 the variety is mentioned below.

3.4.1 BARI Chhola-5

The variety was developed from BARI which released in 1996. The plant attains a height of 45-50 cm, the leaves are light green and its total growth duration is about 125-130 days. Seeds are small and dark brown in color and 1000-seed weight is 110-120 g. Seed contains 20-22% protein and 54-55% carbohydrate. Potential grain yield of the cultivar is 1.8-2.0 t ha^{-1}.

3.5 Land preparation

The land was irrigated before ploughing. After having zoe condition the land was 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. Experimental land was divided into unit plots following the design of experiment.

3.6 Fertilizer application

A fertilizer dose of 17 kg P ha^{-1} as triple super phosphate (TSP), 18 kg K ha^{-1} as muriate of potash (MOP), 7.19 kg S ha^{-1} as gypsum and1 kg B ha^{-1} AS boric acid were applied as basal at the time of final land preparation and incorporated well into the soil. Nitrogen in the form of urea was applied as per treatment.

3.7 Treatments of the experiment

The study comprised the following treatments:

T_1 = No fertilizer and no irrigation (Control)

T_2 = 20 kg N ha^{-1} as basal application without irrigation

T_3 = 20 kg N ha^{-1} as basal application with one irrigation at flower initiation stage

T_4 = 30 kg N ha^{-1} as basal application without irrigation

T_5 = 30 kg N ha^{-1} as basal application with one irrigation at flower initiation stage

T_6 = 40 kg N ha^{-1} as basal application without irrigation

T_7 = 40 kg N ha^{-1} as basal application with one irrigation at flower initiation stage

T_8 = 10 kg N ha^{-1} as basal application and split 10 kg N ha^{-1} with one irrigation at flower initiation stage

T_9 = 15 kg N ha^{-1} as basal application and split 15 kg N ha^{-1} with one irrigation at flower initiation stage

T_{10} = 20 kg N ha^{-1} as basal application and split 20 kg N ha^{-1} with one irrigation at flower initiation stage

3.8 Design of experiment

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The size of each unit plot was 4.0 m × 2.5 m = 10.0 m^2. The distance between two adjacent replications (block) was 1.5 meter and plot-to-plot distance was 1 meter. The intra block and plot spaces were used for irrigation and drainage channels. A layout of the experiment has been shown in Appendix IV.

3.9 Germination test

Germination test was performed before seed sowing in the field. Three layers of filter papers 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

The seeds of chickpea were sown on November 28, 2006. Seeds were treated with Bavistin @ 2.5 g kg^{-1} seed before sowing to control the seed borne disease. The seeds were sown in furrows having a depth of 2-3 cm maintaining a distance of 40 cm in between rows.

3.11 Intercultural operations

3.11.1 Thinning

Seeds were germinated six days after sowing. Thinning was done two times, first thinning was done at 8 DAS and the second 15 DAS following 10 cm seedling to seedling distance to maintain proper plant population in each plot (333333 plants ha^{-1}).

3.11.2 Irrigation, weeding and mulching

Irrigation was done as per treatment following flood irrigation. The crop field was weeded two times during the growing period of crop. The first weeding was done at 20 DAS and the second 45 DAS. Mulching was done after irrigation.

3.11.3 Protection against insect and pest

The crop was attacked by pod borer (*Helicoerpa armigera*) which was controlled by applying Ripcord at the rate of 1 ml/ litre water.

3.12 Crop sampling and data collection

Ten plants from each treatment were randomly sampled and marked with sample card. The data of plant height and number of branches plant^{-1} were recorded from sampled plants at an interval of thirty days which was started from 30 DAS.

3.13 Harvest and post harvest operations

Harvesting was done when 90% of the seed became dark brown in color. The matured crops were harvested from a pre-demarcated area of six linear at the center of each plot. Number of pods plant^{-1}, seeds pod^{-1}, 1000-seed weight and seed yield plant^{-1} were recorded from harvested plants. The seeds were collected from the harvested plants to dried properly under sun and then the seed weight was taken.

3.14 Data collection

The following data were recorded

i. Plant height (cm)

ii. Number of branches plant^{-1}

iii. Number of pods plant^{-1}

iv. Number of seeds pod^{-1}

v. 1000- seed weight (g)

vi. Seed yield (t ha^{-1})

vii. Straw yield (t ha^{-1})

viii. Biological yield (t ha^{-1})

ix. Harvest index (%)

3.15 Procedure of data collection

3.15.1 Plant height (cm)

The height of ten randomly selected plants were measured with a meter scale from the ground level to the top of the plants. The height of each plant was recorded in cm the mean values of ten plants for each plot determined.

3.15.2 Number of branches $plant^{-1}$

The numbers of branches were counted from ten plants. The average number of branches $plant^{-1}$ was determined.

3.15.3 Number of pods $plant^{-1}$

Number of total pods plant`1 from ten randomly selected plants of each plot was counted and the mean was determined as $plant^{-1}$ basis.

3.15.4 Number of seeds $pods^{-1}$

The number of seeds in each pod was also recorded from twenty randomly selected pods at the harvest and was expressed on pod^{-1} basis.

3.15.5 Weight of 1000-seed (g)

One thousand cleaned dried seeds were counted randomly from each individual treatment and weighed by a digital electric balance and weight was expressed in gram.

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

The seeds collected from 2.4 m^2 of each plot cleaned, dried and weighed separately. Grain yield of each plot was recorded kg ha^{-1} individually and adjusted at 12% moisture content.

3.15.7 Straw yield (t ha^{-1})

The straw yield of the harvested crop in each plot was sun dried to a constant weight. Then the straws were weighed and thus the straw yield $plot^{-1}$ was determined. Total weight of each plot was taken in kilograms and converted into tons ha^{-1}.

3.15.8 Biological yield (t ha^{-1})

Grain yield and straw yield are altogether regarded as biological yield.

3.15.9 Harvest index (%)

The harvest index was calculated by using the following formula

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

3.16 Statistical analysis

The collected data on different parameters were statistically analyzed to obtain the level of significance using the MSTAT-computer package program developed by Russell (1986). The mean difference among the treatments were adjusted by using Least Significant Difference (LSD) test at 0.05 level of significance.

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

Present experiment was conducted with different doses of nitrogenous fertilizer and levels of irrigation to study their effects on chickpea. The results regarding the effect of nitrogen and irrigation on different yield attributes and yield of chickpea are presented in this chapter.

4.1 Plant height

Plant height in response to nitrogen and irrigation management over time have shown in Fig.1. Plant height increased progressively over time attaining the highest at 90 DAS and then growth was slow until harvest. The rate of increase, however, varied depending on the growth stages. Significant variation in plant height was observed due to nitrogen and irrigation management except at 30 DAS (Appendix V). The influence of different levels of nitrogen and irrigation was first apparent at 60 DAS and the difference among them persisted throughout the growth period. Tallest plant was obtained from T_{10} treatment which was statistically similar to that of T_3, T_5, T_7, T_8 and T_9 treatments irrespective of growth stages while the shortest in T_1 treatment.

It was revealed that both nitrogen and irrigation application probably influenced cell division or cell elongation of chickpea plants, thus the plant height was increased. Similar results were reported for mungbean by Trung and Yoshida (1983), and Quash and Jafar (1994). Nitrogen also positively increased the plant height in chickpea (Patra *et al.*, 1989, Rathore and Patel, 1991 and Arvadia and Patel, 1988).

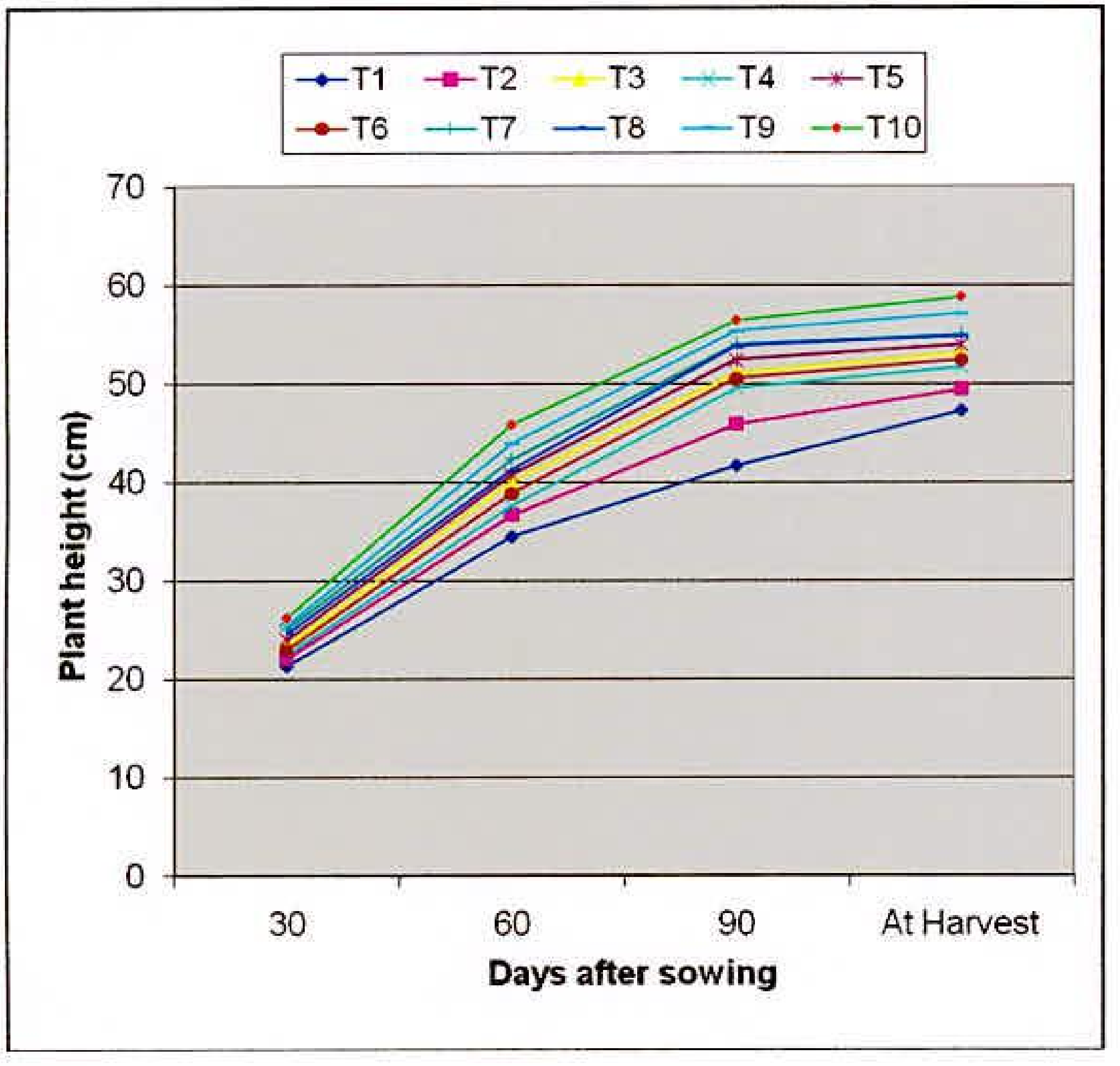

Fig. 1 Effect of integrated nitrogen and irrigation management on plant height of chickpea ($LSD_{0.05}$ = NS, 4.293, 5.447 and 5.287 at 30 DAS, 60 DAS, 90 DAS and harvest, respectively)

4.2 Number of branches plant^{-1}

Number of branches plant^{-1} with different levels of nitrogen fertilizer and irrigation showed significant differences over the growth stages (Appendix vi). Regardless of treatment differences number of branches plant^{-1} increased sharply reaching peak at 60 DAS and then it was evident slow upto harvest (Fig. 2). The rate of increased, however, varied depending on the growth stages. In the beginning of the growth cycle, the difference in number of branches plant^{-1} due to N fertilizer and irrigation was less conspicuous but over time the difference was widened. A rapid growth followed after 30 DAS that continued till at harvest irrespective of N and irrigation application. The plants grown with 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} as split application and one irrigation at flower initiation stage (T_{10}) produced maximum branches plant^{-1} at all growth stages followed by T_7, T_8 and T_9 treatments. It was revealed that Nitrogen enhanced the vegetative growth of chickpea and irrigation also increased cell division of chickpea plants, thus the number of branches plant^{-1} was increased. Similar results were noticed by Ferdous (2001) in pea. The increased in number of branches plant^{-1} of chickpea due to N fertilization was also reported by Chaudhari *et al.* (1998), Rathore and Patel (1991), Vadavia *et al.* (1991) and Dahiya *et al.* (1993). On the contrary, the plants grown without N and irrigation produced the lowest branches plant^{-1}.

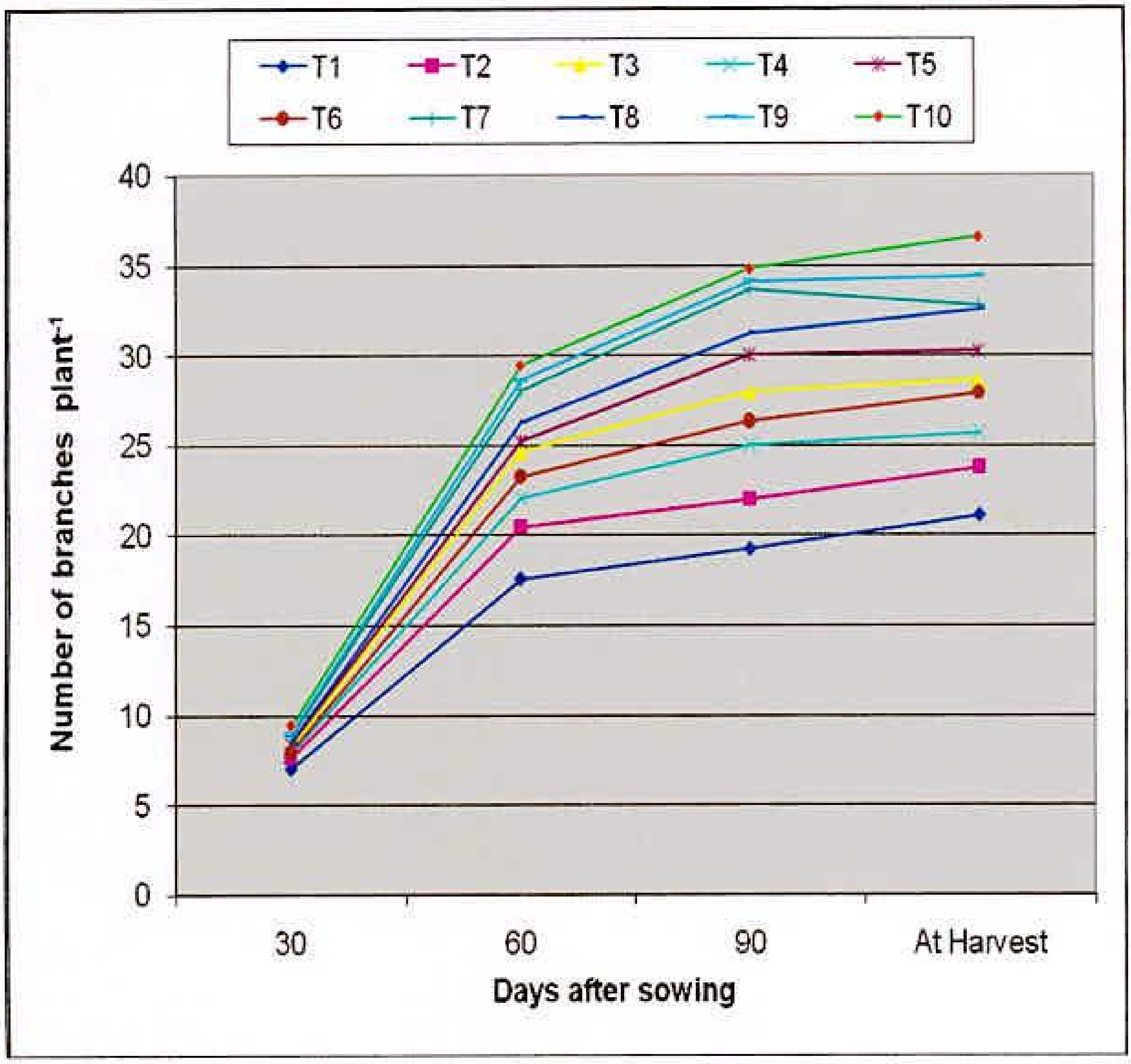

Fig. 2 Effect of integrated nitrogen and irrigation management on number of branches per plant of chickpea ($LSD_{0.05}$ = 0.936, 2.687, 3.645 and 3.488 at 30 DAS, 60 DAS, 90 DAS and harvest, respectively)

4.3 Yield contributing characters

4.3.1 Number of pods plant^{-1}

Number of pods plant^{-1} is one of the most important yield contributing characters in chickpea. Treatment variation exhibited a significant influence on number of pods plant^{-1} (Table 1). Number of pods plant^{-1} ranged from 33.88 to 41.80. The maximum number of pods plant^{-1} (41.80) was found in T_{10} treatment (basal 20 kg N ha^{-1} + split 20 kg N ha^{-1} with one irrigation at flower initiation stage), which was statistically similar to that of T_7, (basal 40 kg N ha^{-1} with one irrigation at flower initiation stage), T_8 (basal 10 kg N ha^{-1} + split 10 kg N ha^{-1} with one irrigation at flower initiation stage) and T_9 (basal 15 kg N ha^{-1} + split 15 kg N ha^{-1} with one irrigation at flower initiation stage) treatment while the minimum number of pods plant^{-1} (33.88) was found in T_1 treatment (no fertilizer + no irrigation). The number of pod plant^{-1} due to T_{10}, T_9 and T_8 treatment were 23.4%, 21.5% and 20% higher than those of control respectively. Number of pods plant^{-1} depended on the number of flowering nodes plant^{-1}, branches plant^{-1} and number of flowers plant^{-1} and their retention. Nitrogen increased the number of pods plant^{-1} due to its role of energy storage, cell division, cell enlargement and metabolic activities. Irrigation also helped nutrient uptake, initiating more flowering buds, which ultimately increased pods plant^{-1}. Biswas (2001) found similar results in fieldbean. Nitrogen positively increased the pods plant^{-1} in chickpea (Chaudhari *et al.*, 1998; Patra *et al.*, 1989; Vadavia *et al.*, 1991; Khan *et al.*, 1992).

4.3.2 Number of seeds pod^{-1}

Number of seeds pod^{-1} varied significantly due to the treatment variation (Table 1). The number of seeds pod^{-1} ranged from 1.31 to 1.82 across the treatments. The maximum number of seeds pod^{-1} (1.82) was found in T_{10} treatment (basal 20 kg N ha^{-1} + split 20 kg N ha^{-1} with one irrigation at flower initiation stage), which was statistically similar to that of T_3, T_5, T_7, T_8 and T_9 treatments. This might be due to larger pod size and trans location of photosynthates to reproductive organs for setting seed. The findings of the present study are in agreement with Rathore and Patel (1991) and Patra *et al*. (1989). Plants grown without N and irrigation (control) had the least seeds pod^{-1}.

4.3.3 1000-seed weight (g)

Seed size was expressed as weight of 1000-seeds and it varied significantly among the treatments (Table 1). Seed size ranged from 108.07 to 124.16 g. The maximum 1000-seed weight (124.16 g) was produced in T_{10} treatment (basal 20 kg N ha^{-1} + split 20 kg N/ha with one irrigation at flower initiation stage), which was statistically similar to that of T_7 and T_9 treatment. The untreated control plot, T_1 (no fertilizer + no irrigation) produced the smallest seeds. This result shows the beneficial effect of nitrogen and irrigation management on the development of seeds. Vadavia *et al*. (1991) showed that application of nitrogen significantly increased the 1000-seed weight in chickpea. Similar results were also reported by Khan *et al.* (1992) in chickpea.

Table 1. Effect of integrated nitrogen and irrigation management on yield contributing characters of chickpea

Treatments	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed weight (g)
T_1	33.88	1.31	108.07
T_2	35.42	1.43	111.58
T_3	37.00	1.54	114.33
T_4	35.95	1.47	112.42
T_5	37.69	1.58	115.69
T_6	36.05	1.49	113.00
T_7	40.00	1.71	120.05
T_8	39.33	1.63	118.11
T_9	40.58	1.75	121.68
T_{10}	41.80	1.82	124.16
$LSD_{(0.05)}$	3.447	0.292	4.063
CV(%)	8.32	10.86	7.04

T_1 = No Nitrogen + No irrigation (control), T_2 = Basal 20 kg N ha^{-1} without irrigation, T_3 = Basal 20 kg N ha^{-1} with one irrigation at flower initiation stage, T_4 = Basal 30 kg N ha^{-1} without irrigation, T_5 = Basal 30 kg N ha^{-1} with one irrigation at flower initiation stage, T_6 = Basal 40 kg N ha^{-1} without irrigation, T_7 = Basal 40 kg N ha^{-1} with one irrigation at flower initiation stage, T_8 = Basal 10 kg N ha^{-1} + split 10 kg N ha^{-1} with one irrigation at flower initiation stage, T_9 = Basal 15 kg N ha^{-1} + split 15 kg N ha^{-1}with one irrigation at flower initiation stage, T_{10} = Basal 20 kg N ha^{-1} + split 20 kg N ha^{-1} with one irrigation at flower initiation stage

4.4 Yield

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

Seed yield ha^{-1} of chickpea also varied significantly due to nitrogen and irrigation management (Table 2). Seed yield differed from 0.84 to 1.78 t ha^{-1}. The maximum seed yield (1.78 t ha^{-1}) was recorded from the T_{10} treatment (basal 20 kg N/ha +split 20 kg N/ha with one irrigation at flower initiation stage), which was statistically similar to that of T_7, T_8 and T_9 treatment. Plants grown without added fertilizer + irrigation gave the lowest seed yield. The seed yield ha^{-1} obtained from T_{10}, T_9 and T_8 produced 111.9% 102.4% and 84.5% more or higher over control. The nitrogen and irrigation management influenced plants to have more branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1} and 1000-seed weight which ultimately elevated seed yield of chickpea. These findings agreed well with Bachchhav *et al.* (1994) who found that application of 30 kg N ha^{-1} resulted with highest seed yield of mungbean. Majumdar *et al.* (2003) also stated that application of 40 kg N ha^{-1} gave the highest seed yield of mungbean. Similar result was also found in frenchbean (Ahlawat and Sharma, 1998) and in pea (Ferdous, 2001). Nitrogen positively increased the seed yield $plant^{-1}$ in chickpea (Javiya *et al.*, 1989; Patra *et al.*, 1989; Vadavia *et al.*, 1991; Khan *et al.*, 1992; Verma 1994 and Dahiya *et al.*, 1993). From Table 2, it appears that there was a quantum jump in yield due to fertilizer N and irrigation application suggesting that the soil was highly deficient in N fertilizer that resulted in yield difference. Moreover, increase in the yield of chickpea under T_{10} treatment might be due to increased number of pods $plant^{-1}$, seeds pod^{-1} and 1000-seed weight. There existed a positive linear relationship between number of pods $plant^{-1}$ and seed yield of chickpea (Fig. 3). This indicated that as number of pods $plant^{-1}$ increased, seed yield was also increased linearly. Over 97 % of the variation in seed yield could be explained from the variation in pods $plant^{-1}$. There was also a positive linear relation between the 1000-seed weight and seed yield (Fig. 4). The functional relationship suggest that over 97% of chickpea yield can be attitude to the difference in 1000-seed weight.

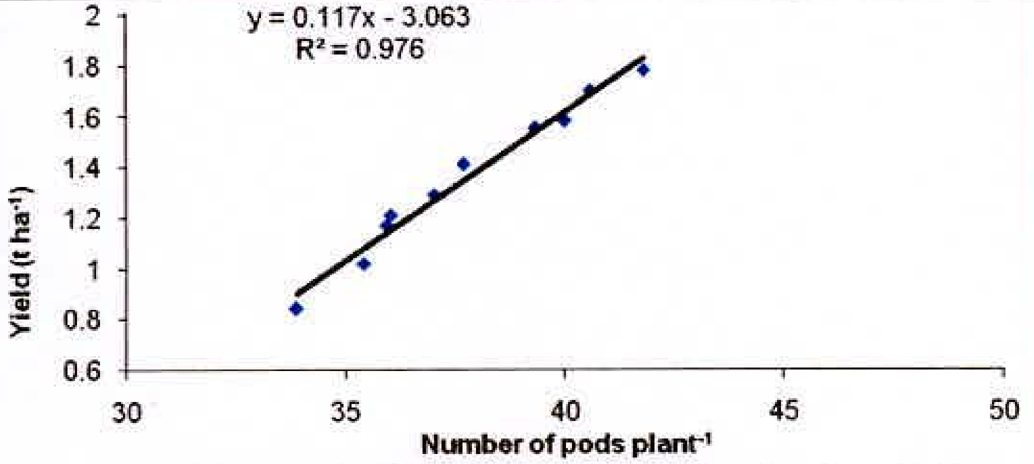

Fig.3 Functional relationship between pods plant^{-1} and seed yield of chickpea

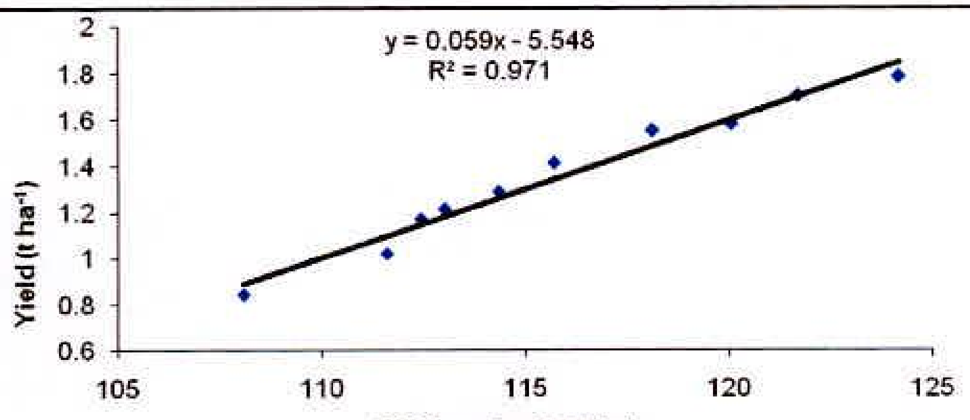

Fig.4 Functional relationship between 1000-seed weight and seed yield of chickpea

Table 2. Effect of integrated nitrogen and irrigation management on yield of chickpea

Treatment	Seed yield (t ha^{-1})
T_1	0.84
T_2	1.02
T_3	1.29
T_4	1.17
T_5	1.41
T_6	1.21
T_7	1.58
T_8	1.55
T_9	1.70
T_{10}	1.78
$LSD_{(0.05)}$	0.326
CV(%)	14.02

T_1 = No Nitrogen + No irrigation (control), T_2 = Basal 20 kg N ha^{-1} without irrigation, T_3 = Basal 20 kg N ha^{-1} with one irrigation at flower initiation stage, T_4 = Basal 30 kg N ha^{-1} without irrigation, T_5 = Basal 30 kg N ha^{-1} with one irrigation at flower initiation stage, T_6 = Basal 40 kg N ha^{-1} without irrigation, T_7 = Basal 40 kg N ha^{-1} with one irrigation at flower initiation stage, T_8 = Basal 10 kg N ha^{-1} + split 10 kg N ha^{-1} with one irrigation at flower initiation stage, T_9 = Basal 15 kg N ha^{-1} + split 15 kg N $ha^{-1}$with one irrigation at flower initiation stage, T_{10} = Basal 20 kg N ha^{-1} + split 20 kg N $ha^{-1}$with one irrigation at flower initiation stage

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

Treatment variation exhibited a significant influence on the straw yield of chickpea plant (Appendix VIII).

Straw yield ranged from 1.26 to 2.29 t ha^{-1} (Fig. 5). The maximum straw yield (2.29 t ha^{-1}) was recorded from T_{10} treatment (basal 20 kg N ha^{-1} + split 20 kg N ha^{-1} with one irrigation at flower initiation stage) and it was statistically similar to that of T_5, T_7, T_8 and T_9 treatments and the minimum (1.26 t ha^{-1}) from T_1 treatment (no fertilizer + no irrigation). Similar result was also reported by Ahlawat and Sharma (1998) in frenchbean and Ferdous, (2001) in pea. Nitrogen positively increased the straw yield in chickpea (Subba Rao *et al.*, 1986; Reddy and Ahlawat, 1998).

4.4.3 Biological yield (t ha^{-1})

Biological yield is the summation of straw and seed yields, which showed significant variation due to treatment imposed on it (Appendix VIII).

Biological yield differed from 2.1 to 4.07 t ha^{-1} (Fig. 5) and it was highest (4.07 t ha^{-1}) for the plants grown under T_{10} treatment (basal 20 kg N ha^{-1} + split 20 kg N ha^{-1} with one irrigation at flower initiation stage) followed by T_5, T_7, T_8 and T_9 treatment. Similar results were also reported by Ahlawat and Sharma (1998) in bushbean and Ferdous (2001) in pea. Beneficial effects of nitrogen addition in chickpea have also been reported by Karadavut and Ozdemir (2001) and Khan *et al.* (1992).

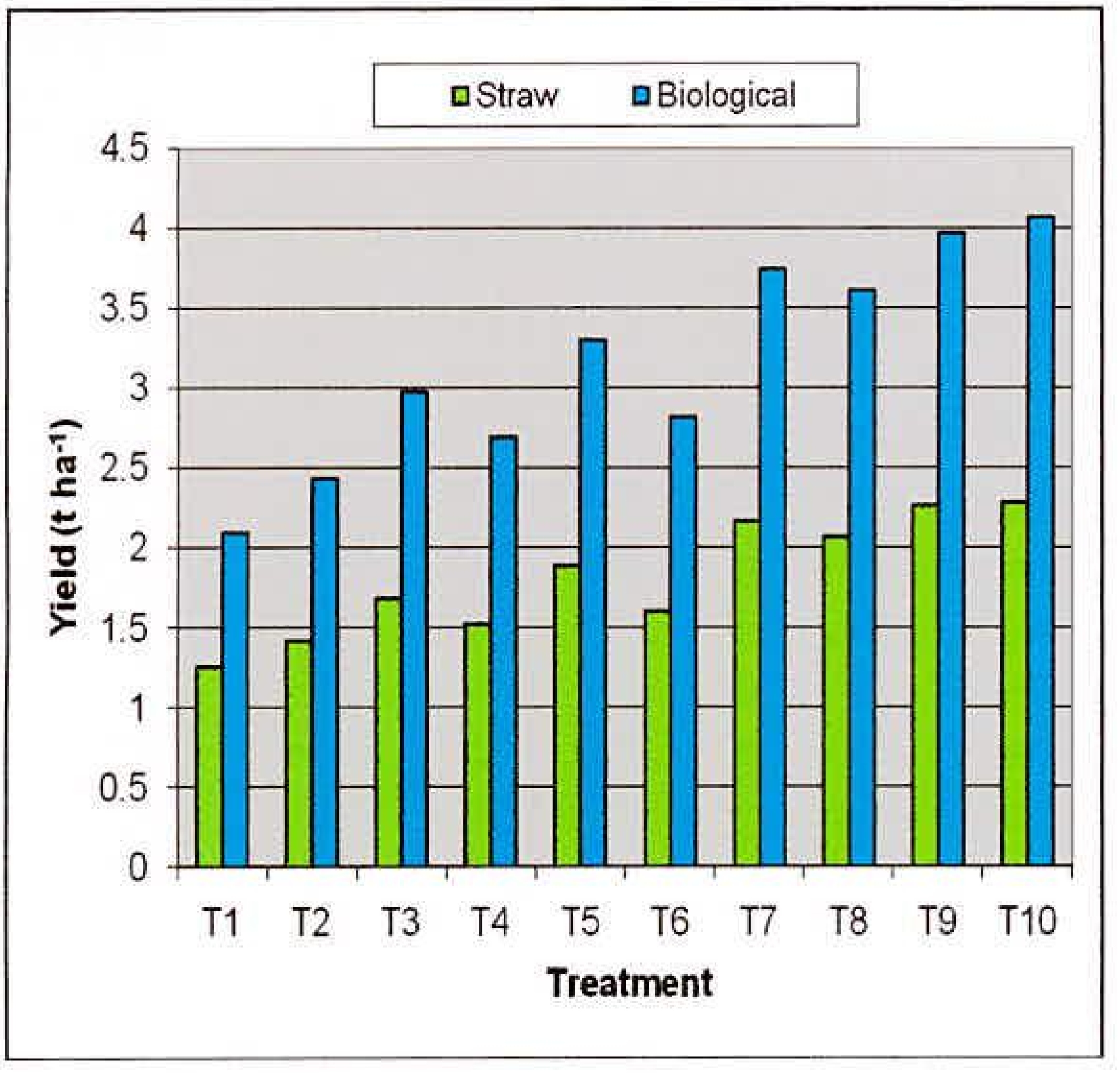

Fig. 5 Effect of integrated nitrogen and irrigation management on straw yield and biological yield of chickpea (LSD $_{0.05}$ = 0.526 and 0.832 for straw yield and biological yield, respectively).

4.5 Harvest Index

Harvest index (HI) indicates the partitioning of dry matter between reproductive and vegetative part. The ratio of economic yield to biological yield is termed as harvest index. Higher HI might be beneficial in obtaining higher economic yield. Harvest index did not differ significantly due to the treatment variation (Appendix VIII). Harvest index varied due to N fertilizer and irrigation application which was 40.08% to 43.73% (Table 3). The highest harvest index (43.73%) was recorded for T_{10} treatment (basal 20 kg N ha^{-1} + split 20 kg N ha^{-1} with one irrigation at flower initiation stage) and the lowest (40.08%) for T_1 treatment (no fertilizer + no irrigation). The results are in agreement with those of Chaudhari *et al.* (1998). Higher harvest index in T_{10} treatment was probably due to increased dry matter accumulation result in from increased metabolization of photosynthates towards seed.

Table 3. Effect of integrated nitrogen and irrigation management on harvest index of chickpea

Treatments	Harvest Index (%)
T_1	40.08
T_2	41.98
T_3	43.29
T_4	43.33
T_5	42.72
T_6	42.92
T_7	42.18
T_8	42.85
T_9	42.88
T_{10}	43.73
$LSD_{(0.05)}$	NS
CV (%)	4.33

NS = Not significant

T_1 = No Nitrogen + No irrigation (control), T_2 = Basal 20 kg N ha^{-1} without irrigation, T_3 = Basal 20 kg N ha^{-1} with one irrigation at flower initiation stage, T_4 = Basal 30 kg N ha^{-1} without irrigation, T_5 = Basal 30 kg N ha^{-1} with one irrigation at flower initiation stage, T_6 = Basal 40 kg N ha^{-1} without irrigation, T_7 = Basal 40 kg N ha^{-1} with one irrigation at flower initiation stage, T_8 = Basal 10 kg N ha^{-1} + split 10 kg N ha^{-1} with one irrigation at flower initiation stage, T_9 = Basal 15 kg N ha^{-1} + split 15 kg N $ha^{-1}$with one irrigation at flower initiation stage, T_{10} = Basal 20 kg N ha^{-1} + split 20 kg N $ha^{-1}$with one irrigation at flower initiation stage

Chapter 5

Summary

CHAPTER 5

SUMMARY

The experiment was conducted during rabi season (November-March, 2006-2007) at Sher-e-Bangla Agricultural University farm, Dhaka. The trial comprised of ten treatments viz. T_1 = no fertilizer 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 flower initiation 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 flower initiation stage, T_8 = basal 10 kg N ha^{-1} and 10 kg N ha^{-1} as split with one irrigation at flower initiation stage, T_9 = basal 15 kg N ha^{-1} and 15 kg N ha^{-1} as split with one irrigation at flower initiation stage and T_{10} = basal 20 kg N ha^{-1} and 20 kg N ha^{-1} as split with one irrigation at flower initiation stage.

The trial was setup in a randomized complete block design (RCBD) with three replications. The plot was fertilized with @ 17 kg P as triple super phosphate, 18 kg K as muriate of potash and 7.19 kg S as gypsum ha^{-1}. N fertilizer was applied as per treatment. Seeds of chickpea variety BARI chhola-5 were sown on 28th November, 2006 and harvested on 27th March, 2007. Data on yield attributes and yield were recorded and analyzed statistically following LSD test at 5% level.

Irrespective of treatments plant height rapidly increased from 30 DAS to 60 DAS and thereafter a slower rate of growth was noticed. The plant height was higher in T_{10} irrespective of growth stages and it was significantly different from other treatments while minimum was found in T_1. Plant height obtained from T_9, T_7, T_8, T_5, T_3, T_6, T_4

and T_2 treatments were almost similar at al growth stages. N and irrigation application influenced the number of branches plant^{-1} in all treatments. Branches plant^{-1} were highest with T_{10} in each sampling except 30 DAS and lowest in T_1 (control) treatment. Number of branches plant^{-1} increased sharply after 30 DAS reaching peak at 90 DAS and thereafter it leveled off. The treatment T_{10} gave highest number of pods plant^{-1} (41.80), while control gave the lowest (33.88). Application of N fertilizer and irrigation caused significant influence on the number of seeds pod^{-1} and 1000-seed weight. T_{10} treatment produced the highest seeds pld^{-1} and 1000-seed weight.

Seed yield is a complex character which depends on the different yield contributing characters. The highest seed yield was observed in T_{10} that was 1780 kg ha^{-1}. The next highest seed yield was 1700 kg ha^{-1} which was attained in T_9. The lowest yield (840 kg ha^{-1}) was recorded from control (T_1) treatment which was 51 and 53% reduction over T_9 and T_{10} treatments respectively.

The maximum straw yield (2.29 t ha^{-1}) was found in T_{10} treatment which was statistically similar to that of $T_{5,}$ $T_{7,}$ T_8 and T_9 treatment while the minimum (1.26 t ha^{-1}) in T_1 treatment.

The maximum biological yield (4.07 t ha^{-1}) was found in T_{10} treatment and it was statistically similar to that of $T_{5,}$ $T_{7,}$ T_8 and T_9 treatment while the minimum (2.10 t ha^{-1}) from T_1 treatment. Harvest index was also influenced by the application of N and irrigation. The highest harvest index was observed in T_{10} followed by $T_{5,}$ $T_{7,}$ $T_{4,}$ T_3 T_2 and T_6 and the lowest in T_1.

The relation between branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, 1000- seed weight and seed yield were significant, positive and linear. The positive relation between this parameters with yield indicated an inter dependent relationship among them.

Chapter 6
Conclusion

CHAPTER 6

CONCLUSION

It might be concluded from the experiment that chickpea being a leguminous crop required supplemental nitrogen during its reproductive stage for its proper grain development towards higher yield. One irrigation given at flower initiation stage helped the plant to uptake nitrogen optimally for its grain development.

Management of N 40 kg ha^{-1} (20 kg N ha^{-1} as basal + 20 kg N ha^{-1} as split application) coupled with one irrigation during flower initiation stage (55 DAS) was favorable for maximum harvest of crop characters, yield attributes and yield of chickpea.

However, this finding could be further verified in different chickpea growing areas of Bangladesh.

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APPENDICES

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

Mechanical composition:

Particle size constitution

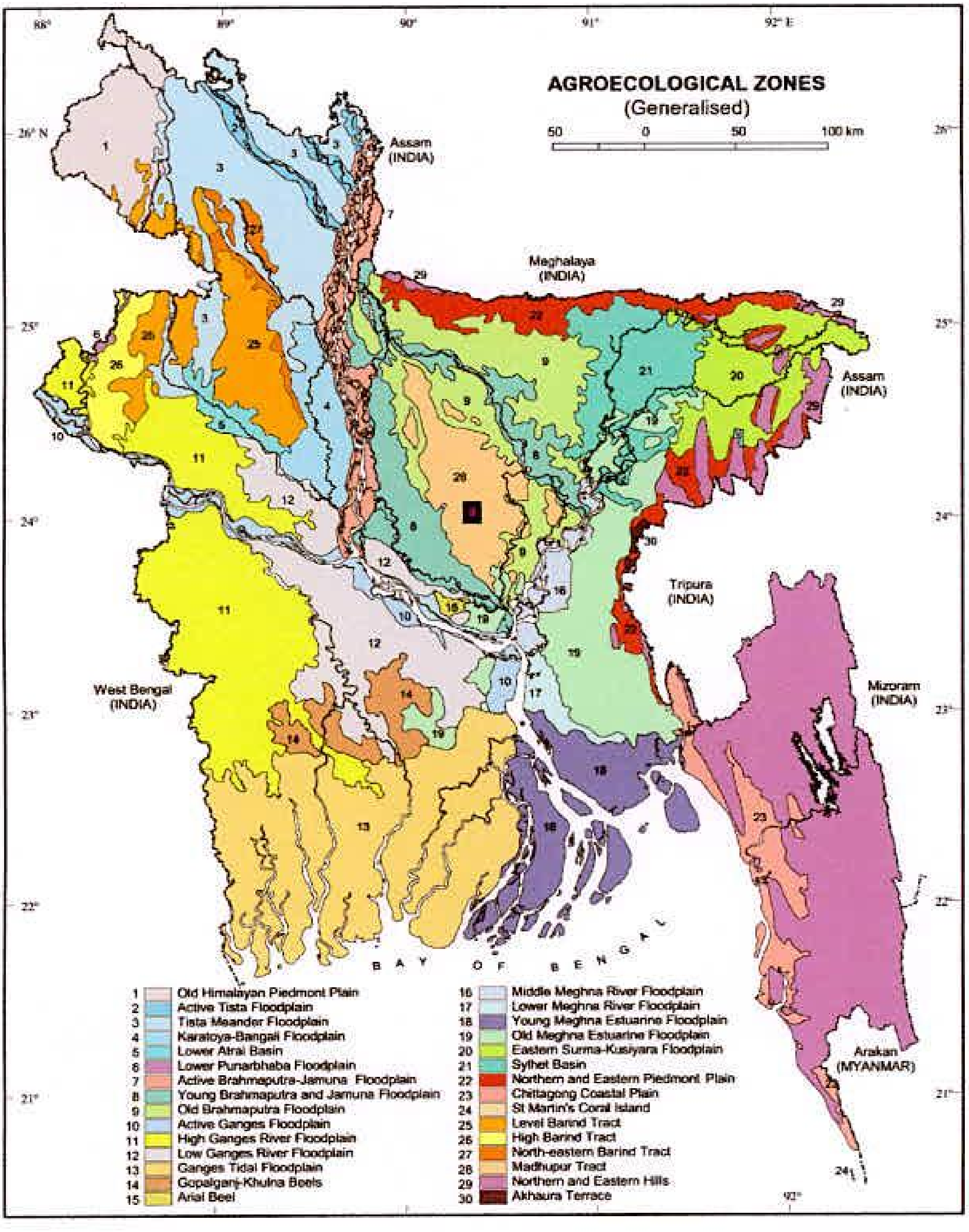
Sand	:	26%
Silt	:	45%
Clay	:	29%
Texture	:	Silty clay
pH	:	5.6

Chemical composition:

Soil parameters	**Observed value**
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	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



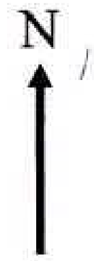
■ = AEZ 28

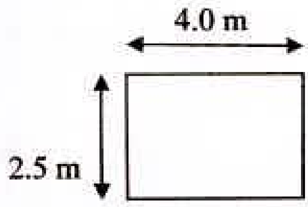
Appendix III. Monthly records of air temperature, relative humidity and rainfall during the period from November 2006 to March 2007.

Year	Month	Air temperature (^0C)			Relative humidity (%)	Rainfall (mm)
		Maximum	Minimum	Mean		
2006	November	29.70	20.10	24.90	65.00	5
	December	27.90	15.80	21.35	68.14	0
2007	January	24.60	12.50	18.55	66.01	0
	February	27.10	16.80	21.95	64.21	2
	March	36.2	22.1	29.1	46.13	0

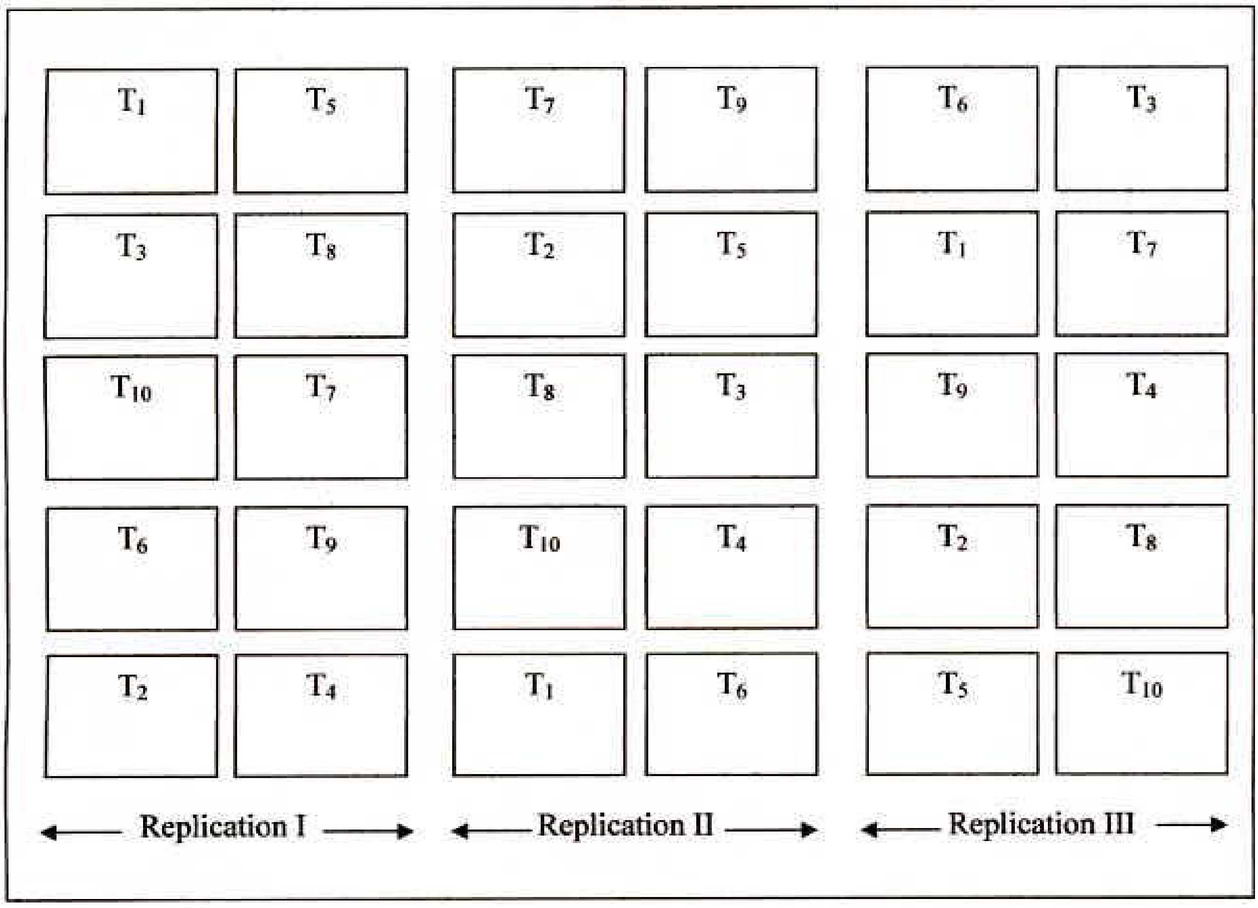
Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207.

Appendix –IV. Experimental layout





Plot size: 4.0 m×2.5 m
Between Plot: 0.75 m
Between replication: 1.50 m



Appendix V. Analysis of variance of the data on plant height as influenced by nitrogen and irrigation managements of chickpea

Source of variation	Degrees of freedom	Mean square Plant height (cm) at 30 DAS	60 DAS	90 DAS	Harvest
Replication	2	1.164	0.071	1.227	3.096
Treatment	9	7.835^{NS}	35.294**	60.203**	34.723**
Error	18	4.014	6.264	10.083	9.501

NS: Not significant; **: Significant at 0.01 level of probability;

Appendix VI. Analysis of variance of the data on number of branches plant^{-1} as influenced by nitrogen and irrigation managements of chickpea

Source of variation	Degrees of freedom	Mean square Number of branches plant^{-1} 30 DAS	60 DAS	90 DAS	Harvest
Replication	2	0.100	0.182	5.461	1.321
Treatment	9	1.516**	43.262**	84.451**	72.156**
Error	18	0.298	2.453	4.516	4.135

** : Significant at 0.01 level of probability;

Appendix VII. Analysis of variance of the data on yield contributing characters and yield as influenced by nitrogen and irrigation managements of chickpea

Source of variation	Degrees of freedom	Mean square		
		Pod plant^{-1}	Seed pod^{-1}	1000 seed weight(g)
Replication	2	1.156	0.009	6.683
Treatment	9	19.689**	0.074*	75.563**
Error	18	4.037	0.029	5.611

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

Appendix VIII. Analysis of variance of the data on yield as influenced by nitrogen and irrigation managements of chickpea

Source of variation	Degrees of freedom	Mean square			
		Seed yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
Replication	2	0.002	0.006	0.015	0.207
Treatment	9	0.276**	0.435**	1.399**	2.948^{NS}
Error	18	0.036	0.094	0.0235	3.401

NS: Not Significant; **: Significant at 0.01 level of probability;