GROWTH AND YIELD OF CHICKPEA AS INFLUENCED BY NPK FERTILIZERS AND IRRIGATION FREQUENCY

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DEDICATED TO
MY
PARENTS & ALL WELL WISHERS

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CERTIFICATE

This is to certify that the thesis entitled ***" GROWTH AND YIELD OF CHICKPEA AS INFLUENCED BY NPK FERTILIZERS AND IRRIGATION FREQUENCY"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***A. K. M. ARIFUL ALAM KHAN,*** *Registration. No.* ***12-05083*** *under my supervision and guidance. No part of this 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:
Dhaka, Bangladesh

(Prof. Dr. Md. Shahidul Islam)
Supervisor

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ABSTRACT

A field experiment was conducted at the Sher-e-Bangla Agricultural University Farm Dhaka, Bangladesh during November, 2017 to March, 2018 in rabi season with a view to study the growth and yield of chickpea as influenced by NPK fertilizers and irrigation frequency. The experiment was carried out in split plot design with three replication. The treatments consisted of NPK fertilizers treatments at main plot factor A as F_1= 25 % less than recommended dose of fertilizer, F_2= Recommended dose of fertilizer (45kg urea ha^{-1} + 85 kg TSP ha^{-1} + 35 kg MP ha^{-1}), F_3=25 % more than recommended dose of fertilizer . In factor B at sub plot there were four levels as I_0= No irrigation, I_1=Single irrigation at vegetative stage, I_2= Single irrigation at reproductive stage, I_3= Irrigation both at vegetative and reproductive stages. Data on different parameters on yield and yield contributing characters were recorded and variation was observed. Results indicated that the maximum height of plant 12.06 cm, 22.02 cm and 35.66 cm from F_3 treatment at 30, 60, and 90 DAS respectively. maximum number of branches $plant^{-1}$ 3.64 at 30 DAS from I_2 and I_3 irrigation frequency respectively, similarly 6.24, 9.19 at 60 and 90 DAS respectively from I_2 irrigation frequency, maximum pods $plant^{-1}$ (29.02), maximum seed yield (0.87 t ha^{-1}) ,HI% (31.46) were obtained from treatment F_2 fertilization . On the other hand, maximum values for plant height (12.85, 23.20, 36. 33 cm at 30, 60, 90 DAS respectively) were found from treatment I_2 irrigation. seed yield (0.94 t/ha) and HI% (32.07) was obtained from treatment I_2 irrigation frequency. The highest value of plant height were observed (13.79 at 30 DAS) from treatment combination I_3F_3 and (24.5, 38.59 at 60, 90 DAS respectively) from treatment combination I_3F_3. Highest value for number of branches $plant^{-1}$ (4.27 at 30 DAS) from treatment combination I_2F_2 and (7.22, 10.95 at 60 .90 DAS respectively) from treatment combination I_2F_2. Maximum seed yield (1.12 t ha^{-1}) from I_2F_2 and maximum HI% was obtained 34.19 from I_2F_2.

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LIST OF ACRONYMS

AEZ = Agro-Ecological Zone

BARI = Bangladesh Agricultural Research Institute

BINA = Bangladesh Institute of Nuclear Agriculture

SRI = System of Rice Intensification

SCI = System of Crop Intensification

SSI = System of Sugarcane Intensification

BBS = Bangladesh Bureau of Statistics

DAS = Days after sowing

et al. = And others

N = Nitrogen

TSP = Triple Super Phosphate

MoP = Muriate of Potash

Ca = Calcium

Mg = Magnesium

K = Potassium

P = Phosphorous

Fe = Iron

ha^{-1} = Per hectare

g = Gram

kg = Kilogram

mm = Millimeter

SAU = Sher-e-Bangla Agricultural University

SRDI = Soil Resources Development Institute

HI = Harvest Index

No. = Number

Wt. = Weight

LSD = Least Significant Difference

^{0}C = Degree Celsius

NS = Non-significant

% = Percent

CV% = Percentage of coefficient of variance

T = Ton

viz. = Videlicet (namely)

CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the leading pulse crops in Bangladesh based on consumption which belongs to the family Fabaceae.The crop is variously known as chola, boot or botjam in different parts of Bangladesh. Chickpea is a temperate crop though it is well adapted in tropical and sub-tropical conditions (Kay,1979).

Two types of chickpea are produced globally, namely Desi and Kabuli chickpeas. Kabuli chickpeas have a larger cream-colored cotyledons with a thin seed coat whereas the desi type has a smaller, reddish brown-colour seed with a thick seed coat (Agricultural and Agri-food Canada, variance, (2004).

Today, chickpea is the third most important pulse crops and about 15% of the world's total pulse productions belong to this crops (FAO, 2010). Chickpea plays a vital role in human and animal nutrition having 20.8% protein (Gowda and Kaul,1982).The total cultivation of chickpea in Bangladesh is about 17468 acre of land and total production 6672 metric ton.The chickpea average yield is 2.61 metric ton per hectare (BBS, 2015).

There are many reasons of lower yield of chickpea of which NPK fertilizer and irrigation management are most important of them, which greatly affected the growth, development and yield of chickpea. In Bangladesh, chickpea crop is grown without fertilizer and irrigation. However there is evidence that the yield of chickpea can be increased substantially by using fertilizer and irrigation (Dahiya *et al*.,1989 and Katare *et al*.,1984).

Pulses also fix nitrogen from atmosphere, but evident are those that nitrogen application become helpful to increase yield (Vadavia *et al*.,1991; Patra *et al*.,Chawdhari *et al*.,1998 and Khan *et al*.,1992). Fertilizer management especially with nitrogen, phosporous and potasium produced seed with high

level of protein and amino acids in chickpea (Gupta and Singh,1982). Judicious and proper amount of fertilizer increase the growth and yield of chickpea.

A low level of soil phosphorus is a great obstacle to the growth and development of leguminous crops (Walley *et al*., 2005). In leguminous crops, phosphorus promotes nitrogen fixation, nutrient-use efficiency, efficient partitioning of photosynthates between source and sink, and biomass production (Mureithi and Gitari, 2003; Ogola *et al.*, 2012). However, phosphatic fertilizers are not only costly but also their supply is lower than their demand. Hence, it is highly demanding to explore the possibilities of improving phosphatic fertilizers use efficiency.

On the other hand, chickpea is a deep rooted crop that extracts water from deep layers when the surface water is depleted. Chickpea Grown in rabi season when rainfall is limited that become serious restriction to crop production.water deficiency has adverse effect on plant growth, yield and crude protein in Fabaceaeous crops. The flowering stage is most vulnerable stage for water stress and chickpea is somewhat tolerant to deficit but susceptible to excess water (Miah *et al.*,1991).

Adequate supply of irrigation water along with chemical fertilizer is essential for normal growth and yield of crops (Ayallew and Tabbada,1987). Nayyar *et al.*(2006) reported that the flowering and pod setting stages appear to be the most sensitive stages to water stress. Saraf *et al.*(1990) stated that excess and deficient moisture conditions both are detrimental and reduce yield of chickpea.

So, none can take risk of growing crops successfully under rainfed condition. Irrigation at responsive stage of the crops becomes necessary to ensure optimum growth and yield of the chickpea.

Hence, the experiment will be carried out to maximize the growth and yield of chickpea with optimum NPK fertilizers and irrigation frequency.

So, the present piece of research work was carried out with the following objectives –

1. To find out the effect of NPK fertilizers on growth and yield of chickpea.
2. To study the effect of irrigation frequency on growth and yield of chickpea.
3. To find out the suitable combination of NPK and irrigation frequency on growth and yield of chickpea.

CHAPTER II

REVIEW OF LITERATURE

Chickpea is an most 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 emphasis 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 debate regarding the rates of NPK and time of irrigation application in chickpea. Application of NPK and irrigation managements of chickpea related to the study are reviewed and presented in the following heads.

2.1 Influence of nitrogen fertilizers on growth and yield

2.1.1 Plant height

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

Arvadia and Patel (1988) observed influence of nitrogen or phosphorus alone at the rate of 25 kg ha^{-1} on the growth of chickpea plants. They stated that these was increase in the plant height than those in control plots. Application of phosphorus alone at the rate of 45 kg ha^{-1} did not show any significant effect on plant height over 25 kg ha^{-1} .

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

Vadavia *et al.*(1991) noticed that application of 25 kg ha^{-1} N and 50 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 20-28 and 45-70 kg ha^{-1} respectively.

2.1.2 Number of branches plant^{-1}

Dahiya *et al.*(1993) reported that application of 19-29 kg N and 45-70 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 of chickpea.

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

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

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

Hopal and Singh (1990) conducted an experiment with the semi dwarf garden pea cv. Lincoln, which received N at the rate of 0. 20, 40 and 60 kg ha^{-1} , P_20_5 at 0, 30, 60 and 90 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 P205 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 levels 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 over control with 20 kg N along with 40 kg P ha^{-1}.

Malik *et al.*(2003) investigated the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and p (0, 55, 85 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 weight of 1000 seed

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.

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

2.1.6 Seed yield

Patel *et al.*(1989) noticed no significant yield variation in chickpea with the application of 15-30 kg N ha^{-1}.

Khokar and Warsi (1987) reported maximum seed yield in chickpea with application of 18 kg N ha^{-1}.

Arvadia and Patel (1988) observed the effect of phosphorus or nitrogen 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 30 kg P ha^{-1}.

Patel *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 30 kg N + 55 kg P ha^{-1} gave the highest yield in the experiment of Javiya nath (1989).

Patel and Rathore (1991) stated that application of 18 kg N along with 46 kg P ha^{-1} increased seed yield of chickpea by 29.7% over no N application.

Reddy and Ahlawat (1998) noticed that application 20 kg N, 46 kg P and 6.25 kg Zn ha^{-1} increased grain and straw yield of chickpea.They also noticed increase in nitrogen, phosphorus and zinc uptake by plants leading to increase in protein yield.

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 25 kg N ha^{-1} increased grain yield .

Shamim and Naimat (1987) reported that application of 15 kg N + 80 kg P205 / ha to *Cicer arietinurn* cv. C-727 increases seed yields cover uninoculated seed from 585 to 879 kg ha^{-1}.

Tomar and Sharma (1985) achieved 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) stated higher seed yield in chickpea over control while using N and P at rate of 19-27 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_20_5 ha^{-1} resulted with significant increase in the chickpea yield.

2.1.7 Straw yield

Vadavia *et al*.(1991) noticed that application of 20 kg ha^{-1} N and 40kg P ha^{-1} increased significant straw yield of chickpea.

Subba Rao *et al*.(1986) also proved 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) said that the application of Rhizobium p. 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_20_5 ha^{-1}.

2.1.9 Harvest index

Harvest index influenced by N fertilization. Chaudhari *et al*.(1998) stated that application of 20-50 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 37.8 kg N ha^{-1}.

2.2 Influence of phosphorous

Kumar *et al.*(2017) conducted a field experiment during the Rabi season of 2013-14 at the Crop Research Farm, Department of Agronomy, Allahabad

School of Agriculture, Uttar Pradesh to find out the effect of different levels of phosphorus, sulphur and cultivars on growth and economics of chickpea (*Cicer arietinum* L). Number of nodules per plant (68.23), dry weight (8.93 g), harvest index (38.15), gross return (Rs 107790), net return (Rs 84542.72) and B-C ratio (4.59) was increased.

Etayeb (2016) stated that, a field experiment was organized at the Experimental Farm of the Faculty of Agriculture, University of Khartoum, Shambat, during 2014/2015 season. The objectives was to study the effect of phosphorus fertilizer and plant spacing on growth and yield of two chickpea (*Cicer arietinum L*.) cultivars under irrigation. Borgug and GYT10 cultivars were sown at three spacings: 10, 20 and 30 cm, and subjected to four levels of fertilization: 0, 50, 100 and 200 kg P_2O_5 ha^{-1}.

Seed yield was increased by phosphorus fertilizer, but the increase was not significant. Spacing between plants did not affect the experimental parameters except plant density. Interactions between treatments were significant for all vegetative growth and yield.

Biçer (2014) found that the effect of different phosphorus doses (0, 15, 30, 40 and 70 kg ha^{-1} on chickpea (*Cicer arietinum* L.). The effect of P on plant height and number of branches per plant was non-significant. Number of branches per plant was different response to phosphorus doses, although statistically was not significant. Number of pods and seeds per plant were affected by phosphorus treatment. Although 1000 seed weight was not affected by P applications, cultivar x P doses interaction was important. Phosphorus doses were significant for yield but yield apparently did not increase. Start dose, 15 kg phosphorus ha^{-1}, initially increased the yield, and 30 kg phosphorus per hectare application slightly increased the yield. The highest number of pods , the yield $plant^{-1}$ and seeds pod^{-1} were found at 35 and 75 kg P ha^{-1} , compared only one of these control and 25 kg P ha^{-1}. Grain yield was increased to 12 and 16% with the application of 30 and 40 kg P ha^{-1}, respectively, when compared with control dose. Chickpea cultivars showed low response to P application. P fertilization

could not be effective due to late sown. Early sown and irrigation supply can be more effectiveness phosphorus intake in this region.

Pingoliya *et al*.(2014) reported that, the effect of phosphorus (P) and iron (Fe) on growth and yield attributes of chickpea (*Cicer arietinum* L.) was studied during rabi season of 2011-2012 with four levels of P (control, 25, 45 and 60 kg P_2O_5 ha^{-1} significantly improved yield. Application of P and Fe fertilizer improved soil fertility status and crop yield, it can be a sustainable tool to enhanced chickpea production.

Hussena *et al*.(2013) carried out a field experiment to study the effect of varying levels of phosphorus (T_1=0 kg ha^{-1}, T_2= 25 kg ha^{-1}, T_3= 60 kg ha^{-1}, T_4=80 kg ha^{-1} and T_5 =110 kg ha^{-1}) on growth performance and yield of chickpea (*Cicer arietinum* L) variety at the experimental field of Wollo University, Kelemmeda, during winter season in 2013. The results revealed that phosphorus levels significantly affected plant height, number of branches $plant^{-1}$ and number of pods $plant^{-1}$. The maximum plant height (39.20cm) was recorded from plots that received 65 kg P_2O_5 ha^{-1} .

2.3 Influence of Potassium

Effect of Potassium on yield of chickpea. The highest seed yield of 23.07 q ha^{-1} was obtained due to application at fertilizers according to the STCR targeted yield equation. It was superior over other treatments. Similar results were observed by Tamboli *et al*.(1996) and Shinde *et al*.(2000). The treatment (N, P_2O_5 and K_2O as per soil STCR targeted yield for 25 kg ha^{-1}) recorded statistically significant straw yield than other treatments. Similar results were also recorded by Yahtya *et al*.(1995), Shinde *et al*.(2000) and Mali *et al*.(2001). The positive effect of potassium on yield component might be due to its requirement in carbohydrate synthesis and translocation of photosynthesis from source to sink and its involvement in protein and fat synthesis which increased yield due to potassium application. This was also reported by Basith *et al*.(1995). Similar trend was also observed in case of biological yield.

2.4 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.

Watanabe *et al*.(1986) showed in an experiment that *Vigna radita* cv. SPRI and soybeans cv. Si 4 were irrigated 8 and 12 times. The irrigation treatment increased pod number and 1000-seed weight.

Katare *et al*.(1984) stated that seed yields of *Cicer arietirnm* with 1, 2, 3, and 4 irrigations were increased by 25, 30, 50 and 51%, respectively.

Giriappa (1971) stated that in 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) found that water stress reduced pods per plant and mean seed weight in *Phascolus vulgaris* and pods plant^{-1} and seeds pod^{-1} in *Lens culinaris*.

Bhan (1977) studied that two or three irrigations given at four to six leaves branch^{-1}. flower pod^{-1} formation stages showed high yield of lentil.

Siowit and Kramer (1977) experiment in soybean that the maximum reduction in yield due to moisture stress during grain filling stage. Drastic yield reduction was also showed in mungbean due to water stress.

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

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

Sadasivam *et al.*(1988) studied 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.

Pannu and Singh (1988) reported that the total dry matter as well as grain yields were affected by moisture stress in Chickpea.

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

Rathi *et al.*(1995) showed that most critical growth stage for moisture stress in lentil is flower initiation followed by pod formation. In case of failure of winter rains, 1 to 2 irrigations were required for increased 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 application of irrigation.

Salter and Goode (1967) showed that the extent of yield reduction from water deficits depends not only on the magnitude of the deficit but also growth appearing stress bushbean. Yield and dry matter production were lower in all growth stage 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) stated that water stress reduced yield of bushbean by 54%,70% and 36% when the stress occurred during pre-flowering, flowering and pod formation stages, respectively.

Turk *et al.*(1980) reported that the response of cowpea to intensities of drought at different stages of growth and reported that yields were not lowered by drought imposed during the vegetative stage; but reduced substantially when imposed during flowering.

Cselotel (1980) stated that a regular water supply particularly during flowering and pod formation is essential for high yield and good quality of soyabean. Higher number of dry pods plant^{-1}, increased seed weight and seed yield ha^{-1} was found when irrigation was done weekly. Haque (1988) showed similar results in peas.

Irrigation increased pigeonpea yield by 97.5% while drought prevai!s during the reproductive phase, which found the major yield-limiting factor (ICRISAT, 1986).

Pinolato *et al.*(1987) found that the deleterious effects of drought stress imposed at flowering reduced photosynthetic leaf surface that affected directly the grain yield of chickpea.

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

Khade *et al.*(1990) stated that highest number of pod per plant, seeds per pods and seed yield where observed with 3 irrigations in field pea

Viera *et al.*(1991) showed that the yield reduction was 36% when drought stress was imposed during seed filling but found no effect on germination or vigour in soybean

Nandan and Prasad (1998) stated that grain yield and net returns were higher with 3 irrigations than with 2 irrigations in frenchbean.

Biswas (2001) showed that irrigation frequency performed a remarkable impact on yield of fieldbean. Application of 3 irrigations increased vegetable pod yield

about 20% and 15% and seed yield about 50% and 30% with 1 and 2 irrigations, respectively compared to no irrigation.

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

Abdulla (1987) carried out an experiment having different irrigation levels on lentil . 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 NPK along with irrigation.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November 2017 to April 2018. Detailed of the experimental materials and methods followed in the study are presented in this chapter.

3.1 Experimental site

The experiment was conducted at experimental plot of Agronomy farm of Sher-e-Bangla Agricultural University in Dhaka city. It is situated at $23^0$77' N latitude and $90^0$33' E longitude at an altitude of 8.2 meter above the sea level.

3.2 Soil characteristics

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture. Soil pH ranged from 5.6-6.5 and had organic matter 0.84-1.00%. The experimental area was flat having available irrigation and drainage system.The area was above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resources and Developmental Institute (SRDI), Dhaka.

3.3 Climate condition

The experimental area is characterized by subtropical rainfall during the month of May to September and scattered rainfall during the rest of the year. The average rainfall is 218 mm per annum and average higher and lower temperature are 29.40^0C and 13.85^0C. Details of the meteorological data of air temperature, relative humidity , rainfall and sunshine hour during the period of the experiment was collected from the weather station of Sher-e-Bangla Nagar.

3.4 Crop : Chickpea

In this experiment BARI Chola – 5 was used . The characteristics of this variety is

given bellow:

BARI chlola-5 was developed by Bangladesh Agricultural Research Institute (BARI) Jovdebpur, Gazipur. It was released as a variety in 1996. This variety bears good phenotypic characters: such as light green leaf, bushy type plant,30-45 cm height. Whitish color flower, seed is smaller in size & deep brown in color, life cycle is 105-125 days and seed yield of 600-1800 kg/ha

3.5 Treatments of the experiments

The experiment consisted of two factors as follows:

Factor : A

NPK fertilizer Dose: 3

F_1= 25% less than recommended dose of NPK fertilizer

F_2= Recommended dose of NPK fertilizer (45 kg urea ha^{-1} + 85 kg TSP ha^{-1} + 35 kg MP ha^{-1})

F_3= 25% more than recommended dose of NPK fertilizer

Factor: B

Irrigation Frequency: 4

I_0= No irrigation

I_1= Single irrigation at vegetative stage

I_2= Single irrigation at reproductive stage

I_3= Irrigation at vegetative and reproductive stage

3.6 Experiment Design And Layout

The experiment was conducted in split-plot design with three replications assigning NPK fertilizer in the main plot and irrigation in the sub-plot. Irrigation water was provided by water can. Total 36 unit plot was made for the experiment. Each plot size was be 3 m × 2m.

3.7 Germination test

Germination test was performed before seed sowing in the field. Three layers of filter papers were placed on petridish. Each petridish contained 100 seeds. Germination percentage was calculated by using the following formula:

Germination (%) = (Number of seeds germinated / Number of seeds taken for germination) x 100

3.8 Sowing of Seeds

The seeds of chickpea were sown on October-2017. Seeds were treated with Bavistin @ 2.5 g / kg seed before sowing to control the seed borne disease. The seeds were sown in furrows having a depth of 3 cm maintaining a distance of 40 cm in between rows.

3.9 Intercultural operations

3.9.1 Thinning

Seeds were germinated five days after sowing. Thinning was done three times, first thinning was done at 10 DAS and the second at 25 DAS and third thinning at 45 DAS following 10 cm seedling to seedling distance to maintain proper plant population in each plot (about 3,33,333 plants ha^{-1}).

3.9.2 Irrigation, weeding and mulching

Irrigation was done as per treatment with water can. The crop field was weeded three times during the growing period of crop. The first weeding was done at 20 DAS, second at 40 DAS and third at 55 DAS. Mulching was done after irrigation. The crop was attacked by pod borer (*Helkverpa armigera*) which was controlled by applying Ripcord at the rate of 1 micro litre per liter water at flowering stage.

3.10 Crop sampling and data collection

Three plants from each treatment were randomly sampled and marked with sample card. The data of plant height and number of branches per plant were recorded from sampled plants at an interval of thirty days, which was started from 30 DAS.

3.11 Harvest and post harvest operations

Harvesting was done when 90% of the pod became dark brown in color it is 10 march in 2018. The matured crops were harvested from a pre-demarcated area of six linear at the center of each plot. Number of pods per plant, seeds per pod. 1000-seed weight and seed yield per plant were recorded from harvested plants. The seeds were collected from the harvested plants to dry properly under sun and then the seed weight was taken.

3.12 Data collection

The following data were recorded

Plant Height	Relative growth rate	1000 grains weight	Seed yield
Number of branches plant^{-1}	Number of pods plant^{-1}	Days to emergence	Stover yield
Dry matter content plant^{-1}	Length of the pod	Days to flowering	Biological yield
Crop growth rate	Number of seeds pod^{-1}	Days to maturity	Harvest index

3.13 Procedure of data collection

3.13.1 Plant height (cm)

The height of three 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 three plants for each plot determined.

3.14.2 Number of branches plant^{-1}

The numbers of branches were counted from three plants in each plot. The average number of branches plant^{-1} was determined.

3.14.3 Number of pods Plant^{-1}

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

3.14.4 Number of seeds pod^{-1}

The number of seeds in each pod was also recorded from three randomly selected pods at the harvest and was expressed on pod basis.

3.14.5 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.

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

The seeds collected from 6 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.

3.14.7 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}.

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

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

3.14.9 Harvest index (%)

Harvest index was calculated by dividing die economic (seed) yield from the net plot by the total biological yield (seed stover) from the sante area (Donald. 1963) and multiplying by 100.

Harvest index (%) = Seed yield (t ha^{-1}) / Biological yield (t ha^{-1}) x 100

3.15 Statistical analysis

The collected data on different parameters were statistically analyzed to obtain the

level of significance using the statistix-10 software.

The mean difference among the treatments were adjusted by using Least Significant Difference (LSD) test at 0.05 level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

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

4.1 Plant height

4.1.1 Effect of NPK fertilizers

Plant height in response NPK fertilizers over time have been shown in (Figure 1,appendix III). Plant height increased progressively over time attaining the highest (figure1) 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 NPK fertilizers except at 30 DAS (Appendix III). The influence of different levels of NPK fertilizers was first apparent at 60 DAS and the difference among them persisted throughout the growth period. Tallest plant (Figure 1) was obtained from F_3 treatment which was statistically similar to that of F_2 treatments irrespective of growth stages while the shortest in F_0 treatment. it was revealed that NPK fertilizers probably influenced cell division or cell elongation of chickpea plants, thus the plant height was increased.

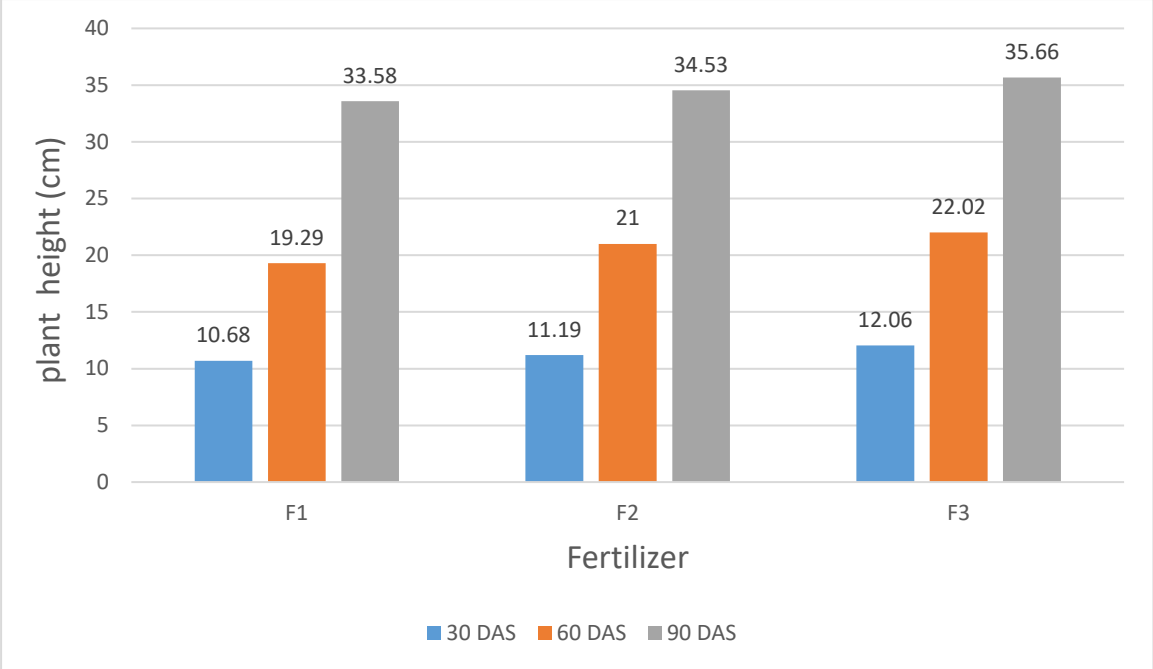

Figure 1. Effect of fertilizer on plant height of chickpea at different days after sowing ($LSD_{0.05}$ = 0.39, 0.81, 0.50 at 30, 60 and 90 DAS, respectively)

4.1.2. Effect of irrigation

Significant variation was observed on the plant height of chickpea due to the application of different doses of Irrigation (Figure 2, Appendix III). Among the different doses of irrigation showed the highest plant height at 90 DAS. (Figure 2). And here I_2 and I_3 which was statistically similar. On the other hand, the lowest plant height 9.84 cm was observed in the I_0 treatment where irrigation not applied.

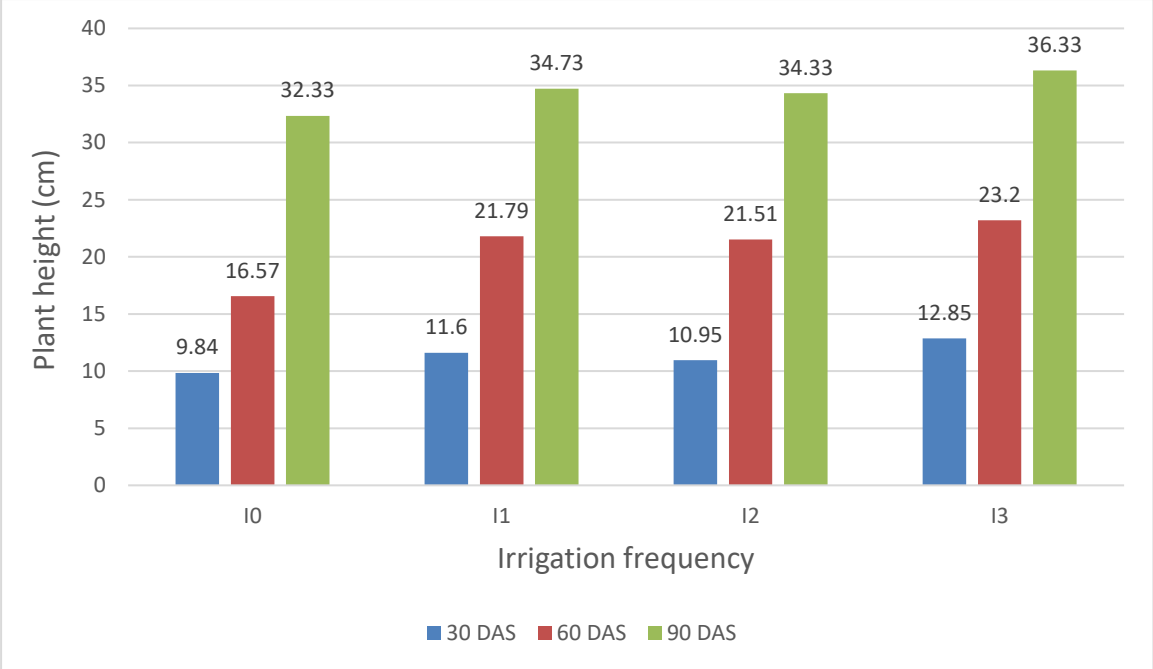

Figure 2. Effect of irrigation on plant height of chickpea at different days after sowing ($LSD_{0.05}$ = 1.27, 1.61, 0.968 at 30, 60 and 90 DAS, respectively)

4.1.3. Combined effect of NPK fertilizers and irrigation frequency

The combined effect of NPK fertilizer and irrigation showed variations on plant height of chickpea at all sampling dates (Table 1,Appendix III). The tallest plant was found in I_3F_3 (13.79 cm, 24.5 cm, 38.59 cm) and shortest plant in I_0F_1 (8.93 cm, 14.64 cm, 30.74 cm) at 30, 60, 90 DAS respectively.

Table 1. Interaction effect of NPK fertilizer and irrigation frequency on plant height of chickpea

Treatment	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
I_0F_1	8.93 g	14.64 h	30.74 g
I_0F_2	9.77 fg	16.67 g	32.66 f
I_0F_3	10.83 ef	18.43 f	33.60 ef
I_1F_1	10.95 def	20.53 de	34.22 de
I_1F_2	11.17 cdef	21.62 cd	34.43 de
I_1F_3	12.70 ab	23.24 ab	35.55 c
I_2F_1	10.57 ef	19.95 ef	33.70 e
I_2F_2	11.34 cde	22.66 bc	34.40 de
I_2F_3	10.94 ef	21.93 bcd	34.91 cd
I_3F_1	12.27 bcd	22.04 bcd	35.68 bc
I_3F_2	12.49 bc	23.05 abc	36.63 b
I_3F_3	13.79 a	24.5a a	38.59 a
LSD	1.27	1.61	0.96
CV %	7.22	4.55	1.62

Here, F_1=25% less than Recommended dose of fertilizer , F_2= Recommended dose of fertilizer (45 kg urea ha^{-1} + 85 kg TSP ha^{-1} + 35 kg MP ha^{-1}), F_3= 25 % more than Recommended dose of fertilizer

I_0= No irrigation, I_1= Single irrigation at vegetative stage, F_2= Recommended dose of NPK fertilizers, F_3 = 25 % more than recommended dose of fertilizer

4.1.2 Number of branches plant^{-1}

4.1.2.1 Impact of NPK fertilizer

The application of NPK fertilizer had a significant impact on number of branches plant-1of chickpea at all sampling dates except 30 DAS (Figure 3, Appendix IV). The branch number showed increasing trend up to 90 DAS and then decreased slightly. The maximum number of branches was recorded 6.46, 8.02 and 7.48 at 30 DAS, 60 DAS and 90 DAS respectively and lowest as 3.00, 3.37, and 3.20 at 30 DAS, 60 DAS, and 90 DAS respectively.

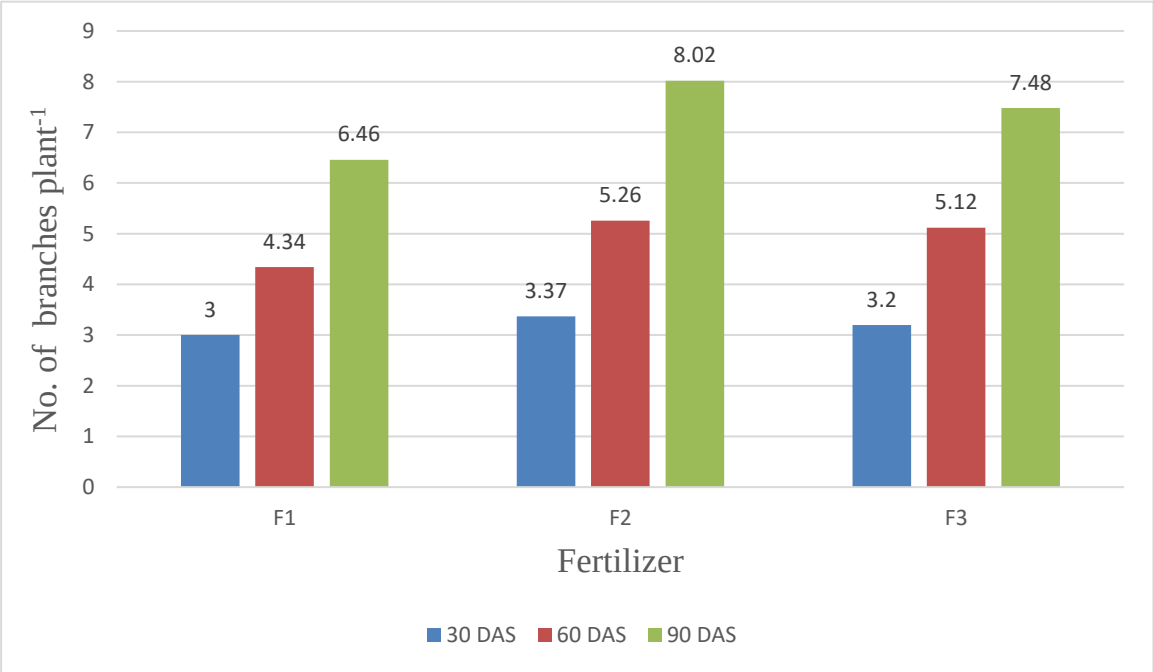

Figure 3. Effect of fertilizer on plant branch number of chickpea at different days after sowing ($LSD_{0.05}$ = 0.12, 0.38, 0.59 at 30, 60 and 90 DAS, respectively)

4.1.2.2 Effect of irrigation

Significant variation was observed on the plant height of chickpea due to the application of different doses of Irrigation (Figure 4, Appendix IV). Among the different doses of irrigation showed the highest number of branches per plant 9.19 at I_2 treatment and lowest number of branches per plant 2.24 in I_0 treatment where irrigation not applied.

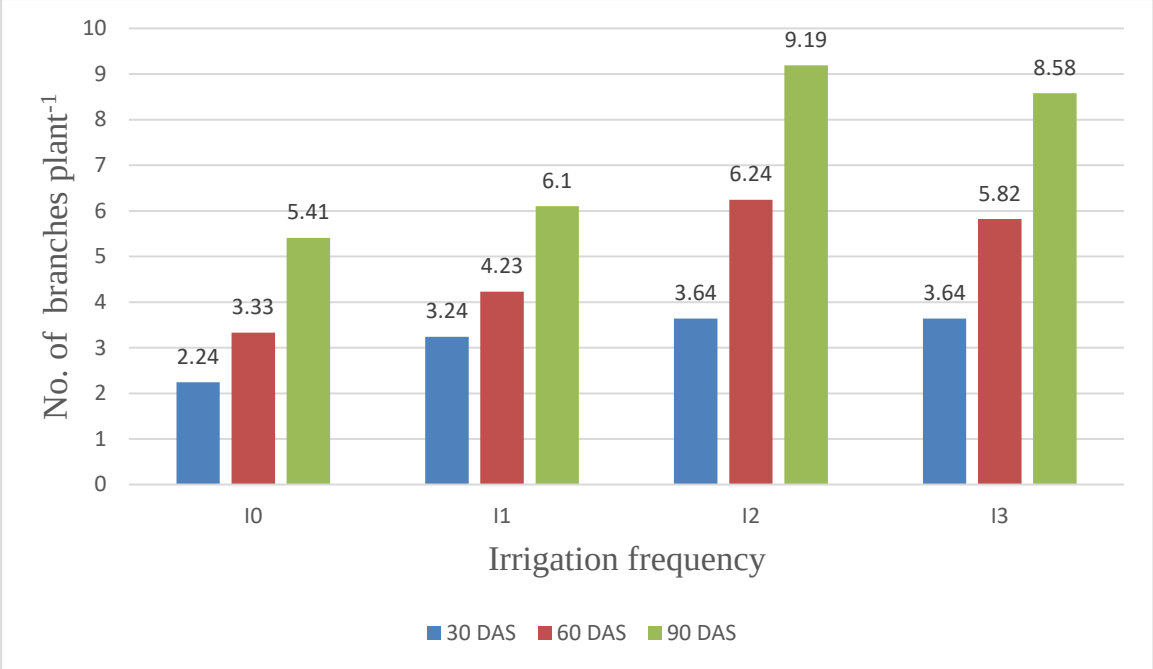

Figure 4. Effect of irrigation on plant branch number of chickpea at different days after sowing ($LSD_{0.05}$ = 0.19, 0.34, 0.50 at 30, 60 and 90 DAS, respectively)

4.1.2.3 Combined effect of NPK fertilizer and irrigation frequency

Number of branches plant^{-1} with NPK fertilizer and irrigation frequency showed significant differences over the growth stages (Appendix iv). Regardless of treatment differences number of branches plant^{-1} increased sharply reaching peak at 60 DAS and then it was evident slow upto harvest (Figure 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 due to NPK fertilizers 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 NPK fertilizers and irrigation frequency application. The plants grown with NPK fertilizers application and one irrigation at flower initiation stage produced maximum branches plant^{-1} at all growth stages.(Figure 2). It was also revealed that NPK fertilizers enhanced the vegetative growth of chickpea and irrigation also increased cell division of chickpea plants, thus the number of branches plant was increased. The highest

number of branches plant^{-1} was I_2F_2 treatment (Table 2). Similar results were noticed by Ferdous (2001) in pea. The increased in number of branches plant of chickpea due to NPK fertilization was also reported by Chaudhari et al.(1998), Rathore and Patel (1991), Vadavia et al(1991). On the contrary, the plants grown less in lower amount of NPK fertilizer and irrigation produced the lowest branches plant^{-1}.The lowest number of branches plant^{-1} at I_0F_1 treatment (Table 2).

Table 2. Interaction effect of NPK fertilizer and irrigation frequency on number of branches plant^{-1} of chickpea

Treatment	No. of branches plant^{-1}		
	30 DAS	60 DAS	90 DAS
I_0F_1	2.12 f	3.25 f	5.17 g
I_0F_2	2.27 f	3.32 f	5.62 fg
I_0F_3	2.35 f	3.41 f	5.46 fg
I_1F_1	3.13 e	3.71 f	5.73 fg
I_1F_2	3.16 e	4.53 de	6.41 ef
I_1F_3	3.44 cde	4.46 e	6.16 ef
I_2F_1	3.25 de	5.29 c	7.08 de
I_2F_2	4.27 a	7.22 a	10.95 a
I_2F_3	3.39 cde	6.23 b	9.54 b
I_3F_1	3.50 bcd	5.11 cd	7.85 cd
I_3F_2	3.77 b	5.97 b	9.12 b
I_3F_3	3.64 bc	6.39 b	8.77 bc
LSD	0.31	0.64	0.95
CV %	6.01	7.18	6.92

Here, F_1=25% less than Recommended dose of fertilizer , F_2= Recommended dose of fertilizer (45kg urea ha^{-1} + 85 kg TSP ha^{-1} + 35 kg MP ha^{-1} , F_3= 25 % more than Recommended dose of fertilizer

I_0= No Irrigation, I_1=Single Irrigation at vegetative stage, I_2= Single Irrigation at reproductive stage, I_3= Irrigation at vegetative and reproductive stage.

4.1.3 Dry weight

4.1.3.1 Effect of NPK fertilizer

Dry weight of chickpea was significantly influenced by NPK fertilizer (Figure 5, Appendix V). the highest dry weight was found 11.28 gm. The lowest dry weight was recorded in 9.99 gm.

4.1.3.2 Effect of irrigation frequency

Irrigation frequency show positively significant impact on dry weight of chickpea (Figure 5, Appendix V). the highest dry weight was obtained in irrigation frequency area. The highest value obtained for dry weight in I_2 (11.78 g) . The lowest value of dry weight was in I_0 (9.61 g).

4.1.3.3 Combined effect of NPK fertilizers and irrigation frequency

The combined effect of NPK fertilizers and Irrigation frequency dry weight showed significant impact (Figure 5, Appendix V). The highest dry weight was found in I_2F_2 (13.31g) and lowest in I_0F_1 (9.37 g).

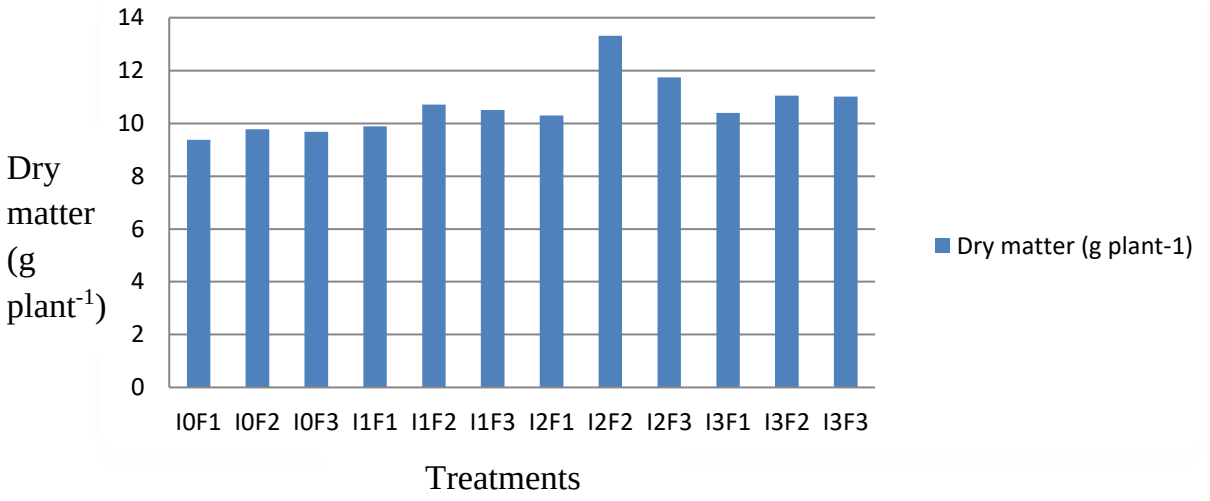

Figure 5. Interaction effect of NPK fertilizers and irrigation frequency on plant dry matter of chickpea at harvest

4.1.4 Number of pods plant^{-1}

4.1.4.1 Effect of NPK fertilizers

The application of NPK fertilizers showed significant impact on number of pods plant^{-1} of chickpea (Table 3, Appendix VI). The maximum number of pods was recorded in F_2 (29.02) and lowest in F_1 (26.06).

Table 3. Effect of NPK fertilizers on number of pods plant^{-1}, number of seeds pod^{-1}, 1000- seed weight (g), seed yield (t ha^{-1})

Treatment	Number of pods plant^{-1}	Number of seed pod^{-1}	1000-seed weight (g)	Seed yield(t ha $^{-1}$)
F_1	26.06 c	1.22 c	114.06 b	0.73 b
F_2	29.02 a	1.44 a	117.37 a	0.87 a
F_3	27.68 b	1.32 b	118.53a	0.79 b
LSD	0.92	0.06	2.15	0.084
CV %	2.95	4.40	1.33	9.30

Here, F_1=25% less than Recommended dose of fertilizer , F_2= Recommended dose of fertilizer (45kg urea ha^{-1} + 85 kg TSP ha^{-1} + 35 kg MP ha^{-1} , F_3= 25 % more than Recommended dose of fertilizer

4.1.4.2 Effect of irrigation frequency

Application of Irrigation frequency had a significant effect on number of pods plant-1 of chickpea (Table 4, Appendix VI). The highest increment was observed with I_2 treatment (31.91) and further dose was not able to increase further. The values pods plant^{-1} range is 24.36 to 31.91. The treatment I_0 produced lowest number of pods plant^{-1}(24.36).

4.1.4.3 Combined effect of NPK fertilizers and irrigation frequency

Number of pods plant^{-1} influenced significantly due to combined effect of NPK fertilizer and Irrigation frequency of chickpea (Table 4, Appendix VI). The maximum number of pods plant^{-1} was recorded in I_2F_2 (34.40) which was significantly higher than other combinations and lowest in I_0F_1 (22.74).

4.1.5 Number of seeds pod^{-1}

4.1.5.1 Effect of NPK fertilizers

Number of seeds pod^{-1} of chickpea positively influenced by NPK fertilizer treatment (Table 3, Appendix VI). the highest number of seeds pod^{-1} was found in F_2 (1.44). The lowest number of seeds pod^{-1} was recorded in F_1 (1.22).

Table 4. Effect of irrigation frequency on number of pods plant^{-1}, number of seeds pod^{-1}, 1000-seed weight (g), seed yield (t ha^{-1})

Treatment	Number of pods plant^{-1}	Number of seeds pod^{-1}	1000-seed weight (g)	Seed yield (t ha $^{-1}$)
I_0	24.36 d	1.13 c	107.76 c	0.63 c
I_1	25.91 c	1.33 b	115.36 b	0.77 b
I_2	31.91 a	1.54 a	122.1 a	0.94 a
I_3	28.15 b	1.30 b	121.4 a	0.86 ab
LSD	0.88	0.079	1.81	0.11

Here, I_0= No Irrigation, I_1=Single Irrigation at vegetative stage, I_2= Single Irrigation at reproductive stage. I_3= Irrigation at vegetative and reproductive stage.

4.1.5.2 Effect of irrigation frequency

Irrigation frequency positively significant impact on number of seeds pod^{-1} of chickpea (Table 4, Appendix VI). The highest value obtained for number of seeds pod^{-1} in I_2 (1.54) (Table 4). The lowest value of number of seeds pod^{-1} was in I_0 and that was 1.22 (Table 4).

4.1.5.3 Combined effect of NPK fertilizers and irrigation frequency

The combined effect of NPK fertilizers and Irrigation frequency showed significant variations on seeds pod^{-1} of chickpea (Table 5, Appendix VI) . the highest number of seeds pod^{-1} was found in I_2F_2 (1.74) and lowest in I_0F_1 combination (1.00).

4.1.6 1000-seeds weight

4.1.6.1 Impact of NPK fertilizers

The application of NPK fertilizers showed significant effect on 1000-seeds weight of chickpea .The highest 1000-seeds weight (118.53g) was recorded in F_2 and lowest (114.06 g) in F_1 (Table 3, Appendix VI).

4.1.6.2 Impact of irrigation frequency

Application of Irrigation frequency had a positive effect on 1000-seeds weight of chickpea. At reproductive stage irrigation frequency dose increased 1000-seeds weight slightly. However, the treatment I_2 produced highest 1000 seeds weight (122.1g) where I_1 produced lowest weight (107.76g) compared to other treatments (Table 4, Appendix VI).

4.1.6.3 Combined effect of NPK fertilizers and irrigation frequency

The 1000-seeds weight showed significant impact due to combined effect of NPK fertilizer and irrigation frequency. the highest value of 1000-seeds weight was recorded in I_2F_2 (124.52 g) and lowest in I_0F_1 (104.70 g) (Table 5, Appendix VI).

4.1.7 Seed yield

4.1.7.1 Effect of NPK fertilizer

Seed yield of chickpea showed significant influences by NPK fertilizers. The highest seed yield was found in F_2 (0.8785 ton ha^{-1}). The lowest seed yield was recorded in F_1 (0.7379 ton ha^{-1}) (Table 3, Appendix VI).

4.1.7.2 Effect of irrigation frequency

Irrigation frequency showed significant impact on seed yield of chickpea (Table 4, Appendix VI). Seed yield values showed a gradual increasing trend with the irrigation frequency and at I_2 (0.94 ton ha^{-1}) other irrigation frequency treatment after that the value reduced marginally. Among the irrigation frequency doses seed yield ranges from 0.63 ton ha^{-1} to 0.94 ton ha^{-1}.

4.1.7.3 Combined effect of NPK fertilizers and irrigation frequency

The combined effect of NPK fertilizers and Irrigation frequency showed significant impact on seed yield (Table 5, Appendix VI). Significantly the highest seed yield was found in I_2F_2 (1.12 ton ha^{-1}) and lowest in I_0F_1 (0.55 ton ha^{-1}) combination.

Table 5. Interaction effect of NPK fertilizer and irrigation frequency Number of pod plant^{-1}, number of seeds pod^{-1}, 1000-seed weight (g), seed yield(t ha^{-1})

Treatment	Number of pods plant^{-1}	Numer of seeds pod^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})
I_0F_1	22.74 g	1.00 g	104.70 h	0.55 d
I_0F_2	25.87 ef	1.21 f	110.30 fg	0.68 bcd
I_0F_3	24.48 f	1.18 f	108.28 g	0.65 cd
I_1F_1	25.07 f	1.23 ef	112.07 f	0.71 bcd
I_1F_2	26.72 de	1.44 bc	117.57 de	0.81 bc
I_1F_3	25.94 ef	1.31 cdef	116.43 e	0.79 bc
I_2F_1	29.22 c	1.37 cd	120.40 bcd	0.84 b
I_2F_2	34.40 a	1.74 a	124.52 a	1.12 a
I_2F_3	32.12 b	1.52 b	121.38 abc	0.86 b
I_3F_1	27.21 de	1.27 def	119.07 cde	0.83 bc
I_3F_2	29.09 c	1.37 cde	121.73 abc	0.88 b
I_3F_3	28.17 cd	1.28 def	123.40 ab	0.86
LSD	1.60	0.13	3.44	0.19
CV %	3.24	6.02	1.57	14.59

Here, F_1=25% less than Recommended dose of fertilizer , F_2= Recommended dose of fertilizer (45kg urea ha^{-1} + 85 kg TSP ha^{-1} + 35 kg MP ha^{-1} , F_3= 25 % more than Recommended dose of fertilizer

I_0= No Irrigation, I_1=Single Irrigation at vegetative stage, I_2= Single Irrigation at reproductive stage.I_3= Irrigation at vegetative and reproductive stage.

4.1.8 Stover yield

4.1.8.1 Effect of NPK fertilizers

The application of NPK fertilizers showed positively significant impact on stover yield of chickpea.The highest stover yield was recorded in F_2 (2.10 ton ha^{-1}) and lowest in F_1 (1.79 ton ha^{-1}) (Table 6, Appendix VII).

4.1.8.2 Effect of irrigation frequency

Application of Irrigation frequency had a positive effect stover yield. The treatment I_2 produced the highest stover yield (2.55 t ha^{-1}) where I_0 produced lowest stover yield (1.21 ton ha^{-1}) (Table 7, Appendix VII).

Table 6. Effect of NPK fertilizer at Stover yield, biological yield and harvest Index

Treatment	Stover yield	Biological yield	Harvest Index
F_1	1.79 b	2.56 b	29.08 b
F_2	2.10 a	2.98 a	31.46 a
F_3	1.90 b	2.72 b	29.52 b
LSD	0.12	0.20	0.45
CV %	5.76	6.53	1.34

Here, F_1=25% less than Recommended dose of fertilizer , F_2= Recommended dose of fertilizer (45kg urea ha^{-1} + 85 kg TSP ha^{-1} + 35 kg MP ha^{-1} , F_3= 25 % more than Recommended dose of fertilizer

4.1.8.3 Combined effect of NPK fertilizers and irrigation frequency

The stover yield showed significant impact due to combined effect of NPK fertilizers and Irrigation frequency. the highest stover yield was recorded in I_2F_2 (2.88 ton ha^{-1}) and lowest in I_0F_1 (1.10 ton ha^{-1}) (Table 8, Appendix VII).

4.1.9 Harvest index

4.1.9.1 Effect of NPK fertilizers

Harvest index of chickpea influenced significantly by NPK fertilizers application. The highest value (31.46 %) of harvest index was found in F_2. The lowest value (29.08 %) of this trait was recorded in F_1 (Table 6, Appendix VII).

Table 7. Effect of irrigation frequency at stover yield, biological yield and harvest Index

Treatment	Stover yield	Biological yield	Harvest Index
I_0	1.21 d	1.91 d	27.20 d
I_1	1.55 c	2.32 c	29.70 c
I_2	2.55 a	3.49 a	32.07 a
I_3	2.42 b	3.28 b	31.11 b
LSD	0.13	0.16	0.86

Here, I_0= No Irrigation, I_1=Single Irrigation at vegetative stage, I_2= Single Irrigation at reproductive stage.I_3= Irrigation at vegetative and reproductive stage.

4.1.9.2 Effect of irrigation frequency

Irrigation frequency showed positively significant impact on harvest index of chickpea. The figure indicated that I_2 irrigation frequency doses produced highest harvest index (32.07 %) (Table 7, Appendix VII). Irrigation frequency applied lower and higher doses than I_2 treatment reduced the value of harvest index. the lowest harvest index (27.20 %) was found in I_0 (control treatment).

Table 8: Interaction effect of NPK fertilizer and irrigation frequency at stover yield, biological yield and harvest Index

Treatment			
	Stover Yield	Biological Yield	Harvest Index
I_0F_1	1.10 f	1.77 f	26.13 g
I_0F_2	1.35 de	2.04 def	28.32 ef
I_0F_3	1.19 ef	1.92 ef	27.16 fg
I_1F_1	1.45 cd	2.17 cde	29.00 de
I_1F_2	1.67 c	2.48 c	31.06 bc
I_1F_3	1.52 cd	2.32 cd	29.06 de
I_2F_1	2.32 b	3.17 b	31.13 bc
I_2F_2	2.88 a	3.99 a	34.19 a
I_2F_3	2.46 b	3.32 b	30.90 c
I_3F_1	2.29 b	3.12 b	30.05 cd
I_3F_2	2.52 b	3.41 b	32.30 b
I_3F_3	2.44 b	3.30 b	30.97 bc
LSD	0.23	0.32	1.36
CV %	7.14	6.20	2.90

Here, F_1=25% less than Recommended dose of fertilizer , F_2= Recommended dose of fertilizer (45kg urea ha^{-1} + 85 kg TSP ha^{-1} + 35 kg MP ha^{-1} , F_3= 25 % more than Recommended dose of fertilizer

I_0= No Irrigation, I_1=Single Irrigation at vegetative stage, I_2= Single Irrigation at reproductive stage.I_3= Irrigation at vegetative and reproductive stage.

4.1.9.3 Combined effect of NPK fertilizers and irrigation frequency

The combined effect of NPK fertilizers and Irrigation frequency showed significant impact on harvest index. The highest value of harvest index was

found in I_2F_2 (31.13 %) and lowest in I_0F_1 combination (26.13 %) (Table 8, Appendix VII).

CHAPTER V

SUMMARY AND CONCLUSION

A study on "growth and yield of chickpea as influenced by NPK fertilizers and irrigation frequency" was conducted at the Agronomy field of Sher-e-Bangla agricultural University, Dhaka-1207 during November, 2017 to March, 2018. The experiment was laid out in split plot design with three replications having fertilization in the main plot and irrigation frequency in the sub plot. The individual plot size was 3m × 2m. There were 12 treatment combinations and the total number of plots were 36. The experiment consisted of two factors. In factor A , the treatments were three , F_1= 25 % less than recommended dose of fertilizer, F_2= Recommended dose of fertilizer(45kg urea ha^{-1} + 85 kg TSP ha^{-1} + 35 kg MP ha^{-1}) , F_3=25 % more than recommended dose of fertilizer . In factor B there were four treatments and they are I_0= No Irrigation, I_1=Single Irrigation at vegetative stage, I_2= Single Irrigation at reproductive stage.I_3= Irrigation both at vegetative and reproductive stage. Experimental data were recorded from 30(DAS) and continued until harvest at an interval of 30 days. Data on different parameters yield and yield contributing characters were recorded and variation was observed. Results indicated that the maximum height of plant 12.06 cm from treatment F_3 and 22.02 cm , 35.66 cm from F_3 treatment at 30, 60, and 90 DAS respectively and shortest plant was recorded (10.61, 19.29 ,33.58 cm) at 30, 60, 90 DAS respectively from treatment F_0. The tallest plant was recorded (12.85, 23.20, 36. 33 cm) respectively from I_2 Irrigation frequency . On the other hand shortest plant was found (9.84 , 16.57 , 32.33 cm) respectively from Irrigation frequency . For treatment combination the tallest plant was recorded 13.79 cm from I_3F_3 24.5 cm and 38.59 cm from I_3F_3 at 30, 60, and 90 DAS respectively and the smallest plant height was found (8.93, 14.64, 30.74 cm at 30, 60 , 90 DAS) respectively from treatment I_3F_3.

The most elevated number of branches were discovered 3.37, 5.26 and 8.02 from treatment F_2 treatment at 30, 60,and 90 DAS separately. The most reduced

number of branches were watched 3.00 from treatment F_1 and 4.34, 6.46 from treatment F_1 at 30, 60, 90 DAS separately. The highest number of branches were found 3.64 at 30 DAS from I_2 and I_3 irrigation frequency similarly and 6.24, 9.19 at 60 and 90 DAS respectively I_2 Irrigation frequency. The lowest number of branches were recorded 2.24, 3.33, and 5.41 at 30, 60, and 90 DAS respectively irrigation frequency . The most noteworthy number of branches were discovered 4.27 from treatment I2F2 at 30 DAS and altogether comparative outcome was seen from I_2F_2 At 60 and 90 DAS the most highest number of branches were determined 7.11, 10.95 individually from treatment I_2F_2 . The most minimal number of branches was discovered 2.12 at 30 DAS from I_0F_1 treatment and at 60 , 90 DAS 3.25, 5.17 individually from I_0F_1 interaction .

The greatest dry weight plant $^{-1}$ were recorded at final dry matter from treatment F_2 (11.21 gm). What's more, the most dry weight plant $^{-1}$ were recorded final dry matter treatment F1 (9.99 gm). The maximum dry weight plant $^{-1}$ were recorded at 11.78 from I_2 irigation frequency and the lowest dry weight plant $^{-1}$ were recorded at final dry matter from I_0 irrigation frequency. The maximum weight was recorded 10.30 gm from the treatment combination I_2F_2 .

The highest number is found on number of pod plant^{-1} at harvesting stage 29.02 for treatment F_2 on the other hand lowest number is found 26.06 for treatment F_1. The highest value was found 31.91 for I_2 irrigation frequency and lowest value was found 24.36 for I_0 sowing .

Highest value of 1000 seed weight was found 117.06 gm for fertilization F_2. Lowest value was observed 114.06 gm for treatment F_1.

The highest value was observed 122.1 gm for irrigation frequency and lowest value was 107.76 for irrigation frequency .

The highest number of pod plant^{-1} was found 34.40 for the treatment combination I_2F_2. The lowest number of pod plant-1 was found 22.74 for the treatment combination I0F1. The maximum value of 1000 seed weight was observed 124.52 gm for treatment combination I_2F_2. The minimum value was observed 104.70 gm for treatment I_0F_1. The maximum Seed yield(0.87 t ha^{-1}) from fertilization F_2 and the lowest value was (0.73 t ha^{-1})from the treatment F_1 .

The highest value of HI was found 31.46 % from treatment F_2 and the lowest value was found 29.08 % from treatment F_1 .

Harvest index maximum value was found 32.07 % from I_2 irrigation frequency which is statistically similar with I_3 irrigation frequency .

From the results of present study it can be concluded that NPK fertilizers influenced individual plant with vigorous growth consequently produced maximum yield contributing characters and I_2 irrigation frequency is more preferable for chickpea production. Recommended NPK fertilizer and irrigation frequency at reproductive stage influenced crop production considerably whereas higher or lower fertilizer and other stages of irrigation has less effect on crop production.

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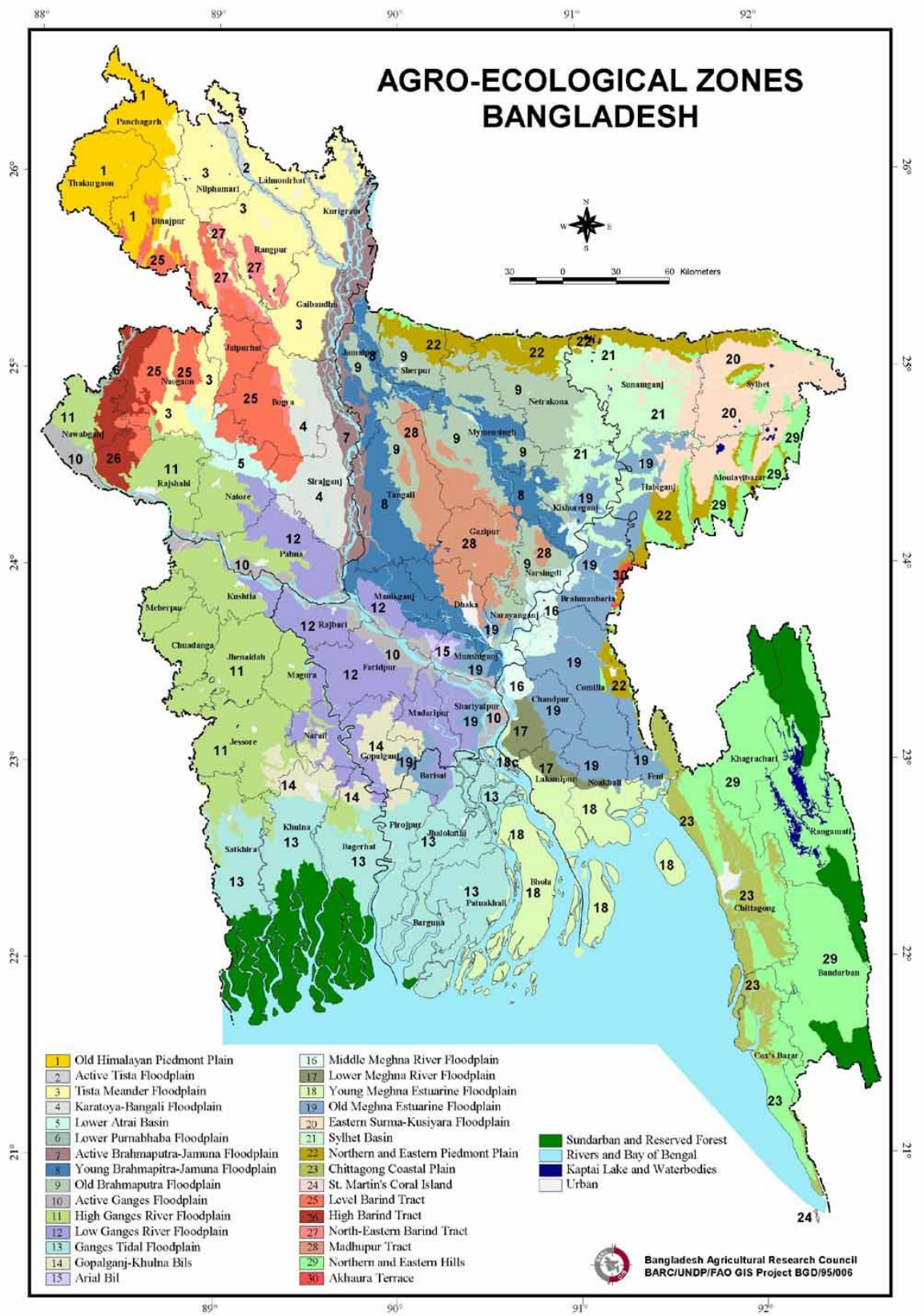
APPENDICES

Appendix I : Photograph showing location of experimental site



Appendix II : Characteristics of experimental soil was analyzed at Soil Resources Development Institute (SRDI). Farmgate. Dhaka.

A. Mechanical analysis

Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

B. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix III : Mean sum square of plant height of chickpea as influenced by fertilization and irrigation after sowing (DAS)

Plant height data at(30, 60, 90 days) and their interaction			
	Mean square		
Source of variation	**30 DAS**	**60 DAS**	**90 DAS**
Replication	0.71391	13.0935	0.8784
Fertilization	0.73280	8.8123	11.6203
Error I	1.48790	14.0384	33.3195
Irrigation	2.42090	5.3384	27.6073
Fertilization X Irrigation	1.54015	2.9136	8.4475
Error II	1.82620	15.2920	13.8920

Appendix IV : Mean sum square of number of branches of chickpea as influenced by fertilization and irrigation days after sowing (DAS)

Number of branches data at(30, 60, 90 days) and their interaction			
	Mean square		
Source of variation	**30 DAS**	**60 DAS**	**90 DAS**
Replication	2.98785	52.7512	21.7298
Fertilization	0.94100	25.9963	2.9776
Error I	1.09807	14.5270	5.4023
Irrigation	0.06076	11.1744	2.9879
Fertilization X Irrigation	0.60665	7.9852	1.4170
Error II	1.41722	13.1856	3.6285

Appendix V : Mean sum square of dry matter of chickpea as influenced by fertilization and irrigation days after sowing (DAS)

Final dry matter data and their interaction	
Source of variation	**Mean square**
Replication	8.16381
Fertilization	0.22461
Error I	1.65402
Irrigation	0.38461
Fertilization X Irrigation	0.40234
Error II	0.58750

Appendix VI : Mean sum square of number of pods plant^{-1}, number of seeds pod^{-1}, 1000- seed weight (g), seed yeild (t ha^{-1}) of chickpea as influenced by fertilization and irrigation days after sowing (DAS)

	Mean square			
Source of variation	**Number of pods plant^{-1}**	**Number of seeds pod^{-1}**	**1000- seed weight (g)**	**Yield (t ha^{-1})**
Replication	130.618	0.05980	40.765	0.01007
Fertilization	362.642	0.07794	320.520	0.00604
Error I	136.006	0.10146	21.239	0.02269
Irrigation	198.114	0.07778	330.208	0.07135
Fertilization X Irrigation	68.986	0.05275	263.176	0.06080
Error II	181.443	0.07008	11.619	0.02826

Appendix VII : Mean sum square stover yield, biological yield, harvest index of chickpea as influenced by fertilization and irrigation days after sowing (DAS)

	Mean Square		
Source of variation	**Stover yeild**	**Biological yeild**	**Harvest indesx**
Replication	0.18050	0.11994	14.6749
Fertilization	0.02529	0.00764	9.8404
Error I	0.02495	0.06529	10.9362
Irrigation	1.64687	2.35261	72.3823
Fertilization X Irrigation	0.17724	0.41782	10.8497
Error II	0.19452	0.18831	46.1487