EFFECT OF TIME AND FREQUENCY OF IRRIGATION ON THE GROWTH AND YIELD ATTRIBUTES OF CHICKPEA (*Cicer arietinum* L.) VARIETIES

A THESIS

BY

MD. MASUM BHUIYAN

DEPARTMENT OF AGRICULTURAL BOTANY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA -1207

JUNE, 2017

EFFECT OF TIME AND FREQUENCY OF IRRIGATION ON THE GROWTH AND YIELD ATTRIBUTES OF CHICKPEA (*Cicer arietinum* L.) VARIETIES

BY

MD. MASUM BHUIYAN

Registration No. : 11-04446

A Thesis
Submitted to the Department of Agricultural Botany
Sher-e-Bangla Agricultural University, Dhaka, in partial
fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE

IN

AGRICULTURAL BOTANY

SEMESTER: JANUARY-JUNE/2015

Approved by:

Prof. Dr. Kamal Uddin Ahamed	**Prof.Dr. Md. Moinul Haque**
Supervisor	**Co-Supervisor**

Prof. Dr. Nasima Akter

Chairman

Examination Committee

Dedicated to my

Beloved Parents

&

Teacher

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

PABX: +88029144270-9

Fax: +88029112649

Ref: *Date: .....*

CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF TIME AND FREQUENCY OF IRRIGATION ON THE GROWTH AND YIELD ATTRIBUTES OF CHICKPEA VARIETIES" submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN AGRICULTURAL BOTANY, embodies the results of a piece of bona fide research work carried out by MD. MASUM BHUIYAN Registration No. 11-04446 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 :June, 2017

Place: Dhaka, Bangladesh

Prof. Dr. Kamal Uddin Ahamed
Dept. of Agricultural Botany
SAU, Dhaka
Supervisor

ACKNOWLEDGEMENTS

All praises goes to Almighty Allah, the Supreme Ruler of the universe who enabled the Author to complete the present piece of work.

I would like to express the heartiest respect, deep sense of gratitude and sincere, profound appreciation to my supervisor, ***Prof. Dr. Kamal Uddin Ahamed****, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.*

I would like to express my heartiest respect and profound appreciation to my Co-supervisor, Dr. ***Md. Moinul Haque****, Professor, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of the thesis.*

I express my sincere respect to the Chairman, ***Prof. Dr. Nasima Akter,*** *and all the teachers of Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for providing the facilities to conduct the experiment and for their valuable advice and sympathetic consideration in connection with the study.*

I would like to thank my all roommates and friends especially senior brother (Arif) to help me in my research work.

Mere diction is not enough to express my profound gratitude and deepest appreciation to my father, mother, brothers, sisters, and friends for their ending prayer, encouragement, sacrifice and dedicated efforts to educate me to this level.

June, 2017 ***The Author***

SAU, Dhaka

EFFECT OF TIME AND FREQUENCY OF IRRIGATION ON THE GROWTH AND YIELD ATTRIBUTES OF CHICKPEA VARIETIES

ABSTRACT

The present experiment was conducted in the Agricultural Botany field laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during rabi season (November 2016 to March, 2017) to study the response of chickpea varieties to different levels of irrigation . In this experiment, the treatment consisted of three chickpea varieties viz. BARI Chola-5, BARI Chola-9 and BARI Chola-7 and four irrigation levels viz. No irrigation, Irrigation after 40 and 50 DAS, Irrigation after 60 and 80 DAS, Irrigation after 50, 70, and 90 DAS. The experiment was laid out in a Randomized Complete Block Design with three replications. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed significant variations among the treatments in respect of majority of the observed parameters. The tallest plant height was obtained from BARI Chola 9. BARI Chola 9 produced maximum number of branch per plant, number of pod per plant, number of seeds per pod, 1000-seed. The highest yield (1.723 t/ha) was recorded in care of BARI Chola-9. The lowest yield was recorded in BARI Chola-5 (1.434 kg/h). Significant influence of different levels of irrigation ware observed on maximum parameters. The tallest plant was recorded with the Irrigation after 60 and 80 DAS. The maximum number of pod per plant (37.39), number of seed per pod (2.28), 1000-seed weight (123.00 g) were produced with the Irrigation after 60 and 80 DAS. The maximum yield of seed per hectare (2.15 t) was obtained from Irrigation after 60 and 80 DAS treatment. The interaction between variety and irrigation was found significant on the all the parameters. The highest yield of seed per hectare (2.52 tones) was obtained from BARI Chola-9 with Irrigation after 60 and 80 DAS treatment combination. The highest yield of stover per hectare 2.62 tones, biological yield per hectare 5.13 tones, harvest index 49.02 % were obtained from BARI Chola-9 with Irrigation after 60 and 80 DAS. treatment combination.

CONTENTS

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDDIX

LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
HRC	=	Horticulture Research Centre
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muriate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days After Transplanting
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

Chapter I

INTRODUCTION

Chickpea, bengal gram or gram (*Cicer arietinum* L.) is the fifth most important legume in the world on the basis of total production after soybean, groundnuts, beans and peas (Muzquiz and Wood, 2017). It is a main nutritive legume crop of rural and urban household of the poor in the developing world. It is an important source of cheap protein with high energy and nutritive value (El-Karamany and Bahr, 2017). It is a rich source of protein, carbohydrate, B-group vitamins, and certain minerals, particularly to the populations of developing nations (Chavan *et al.*, 2017). Chickpea being a leguminous crop improves soil fertility by fixing atmospheric nitrogen up to 99 kg/ha (Schwenke *et al*., 2017) in available from (NH_3 and NH_4) in the root through the phenomenon of symbiosis.

It is used in many forms as dal, chhole, sweets and many attractive dishes. Snacks are prepared from its flour. Its leaves contain malic and citric acid, which are very useful for stomach ailments and it is best blood purifier. Nutritionally, it is very rich as it contains about 18-22 percent protein, 62 per cent carbohydrate and good amount of fat; besides it is a rich source of Ca, Fe and vitamin C (in green stage) and vitamin B_1.

Chickpea is largely cultivated in the temperate region (Joshi *et al*., 2017). However, some studies show that it is grown across a wide range of environments (Rao *et al*., 2017; Siddique *et al*., 2017). It is grown mainly in

Central Asia, West Asia, South Europe, Australia and North Africa (Berger and Turner, 2017). Chickpea is a premier pulse crop of Bangladesh grown in *rabi* season under various cropping systems. In Bangladesh, it is grown on an area about 8233 hectares with an annual production of 6605 metric tonnes and average productivity is 0.76 mt ha^{-1} (BBS, 2017). It contributes about 47% of the total pulse production and about 40% of total pulse growing area in the country.

There are two groups of chickpea, depending on seed size, shape, and colour. The large-seeded chickpeas (in excess of 26 g/100 seeds) are called Kabuli and the smaller ones are called Desi. Desi types are traditionally grown in India, other parts of Asia, and in Ethiopia and account for more than 80% of the world production of chickpea (Muehlbauer et al. 2017). Important strategies to enhance production and productivity of chickpea include: high yielding varieties, appropriate sowing time, irrigation, bio-fertilizer, integrated management of pest and diseases, etc. (Sohu et al. 2017, Patel et al. 2017, Kadam et al. 2017, Moemeni et al. 2017).

It is also a fact that specified genotypes does not exhibit the same phenotypic characteristics in all environmental conditions. The different genotype growth response varies to different environment and their relative ranking usually differ (Eberhort and Russel, 2016) and ultimately decides the selection of genotypes for a particular or different sowing dates for stabilized higher yields (Perkins and Jinks, 2016).

Water management has become the indispensable factor for augmenting the crop productivity especially in legume crops because of their high susceptibility to both water stress and water logging at various growth stages. This warrants the need for adoption of suitable irrigation method which creates a favorable soil moisture environment for maximizing yield by conserving moisture, reducing weed growth and improving crop growth and yield promotional factors. In the present day of water scarcity, optimum method of irrigation plays a vital role in economizing irrigation water and enhancing crop yield. Many research finding also confirm considerable saving in irrigation water through adoption of proper irrigation layout. Modified land configuration such as furrow irrigated raised bed has sown good promise in enhancing chickpea performance and water productivity, (Jat *et.al* 2015). Application of appropriate methods of irrigation, supplemental irrigation and water harvesting is among strategies reducing the risk of crop production within arid and semi arid areas, hence providing relatively permanent yield in these areas. Supplemental irrigation is aimed at supplying minimum amount of plants water requirement and compared to full irrigation during plants growth period. Its efficiency has been reported about 60-70% in some countries.

Supply of timely and adequate irrigation is a key factor for high and economic yield. Land configuration also plays a vital role in increasing the crop production. Raised bed planting also prevented excess moisture problem in heavy soils. Chickpea is very sensitive to water logging condition results in

heavy plant mortality hence, sowing the crop by ridge and furrow method found to be advantageous as compared to normal sowing.

Keeping in view of above facts, a field experiment entitled, “Effect of Time and Frequency of irrigation on the Growth and yield attributes of chickpea varieties” was undertaken with the following objectives:-

1. To investigate the effect of time and frequency of irrigation on the growth attributes of chickpea varieties.

2. To study the effect of time and frequency of irrigation on the morphological characters of chickpea varieties.

3. To envisage the effect of time and frequency of irrigation on the yield of chickpea varieties.

CHAPTER II

REVIEW OF LITERATURE

Chickpea is an important legume crop in Bangladesh which can contribute to a large scale in the national economy. But the research works done on this crop with respect to agronomic practices are inadequate. Only some limited studies have so far been done in respect of management practices of the crop.

2.1 Effect of varieties

Varieties play an important role in determining the yield of a crop. The potential yield of variety within its genetic limit is set by its environment. The release of new short duration varieties of pulses is a major breakthrough in achieving increased pulse production per unit area and time. Yield of these varieties can be further improved by providing optimum environment by manipulating agronomic practices. Varieties differ in their yield potential depending on many physiological processes which are controlled by both genetic makeup and the environment.

2.1.1 Phenology

Dixit (1992) in a field experiment at Powarkheda, Hoshangabad (Madhya Pradesh) and observed that the initiation of each stage from germination to pod setting was late in case of *cv*. Radhey as compared to *cv*. Ujjain-21. Thus, *cv*. Radhey took maximum maturity duration *i.e*., 123.2 days as against 114.4 days in case of *cv*. Ujjain-21.

Ganguly and Bhattacharya (2001) reported that maximum and minimum days to 50 per cent flowering in twenty six chickpea genotypes were considerably lower under late (45 days after normal) than normal sown crops. The local *cv*. PBG1 took more than twice the number of days to first flower than *cv*. ICCV 96029 in the first two sowing dates and in the third sowing date it took 82 days to first flower. Chaitanya and Chandrika (2006) at Tirupati (Andhra Pradesh) found that chickpea *cv*. ICCV 10 took 102 days to reach maturity as compared to Annegeri-1 (98 days) and ICCV 2 (80 days).

Sardar (2009) at Dharwad (Karnataka) observed significant variation in phenological behavior among chickpea cultivars. BG-256 took significantly maximum days to reach first flower (49.83 days), first pod (60.25 days) and harvest (82.75 days), while ICCV-2 took significantly less days to reach first flower (30.16 days), first pod (40.33 days) and harvest (69.50 days).

2.1.2 Plant height (cm)

Brar *et al.* (1993) observed that kabuli chickpea *cv*. L 550 recorded significantly greater plant height over desi chickpea *cv*. GL-769. Reddy and Ahlawat (1998) noticed significantly higher plant height in desi variety BG-261 as compared to Kabuli variety ICCC-32. Chaitanya and Chandrika (2006) at Tirupati (Andhra Pradesh) reported that chickpea *cv*. ICCV 10 exhibited the greater plant height (35.0 cm) as compared to *cvs*. Annigeri 1 (30.7 cm) and ICCV 2 (28.0 cm). Sardar (2009) at Dharwad (Karnataka) observed that the plant height among differed chickpea varieties differed significantly at 30

DAS, 60 DAS and at harvest. Cultivar KAK-2 exhibited significantly greater plant height of 29.3 cm, 45.8 cm and 48.3 cm at 30 DAS, 60 DAS and at harvest, respectively as compared to other cultivars. However, cultivars ICCV-2 and Bheema were found not significant with each other.

2.1.3 Number of branches

Kumar et *al.* (2017) conducted during the Rabi season of 2013-14 at the Crop Research Farm, Department of Agronomy, Allahabad School of Agriculture, SHIATS, Allahabad, Uttar Pradesh. The treatments consisted of three phosphorus levels (40, 60 and 80 kg/ha), 3 levels of sulphur (15, 20 and 25 kg/ha) and two cultivars (Pusa-362 and Radhey) with plot size of 3 x 3 m (9 m2). The results revealed that treatment comprising Pusa-362 + P2O5 60 kg/ha + sulphur 25 kg/ha recorded highest plant height (48.60 cm), number of branches per plant (7.66).

Kumar *et al*. (2003) at Hisar (Haryana) reported that number branches plant-1 were significantly more in chickpea genotype H 96-99 as compared to genotypes H 92 -69 and HC-1.

Sardar (2009) at Dharwad (Karnataka) observed that *cv*. KAK-2 recorded significantly more number of branches *i.e*., 8.05, 17.1 and 18.3 branches plant-1 at 30 DAS, 60 DAS and at harvest, respectively as compared to other cultivars.

Brar *et al.* (1993) observed that kabuli chickpea *cv*. L 550 produced significantly higher total dry matter accumulation than desi chickpea *cv*. GL-769.

Reddy and Ahlawat (1998) observed significantly higher dry matter plant-1 in desi variety BG-261 as compared to Kabuli variety ICCC-32.

Fazlul Kabir (2009) at Gazipur (Bangladesh) reported that chickpea *cv*. BARI Chola-6 exhibited higher TDM (24.3 g m-2) as compared to cvs. BARI Chola-2 (21.0 g m-2) and BARI Chola-4 (20.8 g m-2). Sardar (2009) at Dharwad

(Karnataka) observed that the total biomass accumulation and its partitioning (g plant-1) into leaves, stem and pod were found significantly higher in *cv*. KAK-2 as compared to *cvs*. BG 256, ICCV-2 and Bheema at 30 DAS, 60 DAS and at harvest.

2.1.4 Yield attributes and yield

Brar *et al.* (1993) observed significantly higher number of pods plant-1 in desi variety GL 769 as compared to kabuli variety L550. Reddy and Ahlawat (1998) reported that desi variety BG 261 recorded significantly higher number of pods plant-1 than kabuli variety ICCC-32. The maximum number of pods plant-1 under delayed sown crop on 20 November and 20 December was recorded in *cv*. HC1.

Virk *et al*. (2005) reported that chickpea *cv*. GNG 469 exhibited higher number of pods (75 plant^{-1}) followed by *cvs*. GPF 2 (66.8 plant^{-1}) and PGD 4 (53.3

plant^{-1}). Sardar (2009) at Dharwad (Karnataka) quoted that number of pods plant^{-1} differed significantly among chickpea varieties. Significantly higher number of pods plant^{-1} was recorded in variety BG-256 (40.3) over rest of the varieties *viz*., KAK-2 (37.3), Bheema (34.8) and ICCV-2 (32.6).

Brar *et al.* (1993) reported significantly higher number of seed pod^{-1} in desi variety GL 769 as compared to kabuli variety L550. Reddy and Ahlawat (1998) found that desi variety BG 261 exhibited significantly higher number of seeds pod^{-1} over kabuli variety ICCC-32. Chaitanya and Chandrika (2006) noted that chickpea *cv*. ICCV 10 produced higher number of seeds pod-1 (1.3) as compared to *cvs*. Annigeri 1. (1.27) and ICCV 2 (0.99). Brar *et al.* (1993) found that desi variety GL 769 recorded significantly lower test weight than kabuli variety L550. Reddy and Ahlawat (1998) quoted that kabuli variety ICCC-32 out yielded desi variety BG 261 with respect to 100 seed weight. Sharma *et al*. (1988) observed that *cv*. G-2 produced the higher seed yield of 14.8 q ha-1 as compared with 11.2 -12.6 q ha-1 for other chickpea cultivars.

Siag and Verma (1995) reported that chickpea *cv*. GL 83119 exhibited the highest seed yield (22.6 q ha-1) than *cv*. GNG 146 (20.3 q ha-1).

Singh *et al*. (2004) reported that *cv*. Pant G-114 produced the higher seed yield as compared to *cvs*. Radhey and Awarodhi. Nagarajaiah *et al*. (2005) in Mataprabha Command Area of chickpea observed that chickpea *cv*. Annigeri-1 recorded significant higher seed yield (1408 kg ha-1) over *cv*. ICCV 2 (1332 kg ha-1). Virk *et al*. (2005) reported that chickpea *cv*. GNG 469 produced higher

seed yield (2008 kg ha-1) as compared to *cvs*. GPF 2 (1842 kg ha-1) and PGD 4 (1626 kg ha-1). Kumar *et al*. (2008) at Hisar (Haryana) observed that chickpea *cv*. HC-1 recorded significantly higher seed yield as compared to other varieties. Yadav *et al*. (1998) at New Delhi reported that delayed sowing beyond November decreased seed yield in both desi and kabuli chickpea. However reduction in kabuli chickpea was on the higher side than desi chickpea.

Khatun *et al.* (2010) a field experiments were carried out during 2004-2006 at Bangladesh Agricultural Research Institute Farm in Grey Terrace Soils, Agro-Ecological Zone (AEZ 28), Joydebpur, Gazipur, Bangladesh to determine the effects of harvesting time on yield and yield attributes of chickpea. All the seeds were stored in earthen pot until conducting the field study. Significant variation was not observed in three varieties of chickpea for most of the parameters studied. The highest pods/plant, seeds/pod, and seed yield were observed in BARI Chola-5 and the lowest in BARI Chola-8. Seeds collected at the stage when most of the pods were light brown with a few yellow (H_2 stage) recorded the highest pods/plant, seeds/pod, 1000-seed weight and seed yield. The highest seed yield was recorded from BARI Chola-5 when seeds were collected at H_2 stage.

Reddy and Ahlawat (1998) observed that desi variety BG 261 exhibited significantly greater straw yield as compared to kabuli variety ICCC-32 Similarly.

Sardar (2009) at Dharwad (Karnataka) reported that significantly higher biological yield was recorded in chickpea variety KAK-2 (7402 kg ha-1) over rest of the varieties *viz*., BG-256 (5638 kg ha-1), Bheema (5120 kg ha-1) and ICCV-2 (5087 kg ha-1). However, varieties Bheema and ICCV-2 were at par with each other.

Sekhar *et al.* (2015) conducted to study the performance of chickpea varieties (KAK-2, Pule G 95311(Vihar), JG 11 and Nbeg-3) under five different dates of sowing viz., October first week, October third week, November first week, November third week and December first week at Regional Agricultural Research Station, Chintapalli, Visakhapatnam district of Andhra Pradesh during *rabi* season of the year 2011-12, 2012-13 and 2013-14. The results of three years study revealed that among the five different dates of sowing November first week sowing recorded significantly higher yields (1521.5 kg ha-1) followed by October third week sowing (1296.5 kg ha-1) and among the varieties JG11 produced higher seed yields (1278 kg ha-1) followed by NBeg 3 (1188.8 kg ha-1).

2.1.6 Harvest index (%)

Chaitanya and Chandrika (2006) at Tirupati (Andhra Pradesh) reported that harvest index among different cultivars of chickpea did not differ significantly. However, *cv*. Annigeri-1 had higher value of harvest index (25.7%) over rest of cultivars. Sharma *et al*. (2007) quoted that the higher harvest index was observed in chickpea *cv*. BG 364 as compared to *cvs*. C 214 and K 850. Kaya

(2010) at Isparta (Turkey) reported that harvest index was higher in *cv*. Gokce (47.9%) over the other cultivars *viz*., Akcin 91 (46.4%) and Ispanyol (46.0%). However, no significant differences were determined between *cvs*. Ispanyol and Akcin 91.

2.2 Effect of irrigation on growth and yield of chickpea

El-Warakly and EI Koliey (2017) studied the effect of irrigation on chickpea in Egypt and reported that irrigation at flowering and pod development stage exhibited higher seed yield, number of pods, branches, seed yield/plant, and seed weight over control.

Bandyopadhyay *et al.*(2017),reported that highest growth, yield, consumptive use and coefficient were recorded from chickpea plants subjected to two irrigation applied at branching and pod development. One irrigation during branching also produced an appreciably higher grain yield compared with no irrigation and one irrigation during the pod development stage.

Haqqani *et al.* (2017) reported that yield of chickpea was highest with irrigation at flowering (110 days after sowing) over control and pod formation stages.

Falah (2017) reported that supplemental irrigation have significant effects on yield and yield component, also suitable plant densities and correct

adjustment of row spacing lead to optimum uses of soil and environment factors that produce high yield and yield component in chickpea.

Malik *et al* (2017) studies the performance of chickpea (Cicer arietinium L.) and its economic feasibility as affected by irrigation in Haryana, India obtained highest gross return (37575 rupees ha -1), net return (26340 rupees ha-1) and benefit cost ratio (2.35) with irrigation at the pre-flowering and pod initiation stages.

Sharma *et al* (2017) reported that two irrigation at pre-flowering and pod formation stages of chickpea and irrigation at pod formation stage of chickpea being at par with each other recorded significantly highest yield over the irrigation at per flowering stage of chickpea and no irrigation.

Mustafa *et al*. (2017) reported that the growth and yield of chickpea was highest with the irrigation scheduled at sowing branching, flowering and pod filling stages.

Golldani *et al* (2017) investigated the effects of irrigation levels on physiological characteristics and yield components of chickpea cultivars, in Iran , and found that highest seed yield was obtained with the three times irrigation and the lowest with no irrigation.

Irrigation had a marked effect on growth and yield. There was a 51 % increase in the weighed mean absolute growth rate (WMAGR) with full irrigation over no irrigation. In Kabuli chickpea, WMAGR with full irrigation was 18.6 g m-2

day-1and in narrowleafed lupin it was 23.0 g m-2 day-1 . Seed yields of fully-irrigated crops were treble the unirrigated treatment. With full irrigation, seed yield of chickpea was 326 and that of lupin 581 g m-2. Seed yield of the two legumes fell 45 % with double irrigation compared with full irrigation. Nitrogen (N) fertilizer did not increase seed yield in either legume. The increased seed yield resulted from increased radiation interception. Withfull irrigation, total intercepted photosynthetically active radiation (PAR) increased by 28 % and 33 % over that in nonirrigated plants in Kabuli chickpea and narrow-leafed lupin, respectively. The results of this study suggest that to achieve their yield potential, crops should be irrigated to replace water deficit over the whole of crop growth (Kang *et al*., 2017).

Malhotra *et al.* (2017) conducted an experiment in the field at TEL Hadya, Syria and reported that irrigation given at flowering and seed development stages increased seed yield of chickpea by 44%.

Kahraman *et al.* (2017) Conducted to determine the effect of different supplemental irrigation rates on chickpea grown under semiarid climate conditions. Chickpea plots were irrigation with drip irrigation system and irrigation rates includes the application of 0 (I), 25 (I), 50 (I). 75 (I), 100 (I), 125 (I) % of gravimetrically measured. Soil water deficit, plant height, 100 seed weight yield biomass, and harvest index parameter were determined in addition to yield-water functions, evapotranspiration (ET) water use efficiency (WUE) and irrigation water use efficiency (IWUE)

significantly differences were noted plant height (24 -37.5 cm), 1000 seed weight (192-428.7 gm) and above ground biomass (578-965.3 gm).

Moemeni, *et al* (2017) conducted to evaluate the effect of Supplementary irrigation, on growth indices of Chickpea, an experiment was conducted at Campus of Agriculture and Natural Resources, Razi University Kermanshah, Iran during 2017. Treatment was supplementary irrigation and non irrigation. The results showed that Supplementary irrigation increased total dry matter (TDM), leaf Area index (LAI), crop growth rate (CGR), Relative growth rate (RGR), leaf Area ratio (LAR) and net assimilation rate (NAR). Maximum LAI, LAR and CGR obtaind at 68 days after sowing under non irrigation condition, but under Supplementary irrigation they were observed at 82 days after sowing. RGR and NAR reduced with increasing the age of the plant.

Patel *et al*. (2017) Evaluated to improve chickpea production and to enhance water productivity in Bansagar commond area of Madhya Pradesh four water management treatments. Consisting two farmers' practices treatments, i.e. two irrigation by flooding method and two improved practices i.e. two irrigation at flowering and pod formation stage with border strip method were studied. Under improved practices water was applied twice each of 40 cm depth at flowering and pod formation stage by border strip method. It was researched that improved irrigation management practices gave significantly higher number of nodules (119/plant), and seed yield (1237 kg/ha) of chickpea. An increase of 11.32 % chickpea yield was noticed as compared to farmers practices.

Maleki *et al*. (2017) conducted to study the effects of supplemental irrigation, different levels of nitrogen chemical fertilizer and inoculation with rhizobium bacteria on the grain yield of chickpea, an experiment was carried out using split plot arrangement in randomize complete block design with three replication in agricultural researches station of Zanjan, Iran during 2016-2017 cropping season. The factors of experiment consisted of irritation (without irrigation (I_1), irrigation at flowering stage (I_2), irrigation at flowering and grain filling stages (I_3) and full irrigation (I_4)) and different levels of nitrogen fertilizer (without using of nitrogen fertilizer (N0), 75 kg.ha-1(N75), 150 kg.ha-1 (N150) and inoculation with rhizobium bacteria (N4). The results of the analysis of variance showed that the effects of irrigation, nitrogen fertilizer levels and bacterial inoculation, were significant affect on number of pods per plant, number grains per plant, grain weight, grain yield, biological yield and harvest index at 1% probability level. Also Results showed that the grain yield in full irrigation treatment and inoculated with rhizobium bacteria was significantly higher than the other treatments.

2.3 Combined effect of variety and irrigation

Nawa et al (2015) conducted to examine the impact of irrigation on chickpea yield, to select a variety/ varieties best suited for irrigated farming in irrigated region and to standardize the production technology package of irrigated chickpea. The experiment was conducted at ARS Bannu, in Randomized Complete Block Design with split plot arrangement having three replications. Irrigations (No irrigation, pre-sowing irrigation and irrigation at flowering

stage) were allotted to the main plots while varieties (Karak-1, Karak-2, Sheenghar and KC-98) and sowing dates (Oct. 1st, Oct. 15, Nov, 1, and Nov, 15) were kept in the sub plots. The sub plot size was 4 m by 1.8 m with row to row distance of 30 cm and plant to plant distance of 10 cm. It was found from the results of the above experiment that planting dates significantly affected grain yield and its components. Grain yield significantly decreased with delay in planting beyond Ist November at Bannu. Irrigation did not influence grain yield of chickpea at Bannu as well. Chickpea cultivar Karak-I produced significantly higher grain yield followed by Karak-II at Bannu. It is therefore recommended that chickpea crop may be planted in the month of October or with a maximum delay till early November at Bannu. Chickpea variety Karak-I is recommend for planting at Bannu for obtaining higher grain yield. It is concluded from the above experiment that planting dates at Bannu significantly affected grain yield and its components and higher grain yield was produced in early planting (1^{st} October) and decline with delay in planting at Bannu. Irrigation did not influence grain yield of chickpea.

Ali (2017) was conducted at BINA sub-station Magura, to evaluate the yield potential of new cultivars of chickpea under different irrigation regimes. The experimental design was RCBD (with split-plot) having irrigation treatments in the main plots and chickpea varieties in the sub-plots. The irrigation treatments comprised of: control (no irrigation) [T1], irrigation at vegetative stage (25-30 DAS) [T2], irrigation at flowering stage (45- 50 DAS) [T3], and irrigation at vegetative stage (25-30 DAS) and flowering stage (45-50 DAS) [T4]. The

varieties were: V1 = Binasola-5; V2 = Binasola-6 and V3 = Binasola-4. Irrigation water was applied up to field capacity as per treatment. The results revealed that irrigation treatments had detrimental effect on all yield attributes (plant height, seed per pod, branch per plant) and seed yield. The seed yield gradually reduced when irrigation was applied. The highest seed yield (1.87 t ha-1) was obtained from control treatment which received no irrigation. The varieties had also significant effect on all yield attributes and seed yield. The cultivar binasola-5 produced the highest yield (1.20 t ha-1). The highest water use efficiency (263.01 kg ha-1 cm-1) was also found in control treatment (T1), which received no irrigation. From the results of the study, it is revealed that under the prevailing climatic and soil condition, the chickpea cultivars do not need any irrigation at Magura, rather it reduces yield.

CHAPTER III

MATERIALS AND METHODS

The experiment was undertaken during rabi season (November 2016 to March, 2017) to determine the 'Effect of time and frequency of irrigation on the growth and yield attributes of chickpea varieties'.

3.1 Site selection

The present experiment was conducted in the Agricultural Botany field laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^0 74^/$N latitude and $90^0 35^/$E longitude and at an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Climate

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). The present experiment was conducted in rabi season. Cold temperature and minimum rainfall is the main feature of the rabi season. The monthly total rainfall, average sunshine hour, temperature during the study period (October to March) collected from the Bangladesh Meteorological Department, Agargoan, Dhaka are presented in Appendix I.

3.3 Characteristics of Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. It had shallow red brown terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka and details of the record of soil characteristics have been presented in Appendix II.

3.4 Details of the experiment

3.4.1 Seed

The crop used in this study was three cultivars of chickpea viz., BARI Chola-5, BARI Chola-7 and BARI Chola-9 varieties have been developed by the Bangladesh Agricultural Research Institute (BARI) for cultivation in this country. The seeds were collected from BARI, Joydebpur, Gazipur. The seeds were healthy, pulpy, well matured and free from mixture of other seeds, weed seeds and extraneous materials.

3.4.2 Fertilizers

Recommended dose of nutrients in chickpea are as follows:

$N = 20$ kg ha^{-1}

$P_2O_5 = 40$ kg ha^{-1}

$K_2O = 18$ kg ha^{-1}

Boric Acid = 10 kg ha^{-1}

Under the present experiment, Urea (as nitrogen) and TSP (as phosphorus), Muriate of Potash, Boric acid were applied as per recommended dose as per treatment .

3.5 Methods

3.5.1 Treatments

The experiment was consisted of two factors as follows:

Factor A: Cultivar-3

V_1= BARI Chola-5

V_2= BARI Chola-9

V_3= BARI Chola-7

Factor B: Treatment

I_1= No irrigation

I_2= Irrigation after 40 and 50 DAS

I_3= Irrigation after 60 and 80 DAS

I_4= Irrigation after 50, 70 and 90 DAS

Treatment combinations were: 3*4=12

Treatment combinations were-

$V_1 I_1, V_1 I_2, V_1 I_3, V_1 I_4, V_2 I_1, V_2 I_2, V_2 I_3, V_2 I_4, V_3 I_1, V_3 I_2, V_3 I_3, V_3 I_4$

3.5.2 Land Preparation

The experimental plot was irrigated to remove its hard dryness before ploughing. Then it was first opened with tractor drawn disc plough after having proper condition. Ploughed soil was then brought into desirable tilth by 4 operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 09 November and 17 November 2016, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before planting and the basal dose of fertilizers were incorporated thoroughly.

3.5.3 Fertilization

The amounts of fertilizer as per treatment in the forms of urea, Triple Super Phosphate and recommended dose of Muriate of Potash required per plot were calculated. Half of urea and total amount of all other fertilizers of each plot were applied and incorporated into soil. Rest of the urea was top dressed after 30 days of sowing (DAS).

3.5.4 Design and layout

The experiment was laid out in a Randomized Complete Block Design with three replications. The total plot number was 12 × 3 = 36. The unit plot size was 3 m × 2 m = 6 m^2. The replications were separated from one another by 1 m. The distance between plots was 0. 5 m.

3.5.5 Sowing of seeds

Sowing was done on 19 November, 2016 in rows 40 cm apart. Seeds were sown continuously in rows. The seeds were sown at a rate of 45 kg ha^{-1}. Seeds were treated with Bavistin before sowing the seeds to control the seed borne disease. After sowing, the seeds were covered with the soil, and slightly pressed by hand.

3.5.6 Thinning

The optimum plant population was maintained by thinning excess plants. Seeds germinated 6 days after sowing (DAS). First and second thinning was done at 15 and 30 DAS respectively to maintain plant to plant distance as 10 cm.

3.5.7 Weeding

Weeding was done twice; first weeding was done at 20 DAS and second weeding was done at 45 DAS.

3.5.8 Irrigation

Irrigation was given as per treatment. Equal amount of water was applied in each treatment during irrigation keeping the frequently different for different treatments. Proper care was taken to proper plot to plot leaching of water. After irrigation when the plots were in proper condition, spading was done uniformly and carefully to conserve the soil moisture.

3.5.9 Crop protection

The research field looked nice with normal green plants. The field was observed time to time to detect visual difference among the treatments and any kind of infestation. The experimental crop was infected with fungal disease and Ridomil Gold fungicide was used. At later stage of growth, pod borer (*Maruca testulalis*) attacked the plant. For pod borer furadan 5G at the rate of 1ml/litre of water per ha were sprayed.

3.6 Crop sampling and data collection

Selected ten plants from each treatment were randomly sampled and marked with tag for recording plant characters. The data of plant height, number of branches, dry weight, 1000 seed weight, yield etc. were recorded before and after the harvest.

3.7 Harvesting and threshing

Crops were harvested when 90% of the pod became brown to black in color. The matured crops were harvested on 25 March, 2017 and the harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

3.8 Drying and weighing

The seeds and stovers thus collected were dried in the sun for couple of days. Dried seeds and stovers of each plot was weighed and subsequently converted into kg ha^{-1}.

3.9 Data collection

The following data were collected for the present study

- Plant height (cm)
- No. of branches $plant^{-1}$
- Number of flower $plant^{-1}$
- Days to first fruit set
- Number of pods $plant^{-1}$
- Number of seeds pod^{-1}
- Weight of 1000 seeds (g)
- Seed yield (t ha^{-1})
- Stover yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest index (%)

3.10 Procedure of recording data

3.10.1 Plant height (cm)

The height of ten plants were measured 20 DAS, 40 DAS, 60 DAS and at harvest from ground level (stem base) to the tip of the plant. Mean plant height was calculated and expressed in cm.

3.10.2 Number of branches plant^{-1}

The number of branches of ten randomly selected plants were counted at 20 DAS, 40 DAS, 60 DAS, at harvest and recorded. Average value of ten plants was recorded as number of branches plant^{-1}.

3.10.3 Number of flowers plant^{-1}

The number of flowers of ten randomly selected plants were counted at harvest and recorded. Average value of ten plants was recorded as number of flowers plant^{-1}.

3.10.4 Days to first fruit set

Dates of first fruit set were recorded treatment wise and the period of time for first fruit set in days was calculated from the date of sowing.

3.10.5 Number of pods plant^{-1}

Total number of pods were collected from 10 randomly selected plants and then averaged to express in number of pods plant^{-1}.

3.10.6 Number of seeds pod^{-1}

Total number of pods was collected from 10 randomly selected plants and total number of seeds was counted and then number of seeds/pod was measured by the following formula:

$$\text{Number of seeds pod}^{-1} = \frac{\text{Total number of seed}}{\text{Total number of pod}}$$

3.10.7 Weight of 1000-seeds

A composite sample was taken from the yield of ten plants. The 1000-seeds of each plot were counted and weighed with a digital electronic balance. The 1000-seed weight was recorded in gram.

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

After threshing, cleaning and drying, total seed from harvested area (3.24 m^2) taken from the middle portion of the plot were recorded and was converted to t ha^{-1}.

3.10.9 Stover yield (t ha^{-1})

After separation of seeds from plant, the straw and shell per harvested area was sun dried and the weight was recorded and then converted into kg ha^{-1}.

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

The summation of seed yield and above ground stover yield per hectare was the biological yield. Biological yield = Grain yield + Stover yield

3.10.11Harvest index (%)

Harvest index was calculated by dividing the economic (seed) yield from the net plot by the total biological yield (seed + stover) from the same area and multiplying by 100.

$$\text{Harvest index (\%)} = \frac{\text{Seed yield (t /ha)}}{\text{Biological yield (t /ha)}} \times 100$$

3.11 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference between the results of different levels of irrigation on growth, yield and yield contributing characters of chickpea. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance difference among the treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter. The data have been presented in different tables and figures . The results have been presented and discussed, and possible interpretations have been given under the following headings**.**

4.1 Plant height

Data on plant height were recorded periodically at 20, 40 and 60 days after sowing (DAS). The plant height was significantly affected due to the different varieties at different days after sowing. The tallest plant height (12.93, 27.34, and 38.48 cm at 20, 40 and 60 DAS, respectively) was obtained from V_2 (BARI Chola 9) and the shortest plant height (1.86, 21.48 and 30.82 cm at 20, 40 and 60 DAS, respectively) was obtained in V_1 (BARI Chola 5) (Fig. 1). The plant height depends on their varietal characters. This character is governed by genetic factors. Kabir *et al.* (2017) observed in plant height, BARI Chola-4 produced the tallest plants (32.30 cm) being closely followed by BARI Chola-2 (30.90 cm). The shortest plants (29.26 cm were found in BARI Chola-6. Das (2017) also found significant variation among chickpea varieties BU Chola-1, BARI Chola-6 and BARI Chola-7 varied from 32.14 cm to 35.16 cm. the BARI Chola-7 was the tallest and BU Chola-1 was the shortest. Karasu *et al.* (2017) showed maximum plant height was recorded on popular local genotype of chickpea named Yerli (58.7 cm), Canıtez-87 cultivar and ILC-114 line had shorter plant height (54.7 and 53.7 cm, respectively).

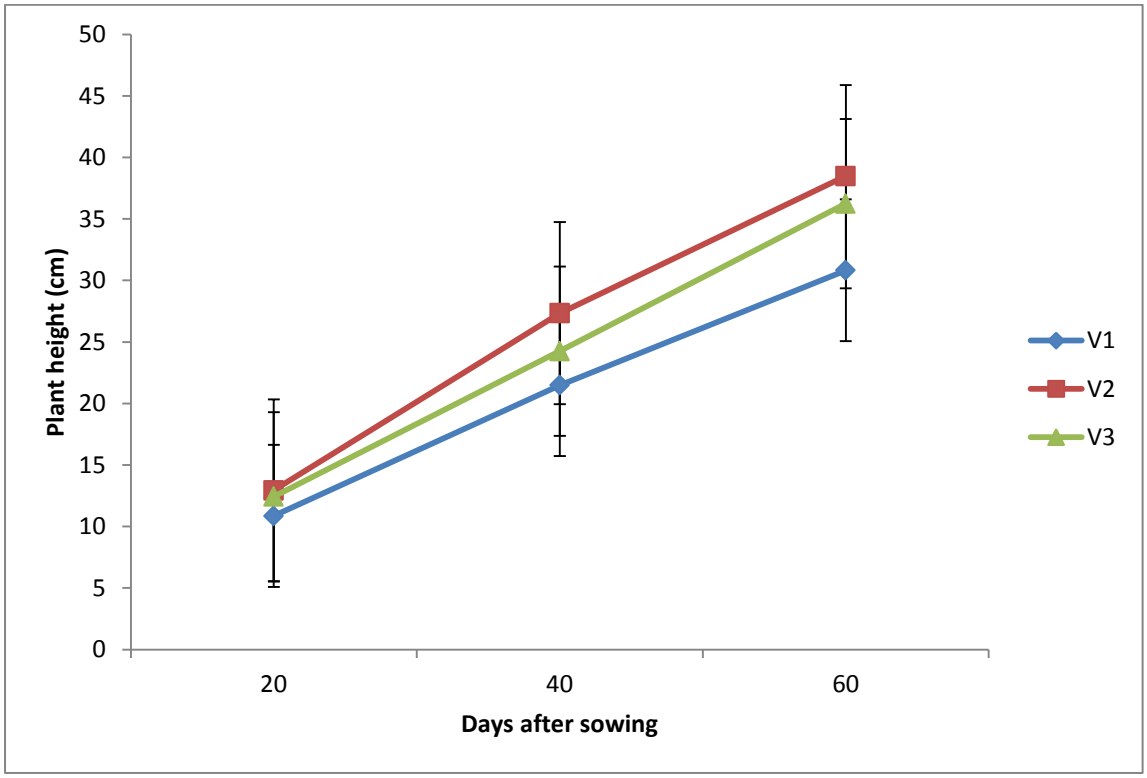

Figure 1. Effect of varieties on the plant height of chickpea at different days after sowing

Time and Frequency of irrigation influenced the height of chickpea plant non significantly at 20, 40 DAS but significant at 60 days after sowing (DAS) (fig. 2). The tallest plant (12.3, 25.82, 38.38 cm at 20, 40 and 60 DAS, respectively) was recorded with I_3 (Irrigation after 60 and 80 DAS). In contrast, the shortest plant (11.73, 22.32 and 30.04 cm at 20, 40 and 60 DAS, respectively) was recorded from I_1 (no irrigation). The result corroborates with the findings of Siag *et al*. (1993) who observed maximum plant height in the irrigation application treatment during branching and development stages.

The combined use of variety and irrigation had non significant effect on plant height at 20, 40 but significant at 60 days after sowing (DAS) (Table 1). The tallest plant (13.15, 27.72 and 39.73 cm at 20, 40 and 60 DAS, respectively) was found in V_2I_3 (BARI Chola-9 with Irrigation after 60 and 80 DAS) treatment combination, which was statistically similar to V_2I_2 treatment. The shortest plant (10.63, 19.05 and 19.60 cm at 20, 40 and 60 DAS, respectively) was observed in V_1I_1 (BARI Chola-5 with No irrigation) treatment combination.

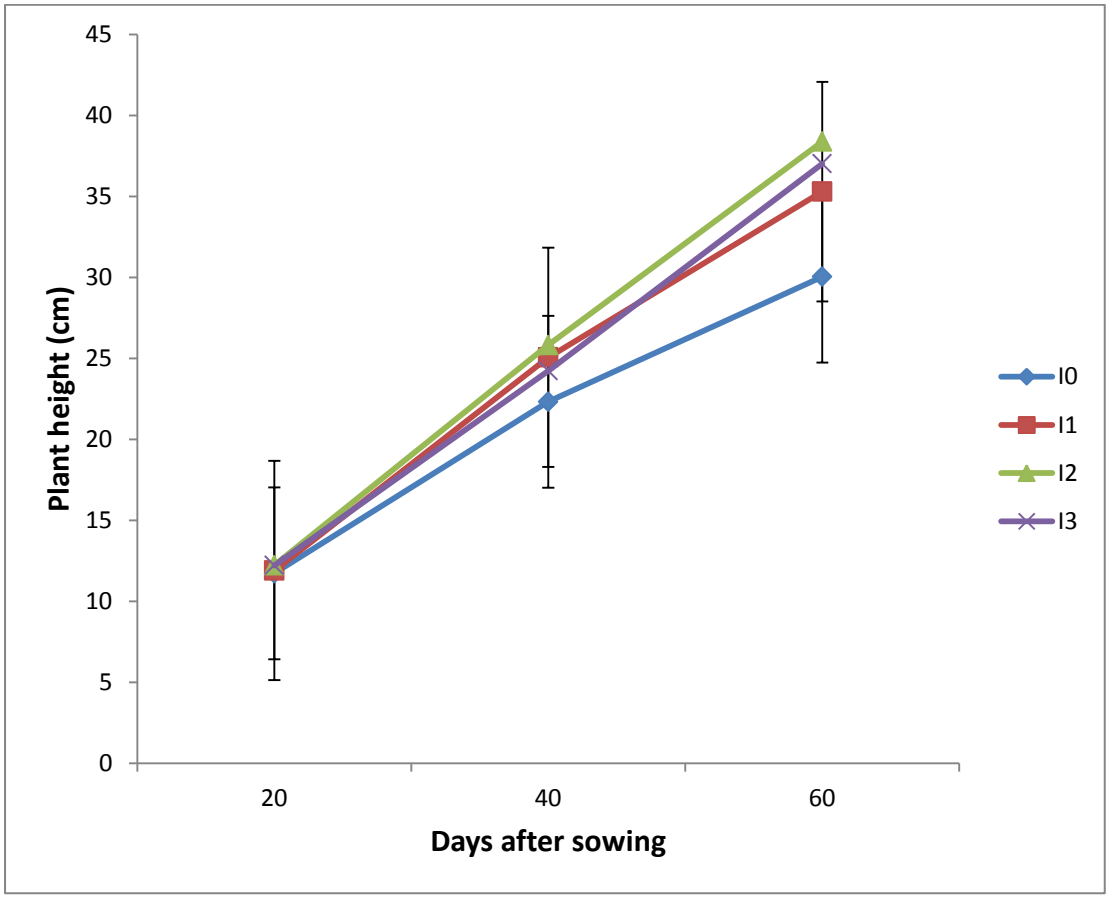

Figure 2. Effect of Time and frequency of irrigation on the plant height of chickpea at different days after sowing

Table 1. Combined effect of varieties with Time and Frequency of irrigation on the plant height of chickpea at different days after sowing

Treatment	Plant height (cm)		
	20 DAS	40 DAS	60 DAS
V_1I_1	10.63	19.05	19.60 e
V_1I_2	10.75	19.83	31.17 d
V_1I_3	10.88	24.54	36.40 ab
V_1I_4	11.18	22.50	36.10 ab
V_2I_1	12.80	26.87	36.87 ab
V_2I_2	12.76	27.24	38.27 ab
V_2I_3	13.15	27.54	39.73 a
V_2I_4	13.01	27.72	39.07 ab
V_3I_1	12.36	20.27	37.83 ab
V_3I_2	12.21	25.43	32.27 cd
V_3I_3	12.81	25.93	35.57 bc
V_3I_4	12.34	25.37	39.30 ab
$LSD_{(0.05)}$	0.52 ns	3.65 ns	3.39
CV (%)	5.14	8.84	7.93

4.2 Number of branch per plant

The number of branch per plant counted at different days was not significantly influenced by varieties. Treatment V_2 (BARI Chola 9) produced maximum number of branch (3.64, 7.09 and 11.72 at 20, 40 and 60 DAS, respectively) and the minimum (3.40, 6.24 and 10.15 at 20, 40 and 60 DAS, respectively) number of branch were recorded in V_1 (BARI Chola 5) treatment (Fig. 3). Das (2017) showed that the total number of branches across the varieties BU Chola-1, BARI Chola-5 and BARI Chola-7 averaged from 13.78 to 15.98. BARI Chola-9 produced the highest and BARI Chola-5 produced the lowest number of branches plant^{-1}. Similar results were noticed by Ferdous (2017) in pea.

The irrigation was not significant variation in the number of branches per plant at 20, 40 and but significant at 60 DAS (Fig. 4). The maximum number of branches per plant (3.622, 7.28 and 11.74 at 20, 40 and 60 DAS, respectively) was produced by I_3 treatment. No irrigation (I_1) produced the minimum number of branches per plant (3.21, 5.74 and 10.42 at 20, 40 and 60 DAS, respectively). Similar finding was reported by Joarder *et al.* (2016) that irrigation increased primary and secondary branches plant^{-1}.

The interaction between variety and irrigation was found non significant on the number of branches per plant at 20, 40 but significant at 60 DAS (Table 2). The maximum number of branches per plant (4.10, 8.433 and 12.73, at 20, 40 and 60 DAS, respectively) was found in V_2I_3 treatment combination, whereas the lowest number of branches per plant (2.97, 4.7 and 8.6 at 20, 40 and 60 DAS, respectively) was found in V_1I_1 treatment.

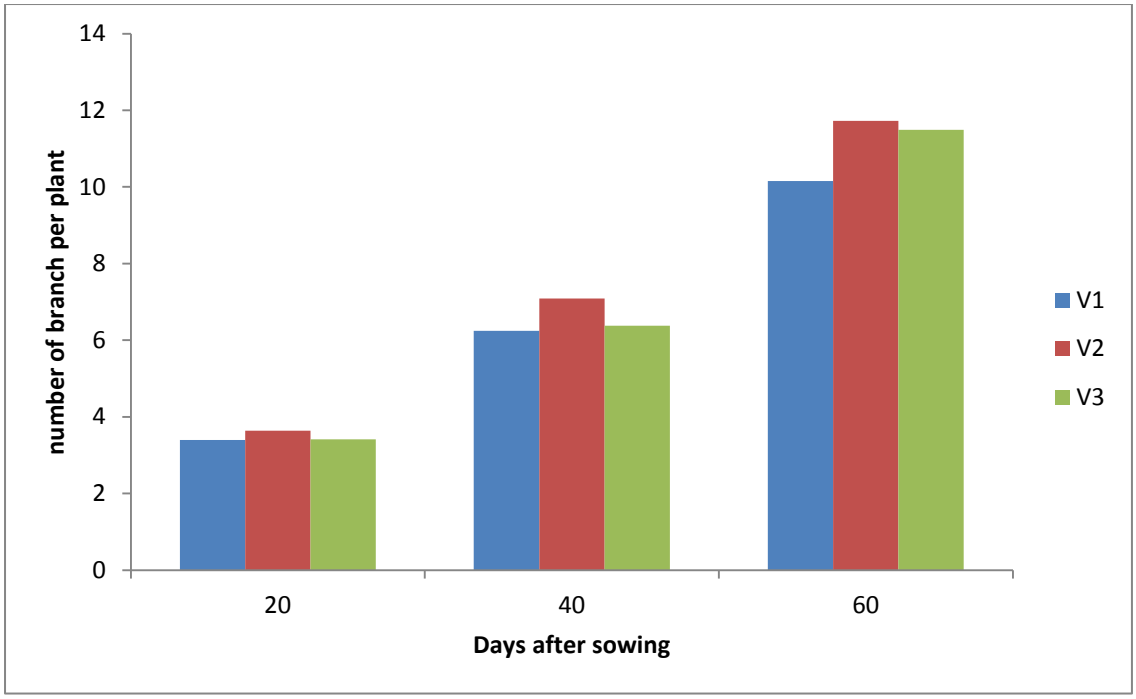

Figure 3. Effect of varieties on the number of branch per plant of chickpea at different days after sowing

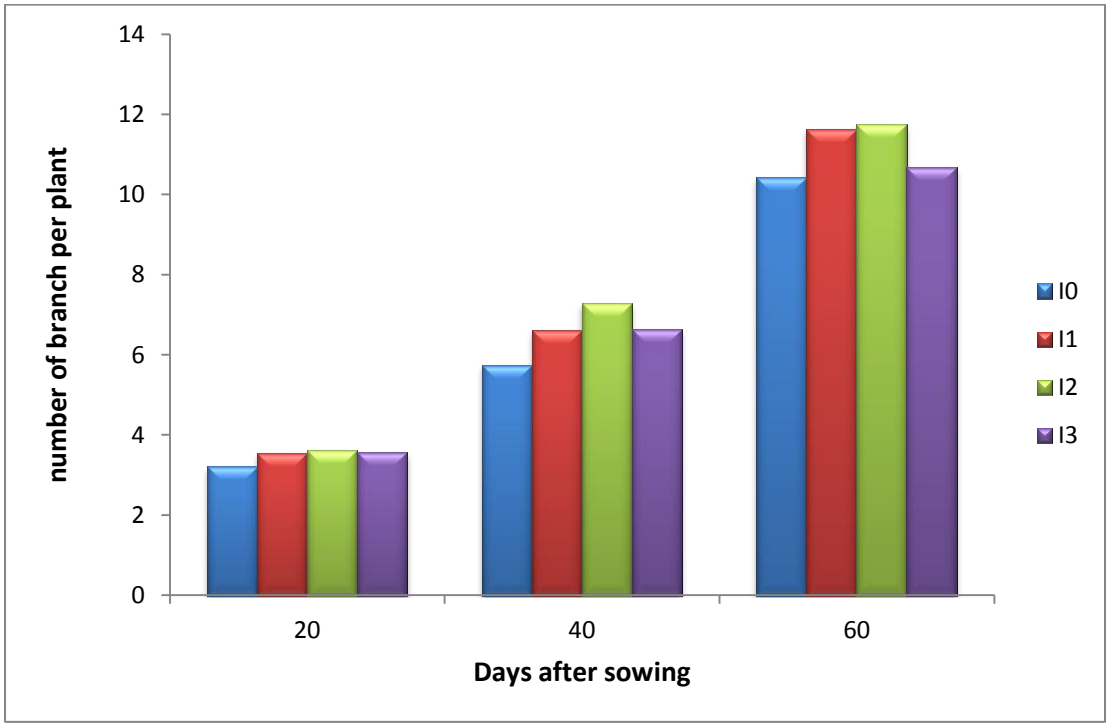

Figure 4. Effect of Time and Frequency of irrigation on the number of branch per plant of chickpea at different days after sowing

Table 2. Combined effect of varieties with Time and Frequency of irrigation on the Number of branch per plant of chickpea at different days after sowing

Treatment	Number of branch per plant			
	20 DAS	40 DAS	60 DAS	
V_1I_1	2.97	4.70	8.60	b
V_1I_2	3.27	6.53	12.57	a
V_1I_3	3.63	5.07	12.17	ab
V_1I_4	3.37	6.83	12.63	a
V_2I_1	3.57	6.63	10.57	ab
V_2I_2	3.40	6.00	12.13	ab
V_2I_3	4.10	8.43	12.73	a
V_2I_4	3.50	7.30	11.43	ab
V_3I_1	3.33	6.53	9.93	ab
V_3I_2	2.97	6.70	10.53	ab
V_3I_3	3.73	7.70	11.30	ab
V_3I_4	3.40	6.40	8.83	ab
LSD (0.05)	0.82 ns	1.47 ns	3.40	
CV (%)	6.92	6.20	10.15	

4.3 Number of flowers per plant

The number of flowers per plant was significantly varied by varieties. The highest number of flower per plant (32.33) was recorded in V_2 (BARI Chola-9). The minimum number of flower per plant (28.80) was observed in V_1 (BARI Chola-5) (Table 3).

The irrigation showed variation in the number of flower per plant (Table 4). The maximum number of flower per plant (39.68) was produced by I_3, whereas I_1 produced the minimum number of flower per plant (25.45). Flower per plant were increased with the irrigation due to the supply of adequate soil moisture which helped to produce the more pod having number of seeds. This phenomena is reported by Prasad and Ashanullah (1988), Sarker and Hassan (1988), Sharma and Kumar (1989).

Number of flower per plant indicated a significant variation among the treatment combinations of variety and irrigation (Table 5). The maximum number of flower per plant (43.50) was found in V_2I_3 treatment combination, which was statistically similar with V_1I_3, whereas the minimum number of flower per plant (24.38) was found in V_1I_1treatment.

4.4 Days to first fruit setting

There was a marked difference among the varieties in the days to first flowering. The earliest of days to first fruit setting (49.42 DAS) was found in V_2 and the longest time (54.08 DAS) were recorded in V_1 treatment (table 3).

There was not marked difference among the different irrigation in the days to first flowering. The earliest of days to first fruit setting (51.22 DAS) was found in I_3 and the longest time (51.44 DAS) were recorded in I_1 treatment (Table 4). The combined effect of variety and irrigation was significantly varied from in the days to first flowering. The earliest of days to first fruit setting (49.0 DAS) was found in V_2I_2, V_2I_3 and V_2I_4 and the longest time (54.33 DAS) were recorded in V_1I_1 treatment (table 5).

4.5 Number of pod per plant

The number of pod per plant was significantly influenced due to the different varieties at harvest (Table 3). The highest number of pod per plant (28.82) was recorded in V_2 (BARI chola 9). The lowest number of pods plant^{-1} (25.36) was recorded in BARI Chola 5. Pod number plant-1 of a cultivar depends on nutrient availability during reproductive stage as well as on genetical factor. Kabir *et al.* (2017) observed the highest number of (26.37) pods plant-1 in BARI Chola-4 followed by BARI Chola-2. The lowest number of (21.27) pods were found in BARI Chola-6. Hasanuzzaman *et al.* (2007) showed that BARI chola-4 produced maximum number of pods per plant (33.35) and BARI chola-1 produced lower pod. It reveals that all the varieties have similar capabilities of pod production. The maximum production of pod was 44% greater than the lower pod production. Ali *et al.* (2016) showed that among the performance of six brown chickpea (*Cicer arietinum* L.) genotypes viz. 90261, 93127, 97086, 98004, 98154, genotype 98004 expressed comparatively more pods per plant (77.58).

Table 3. Effect of varieties on the yield contributing character of chickpea

Treatment	Number of flower per plant(days)	First fruit setting per plant(days)	Number of pods per plant	Number of seed per pod	1000-seed weight (g)
V_3	30.66 ab	54.08 a	27.62 ab	1.94 b	116.90 a
V_2	32.33 a	49.42 c	28.82 a	2.10 a	117.30 a
V_1	28.80 b	50.50 b	25.36 b	1.86 b	115.20 a
$LSD_{(0.05)}$	2.88	0.96	3.36	0.16	6.36
CV (%)	9.62	5.47	6.15	4.77	5.57

Table 4. Effect of Time and Frequency of irrigation on the yield contributing characters of chickpea

Treatment	Number of flower per plant	First fruit setting per plant (days)	Number of pods per plant	Number of seed per pod	1000-seed weight (g)
I_1	25.45 c	51.44 a	20.51 c	1.60 c	110.60 c
I_2	29.43 b	51.33 a	26.46 b	2.00 b	116.10 b
I_3	39.68 a	51.22 a	37.39 a	2.28 a	123.00 a
I_4	27.82 bc	51.33 a	24.72 b	1.99 b	116.10 b
$LSD_{(0.05)}$	3.36	0.71	2.86	0.14	2.93
CV (%)	9.62	5.47	6.15	4.77	5.57

Table 5. Effect of variety with Time and Frequency of irrigation on the yield contributing characters of chickpea

Treatment	Number of flower per plant	First fruit setting(days)	Number of pods per plant	Number of seed per pod	1000-seed weight (g)
V_1I_1	24.38 e	54.33 a	22.19 g	1.67 e	110.50 e
V_1I_2	27.13 cde	54.00 a	23.25 fg	1.96 cd	119.10 abcd
V_1I_3	41.70 a	54.00 a	38.67 b	2.19 b	119.90 abc
V_1I_4	29.43 bcde	54.00 a	26.39 de	1.95 cd	118.60 abcd
V_2I_1	27.07 cde	50.67 b	20.45 gh	1.62 e	111.20 de
V_2I_2	30.13 bcd	49.00 b	26.77 de	2.11 bc	116.50 bcde
V_2I_3	43.50 a	49.00 b	42.17 a	2.58 a	125.60 a
V_2I_4	28.60 bcde	49.00 b	25.89 ef	2.11 bc	115.80 bcde
V_3I_1	24.90 de	49.67 b	18.88 h	1.50 e	110.10 e
V_3I_2	31.03 bc	50.67 b	29.35 cd	1.95 cd	112.70 cde
V_3I_3	33.83 b	51.00 b	31.33 c	2.07 bcd	123.60 ab
V_3I_4	25.43 cde	50.67 b	21.88 g	1.91 d	113.80 cde
LSD (0.05)	4.99	2.15	2.84	0.16	7.04
CV (%)	9.62	5.47	6.15	4.77	5.57

Number of pod per plant is one of the most important yield contributing characters in chickpea. The irrigation showed variation in the number of pod per plant (Table 4). The maximum number of pod per plant (37.39) was produced by I_3 and I_1 produced the minimum number of pod per plant (20.51). The results were partially supported by Clarke and Simpson (1978) and fully supported by Sharma and Kumar (1989) who stated that irrigation increased pod plant^{-1}.

A significant variation was found in the treatment combinations of variety and irrigation on number of pod per plant (Table 5). The maximum number of pod per plant (42.17) was found in V_2I_3, whereas the minimum number of pod per plant was found in V_3I_1 treatment combination.

4.6 Number of seeds per pod

The number of seeds per pod was significantly varied by varieties. The highest number of seeds per pod (2.10) was recorded in V_2 (BARI Chola-9). The minimum number of seeds per pod (1.86) was observed in V_1 (BARI Chola-5) (Table 3). Das (2017) showed the averaged number of seed pod-1 across the varieties ranged from 1.20-1.42 pod-1. The BARI Chola-9 produced the highest and BU Chola-1 produced the lowest number of seed pod-1 respectively. The study indicated that genotypes with more pod development period having higher seed growth would be desirable character for maintaining higher yield.

The irrigation showed variation in the number of seeds per pod (Table 4). The maximum number of seed per pod (2.28) was produced by I_3, whereas I_1

produced the minimum number of seeds per pod (1.60). Seeds per pod were increased with the irrigation due to the supply of adequate soil moisture which helped to produce the more pod having number of seeds. This phenomena is reported by Prasad and Ashanullah (2017), Sarker and Hassan (2017), Sharma and Kumar (2017).

Number of seed per pod indicated a significant variation among the treatment combinations of variety and irrigation (Table 5). The maximum number of seeds per pod (2.58) was found in V_2I_3 treatment combination, whereas the minimum number of seed per pod (1.5) was found in V_3I_1treatment, which was statistically similar with V_1I_1 and V_2I_1.

4.7 1000-seed weight

Variety had significant effect in 1000-seed weight and it was also observed in studied varieties of chickpea (Table 3 and appendix VI). The highest 1000-seed weight was recorded in BARI Chola-9 (117.3 g). In contrast, the lowest 1000-seed weight was recorded in BARI Chola5 (115.2 g). Thousand-seed weight ranged from 110-120 g in BARI Chola-5, 140-150 g in BARI Chola-7, and 250-260 g in BARI Chola-9 was observed by Bakr *et al.* (2002). Khatun *et al.* (2017) and Bhuiyan *et al.* (2017) reported the same.

The irrigation showed variation in the 1000-seed weight (Table 3). The maximum 1000-seed weight (123.00 g) was produced by I_3, whereas I_1 produced the minimum 1000-seed weight (110.60 g).

1000-seed weight indicated a significant variation among the treatment combinations of variety and irrigation (Table 3). The maximum 1000-seed weight (125.60 g) was found in V_2I_3 treatment combination, whereas the minimum 1000-seed weight (110.1 g) was found in V_3I_1treatment, which was statistically similar with V_1I_1 treatment.

4.8 Yield (t/ha)

The yield was significantly affected by varieties. Yield is a function of various yield components such as number of pod per plant, seed per pod and 1000-grain weight. The highest yield (1.723 t/ha) was recorded in BARI Chola 9. In contrast, the lowest yield was recorded in BARI Chola-5 (1.434 kg/h), which was statistically similar with V3 (BARI Chola7) (Table 6). Rashid *et al.* (2017) reported seed yield of chickpea as 1300-1600 kg/ha, 1900-2000 kg/ha and 1800-2000 kg/ha form BARI Chola-2, BARI Chola-4 and BARI Chola-6, respectively. Hasanuzzaman *et al.* (2016) showed among the varieties, BARI chola-5 gave the maximum seed yield (1.81 t ha) which was 36.09% more over BARI chola-1 which produced the lowest seed yield (1.33 t ha). Das (2017) showed the averaged yield ha-1 among the varieties was 608.18 kg in BU Chola-1, 641.87 kg in BARI Chola-5 and 661.16 kg in BARI Chola-7 respectively.

The seed yield of chickpea per plot was converted into per hectare, and has been expressed in metric tons (Table 7). The different dose of irrigation had effect on the yield of seed per hectare. The maximum yield of seed per hectare

(2.15 t) was obtained from I_3 treatment, whereas the minimum yield of seed per hectare (1.14 t) was obtained from I_1. In control condition, high mortality of seedlings resulting from shortage of soil moisture might have drastically reduced the yield. Malavia *et al.* (2016) reported similar results in mustard in respect of seed yield. Under no irrigation treatment internal moisture deficit led to lower plant height, failed to increase in growth parameters and reduce the net assimilation rate, which adversly affected yield components and thus yield was reduced. The present result was in agreement with those obtained by Sharma and Kumar (2017) and Joarder *et al*. (2017) who reported that irrigation increased seed yield of mustard.

The combined effect of variety irrigation was significant on yield of seed per hectare (Table 8). The highest yield of seed per hectare (2.52 tones) was obtained from V_2I_3 treatment combination. The lowest yield of seed per hectare (1.02 tones) was obtained from V_3I_1 treatment.

4.9 Stover yield

Stover yield varied significantly among the three varieties (Table 6). Significantly the highest (2.10 ton ha^{-1}) stover yield was found in BARI Chola-9. On the other hand BARI Chola-7 showed significantly the lowest (1.89 ton ha^{-1}) followed by BARI Chola-5 (1.91 ton ha^{-1}). Ali *et al.* (2017) showed in their study chickpea genotype 97086 produced higher biological (7658 kg/ha). Purushotham *et al.* (2017) reported that among different cultivars UPC-921, UPC-952, UPC-953, IFC-9502, IFC-9503, UPC-5286 and Bund lobia (control), the highest mean dry matter was registered by IFC-9503 (18.1 q/ha).

Table 6. Effect of varieties on yield and yield of chickpea plant

Treatment	Seed yield (t ha-1)	Stover yield (t ha-1)	Biological yield (t ha-1)	Harvest index (%)
V_3	1.52 b	1.89 b	3.41 ab	44.56 a
V_2	1.72 a	2.10 a	3.82 a	45.03 a
V_1	1.43 b	1.92 ab	3.35 b	42.66 b
$LSD_{(0.05)}$	0.16	0.19	0.44	0.57
CV (%)	11.50	9.57	5.53	7.90

Table 7. Effect of Time and Frequency of irrigation on yield and yield of chickpea plant

Treatment	Seed yield (t ha-1)	Stover yield (t ha-1)	Biological yield (t ha-1)	Harvest index (%)
I_1	1.14 c	1.48 c	2.62 c	43.45 b
I_2	1.50 b	1.92 b	3.42 b	43.76 b
I_3	2.15 a	2.39 a	4.54 a	47.21 a
I_4	1.45 b	2.09 b	3.53 b	41.13 c
$LSD_{(0.05)}$	0.28	0.30	0.67	0.49
CV (%)	11.50	9.57	5.53	7.90

Table 8. Combined effect of varieties with Time and Frequency of irrigation on yield and yield of chickpea plant.

Treatment	Seed yield (t ha-1)	Stover yield (t ha-1)	Biological yield (t ha-1)	Harvest index (%)
V_1I_1	1.27 ef	1.57 de	2.84 d	44.60 b
V_1I_2	1.64 cd	2.01 bc	3.65 bc	44.85 b
V_1I_3	1.86 bc	2.34 ab	4.20 b	44.25 b
V_1I_4	1.31 def	1.63 cde	2.94 cd	44.55 b
V_2I_1	1.13 ef	1.60 cde	2.74 d	41.37 d
V_2I_2	1.61 cd	1.99 bcd	3.60 bc	44.86 b
V_2I_3	2.52 a	2.62 a	5.13 a	49.02 a
V_2I_4	1.63 cd	2.19 ab	3.82 b	42.51 c
V_3I_1	1.02 f	1.27 e	2.28 d	44.39 b
V_3I_2	1.26 ef	1.76 cd	3.01 cd	41.58 d
V_3I_3	2.07 b	2.21 ab	4.27 b	48.35 a
V_3I_4	1.40 de	2.44 a	3.83 b	36.32 e
$LSD_{(0.05)}$	0.30	0.39	0.69	0.67
CV (%)	11.50	9.57	5.53	7.90

The stover yield of chickpea per plot was converted into per hectare, and has been expressed in metric tons (Table 7). The different dose of irrigation had effect on the stover yield per hectare. The maximum yield of stover per hectare (2.39 t) was obtained from I_3, treatment, whereas the minimum yield of stover per hectare (1.48 t) was obtained from I_1. It is interesting that irrigation helped to produce tallest plant, more number of branches per plant and number of pod plant which ultimately increased stover yield. Patel *et al.* (2017), Sarker *et al.* (2017), and Sarker *et al*. (2017) reported similar views in respect of stover yield that irrigation increased stover yield.

The combined effect of variety and irrigation was significant on yield of stover per hectare (Table 8). The highest yield of stover per hectare (2.62 tones) was obtained from V_2I_3 treatment combination. The lowest yield of stover per hectare (1.27 tones) was obtained from V_3I_1 treatment.

4.10 Biological yield

Biological yield varied significantly due to variety treatments (Figure 13). It was observed the BARI Chola-9 (V_2) produced the highest (3.82 t ha^{-1}) Biological yield while BARI Chola-5 (V_1) produced the lowest (3.35 t ha^{-1}) Biological yield.

Irrigation had effect on the biological yield per hectare. The maximum biological yield per hectare (4.54 t) was obtained from I_3, treatment, whereas the minimum biological yield per hectare (2.62 t) was obtained from I_1 (Table 4).

The combined effect of variety and irrigation was significant on biological yield per hectare (Table 4). The highest biological yield per hectare (5.13 tones) was obtained from V_2I_3 treatment combination. The lowest biological yield per hectare (2.28 tones) was obtained from V_3I_1 treatment, which was satistically similar with V_1I_1 and V_2I_1.

4.11 Harvest index

Harvest index varied significantly among the three varieties (Appendix XI & Figure 21). Significantly the highest (45.03%) harvest index was found in BARI Chola-9, which was statistically similar with BARI Chola-7(44.44%). On the other hand BARI Chola-5 showed significantly the lowest (42.66%) harvest index among the three varieties. Das *et al.* (2017) showed the highest harvest index (37.68 %) was found in the variety BARI Chola-7 and the lowest (36.28%) in the variety BARI Chola-6.

The different irrigation had significant effect on the harvest index of chickpea. The maximum harvest index (47.21 %) was obtained with I_3, and the minimum harvest index (41.13 %) was obtained from I_4 treatment (Table 4).

The combined effect of variety and irrigation was significant on harvest index (Table 4). The highest harvest index (49.02 %) was obtained from V_2I_3 treatment combination. The lowest harvest index (41.37 %) was obtained from V_2I_1 treatment.

CHAPTER IV

SUMMARY AND CONCLUSION

The present experiment was conducted in the Agricultural Botany field laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during rabi season (November 2016 to March, 2017) determine to study the response of chickpea varieties to different nitrogen managements. In this experiment, the treatment consisted of three chickpea varieties viz. V_1= BARI Chola-5, V_2= BARI Chola-9 and V_3= BARI Chola-7 and four irrigation viz. I_1= No irrigation, I_2= Irrigation after 40 and 50 DAS, I_3= Irrigation after 60 and 80 DAS, I_4= Irrigation after 50, 70 and 90 DAS. The experiment was laid out in a Randomized Complete Block Design with three replications. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed that a significant variation among the treatments in respect majority of the observed parameters.

The plant height was significantly affected due to the different varieties at different days after sowing. The tallest plant height (12.93, 27.34, and 38.48 cm at 20, 40 and 60 DAS, respectively) was obtained from V_2 (BARI Chola 9). The number of branch per plant counted at different days was not significantly influenced by varieties. Treatment V_2 (BARI Chola 9) produced maximum number of branch (3.64, 7.09 and 11.72 at 20, 40 and 60 DAS, respectively). The earliest of days to first fruit setting (49.42 DAS) was found in V_2. The number of pod per plant, number of seeds per pod, 1000-seed weight was

significantly influenced due to the different varieties at harvest. The highest number of flower per plant (32.33), number of pod per plant (28.82), number of seeds per pod (2.10), 1000-seed weight (117.3 g) was recorded in V_2 (BARI chola 9). The highest yield (1.723 t/ha) was recorded in BARI Chola-9. In contrast, the lowest yield was recorded in BARI Chola-5 (1.434 kg/h). Significantly the highest (2.10 t ha^{-1}) stover yield, Biological yield (3.82 t ha^{-1}) was found in BARI Chola-9.

Irrigation was influenced the height of chickpea plant significantly at 20, 40 and 60 days after sowing (DAS). The tallest plant (12.3, 25.82, 38.38 cm at 20, 40 and 60 DAS, respectively) was recorded with I_3 (Irrigation after 60, 80 and 90 DAS). The irrigation was not significant variation in the number of branches per plant at 20, 40 DAS but significant at 60 DAS. The maximum number of branches per plant (3.622, 7.28 and 11.74 at 20, 40 and 60 DAS, respectively) was produced by I_3 treatment. The maximum number of flower per plant (39.68) was produced by I_3. The earliest of days to first fruit setting (51.22 DAS) was found in I_3. The irrigation showed variation in the number of pod per plant, number of seed per pod. The maximum number of pod per plant (37.39), number of seed per pod (2.28), 1000-seed weight (123.00 g) was produced by I_3. The different dose of irrigation had effect on the yield of seed per hectare. The maximum yield of seed per hectare (2.15 t) was obtained from I_3 treatment, whereas the minimum yield of seed per hectare (1.14 t) was obtained from I_1. . The maximum yield of stover per hectare (2.39 t), biological

yield per hectare (4.54 t) was obtained from $I_{3,}$ treatment. The maximum harvest index (47.21 %) was obtained with $I_{3.}$

The interaction between variety and irrigation was found significant on the all parameter. The tallest plant (13.15, 27.72 and 39.73 cm at 20, 40 and 60 DAS, respectively) was found in V_2I_3 (BARI Chola-9 with Irrigation after 60, 80 and 90 DAS) treatment. The maximum number of branches per plant (4.10, 8.433 and 12.73, at 20, 40 and 60 DAS, respectively) was found in V_2I_3treatment combination. The maximum number of flower per plant (43.50) was found in V_2I_3 treatment combination. The earliest of days to first fruit setting (49.0 DAS) was found in $V_2I_{2,}$ V_2I_3 and $V_2I_{4.}$. The maximum number of pod per plant (42.17) was found in V_2I_3. The maximum number of seeds per pod (2.58) was found in V_2I_3 treatment. The maximum 1000-seed weight (125.60 g) was found in V_2I_3 treatment combination. The highest yield of seed per hectare (2.52 tones) was obtained from V_2I_3 treatment combination. The lowest yield of seed per hectare (1.02 tones) was obtained from V_3I_1 treatment. The highest yield of stover per hectare (2.62 tones) was obtained from V_2I_3 treatment combination. The highest biological yield per hectare (5.13 tones) was obtained from V_2I_3 treatment combination. The highest harvest index (49.02 %) was obtained from V_2I_3 treatment combination.

Considering the above results, it may be summarized that growth, seed yield contributing parameters of chickpea are positively correlated with variety and irrigation. Therefore, the present experimental results suggest that the combined use of BARI chola-9 with irrigation after 60 and 80 DAS would be

beneficial to increase the seed yield of chickpea under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. The results are required to substantiate further with different varieties of chickpea.
3. It needs to conduct more experiments with irrigation whether can regulate the growth, yield and seed quality of BARI chola 9.

REFERENCES

Ali, M. H. (2017). Response of Chickpea Varieties to Different Irrigation Regimes. *Asian J. Advances in Agril. Res.* **2**(4): 1-7**.**

Ali, Abbas., Ali, Zulfiqar., Iqbal, Javaid., Nadeem, Mustaq. Ahmad., Akhtar, Naveed., Akram, H. M. and Sattar, Abdus. (2010). Impact of nitrogen and phosphorus on seed yield of chickpea. *J. Agric. Res.,* **48**(3):335-343.

Anonymous. (1989). Annual Report. 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

Bakr, M.A., Siddique, K.H.M. and Johansen, C. (2002). Integrated management of botrytis grey mould of chickpea in Bangladesh and Australia. Summary Proceedings of a Project Inception Workshop. 1-2, June 2002, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh. pp. 22-23.

Bandyopadhyay, P. ,Dhiman Ray., Jana, P.K. and Bhomick, M.K.(2001). Influence of irrigation schedules on yield, consumptive use and crop coefficient of chickpea. *J. of Interacedmicia*. **5** : (1): 33-38.

BBS (Bangladesh Bureau of Statistics). (2010). Stistical Year Book of Bangladesh. Statistics Dvision, Ministry of Planning, Government of the People Republic of Bangladesh, p. 34.

Berger, J. D. and N. C. Turner (2007). The ecology of chickpea: evolution, distribution, stresses and adaptation from an agro-climatic perspective. In: Yadav, S.S. Redden, R. Chen, W. Sharma, B. (Eds.), Chickpea Breeding and Management. CABI, Wallingford, UK, pp. 47-71.

Brar, Z. S., J. S. Deol and J. N. Kaul (1993). Influence of foliage applied plant regulators on the performance of normal and late sown chickpea plant types. *Ann. Agric. Res.* crops, cool season food legumes. Kluwer Academic Publishers, Dordrecht, pp. 445–457.

Chaitanya, S. K and Chandrika (2006). Response of chickpea genotype to different date of owing in alligols of chittor district. Andhra Pradesh, India. *Int. Chickpea and Pigeonpea Newsletter*,**10**: 8-9.

Chavan, J. K., S. S. Kadam, D. K. Salunkhe, L .R. Beuchat (1987). Biochemistry and technology of chickpea (*Cicer arietinum* L.) seeds. Crit. Rev. Food. Sci. Nutr., **25**(2): 107-158.

Clarke. J. M. and Simpson, G.M. (1978). Influence of irrigation and seeding rates on yield and yield components of Bras.ssica napus cv. Tower. Canadian. I Plant Sd. 58 (3): 73 1-737.

Das, Anil, Kumar. (2006). Effect of applied phosphorus on the growth, nutrient uptake and yield in chickpea. MS thesis, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur-1706, winter, 2006., pp. 17-41.

Dixit, J. P. (1992).Growth behaviour and production of chickpea in relation to sowing time and moisture levels. *Crop Res*., **5**: 87-91.

Eberhort, S. A. and W. A. Russel (1966). Stability parameters for comparing varieties. *CropSci*., **6**: 36-40.

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. 1979. Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh. Dept. Soil Survey, Govt. People's Republic of Bangladesh. 118 p.

El-Karamany, M. F. and A. A. Bahr (1999). Effect of mineral fertilization, organic manuring and biofertilization on yield and yield components of chickpea (*Cicer arietinum* L.) cultivars in sandy soil. *Egypt J. Appl. Sci.*, **14**(11): 68-76.

El-Warakly, M.K., and El-Koliey, M.M.(2000),Research of two chickpea genotype to irrigation at different physiological stages of growth, Assiut J. of Agric. Sci. 31 (5):137-150.

Falah, S.(2002), Effect of plant densities and soil moisture in yield and yield component of chickpea cultivars, Master Thesis, Isfahan University.

FAO. (1988). Food and Agricultural Organization of the United Nations, Soil Survey Project of Bangladesh. Soil Resources Tech. Rep. pp. 101-159.

Fazlul Kabir, A. H. M., M. N. Bari, M. D. Abdul Karim, Qazi Abdul Khaliq and Jalal Uddin Ahmed (2009). Effect of sowing time and cultivars on the growth and yield of chickpea under rainfed condition. *Bangladesh J. Agric. Res.,* **34** (2): 335- 342.

Ferdous, A. K. M. (2001). Effects of nitrogen and phosphorus fertilizers on nutrients uptake and productivity of edible poddedpea. M. S. Thesis Bangladesh Sheikh Mujibur Rahaman Agricultural University, Gazipur-1706.

Ganguly, S. B. and A. Bhatacharya (2001). Effect of physiological traits on chickpea yield under normal and late seeding. *Legume Res.,* **24** (1): 6-10.

Golldani, A. and Moghaddam, P.R. (2006), Effect of different irrigation levels on physiology characteristics, and yield components of three chickpea (Cicer arietinum L.) cultivars in Mashhad (persian) Agric. Sci. and Techno. 20 (3) 21-32.

Gomez, K.A. and Gomez.A.A.(1984). Statistical procedure for Agricultural Research (2^{nd} edn.) Int. Rice Res. Inst., A willey inter Science Pub., pp. 28-192.

Haqqani, A.M.,Khan,H.R. and Malik,B.A. (2000) Influence of irrigation at various growth stages on water use efficiency and yield of chickpea (Cicer arietinum L.). Sarhad J. of Agric. 16 (2) 123-129.

Hasanuzzaman, Mirza., Karim, Md. Fazlul., Fattah, Quazi. Abdul. and Nahar, Kamrun. (2007). Yield Performance of Chickpea Varieties Following Application of Growth Regulator. *Am-Euras. J. Sci. Res.*, **2**(2):117-120.

Jat , M.L., Singh, S., Rai, H.K.,Chhokar, R.S.,Sharma,S.K. and Gupta Raj, K.(2005). Furrow irrigated raised bed (FIRB) planting technique for diversification of rice-wheat system in indo-Gangetic plains.*Japan Asso. for International Collaboration of Agric. and Fore.* **28** (1):25-42.

Joarder, 0. L.; Paul, K. and Goose, S. K. (1979). Effect of irrigation and fertilizer on mustard (*Brassica juncea*). *Expt. Agric*. 15(3): 299-302.

Joshi, P. K., R. P. Parthasarathy, C. L. L. Gowda, R. B. Jones, S.N. Silim, K.B Saxena, J. Kumar (2001). The World chickpea and pigeonpea economies: facts, trends, and outlook. International Crops Research Institute for the Semi-Arid Tropics: Patancheru, Andhra Pradesh, India, p. 68.

Kabir, A. H. M. Fazlul., Bari, M. N., Karim, Md. Abdul., Khaliq, Qazi, Abdul. and Ahmed, Jalal, Uddin. (2009). Effect of sowing time and cultivars on the growth and yield of chickpea under rainfed condition. *Bangladesh J. Agril. Res.*, **34**(2):335-342.

Kadam CS, Thanki JD, Gudadhe NN. (2014). Response of chickpea to irrigation methods, fertilisers and biofertiliser under south Gujarat condition. Indian J. Fert. 10(4):20-24.

Karasu, A., Oz, M. and Dogan, R. (2009). The effect of bacterial inoculation and different nitrogen doses on yield and yield components of some chickpea genotypes (*Cicer arietinum* L.). *Afr. J. Biotechnol.,* **8**(1):59-64.

Khatun, A., Bhuiyan, M.A.H., Nessa, A., & Hossain, S.B. (2010). Effect of harvesting time on yield and yield attributes of chickpea (Cicer arietinum L.). *Bangladesh J. Agril. Res.* **35**(1): 143-148.

Kumar, P. , OP Prajapat and Parihar, R.(2017). Effect of different levels of hosphorus, sulphur and cultivars on growth and economics of chickpea (*Cicer arietinum* L). *Intel. J. Sci.* **7(2):** 57-59.

Kumar, S., R. Kumar, V. Malik and, V. S. Kadian (2008). effect of sowing dates on chickpea crop cultivars under irrigation condition of south-west *Haryyana j. Agron.* **24** (1&2): 9-11.

Maleki, A., Pournajaf, M., Naseri, R. and Rashnavadi, R. (2014). Effect of Supplemental Irrigation, Nitrogen Chemical Fertilizer, and Inoculation with Rhizobium Bacteria on Grain Yield and Its Components of Chickpea (Cicer arietinumL.) Under Rainfed Conditions. World Academy of Science, Engineering and Technology *International J. Agricultural and Biosystems Engineering.* **8**(2):164-168.

Malhotra, R.S., Singh, K.B., and Saxena, M.C. (2009), Effect of irrigation on winter sown chickpea in a medditerrean environment. J. of Agron. and Crop Sci. 178 (2): 237-243.

Malik, S.S. and Punia R.K.(2005),Performance of chickpea (Cicer arietinum L.) and its economic feasibility as affected by irrigation. Haryana Agric. Univer. J. of Res. 35 (2)131-134.

Moemeni, F. Ghobadi, M. Saeid jalali-honarmand and Parviz Shekaari. 2013. Effect of Supplementary Irrigation on growth analysis of Chickpea (Cicer arietinum L.). *Intl J Agri Crop Sc*i. **5** (14), 1595-1600.

Muehlbauer FJ, Short RW, Kaiser WJ.(1982). Description and culture of garbanzo beans. Coop. Ext. Publ. EB 1112, Washington State Univ., Pullman.

Mustafa, M.N.,Sagar, G.K., ChandrikaV. and Reddy,P.M. (2008), Growth and yield of chickpea as influenced by irrigation. Legume Res. 31 (3):221-223.

Muzquiz, M. and J. A. Wood (2007). Edited by S. S.Yadav, R. Redden, W. Chen, B. Sharma Chickpea breeding and management. Antinutritional Factors. **6:** 143-166

Nawab, K. Kamal, T., Rab, A. Rahmatullah and Iqba, M. (2015). Effect of Irrigation on Chickpea Varieties Sown on Different Dates on Irrigated Fields of Bannu, Khyber Pakhtunkhwa,Pakistan. Journal of Biology, Agriculture and Healthcare. **5** (11): 37-41

Patel, A.K.; Singh, Dhananjay; Baghel, K.S. and A.K Pandey (2014) Enhancing water productivity chickpea production in Bansagar

commond area of JNKVV Krishi Vighyan Kendra Rewa (M.P). J. of Agrireaserch 1 (1) 19-21.

Patel, B. R,; Singh, D. and Gupta, M. L. (1991). Effect of irrigation and intercropping on gram and mustard. *Indian J. Agron*. **36**(2): 283 -284.

Perkins, J. M. and J. L. Jinks (1968). Environmental and genotype environmental components of variability. *Heredity* **23**: 339-356.

Prasad, U. K. and Eshanullah, M. (1988). Effect of irrigation and nitrogen on yield and yield attributes of mustard. *Indian J. Agron*. **33**(1): 47-51.

Purushotham, S., Narayanswamy, G. V., Siddaraju, R. and Girejesh, G. K., (2001). Production potential of fodder cowpea genotypes under rainfed conditions. *Karnataka J. Agric. Sci.*, **14**(2):446-448.

Rao, DLN., KE. Giller, AR. Yeo, TJ. Flowers (2002).The effects of salinity and sodicity upon nodulation and nitrogen fixation in chickpea (*Cicer arietinum* L.). Ann. Bot., **89** (5): 563-570.

Rashid, Md., Ali, M. S. M., Oyahab, M. A., Amin, M. S. and Alam, S. S. (1999). (Eds) Krishi projukti hatboi, (Hand book on Agro-technology), Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. pp: 75-85.

Reddy, N. R. N. and I. P. S. Ahlawat (1998). Response of chickpea genotypes to irrigation and fertilizer under late sown conditions. *Indian J. Agron*.**,** **43** (1): 95-101.

Sardar, R.G. (2009). Performance of chickpea (*Cicer arietinum* l.) genotypes for green purpose to dates of sowing in northern transition zone of Karnataka. M.Sc. Thesis. *Dharwad Uni. Agric. Sci*., Dharwad (Karnataka).

Sarkar, G., Salam, M.A., Islam, M.A., Islam, M.R. and Sultana, R. (2001). Adaptibility of BINA mustard, Boro rice and mungbean mutant varities in different saline habitats. A study report. GOLDA project, CARE-Bangladesh. Pp.1-6.

Sarkar, G., Salam, M.A., Islam, M.S. Sultana, R and Roy, R. (2000). Effect of variety and moisture regimes on the yield and yield component of mustard in saline soil. A study paper. GOLDA project, CARE-Bangladesh. Pp.1-6.

Sarker, A. A. and Hassan, A. A. (1988). Irrigation scheduling to mustard using pan evaporation. *Thai J. Agric. Sci*. **21**(4): 3 11-321.

Schwenke, G. D., M. B. Peoples, G. L.Turner and D. F. Herridge (1998). Doses nitrogen fixation of commercial, dryland chickpea and faba bean crops in north-west New south wales maintain or enhance soil nitrogen. Aust, J. Ex, Agric., **38**: 61-70.

Sekhar, D., Pradeep Kumar, P.B. and Tejeswara Rao, K. (2015). Performance of Chickpea Varieties under Different Dates of Sowing in High Altitude Zone of Andhra Pradesh, India. *Int.J.Curr.Microbiol.App.Sci* **4**(8): 329-332

Sharma, D. K. and Kumar. A. (1989). Effect of irrigation on growth analysis, yield and water use in Indian mustard (Brassica juncea). *Indian J. Agric. Sd.* **59**(3): 162- 165.

Siag, R. K.; Kumar, S.; Verma, B. L. and Singh, V. (1993). Effect of irrigation schedule on yield, water use and oil content of toria (Brasica napus var napus). *Indian J. Agron*. 38(1): 42-44.

Siddique K.H.M., R. B. Brinsmead, R. Knight, E. J. Knights, J. G. Paull, I. A Rose (2000). Adaptation of chickpea (*Cicer arietinum* L.) and faba bean (*Vicia faba* L.) to Australia. In: "Linking research and marketing opportunities for pulses in the 21st century". (Ed. Knight, R.) Kluwer academic Publishers, pp. 289-303.

Sohu I, Gandahi AW, Bhutto GR, Sarki MS, Gandahi R. (2015). Growth and yield maximization of chickpea (*Cicer arietinum*) through integrated nutrient management applied to rice-chickpea cropping system. *Sarhad J. Agric.*. **31**(2): 131-138.

UNDP (1988). Land resources appraisal of Bangladesh for Agricultural Development. Report. 2. Agro-ecological Regions of Bangladesh. United Nations Dev. Prog. and Food and Agric. Organization. pp. 212-221.

Virk, H. K. Guriqbal, Singh and H. S. Sekhon (2005). Effect of time of sowing on the productivity of chickpea (Cicer arietinum L.) varieties, *J. Res., PAU*, **42**(2): 148-149.

APPENDICES

Appendix I: Monthly average air temperature, relative humidity and total rainfall of the experimental site during 2016-2017

Month	Air temperature (°C)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
November	26.98	14.88	71.15	40
December	25.78	14.21	68.30	30
January	25.00	13.46	69.53	20
February	29.50	18.49	50.31	40
March	33.80	20.28	44.95	80

Source: Bangladesh Mateorological Department (climate and weather division), Agargaon, Dhaka

Appendix II: Characteristics of soil of experimental is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Field laboratory, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium hHigh land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI)

Appendix III: Analysis of variance of the data on plant height of Chickpea as influenced by different variety with time and frequency of irrigation

Sources of Variation	Degrees of freedom	plant height (cm)		
		20 DAS	40 DAS	60 DAS
Replication	2	0.184	7.608	115.59
Factor A	2	14.031*	103.18*	186.47*
Factor B	3	0.288*	20.349*	119.89*
AB	6	0.093*	10.228*	48.918*
Error	22	0.385	4.641	24.008

*significant at 5% level of probability

Appendix IV: Analysis of variance of the data on Number of branch per plant of Chickpea as influenced by different variety with time and frequency of irrigation

Sources of Variation	Degrees of freedom	Number of branch per plant		
		20 DAS	40 DAS	60 DAS
Replication	2	0.197	0.042	4.944
Factor A	2	0.219^{NS}	2.508^{NS}	8.61^{NS}
Factor B	3	0.312^{NS}	3.568^{NS}	4.008^{NS}
AB	6	0.193*	3.123*	6.564*
Error	22	0.235	0.752	5.021

*significant at 5% level of probability

NS-Non Significant

Appendix V: Analysis of variance of the data on yield and yield contributing character of Chickpea as influenced by different variety with time and frequency of irrigation

Sources of Variation	Degrees of freedom	first fruit setting	pods per plant	seed per pod	1000-seed weight (g)
Replication	2	0.44	24.263	0.398	454
Factor A	2	71.583*	37.016*	0.189*	15.047^{NS}
Factor B	3	0.074^{NS}	465.97*	0.713*	233.91*
AB	6	1.546*	36.485*	0.035*	19.698*
Error	22	1.606	2.813	0.009	17.275

*significant at 5% level of probability
NS-Non Significant

Appendix VI: Analysis of variance of the data on yield and yield contributing character of Chickpea as influenced by different variety with time and frequency of irrigation

Sources of Variation	Degrees of freedom	Seed yield (t ha-1)	Stover yield (t ha-1)	biological yield (t ha-1)	Harvest index (%)
Replication	2	0.319	0.284	1.203	7.964
Factor A	2	0.264*	0.159*	0.797*	13.611*
Factor B	3	1.613*	1.291*	5.548*	56.511*
AB	6	0.113*	0.216*	0.478*	27.336*
Error	22	0.032	0.052	0.166	0.157

*significant at 5% level of probability
NS-Non Significant