INFLUENCE OF SUPPLEMENTARY NITROGEN, IRRIGATION AND HORMONES ON FLOWER DROPPINGS, GROWTH AND YIELD OF CHICKPEA

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CERTIFICATE

This is to certify that the thesis entitled **'Influence of Supplementary Nitrogen, Irrigation and Hormones on Flower Droppings, Growth and Yield of Chickpea'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of bonafide research work carried out by **Indrajit Roy**, Registration number: **07-02474** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 20/11/14
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INFLUENCE OF SUPPLEMENTARY NITROGEN, IRRIGATION AND HORMONES ON FLOWER DROPPINGS, GROWTH AND YIELD OF CHICKPEA

ABSTRACT

The experiment was conducted during the period from 11 December, 2012 to 30 March 2013 to study the influence of supplementary nitrogen, irrigation and hormones on flower droppings, growth and yield of chickpea. The experiment consists of two factors: Factor A: Chickpea variety (2) as V_1: BARI chola 8 and V_2: BARI chola 9, Factor B: Supplementary treatments (5 levels) as T_1: Control i.e. no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF); T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering and T_5: Kinetine spray before flowering. The two factors experiment was laid out in split-plot design with three replications. Statistically significant variation was recorded for different parameters. The lower flower dropping (60.27%), the lower pod dropping (3.62%), maximum pods plant^{-1} (27.58), longer pod (1.85 cm), maximum seeds pod^{-1} (1.65), higher shelling percentage (0.69), higher seed yield (1.69 t ha^{-1}) and higher stover yield (2.72 t ha^{-1}) were recorded from V_2 whereas, the higher flower dropping (64.98%), higher pod dropping (3.79%), minimum pods plant^{-1} (26.03), shorter pod (1.75 cm), minimum seeds pod^{-1} (1.54), lower shelling percentage (0.67), lower seed yield (1.43 t ha^{-1}) and lower stover yield (2.47 t ha^{-1}) were recorded from V_1. The lowest flower dropping (59.17%), the lowest pod dropping (3.10%), the maximum pods plant^{-1} (28.52), the longest pods (1.95 cm), the maximum seeds pod^{-1} (1.67), the highest shelling percentage (0.73), the highest seed yield (1.84 t ha^{-1}) and the highest stover yield (2.84 t ha^{-1}) were found from T_3, while the highest flower dropping (67.07%), highest pod dropping (4.82%), the minimum pods plant^{-1} (25.00), the shortest pod (1.63 cm), the minimum seeds pod^{-1} (1.51), the lowest shelling percentage (0.64), the lowest seed yield (1.25 t ha^{-1}) and the lowest stover yield (2.33 t ha^{-1}) were observed from T_1. The lowest flower dropping (57.27%), the lowest pod dropping (3.07%), the maximum pods plant^{-1} (28.80), the longest pod (1.96 cm), the maximum seeds pod^{-1} (1.74), the highest shelling percentage (0.75), the highest seed yield (1.94 t ha^{-1}) and the highest stover yield (2.92 t ha^{-1}) were recorded from V_2T_3 and the highest flower dropping (71.20%), the highest pod dropping (4.97%), the minimum pods plant^{-1} (24.57), the shortest pod (1.45 cm), the minimum seeds pod^{-1} (1.47), the lowest shelling percentage (0.58), the lowest seed yield (1.19 t ha^{-1}) and the lowest stover yield (2.11 t ha^{-1}) were recorded from V_1T_1. BARI chola 9 cultivation with applying supplemental irrigation before flowering + aqueous N before flowering revealed maximum yield contributing characters and yield.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

DEDICATED

TO

MY BELOVED PARENTS

Chapter I

Introduction

Flower and pod droppings play an important role for the lower yield of chickpea. Aziz *et al.* (1960) reported 20-50% flower and pod dropping in chickpea. Being leguminous in nature, chickpea needs low but optimum nitrogen during onset of flowering and podding. Mansoor (2007) noted that lack of attention on fertilizer application in proper way with appropriate amount is identified for lowering chickpea yields. Experimental findings revealed that pulse crop stop to nourish *Rhizobia* rather translocally energy towards development of flowers and pods. Thus, nitrogen fixation is totally ceased during reproductive stage which eventually hampers the development of reproductive traits. In this situation nitrogen given as basal to the crop is not sufficiently available to the plant for nourishing its flowers and pods thus seed yield value is lower (Patel *et al.,* 1984; BARC, 2005). So, nitrogen management is required synchronizing this demand of plant growth stages and before flowering. Triggering nitrogen at the plant demand would be attempt towards yield improvements of pulse (Deolankar, 2005; Mukesh, 2006). Nitrogen placement before flowering might have some influencing technique that would be better utilization by the major nutrient for nitrogen for reducing flower and pod droppings.

Water deficiency has adverse effects on plant growth, average yield and crude protein in legume crops. The flowering stage is the most vulnerable stage for water stress and chickpea is somewhat tolerant to deficit water 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 a crop (Ayallew and Tabbada, 1987; Kumar *et al*., 1995). On the other hand, chickpea is grown in rabi season when lack of water becomes a serious restriction specially after flowerings. Saraf *et al.* (1990) stated that excess and deficient moisture conditions both are detrimental and reduce yield of chickpea. Water deficits reduce growth and yield (Castellanos *et al.*, 1996; Anwar *et al.*, 2003; Thomas *et al.*, 2004). Nayyar *et al.* (2006) reported that the flowering and pod setting stages appear to be the most sensitive stages to water stress.

CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum* L.), commonly known as gram, is one of the important pulse crops in Bangladesh. Today, chickpea is the third most important pulse crop and about 15% of the world's total pulse productions belong to this crop (FAO, 2010). The crop is variously known as chola, boot or botjam in different parts of Bangladesh. It is generally grown under rain-fed or residual soil moisture conditions in rabi season. Among the major pulses that grown in Bangladesh chickpea ranked fifth in area and production but second in consumption priority. Chickpea occupies third position in terms of acreage (13,765 ha) and production (10,000 metric ton) and contributes about 20% of the total pulses (BBS, 2010). The acreage of chickpea cultivation in Bangladesh is decreasing due to less return as compared to other crops and also due to increase in area under boro rice, maize and potato cultivation (BBS, 2010).

Chickpea plays a vital role in human and animal nutrition having 20.8% protein (Gowda and Kaul, 1982). It is a major source of dietary protein to the large vegetarian population of South Asian countries. Taking chickpea in "Iftar" during *Ramadan* is a common food in Bangladesh. According to the FAO (2012) yield of chickpea in Bangladesh is miserably low (761 kg ha^{-1}) as compared to that of other countries like India (833 kg ha^{-1}), Myanmar (1,106 kg ha^{-1}), Mexico (1,600 kg ha^{-1}), Israel (1813 kg ha^{-1}), Russian Federation (2,400 kg ha^{-1}), Kazakjhastan (3,000 kg ha^{-1}) and China (6,000 kg ha^{-1}). Yield of chickpea is very low in Bangladesh and such low yield however is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons, viz., unavailability of quality seeds of high yielding varieties, delayed sowing after the harvest of boro rice, fertilizer management, disease and insect infestation and improper or limited irrigation facilities which causes flower and pod droppings. Among different factor supplementary nitrogen, irrigation and application of growth hormones are also the most important factor.

Limitation of source and plant growth regulators (PGR's) or hormone may also responsible for flower and pod droppings. Plant growth regulators (PGR's) are organic compounds, which in small amounts, somehow modify a given physiological plant process. It plays an essential role in many aspects of plant growth and development (Patil *et al.*, 1987 and Dharmender *et al.*, 1996). These compounds have now been applied to a large variety of plant organs in several ways and it has been found to greatly enhance stem elongation as its most striking effect. This was observed in many plants after treatment with minute amount of gibberellic acid (GA_3). Reports so far been made to indicate a promising results on yield of chickpea and other pulse crops due to the use of bio-chemical substances or hormone, such as Napthaline acetic acid (NAA), Gibberelic acid (GA_3), Indole acetic acid (IAA) etc. Among the growth nutrients gibberellic acid stimulates cell division and cell enlargement. Application of gibberellic acid can stimulate morphological characters of chickpea like plant height, number of leaves, flower and pod droppings. L-tryptophan (L-TRP), the most important plant growth regulator is a physiological precursor of auxin biosynthesis both in microbes and higher plants. Exogenous application of L-TRP has been reported to improve the growth and yield of various crops (Akhtar *et al.*, 2007; Frankenberger and Arshad, 1995; Zahir *et al.*, 2005).

Hence, an experiment was conducted with supplementary nitrogen, irrigation and hormone application with the following objectives:

a. To study the varietal variation in flower and pod droppings and yield of chickpea.

b. To study the impact of different supplementary treatments to control flower and pod droppings of chickpea.

c. To determine the possibility of increasing chickpea yield by reducing droppings.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

In Bangladesh and in many countries of the world chickpea is an important pulse crop. The crop has conventional less attention by the researchers on various aspects because normally it grows without/less care or management practices. Based on this a very few research work related to flower dropping, growth and yield of chickpea have been carried out in our country. However, researches are going on in home and abroad to maximize the yield of chickpea with different cultivars. Supplementary nitrogen, irrigation and hormones play an important role in improving chickpea growth and yield. But research works related to supplementary nitrogen, irrigation and hormones on chickpea are limited in Bangladesh context. However, some of the important and informative works and research findings related to the variety, supplementary nitrogen, irrigation and hormones so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1 Varietal performance of chickpea in relation to flower droppings, growth and yield

An experiment was carried out by Mirzakhani *et al.* (2013) with water deficit and three cultivars of chickpea (Arman, Azad and ILC-482). Based on the results obtained from the analysis of variances the Arman cultivar had the maximum number of pods in branch, the weight of seeds in multiple seed pods and the Azad and ILC-482 had the maximum seed weight in multiple seed pods. But for the weight of 100 seeds and the number of pods in the plant there were no significant differences between the different cultivars under study.

To investigate the effects of different irrigation levels on phenology, physiological characteristics and yield components of chickpea cultivars, an experiment was conducted by Golldani and Moghaddam (2006) in Mashhad, Iran. There were 4 irrigation levels and three kabuli chickpea cultivars (Jam, Karaj 12-60-31 and

ILC482) were compared. Karaj 12-60-31 had the highest seed yield while ILC482 had the lowest. Physiological characteristics (dry mater, leaf area index, crop growth rate and relative growth rate) were also evaluated. Karaj (12-60-31) with 3 times irrigations showed the best physiological characteristics.

A field experiment was conducted by Singh and Sekhon (2006) in Ludhiana, Punjab, India, during the winter (rabi) season to study the effect of row spacings (30 and 45 cm) and seed rates (30, 40 and 50 kg/ha) on the performance of genotypes GPF 2 and GNG 469 of desi chickpea (*Cicer arietinum*). Bold-seeded genotype, i.e. GNG 469 recorded higher 100-seed weight (22.81 g) and lower pods per plant than the small-seeded (14.85 g) genotype GPF 2.

A field experiment was conducted by Singh and Sekhon (2006) in Ludhiana, Punjab, India, during the winter (rabi) season to study the effect of row spacings and seed rates on the performance of genotypes GPF 2 and GNG 469 of desi chickpea (*Cicer arietinum*). GNG 469 recorded higher 100-seed weight (22.81 g) and lower pods per plant (14.85 g) than the genotype GPF 2. The cultivar GNG 469 produced higher grain yield at 50 kg/ha seed rate, whereas 40 kg/ha seed rate was sufficient for GPF 2.

A field experiment was conducted by Singh and Chaudhary (2006) with chickpea cultivars RSG-44 and RSG-888 during the winter (rabi) seasons on S-deficient sandy loam soil in Rajasthan, India. The treatments comprised recommended dose of P (40 kg/ha) through with and without S-containing fertilizers, i.e. diammonium phosphate (16% N and 46% P_2O_5) and single superphosphate (12% S and 16% P2O5), and 3 irrigation schedules, i.e. rainfed, one irrigation at 45 days stage and 2 irrigations at 45 and 75 days. Plant height, days to flowering, maturity and water use were higher in RSG-44 compared to RSG-888, while the reverse trend was found in water use efficiency, grain, straw and protein yields. The mean increase in grain and protein yields of RSG-888 was 30.9 and 36.7% higher over RSG-44.

A field experiment was conducted by Mukesh (2006) in Jhansi, Uttar Pradesh, India, to study the impact of starter doses of nitrogen on nodulation and yield of different cultivars (Radhey, Avarodhi and K-850) of chickpea under irrigated condition. Among the three genotypes, K-850 proved better in terms of seed yield, whereas Radhey proved better in terms of harvest index in relation to nitrogen application.

A field experiment was conducted by Mukherjee and Singh (2005) during the winter season at Varanasi with three chickpea cultivars (Avarodhi, Radhey and Pant G 114) and four weed flora density levels to find out the suitable cultivars as influenced by weed population. Chickpea genotypes differed significantly with respect to grain yield. Cultivar Radhey proved to be the most competitive and arrested maximum weed growth and recorded higher grain yield as compared to Avarodhi and Pant G 114.

Two field experiments were carried out by Fallah *et al.* (2005) in Khorram-abad (Lorestan, Iran) to investigate the effect of 4 plant densities and 2 soil moisture regimes on the growth, yield and yield components of chickpea cultivars Greet, Karaj 12-60-31 and Hashem. Greet produced a higher number of pods per plant, grain yield and final dry matter, and Karaj 12-60-31 produced a more pronounced number of grains per pod, grain weight and harvest index compared with other genotypes. Planting Greet at 20 plants/m^2, along with supplementary irrigation, may lead to a significant increase in grain yield under dryland conditions of Khorram-abad.

A field experiment was conducted by Singh *et al.* (2004) in Uttar Pradesh, India during the rabi season to investigate the optimum sowing date of chickpea cultivars Radhey, T-3, Pant G-114 and Awarodhi. The grain yield of T-3 was 2.35, 0.52 and 2.20 q/ha higher than that of Radhey, Pant G-114 and Awarodhi, respectively.

A study was conducted by Ozcelik and Bozoglu (2004) to determine heritability and correlation between seed yield and some characters of newly registered chickpea cultivars. Seven registered cultivars of chickpea (Akcin-91, Aziziye-94, Izmir-92, Aydn-92, Menemen-92, Cantez-87 ve Damla-89) were grown at 5 locations. The seed yield of cultivars varied between 62.15 and 120.84 kg/da. The highest seed yield was obtained from Aydn-92 and Damla-89.

Field experiments were conducted by Singh *et al.* (2003) in Uttar Pradesh, India during the winter seasons of 1996-98 to determine the effects of row spacing (30 or 45 cm), cultivars (Avarodhi, Radhey and Pant G 114) and weed management (weedy or weed-free) on the yield of chickpea and the growth of the weeds associated with the crop. Avarodhi recorded the tallest plants, thickest canopy cover, highest grain yield and lowest weed dry matter accumulation.

An experiment was conducted by Gurha *et al.* (2001) on chickpea cultivars BG 256, BG 1095, BGD 122, BGD 123, CSJ 126, H 96-112, and RSG 807 in Kanpur, Uttar Pradesh, India to determine the effect of stunt disease on chickpea characteristics and yield components. The reduction in the production of main branches was 28.5% in CSJ 126 and 50% in BG 1095 and H 96-112. There was also an observed reduction in the number of pods/plant (37.8% in BGD 123 to 97.0% in CSJ 126). The decrease in number of seeds/plant ranged from 40.0% in BGD 123 to 97.1% in CSJ 126. The decrease in total seed weight/plant ranged from 58.5% in BGD 122 to 98.2% in CSJ 126.

Two field experiments were conducted by Hafiz (2000) in Egypt to study the effects of late foliar spraying of aqueous solution of 1% and 3 nitrogen fertilizer rates applied 21 days after sowing on the growth, yield and yield components of chickpea cultivars Giza 1, Giza 88 and Giza 195. The cultivars differed insignificantly from each other in terms of the studied traits except cv. Giza 195 which significantly surpassed both Giza 1 and Giza 88 in terms of the number of branches per plant. Giza 88 had heavier 100-seed weight compared to the other cultivars, whereas Giza 1 produced the highest seed protein content.

2.2 Nitrogen on flower droppings, growth and yield of chickpea

An experiment was conducted by Abbasi *et al.* (2013) with nitrogen rates at four levels (0, 25, 50 and 75 kg urea ha^{-1}) as N_0, N_1, N_2 and N_3 respectively and five levels of inoculation seed with *Rhizobium legominuzarum* and plant growth promoting rhizobacteria as T_0, T_1, T_2, T_3 and T_4 respectively in order to study nitrogen rates effects and seed inoculation with *Rhizobium legominosarum* and plant growth promoting rhizobacteria (PGPR) on yield and total dry matter of Chickpea (*Cicer arietinum* L.). Plant height, number of pod plant^{-1}, 100-grain weight, grain yield, number and weight of nodules plant^{-1} were significantly affected by nitrogen rates and seed inoculation. Means comparison showed that maximum grain yield (1276.78 kg ha^{-1}) and number of pod plant^{-1} (32.48) was obtained in the higher nitrogen rates. Increasing of nitrogen rates up 50 kg ha^{-1} increased number and weight of nodules plant^{-1} but it decreased in application of 75 kg N ha^{-1}.

The effects of seed inoculation with Rhizobium and inorganic nitrogen fertilization on some physiological and agronomical traits of chickpea (*Cicer arietinum* L.) cv. ILC 482, investigated by Namvar *et al.* (2013) with mineral nitrogen fertilizer at four levels (0, 50, 75 and 100 kg urea ha^{-1}) in the main plots, and two levels of inoculation with Rhizobium bacteria (with and without inoculation) as sub plots. N application and Rh. inoculation showed positive effects on physiological and agronomical traits of chickpea. In the case of agronomical traits, the highest values of plant height, number of primary and secondary branches, number of pods plant^{-1}, number of grains plant^{-1}, grain and biological yield were obtained from the highest level of nitrogen fertilizer (100 kg urea ha^{-1}) and Rh. inoculation. Application of 75 kg urea ha^{-1} was statistically at par with 100 kg urea ha^{-1} in all of these traits. The results pointed out that some N fertilization (i.e. between 50 and 75 kg urea ha^{-1}) as starter can be beneficial to improve growth, development, physiological traits and total yield of inoculated chickpea.

A field experiment was conducted by Aliloo *et al.* (2012) to study the effects of foliar spraying of aqueous solutions 2 and 4% urea at two stages (before and after flowering) and 20 kg ha^{-1} urea application in soil (three-week after sowing) on growth, yield and yield components of chickpea cultivars (Azad and ILC 482) under rain-fed conditions. Results showed that the effect of urea treatment on plant height was notable but other traits were not significantly affected by nitrogen applications. The highest plant height was obtained by application of 20 kg ha^{-1} urea in soil. However, difference among 20 kg urea application, 2% and 4% urea spraying before flowering was not significant. It can be concluded that the nitrogen fertilizer applying in rain-fed chickpea is not effective. Consequently, unused nitrogen in the soil/or plant can cause soil and air pollution.

To study the effects of N application on growth and biomass of a local variety (cv. Kabouli) of chickpea under water deficit, a study was carried out by Bahavar *et al.* (2009) hydroponically in growth chamber using three concentrations of N (0.25, 0.5 and 1 Mm) and four levels of drought stress (0, -0.3, -0.6 and -0.9 MPa). According to observed data, N application was increased the leaf water content, membrane stability, chlorophyll, leaf water potential, leaf area, nodule water content, nodule number and biomass. The experiment showed that N fertilizer application (with a concentration of 1 Mm) can increase leaf and nodule Relative Water Content (RWC), leaf water potential, membrane stability index, leaf chlorophyll content, leaf area and biomass under water deficit condition. Therefore, it seems that mineral nitrogen application can mitigate the adverse effects of water deficit stress and improve growth and biomass in chickpea. Consequently, nitrogen application after moisture stress decrease negative effects of drought.

A field experiment was conducted by Mukesh (2006) during rabi season in Jhansi, Uttar Pradesh, India, to study the impact of starter doses of nitrogen (0, 15 and 30 kg ha^{-1}) on nodulation and yield of different cultivars (Radhey, Avarodhi and K-850) of chickpea under irrigated condition. Application of 30 kg N ha^{-1} produced the highest number of nodules $plant^{-1}$ except at 30 days after sowing (DAS). The number of nodules increased up to 60 DAS and thereafter decreased at 90 and 120 DAS. Yield attributes, such as number of pods plant^{-1}, number of seeds plant^{-1}, 100-seed weight and harvest index, were highest in the crop treated with 30 kg N ha^{-1}. Seed protein content was also highest in crops receiving 30 kg N ha^{-1} and lowest in control plots.

Tufenkci *et al.* (2005) conducted a greenhouse experiment to study the effects of inoculation with arbuscular mycorrhizal fungi (AMF; Glomus intraradices) and P (0, 50 and 100 mg kg^{-1}) and N (0, 100 and 200 mg kg^{-1}) fertilizer application on the yield and nutrient content of chickpea cv. Aziziye-94. Data were recorded for plant height, fresh weight and dry weight. AMF inoculation significantly increase the growth parameters and contents of P, K, Ca and Zn. AMF inoculation with 50 mg P and 100 mg N kg^{-1} recommended treatment for chickpea production.

An experiment was conducted by Deolankar (2005) to determine the effects of five levels of fertigation (150, 125, 100, 75 and 50%) of recommended dose of liquid fertilizers (25:50:25 NPK kg ha^{-1}) to chickpea (cv. Vishal) compared with recommended dose of conventional fertilizers with surface irrigation on sandy clay loam soil (Entisol) in Maharashtra, India. Fertigation of liquid fertilizer improved chickpea growth and increased the grain yield and water use efficiency compared with surface irrigation. Results indicated the possibility of saving of 25% of recommended dose of fertilizers and 52% in irrigation water. Thus, fertigation improved chickpea productivity, and drip irrigation can be successfully used for the rabi crop of chickpea in a cropping system.

Walley *et al.* (2005) conducted a field experiments at various locations in Saskatchewan to investigate chickpea response to starter N (0, 15, 30, and 45 kg N ha^{-1}) and P (0, 20 and 40 kg P_2O_5 ha^{-1}) using desi cv. Myles and kabuli cv. Sanford. Starter N was side banded (2.5 cm to the side and 4 cm below the seed) and the P was placed in the seed row or side banded. Starter N promoted early vegetative growth of both desi and kabuli chickpea, but kabuli seed yield was unaffected by N application. Application of 30 or 45 kg N ha^{-1} enhanced desi yield by as much as 221 kg ha^{-1}. The results suggest that although N and P application had no effect on kabuli seed yield, desi yields may be optimized by the application of low rates of starter N (i.e., 30 kg N ha^{-1}).

The effect of foliar application of isotopically labelled nitrogen (15N-urea) at 4 stages during flowering and podding on the uptake and utilisation of nitrogen by chickpea (*Cicer arietinum* L.) under conditions of terminal drought was investigated by Palta *et al.* (2005) in a glasshouse study. Five treatments were used to investigate the effect of timing of foliar application of urea, equivalent to 30 kg N ha^{-1}, on the uptake and utilisation of nitrogen for biomass, yield, seed protein content, and seed size: foliar application at (i) first flower, (ii) 50% flowering, (iii) 50% pod set and (iv) the end of podding and (v) an unsprayed control treatment. The results indicated the potential to increase yields of chickpea by application of foliar nitrogen near flowering in environments in which terminal droughts reduce yield.

A field experiment was conducted by Shri-Krishna *et al.* (2004) in Kanpur, Uttar Pradesh, India, during the rabi seasons to study the interactive effects of nitrogen (0, 15, 30 and 45 kg ha^{-1} through urea) and sulfur on the yield, harvest index, total N and S uptake, and protein content of chickpea (cv. Radhey). The application of 15 kg N ha^{-1} and 40 kg S ha^{-1} significantly increased seed yield, N and S uptake, and protein content over the control in both years. In general, 15 kg N ha^{-1} with 20 kg S ha^{-1} was superior with respect to the evaluated traits.

A field trial was conducted by Giunta and Motzo (2003) in Sardinia, Italy to analyse the effects of sowing date nitrogen rate of 0, 3.5 and 10 g N rate (0, 3.5 and 10 g N_2 m^{-1}, applied as urea), water availability (rainfed or irrigated), and their interactions, through the evaluation of solar radiation intercepted by the crop (RI), conversion of radiation into dry matter (RUE) and harvest index (HI), on the grain yield of chickpea. Similar amounts of aboveground dry matter (AGDM) were produced by both sowings because of both the lower RUE of the winter sowing during the vegetative growth (0.57 against 0.93 g MJ^{-1}), and of the same

RI values observed in the 2 sowings at the start of podding. Nitrogen showed a positive and significant effect on AGDM by increasing RUE of the irrigated treatments from 0.61 to 0.84 g MJ^{-1}.

Hafiz (2000) carried out two field experiments in Egypt to study the effects of late foliar spraying of aqueous solution of 1% urea (sprayed twice 80 and 90 days after sowing) and 3 nitrogen fertilizer rates (0, 20 and 40 kg N fad^{-1}) applied 21 days after sowing on the growth, yield and yield components of chickpea cultivars Giza 1, Giza 88 and Giza 195 and early soil application of nitrogen fertilizer up to 40 kg N fad^{-1} significantly increased plant height; number of branches $plant^{-1}$; leaf area $plant^{-1}$; leaf area index; number of pods $plant^{-1}$; number of seeds pod^{-1}; 100-seed weight; pod and seed yield $plant^{-1}$; shelling percentage; seed, protein, straw and biological yields fad^{-1}; and seed protein content. Late supplementary foliar spraying with aqueous solution of 1% urea significantly increased all the studied growth characters, yield, yield components and yield quality compared to the unsprayed control.

2.3 Irrigation on flower droppings, growth and yield of chickpea

An experiment was carried out by Mirzakhani *et al.* (2013) in the research field of Islamic Azad University, Tabriz Branch. Water deficit as the main factor included seven levels: Control (without stress), stopping irrigation in vegetative growth stage (chickpea height: 15 cm), stopping irrigation in reproductive growth stage (50% flowering), stopping irrigation in the grain filling stage, irrigation starting from the vegetative growth stage once every 16 days, irrigation starting from the reproductive growth stage once every 16 days, irrigation starting from the grain filling stage once every 16 days and three cultivars of chickpea (Arman, Azad and ILC-482) were the secondary factors. The maximum amount of reduction in the number of pods in the plant was related to the treatment of irrigation stopping in the vegetative growth stage. In this treatment, the number of pods in the plant was 67% less than the number of pods in the plant in control. Irrigation stopping in the reproductive growth stage also resulted in a significant reduction in the number of pods in the plant and reduced this trait up to 25%. Comparing the mean seed yield unit^{-1} area under different treatments of water deficit stress showed that irrigation starting from the vegetative growth stage once every 16 days and irrigation starting from the reproductive growth stage once every 16 days and irrigation starting from grain filling stage once every 16 days had no significant effect on the grain yield in the plant.

Twenty nine chickpea genotypes were evaluated during rabi season in Badnapur, Maharashtra, India by Toprope *et al.* (2013) under moisture stress and irrigated conditions. One set of experiment was sown under controlled condition with sufficient moisture condition for good germination. Then, two additional irrigations were given to the irrigated experiment at flowering and podding stages of the crop. Among the genotypes, BCG 57, BCP 60 and BDNG 2011-2 showed the highest yield levels under moisture stress (2,220, 2,179 and 1,905 kg ha^{-1}, respectively) and irrigated conditions (2,435, 2,280 and 2,036 kg ha^{-1}). These high-yielding genotypes (BCG 57, BCP 60 and BDNG 2011-2) had the highest number of pods plant^{-1} under moisture stress (43.2, 43.3 and 47.8, respectively) and irrigated condition (45.1, 47.3 and 51.0, respectively).

An experiment was conducted by Chauhan and Yadav (2012) on chickpea with levels and depth of irrigation water as variables in four replications during Rabi 2006–07 to 2008–09 at Agricultural Research Station, Sriganganagar. The treatments comprising of the combination of 3 levels of sprinkler irrigation (IW/CPE 0.5, 0.6 and 0.7) and 3 depths of irrigation (4, 5 and 6 cm) along with one control treatment of border strip irrigation (As per recommendation). On the basis of experimentation, it was observed that under sprinkler irrigation system the seed yield of gram significantly increased with the increase in irrigation level up to IW/CPE 0.6. It increased 1.5% seed yield and saved 9.8% irrigation water over conventional boarder strip irrigation. Further, the yield of gram was increased significantly with every increase in the depth of irrigation water. Highest seed yield (23.00 q ha^{-1}) was recorded with 6 cm depth.

In order to evaluate the effect of supplementary irrigation, on growth indices of Chickpea, an experiment was conducted by Moemeni *et al.* (2013) at Campus of Agriculture and Natural Resources, Razi University Kermanshah, Iran. Treatment were 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.

To study the effects of N application on growth and biomass of a local variety (cv. Kabouli) of chickpea under water deficit, a study was carried out by Bahavar *et al.* (2009) hydroponically in growth chamber using three concentrations of N (0.25, 0.5 and 1 Mm) and four levels of drought stress (0, -0.3, -0.6 and -0.9 MPa), Ardebil, under the Iran conditions. Water deficit stress were evaluated for leaf water content, leaf water potential, membrane stability index, chlorophyll content, leaf area, root area, root/shoot ratio, nodule water content, nodule number and biomass. According to observed data, N application was increased the leaf water content, membrane stability, chlorophyll, leaf water potential, leaf area, nodule water content, nodule number and biomass.

The response in growth and yield of *Kabuli* chickpea (*Cicer arietinum* L.) cv. Princepe and narrow-leafed lupin (*Lupinus angustifolius* L.) cv. Fest to different irrigation levels as unirrigated (water stressed), given half irrigation, full irrigation and double irrigation (waterlogged) and full irrigation with 150 kg N ha^{-1} (optimum, control plots) was investigated by Kang *et al.* (2008) on a Templeton silt loam soil at Lincoln University. 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. 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. 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.

A field experiment was conducted by Sher-Singh *et al.* (2006) in the winter seasons of in Hisar, Haryana, India to evaluate the effect of irrigation (one irrigation at pre-flowering; and 2 irrigations, at pre-flowering and pod development), S (20 and 40 kg ha^{-1}) and seed inoculation (Rhizobium; phosphate solubilizing bacteria, PSB; and Rhizobium sp. + PSB) on late sown chickpea cv. HC1. Rhizobium sp. + PSB and S at 40 kg ha^{-1} resulted in the highest pod number $plant^{-1}$ (37.87), seed yield (1744 kg ha^{-1}), total S uptake (45.57 kg ha^{-1}) and net returns (Rs. 2357 ha^{-1}). The control treatment (no irrigation and S treatment) showed the lowest values for these parameters. Seed yield was significantly and positively correlated with dry matter accumulation, yield attributes, nutrient uptake, protein yield and consumptive water use.

To investigate the effects of different irrigation levels on phenology, physiological characteristics and yield components of chickpea cultivars, an experiment was conducted by Golldani and Moghaddam (2006) in Mashhad, Iran. There were 4 irrigation levels, i.e. no irrigation, irrigation only at planting time, irrigation at planting time and before flowering, and irrigation at planting time, before flowering and podding. Three kabuli chickpea cultivars were compared. Significant differences among number of branches, number pods and number of seeds square $metre^{-1}$ in the irrigation levels were observed. The highest seed yield was obtained with the 3 times irrigation and the lowest with no irrigation. Karaj 12-60-31 had the highest seed yield while ILC482 had the lowest. Karaj (12-60-31) with 3 times irrigations showed the best physiological characteristics. The growth period for Karaj 12-60-31 with 3 times irrigation was longer than the others.

To investigate the effect of different irrigation regimes on some agronomic and physiological characters of three chickpea cultivars, a field experiment was conducted by Mohammadi *et al.* (2006) in Tabriz, Iran. A split plot experiment, in which irrigation treatments (full irrigation, irrigation at only branching or flowering and or pod formation stage) were in the main plots and chickpea cultivars were in the subplots. Under limited irrigation conditions, there were no significant differences among irrigation regimes for green cover percentage and number of pods $plant^{-1}$ while rate and duration of grain filling, grain weight and grain yield were significantly higher for irrigation at pod formation than for irrigation at branching or flowering stage. The mean of all the characters, except for number of seeds pod^{-1}, were significantly higher for full irrigation than for limited irrigation treatments. The rate of grain filling, maximum grain weight and grain yield were significantly higher for irrigation at flowering than for irrigation at branching stage. Among phenological stages of chickpea, pod formation was the most sensitive to water deficit, and that under water limitation conditions chickpea yield could be improved by irrigation at this stage.

A field experiment was conducted by Singh and Smita (2006) with chickpea cultivars RSG-44 and RSG-888 during the winter (rabi) seasons on S-deficient sandy loam soil in Rajasthan, India. The treatments comprised recommended dose of P (40 kg ha^{-1}) through with and without S-containing fertilizers, i.e. diammonium phosphate (16% N and 46% P_2O_5) and single superphosphate (12% S and 16% P_2O_5), and 3 irrigation schedules, i.e. rainfed, one irrigation at 45 days stage and 2 irrigations at 45 and 75 days. Irrigation proved better in terms of growth, water use, grain, straw and protein yield. The water use efficiency was highest (159.2 kg grain cm^{-1} ha^{-1}) in rainfed conditions, followed by one irrigation (144.6 kg grain cm^{-1} ha^{-1}), compared with 2 irrigations (109.4 kg grain cm^{-1} ha^{-1}).

The effect of different plant densities (30, 450, 60 and 75 seeds m^{-2}) on the yield and yield components of some chickpea cultivars (Er-99 and Aziziye-94) under dry and irrigated conditions was evaluated by Togay *et al.* (2005) in Turkey. Irrigation was done during flowering and pod filling. The parameters tested included: plant height, first pod height, main branch number, pod number $plant^{-1}$, seed number $plant^{-1}$, seed number pod^{-1}, 1000-grain weight, seed yield $area^{-1}$ and harvest index. The effect of cultivar, irrigation and plant density on the yield and yield components (except seed number pod^{-1}) was significant. The highest grain yield area^{-1} was obtained with irrigation (95.4 and 92.5 kg da^{-1}) and the lowest under dry land condition (58.7 and 52.6 kg da^{-1}).

A field experiment was conducted by Patel and Patel (2005) in Thasra, Anand, Gujarat, India, on sandy clay loam soil in rabi season to study the effect of irrigation, farmyard manure and sulfur fertilizer on chickpea cv. ICCC 4. The treatments comprised: irrigation at presowing and at presowing + at flowering; 0 and 10 t farmyard manure ha^{-1}; and 0, 20 and 40 kg S ha^{-1}. Data were recorded for number of branches plant^{-1}, number of pods plant^{-1}, grain yield, straw yield, protein content, S content, status of N, P, K and S in the soil after harvest, and soil moisture content at 30 cm depth during flower and pod development stages. Irrigation at pre-sowing and flowering stage + 10 t farmyard manure ha^{-1} + 20 kg S ha^{-1} increased yield.

Two field experiments were carried out by Fallah *et al.* (2005) in Khorram-abad (Lorestan, Iran) to investigate the effect of 4 plant densities and 2 soil moisture regimes (dryland with and without supplementary irrigation) on the growth, yield and yield components of chickpea cultivars Greet, Karaj 12-60-31 and Hashem. The supplementary irrigation treatment was implemented at grain filling stage. The supplementary irrigation led to a significant increase in grain weight and grain yield. Planting Greet at 20 plants m^{-2}, along with supplementary irrigation, may lead to a significant increase in grain yield under dry land conditions.

Theib *et al.* (2004) carried out an experiment over four cropping seasons at ICARDA's main station at Tel Hadya, Aleppo, northern Syria. The experiment included three sowing dates (late November, mid-January, and late February) and four levels of supplemental irrigation (S_I): full S_I, 2/3 S_I, 1/3 S_I, and no S_I, i.e. rainfed. Water use efficiency was determined as the ratio of crop yield unit^{-1} area to seasonal evapotranspiration. The results showed that chickpea yield unit^{-1} area increases with both earlier sowing and increased SI. However, water use efficiency under supplemental irrigation decreases with earlier sowing, due to the relatively large increase that occurs in the amount of evapotranspiration at early sowing dates. The study's results indicated that a 2/3 S_I level gives the optimum water use efficiency for chickpea under supplemental irrigation.

Twelve chickpea cultivars (Sari 98, Diyar 95, Gokce, Aziziye 94, Uzunlu 99, Kusmen 99, Damla 89, Aydin 92, Akcin 91, Er 99, Menemen 92 and Izmir 92) were subjected to rainfed or irrigated conditions in a field experiment conducted in Turkey by Bicer *et al.* (2004) during the spring. In general, natural plant height; natural pod height; leaf length; rachis width; number of leaflets; leaflet length and width; flower length; biological yield plant^{-1}; number of pods plant^{-1}; number of seeds plant^{-1}; seed yield plant^{-1}; pod and seed length, width and roughness; and 100-seed weight were higher, whereas protein content was lower under irrigated than rainfed conditions.

A field experiment was conducted by Sekhon *et al.* (2004) comprising 3 planting methods (PMs) (flat bed sowing at 30 cm row spacing; 2 rows of chickpea at 30 cm distance on 67.5 cm wide raised bed; and 3 rows of chickpea on 67.5 cm wide raised bed) and 3 irrigation levels (ILs) (no irrigation; one irrigation at flower initiation; and 2 irrigations at vegetative stage 50 days after sowing and at flower initiation) was conducted in Gurdaspur, Punjab, India. The effects due to PMs and ILs were not significant on the grain yield of chickpea sown after maize. The interaction effects were also not significant. At Rauni, the effects due to PMs were significant on the grain yield of chickpea sown after rice, while ILs did not affect the grain yield. The flat bed treatment had almost half the yield levels compared to raised bed treatments when one irrigation was given. The grain yield further reduced with 2 irrigations in flat bed. The grain yields were reduced drastically in flat bed with one and 2 irrigations. Treatment with no irrigation in raised bed with 2 or 3 rows yielded significantly less than the raised bed with one or 2 irrigations.

Ten chickpea cultivars were evaluated by Sanap *et al.* (2004) in Rahuri, Maharashtra, India, during rabi for growth and yield under drought (T_1) and well-irrigated (T_2) conditions. One pre-sowing irrigation and one post-sowing irrigation were given under T_1; additional irrigation at flowering and pod development stages was provided under T_2. Dry matter accumulation (DMA) increased slowly at the initial growth stages, then increased rapidly from pre-flowering to maturity. DMA at harvest ranged from 6.80 (ICCV-4) to 14.89 g $plant^{-1}$ (Phule G-87227) under T_1, and from 10.20 (ICCV-4) to 22.19 g $plant^{-1}$ (ICC-4958) under T_2. The average grain yield of 6.10 g $plant^{-1}$ under T_2 was reduced by 35.73% under T_1.

A study was conducted by Dahiwalkar *et al.* (2004) to determine the response of chickpea (*Cicer arietinum* var. Vishal) to the suitability of surge flow irrigation owing to the limited moisture availability in rabi season in Maharashtra, India. Five irrigation treatments include conventional flow irrigation (T_1), conventional flow with two splits (T_2), two surges (T_3), three surges (T_4) and four surges (T_5) on a sandy clay loam soil. The results showed that the chickpea responded significantly to irrigation water management with surge flow irrigation. T_5 was found superior in respect to growth, measured in plant height, spread, number of pods and dry matter $plant^{-1}$. Consequent upon the better growth and development of chickpea due to uniform and efficient application of irrigation water in the field, the yield contributing characters and finally the grain and bhusa yield was also increased significantly in treatment T_5. Water use efficiency was found maximum in T_5 and overall irrigation was increased due to four surges.

Hamed (2003) reported that chickpea cultivars Giza 1, Giza 2, Giza 88 and Giza 195 were either coated or not with Cotoongen, a source of micronutrients, before sowing and subjected to irrigation at the branching stage (I_1), at the branching and flowering stages (I_2) and at the branching, flowering and pod development stages (I_3) in a field experiment conducted in Egypt. Plant height, number of branches $plant^{-1}$, straw yield, 100-seed weight and biological yield were highest with I_3, followed by I_2 and I_1. The number of pods $plant^{-1}$, and pod, seed and protein yield were higher with I_1. Giza 88 recorded the highest values of the parameters examined except for straw protein content which was highest in Giza 195. Seed coating with Cotoongen resulted in higher straw weight $plant^{-1}$, pod number and weight $plant^{-1}$, seed weight $plant^{-1}$ and pod, seed protein and oil yield fed^{-1}.

2.4 Hormones on flower droppings, growth and yield of chickpea

Abbas *et al*. (2013) reported that exogenous application of plant growth regulators is an important element in modern day agricultural production technology. The precursor of auxin, L-Tryptophan (L-TRP), is the most important plant growth regulator and is physiologically very vital in model ling plant growth and development. To evaluate the effect of L-TRP on chickpea plant weight and pod weight, a field experiment was conducted with the treatments of L-TRP @ 10^{-2} M, L-TRP @ 10^{-3} M, L-TRP @10^{-4} M and a control. Analysis showed that L-TRP @ 10^{-3} M had a significant effect on plant and pod weight, suggesting the additional effect of plant growth promoting factor provided by auxin production. The L-TRP improved the crop vegetative and reproductive growth that consequently increases pod weight.

Leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR), net assimilation rate (NAR) and above ground dry matter accumulation (AGDM) of a cultivar of chickpea (*Cicer arietenum*) were studied by Karim and Fattah (2007) with the application of potassium naphthenate (KNap) and naphthalene acetic acid (NAA) as foliar spray. The growth regulators had greater influence on plants which showed comparable values of LAI, LAD, CGR, NAR and TDM over control plants. Out of the growth regulator treatment, 1500 ppm Knap produced 26.7 to 37.5% more TDM at different stages of growth than those of control, and it was superior to other treatments with NAA. Other growth parameters also increased following 1500 ppm KNap treatment. LAI, CGR, NAR and AGDM had a significant linear relationship with seed yield. The combination treatments of KNap and NAA concentrations did not show any cumulative influence on any of the parameters.

Seeds of chickpea (*Cicer arietinum*) were germinated with distilled water alone or supplemented with different plant growth regulators, i.e. L-arginine monohydrochloride, salicylic acid, phenyl hydrazine hydrochloride and cinnamic acid, all applied at concentrations of 25, 50 and 100 ppm by Amitr and Singh

(2006) and reported that application of these substances at low concentrations promoted seed germination and seedling growth in chickpea.

Pankaj and Deshmukh (2006) conducted an experiment with BA [benzyladenine] (50 ppm), abscisic acid (ABA; 25 ppm), BA + ABA, and water (control) were sprayed to the foliage of chickpea genotypes grown in pots at the beginning of the moisture stress treatment. C-214 was more tolerant of drought than BG-362. However, both the genotypes were more sensitive to moisture stress at the early vegetative growth stage. The greatest reduction in yield and yield components was observed when the moisture stress treatment was given at 40-60 days after sowing (DAS), followed by stress imposed at 61-80 DAS. Among the growth regulator treatments, BA + ABA was optimum for all the parameters (biomass production, yield and yield components), followed by ABA.

The effects of mepiquat chloride, potassium nitrate, borax and triacontanol, applied alone or in combination, on flower abortion, pod setting and yield of chickpea were determined by Rao *et al.* (2005) in a field experiment conducted in Andhra Pradesh, India during the rabi season. Application of 50 ppm mepiquat chloride, 1.25 ppm triacontanol, 0.2% borax and 1% potassium nitrate resulted in the highest flowers setting, 100-seed weight, biomass at harvest, seed yield and harvest index, and lowest number of aborted flowers.

The effects of plant growth regulators on bud retention in 6 F_1 chickpea crosses (GNG 469 × GPF 2, CSG 9707 × GPF 2, CSG 8962 × GPF 2, GJG 9807 × GPF 2, PBG 1 × FG 1712 and PBG 1 × ICC 4075) were studied by Ajinder, *et al.* (2005). The pedicels of pollinated buds were treated with a mixture of growth regulators (120 ppm GA_3 [gibberellic acid] + 30 ppm NAA + 15 ppm kinetin) in the morning (10.00 h) or in the morning and evening (16.00 h) for 3 consecutive days. After 10 days, crossed bud retention was evaluated. The application of growth regulators to pollinated buds once and twice daily increased bud retention by 166.5 and 193.9%, respectively, on average, over the control. Percent bud retention was significantly higher when the growth regulators were applied twice.

In an experiment conducted by Raut and Sabale (2003) during the rabi season in Maharashtra, India, with chickpea cv. PG 81-1-1, the effect of the following treatments were evaluated: NPK (kg ha^{-1}) at F_1 (recommended rate (25:50:0)), F_2 (fertilizer for targeted yield of 30 q ha^{-1} (31.20 : 60.70 : 27.00), F_3 (35 q ha^{-1} (47.45 : 80.33 : 33.45) F_4 (40 q ha^{-1} (73.77 : 99.40 : 39.90), F_5 (45 q ha^{-1} (99.95 : 118.75 : 46.35) and F_6 (50 q ha^{-1} (126.0 : 138.0 : 52.8)) and Cycocel [chlormequat] at 0 or 1000 ppm (C_0 and C_1, respectively). C_1 significantly controlled the plant height and diverted the food material towards the reproductive growth instead of vegetative growth. C_1 did not affect the plant spread and stover yield. C_1 increased the branch number, dry matter, pod number $plant^{-1}$, grain number $plant^{-1}$, grain weight $plant^{-1}$, 1000-grain weight, harvest index and grain yield, but decreased the stover : grain ratio. F_6 treatment recorded the highest grain number $plant^{-1}$ and 1000-grain weight and the lowest stover : grain ratio.

A field experiment was conducted by Narendra (2003) to study the effect of sulfur and plant growth-regulators on yield and quality of chickpea during the rabi season of 1998-99 in Rajasthan, India. Treatments consisted of four sulfur rates (0, 20, 40 and 60 kg ha^{-1}) and four plant growth regulators (PGRs) including control (water spray), 20 ppm NAA, 50 ppm Cycocel [chlormequat] and 50 ppm maleic hydrazide (MH). Application of PGRs showed significant increase in chickpea yield (straw and grain) and quality. The increase in grain yield due to NAA, Cycocel and MH was 25.42, 24.16 and 26.12%, respectively, over the control. NAA, Cycocel and MH increased the grain protein content over the control by 19.98, 17.91 and 20.65%, respectively.

Chickpea cv. Avarodhi plants were supplied with 20 ppm TIBA; 1000 ppm ALAR [daminozide]; 5 ppm Miraculam; 50 ppm IAA, gibberellic acid, NAO and Planofix [NAA]; 5 ppm cytokinin, 10 ppm Mixtalol [triacontanol] and 4000 ppm CCC [chlormequat] in a field experiment conducted by Tripathi *et al.* (2003) in Kanpur, Uttar Pradesh, India. Chlorophyll content was highest with 20 ppm TIBA treatment at pre and post-anthesis (2.60 and 2.82, respectively). Dry matter production, and protein and starch content were highest with the 20 ppm TIBA, 5 ppm cytokinin and 50 ppm IAA treatment, respectively.

A field experiment was conducted by Upadhyay (2002) in Berthin, Himachal Pradesh, India, to study the effect of NAA, gibberellic acid (GA_3), and kinetin (10, 20, and 30 ppm) on chickpea physiology and yield parameters. All growth regulators, sprayed at approximately one week before bud initiation and at the pod formation stage, significantly enhanced grain and biological yields and yield components. Among the growth regulators, NAA was most effective as it gave the greatest number of pods, flowers, and buds plant^{-1}; length and circumference of pod; number of grains pod^{-1}; biological yield; test weight; and grain yield. Flowering was induced by NAA but was delayed by kinetin. NAA at 30 ppm resulted in the earliest flowering and crop maturity. The lowest incidence of flower shedding and the highest grain yield were recorded for crops sprayed with 20 ppm NAA. Among the yield components, the number of pods plant^{-1} was most responsive to the growth regulators, especially to NAA.

The effects of the plant growth regulators CCC [chlormequat] (50 ppm), paclobutrazol (100 ppm), Hico-110 R (100 ppm), and 8-H-Q (100 ppm), and of the antitranspirants calcium carbonate (2%), kaolin (2%), and china clay (2%) on the yield of chickpea cv. Phule G-5 were studied by Mahurkar *et al.* (2000) in Akola, Maharashtra, India, during the rabi seasons. The growth regulators and antitranspirants were sprayed during flowering and at 15 days after the initial flowering. The highest dry matter production was obtained with 8 H-Q, followed by CCC and kaolin. The rest of the treatments were on at par with the control. 8 H-Q and CCC gave the highest number of pods plant^{-1} and grain yields. The other treatments were either as effective or less effective than the control.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from 11 December, 2012 to 30 March 2013 to study the influence of supplementary nitrogen, irrigation and hormones on flower droppings, growth and yield of chickpea. This chapter includes materials and methods that were used in conducting the experiment are presented below under the following headings:

3.1 Experimental site

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated between $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude and at an elevation of 8.4 m from sea level (Anon., 1989).

3.2 Soil

The soil of the experimental site belongs to Tejgaon series under the Agro-ecological zone, Madhupur Tract (AEZ-28), which falls into Deep Red Brown Terrace Soils. Soil samples were collected from the experimental plots to a depth of 0-15 cm from the surface before initiation of the experiment and analyzed in the laboratory. The soil was having a texture of sandy loam with pH and Catayan Exchange capacity 5.6 and 2.64 meq 100 g $soil^{-1}$, respectively. The morphological characteristics of the experimental field and physical and chemical properties of initial soil are given in Appendix I and II (Khatun, 2014).

3.3 Climate

The climate of experimental site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix III.

3.4 Planting material

The variety BARI chola 8 and BARI chola 9 were used as the test crops. The seeds were collected from the Agronomy Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. BARI chola 8 and BARI chola 9 are the released varieties of chickpea, which was recommended by the national seed board. They grow both in *Kharif* and *Rabi* season. Life cycle of this variety ranges from 125 to 130 days. Maximum seed yield is 1.5 to 2.0 t ha^{-1}.

3.5 Land preparation

The land was irrigated before ploughing. After having 'zoe' condition the land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 4 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 01^{th} and 10^{th} December, 2012, respectively. Experimental land was divided into unit plots following the design of experiment.

3.6 Treatments of the experiment

The experiment consists of two factors:

Factor A: Chickpea variety (2)

i) V_1: BARI chola 8
ii) V_2: BARI chola 9

Factor B: Supplementary treatments (5 levels)

i) T_1: Control i.e., no spray at flowering and afterwards
ii) T_2: Supplemental irrigation before flowering (SIBF)
iii) T_3: SIBF + Aqueous N before flowering
iv) T_4: PRH (a phytohormone) spray before flowering
v) T_5: Kinetine spray before flowering

There were in total 10 (2×5) treatment combinations such as V_1T_1, V_1T_2, V_1T_3, V_1T_4, V_1T_5, V_2T_1, V_2T_2, V_2T_3, V_2T_4 and V_2T_5.

3.7 Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MoP), gypsum, zinc sulphate and boric acid were used as a source of nitrogen, phosphorous, potassium, gypsum, sulphur and boron, respectively. Urea, Triple super phosphate (TSP), Muriate of potash (MoP), gypsum, zinc sulphate and boric acid were applied at the rate of 50, 90, 40, 110, 7 and 10 kg hectare^{-1}, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation. All of the fertilizers except urea were applied during final land preparation.

3.8 Experimental design and layout

The two factors experiment was laid out in split-plot design with three replications. An area of 22.7 m × 22 m was divided into blocks. The two varieties were assigned in the main plot and five supplementary treatments in sub-plot. The size of the each unit plot was 4.0 m × 3.2 m. The space between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.9 Sowing of seeds in the field

The seeds of chickpea were sown on December 11, 2012 in solid rows in the furrows having a depth of 2-3 cm and row to row distance was 40 cm.

3.10 Application of supplementary treatment

As a supplementary treatment supplemental irrigation before flowering (SIBF), SIBF + Aqueous N before flowering, PRH (a phytohormone) spray before flowering and Kinetine spray before flowering were applied.

3.10.1 Supplemental irrigation before flowering (SIBF)

Supplementary irrigation was applied before flowering and it was done at 15 February at 65 Days after Sowing (DAS). Selected 6 plots were provided with flood irrigation.

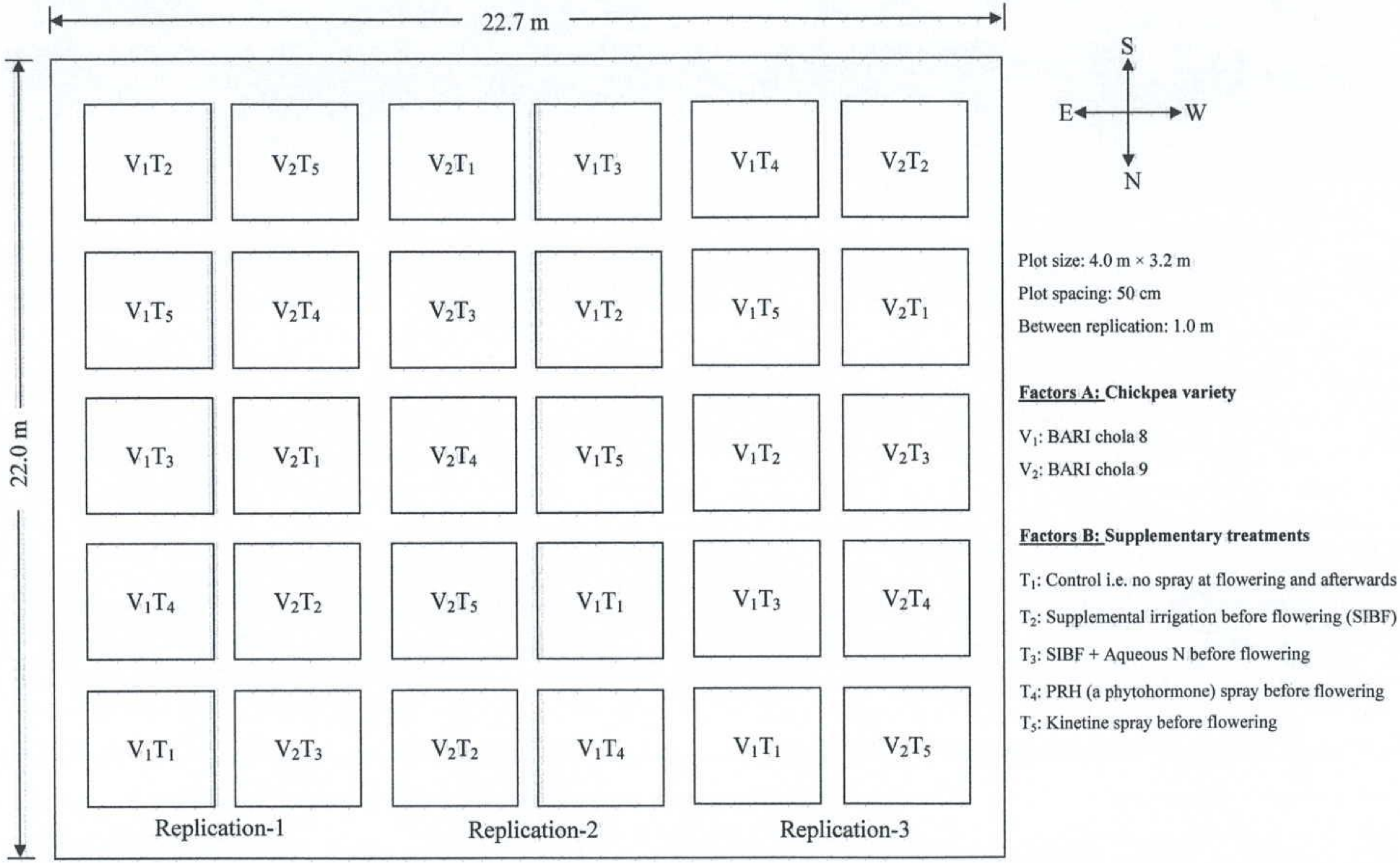


Figure 1. Field layout of the experiment in the split-plot design

3.10.2 SIBF + Aqueous N before flowering

SIBF + Aqueous N before flowering was applied before flowering and done at 05 February at 55 Days after Sowing (DAS). Selected 6 plots were provided with flood irrigation and aqueous N. For aqueous nitrogen 153.6 g urea were mixed with 6 liter of water and sprayed in the plots.

3.10.3 PRH (a phytohormone) spray before flowering

PRH is a hormone that prepared by Natural Bio Agro Tech Co. (Pvt.) Ltd. and made from fruits vinegar and other natural ingredients. It is 100% organic. PRH were sprayed before flowering and solution were made by adding 12 spoons of PRH with 6 liter of water and applied at 05 February at 55 DAS.

3.10.4 Kinetine spray before flowering

Kinetine (kinetine puriss CHR : 6-Furfurylaminopurine, $C_{10}H_5OH$) were sprayed before flowering and soluation were made by adding 150 mg kinetene and 10 ml ethanol (C_6H_5OH) with 6 liter of water and applied at 05 February at 55 DAS.

3.11 Intercultural operations

3.11.1 Thinning

Seeds started germination of four Days After Sowing (DAS). Thinning was done two times; first thinning was done at 8 DAS and second was done at 15 DAS to maintain optimum plant population in each plot.

3.11.2 Irrigation and weeding

Irrigation was provided for two times for vegetative growth for all experimental plots equally. But additionally supplementary irrigation was provided as per treatment before flowering. The crop field was weeded as per necessary.

3.11.3 Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) infested the young plants and at later stage of growth pod borer (*Maruca testulalis*) attacked the plant.

Ripcord 10 EC was sprayed at the rate of 1 mm with 1 litre water for two times at 15 days interval after seedlings germination to control the insects.

3.12 Crop sampling and data collection

Five plants from each treatment were randomly selected and marked with sample card. Plant height, branches plant^{-1} and dry matter plant^{-1}were recorded from selected plants at an interval of 15 days started from 60 DAS to 105 DAS.

3.13 Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown in color. The matured pods were collected by hand picking from a pre demarcated area of 6.4 m^2 at the center of each plot.

3.14 Data collection

The following data were recorded

i. Plant height at 60, 75, 90 and 105 DAS
ii. Number of branches plant^{-1} at 60, 75, 90 and 105 DAS
iii. Dry matter contents plant^{-1} at 60, 75, 90 and 105 DAS
iv. Flower dropping (%)
v. Pod dropping (%)
vi. Total (flower and pod) dropping (%)
vii. Pod remaining (%)
viii. Number of pods plant^{-1}
ix. Pod length (cm)
x. Number of seeds pod^{-1}
xi. Weight of 1000 seeds (g)
xii. Shelling percentage
xiii. Seed yield hectare^{-1}
xiv. Stover yield hectare^{-1}
xv. Biological yield hectare^{-1}
xvi. Harvest index (%)

3.15 Procedure of data collection

3.15.1 Plant height

The plant height was measured at 60, 75, 90 and 105 DAS with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

3.15.2 Number of branches plant^{-1}

The number of branches plant^{-1} was counted at 60, 75, 90 and 105 DAS from selected plants. The average number of branches plant^{-1} was determined.

3.15.3 Dry matter content plant^{-1}

After taking fresh weight at 60, 75, 90 and 105 DAS, the sample was sliced into very thin pieces and put into envelop then placed in oven maintained at 70^0C for 72 hours. It was then transferred into desiccators and allowed to cool down at room temperature. The final dry matter content was taken by following formula:

$$\text{Dry matter content of plants} = \frac{\text{Dry weight of plants (g)}}{\text{Fresh weight of plants (g)}} \times 100$$

3.15.4 Flower dropping

Flower dropping was counted for 5 selected plants and recorded in each plot. Dropping of flower was counted in every morning by using clean paper as per plate 1 during flowering time and recorded.

3.15.5 Pod dropping

Pod dropping was counted for 5 selected plants and recorded in each plot. Dropping of pod was counted in every morning as per the way of counting flower dropping during pod development stage and recorded.

3.15.6 Total dropping

Pod dropping was calculated by adding flower dropping and pod dropping from 5 selected plants and recorded in each plot.

3.15.7 Pod remaining

Pod remaining was calculated by deducting total pod dropping from 100 and recorded in each plot.

Plate 1. Photograph showing counting of dropped flower and pod

3.15.8 Number of pods plant^{-1}

Numbers of total pods of selected plants from each plot were counted and the mean numbers were expressed as plant^{-1} basis. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.15.9 Pod length

Pod length was taken of randomly selected ten pods and the mean length was expressed on pod^{-1} basis.

3.15.10 Number of seeds pod^{-1}

The number of seeds pods^{-1} was recorded from randomly selected 10 pods at the time of harvest. Data were recorded as the average of 10 pods from each plot.

3.15.11 Weight of 1000 seeds

One thousand cleaned, dried seeds were counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.15.12 Shelling percentage

The mass of seeds obtained from the pods that were randomly drawn from a bulk sample and calculated the shelling percentage by using the following formula:

$$\text{Shelling percentage} = \frac{\text{Seed mass}}{\text{Pod mass}} \times 100$$

3.15.13 Seed yield

The seeds collected from 6.4 (2 m ×3.2 m) square meter of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha^{-1}.

3.15.14 Stover yield

The stover collected from 6.4 (2 m ×3.2 m) square meter of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha^{-1}.

3.15.15 Biological yield $hectare^{-1}$

Seed yield and stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Seed yield + Stover yield.

3.15.16 Harvest index

Harvest index was calculated from the seed yield and stover yield of chickpea for each plot and expressed in percentage.

$$\text{HI (\%)} = \frac{\text{Economic yield (seed weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.16 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different chickpea varieties and supplementary treatments on pod dropping, yield and yield contributing characters. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the influence of supplementary nitrogen, irrigation and hormones on flower droppings, growth and yield of chickpea. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix IV-IX. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

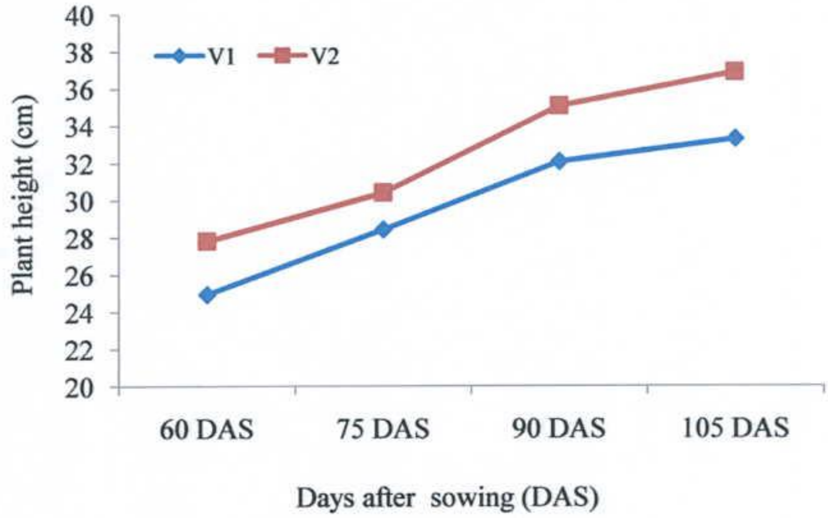
4.1 Plant height

4.1.1 Effect of variety

Statistically significant variation was recorded in terms of plant height of BARI chola 8 and BARI chola 9 at 60, 75, 90 and 105 DAS (Figure 2). At 60, 75, 90 and 105 DAS the tallest plants (27.82, 30.42, 35.06 and 36.88 cm, respectively) were recorded from V_2 (BARI chola 9), whereas the shortest plants (24.96, 28.44, 32.07 and 33.30 cm, respectively) were found from V_1 (BARI chola 8). Different varieties produced different plant height on the basis of their varietal characters and improved varieties is the first and foremost requirement for initiation and accelerated production program. Golldani and Moghaddam (2006) reported various plant height for different chickpea varieties.

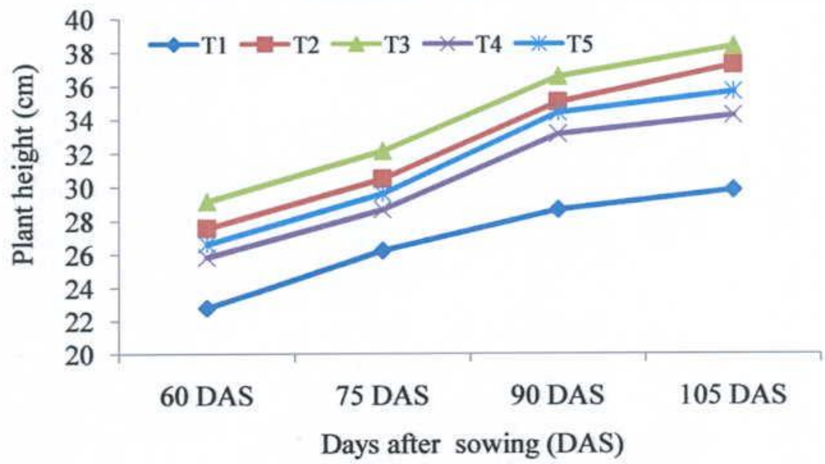
4.1.2 Effect of supplementary treatments

Plant height at 60, 75, 90 and 105 DAS showed significant variation for different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones (Figure 3). At 60, 75, 90 and 105 DAS, the tallest plant (29.15, 32.14, 36.56 and 38.39 cm, respectively) was found from T_3 (SIBF + aqueous N before flowering), which was statistically similar (27.56, 30.49, 35.05 and 37.27 cm, respectively) to T_2 (supplemental irrigation before flowering-SIBF) and followed (26.62, 29.62, 34.41 and 35.68 cm, respectively) by T_5 (kinetine spray before flowering), while, the shortest plant (22.78, 26.23, 28.66 and 29.84 cm, respectively) was observed from T_1 (control i.e., no spray at flowering and afterwards). Supplementary spraying ensured favorable condition for chickpea plant with longest plant Fallah *et al.* (2005) recorded highest plant growth applying supplementary irrigation.



V_1: BARI chola 8; V_2: BARI chola 9

Figure 2. Effect of variety on plant height of chickpea ($LSD_{0.05}$ = 1.959, 1.630, 2.958 and 3.520 at 60, 75, 90 and 105 DAS)



T_1: Control i.e. no spray at flowering and afterwards;
T_2: Supplemental irrigation before flowering (SIBF)
T_3: SIBF + Aqueous N before flowering;
T_4: PRH (a phytohormone) spray before flowering
T_5: Kinetine spray before flowering

Figure 3. Effect of supplementary treatments on plant height of chickpea ($LSD_{0.05}$ = 0.975, 1.130, 1.665 and 1.600 at 60, 75, 90 and 105 DAS)

4.1.3 Interaction effect

Interaction effect of chickpea varieties and different supplementary treatments showed significant differences on plant height at 60, 75, 90 and 105 DAS (Table 1). At 60, 75, 90 and 105 DAS the tallest plant (30.13, 32.66, 37.13 and 39.31 cm, respectively) was recorded from V_2T_3 (BARI chola 9 and SIBF + Aqueous N before flowering), while the shortest plant (21.13, 24.13, 25.00 and 25.94 cm, respectively) from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards). Kang *et al.* (2008) reported that to achieve yield potential, crops should be irrigated over the whole of crop growth.

4.2 Number of branches plant^{-1}

4.2.1 Effect of variety

Number of branches plant^{-1} of BARI chola 8 and BARI chola 9 showed significant variation at 60, 75, 90 and 105 DAS (Figure 4). At 60, 75, 90 and 105 DAS the maximum number of branches plant^{-1} (4.81, 5.53, 5.84 and 5.91, respectively) was observed from V_2 (BARI chola 9) and the minimum number (4.37, 4.85, 5.13 and 5.19, respectively) from V_1 (BARI chola 8). Management practices influence the number of branches plant^{-1} but varieties itself also manipulated it.

4.2.2 Effect of supplementary treatments

Different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones showed significant variation for number of branches plant^{-1} at 60, 75, 90 and 105 DAS (Figure 5). At 60, 75, 90 and 105 DAS, the maximum number of branches plant^{-1} (4.93, 5.63, 6.00 and 6.10, respectively) was recorded from T_3 (SIBF + aqueous N before flowering), which was statistically similar (4.80, 5.43, 5.70 and 5.70, respectively) to T_2 (supplemental irrigation before flowering-SIBF) and closely followed (4.63, 5.33, 5.53 and 5.53, respectively) by T_5 (kinetine spray before flowering), while the minimum number (4.10, 4.47, 4.73 and 4.87, respectively) was found from T_1 (control i.e., no spray at flowering and afterwards). Supplementary spraying ensured favorable condition for the growth of chickpea plant with maximum branches plant^{-1}. Hafiz (2000) reported that late supplementary foliar spraying with aqueous solution of 1% urea significantly increased all the studied growth characters.

Table 1. Interaction effect of variety and supplementary nitrogen, irrigation and hormone spray on plant height of chickpea

Treatments	Plant height (cm) at			
	60 DAS	75 DAS	90 DAS	105 DAS
V_1T_1	21.13 g	24.13 f	25.00 e	25.94 e
V_1T_2	26.62 cd	30.23 bc	34.74 a-c	36.65 b
V_1T_3	28.16 b	31.62 ab	36.00 a	37.47 ab
V_1T_4	23.43 f	26.94 e	31.56 d	32.45 d
V_1T_5	25.46 de	29.25 cd	33.07 b-d	33.99 cd
V_2T_1	24.44 ef	28.33 de	32.33 cd	33.74 cd
V_2T_2	28.51 b	30.74 bc	35.36 ab	37.89 ab
V_2T_3	30.13 a	32.66 a	37.13 a	39.31 a
V_2T_4	28.24 b	30.39 bc	34.74 a-c	36.08 bc
V_2T_5	27.79 bc	29.99 b-d	35.75 a	37.37 ab
$LSD_{(0.05)}$	1.379	1.599	2.355	2.262
Level of significance	0.05	0.01	0.01	0.01
CV(%)	3.01	3.14	4.05	3.72

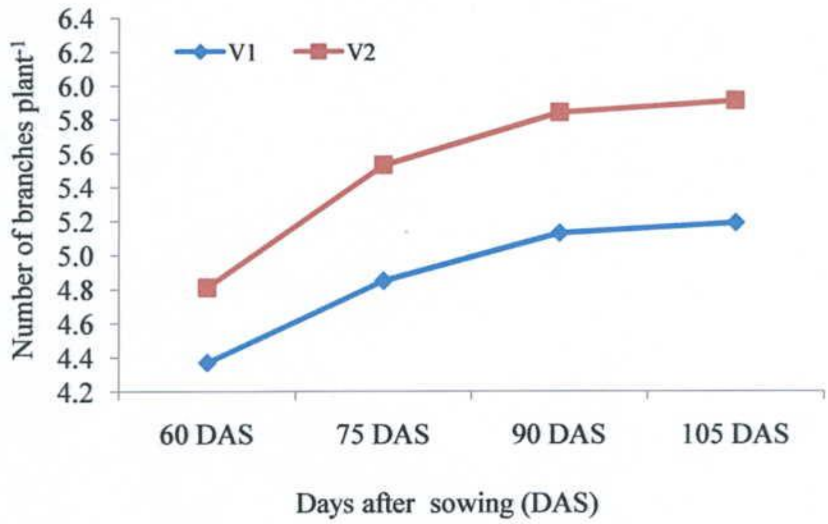
In a column, similar letter do not differ significantly at 0.05 level of probability

V_1: BARI chola 8; V_2: BARI chola 9

T_1: Control i.e., no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF)

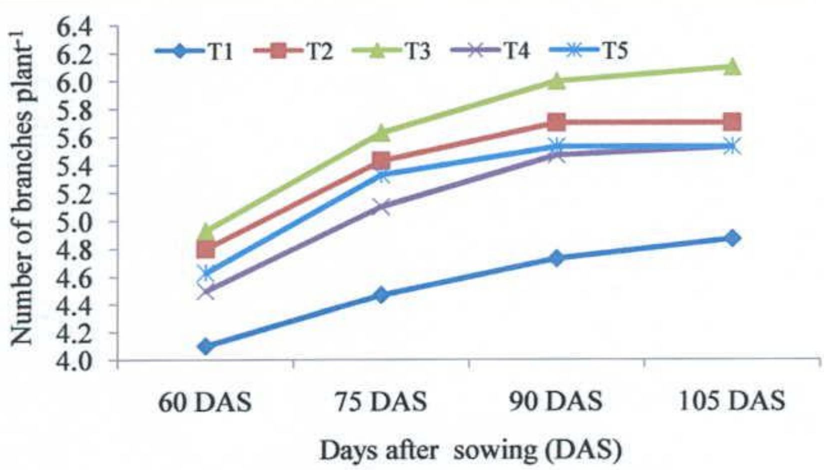
T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering

T_5: Kinetine spray before flowering



V_1: BARI chola 8; V_2: BARI chola 9

Figure 4. Effect of variety on number of branches plant^{-1}of chickpea ($LSD_{0.05}$ = 0.172, 0.455, 0.489 and 0.344 at 60, 75, 90 and 105 DAS)



T_1: Control i.e. no spray at flowering and afterwards;
T_2: Supplemental irrigation before flowering (SIBF)
T_3: SIBF + Aqueous N before flowering;
T_4: PRH (a phytohormone) spray before flowering
T_5: Kinetine spray before flowering

Figure 5. Effect of supplementary treatments on number of branches plant^{-1} of chickpea ($LSD_{0.05}$ = 0.242, 0.274, 0.391 and 0.373 at 60, 75, 90 and 105 DAS)

4.2.3 Interaction effect

Chickpea varieties and different supplementary treatments showed significant differences on number of branches plant^{-1} at 60, 75, 90 and 105 DAS due to their interaction effect (Table 2). At 60, 75, 90 and 105 DAS the maximum number of branches plant^{-1} (5.00, 5.93, 6.47 ad 6.53, respectively) was attained from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering), whereas the minimum number of branches plant^{-1} (3.60, 3.80, 4.07 and 4.20, respectively) from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

4.3 Dry matter content plant^{-1}

4.3.1 Effect of variety

At 60, 75, 90 and 105 DAS dry matter content plant^{-1} of BARI chola 8 and BARI chola 9 varied significantly (Figure 6). Data revealed that at 60, 75, 90 and 105 DAS the maximum dry matter content plant^{-1} (4.37 g, 5.33 g, 5.78 g and 6.03 g, respectively) was found from V_2 (BARI chola 9), while the minimum dry matter content plant^{-1} (3.83 g, 4.61 g, 5.14 g and 5.43 g, respectively) was recorded from V_1 (BARI chola 8).

4.3.2 Effect of supplementary treatments

Statistically significant variation was recorded for dry matter content plant^{-1} at 60, 75, 90 and 105 DAS due to different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones (Figure 7). At 60, 75, 90 and 105 DAS, the maximum dry matter content plant^{-1} (4.75 g, 5.53 g, 5.99 g and 6.25 g, respectively) was observed from T_3 (SIBF + aqueous N before flowering), which was statistically similar (4.30 g, 5.34 g, 5.83 g and 6.14 g, respectively) to T_2 (supplemental irrigation before flowering-SIBF) and closely followed (4.18 g, 5.05 g, 5.59 g and 5.86 g, respectively) by T_5 (kinetine spray before flowering), whereas the minimum dry matter content plant^{-1} (3.34 g, 4.11 g, 4.38 g and 4.65 g, respectively) was recorded from T_1 (control i.e., no spray at flowering and afterwards). Supplementary spraying ensured favorable condition for the growth of chickpea plant with optimum vegetative growth and the ultimate results was the highest dry matter content plant^{-1}.

Table 2. Interaction effect of variety and supplementary nitrogen, irrigation and hormone spray on number of branches plant^{-1} of chickpea

Treatments	Number of branches plant^{-1} at			
	60 DAS	75 DAS	90 DAS	105 DAS
V_1T_1	3.60 e	3.80 d	4.07 d	4.20 e
V_1T_2	4.67 a-c	5.07 bc	5.40 bc	5.40 cd
V_1T_3	4.87 a-c	5.33 b	5.53 bc	5.67 b-d
V_1T_4	4.20 d	4.80 c	5.13 c	5.13 d
V_1T_5	4.53 cd	5.27 b	5.53 bc	5.53 b-d
V_2T_1	4.60 bc	5.13 bc	5.40 bc	5.53 b-d
V_2T_2	4.93 ab	5.80 a	6.00 ab	6.00 b
V_2T_3	5.00 a	5.93 a	6.47 a	6.53 a
V_2T_4	4.80 a-c	5.40 b	5.80 b	5.93 bc
V_2T_5	4.73 a-c	5.40 b	5.53 bc	5.53 b-d
$LSD_{(0.05)}$	0.342	0.387	0.553	0.528
Level of significance	0.01	0.01	0.05	0.05
CV(%)	4.30	4.29	5.82	5.50

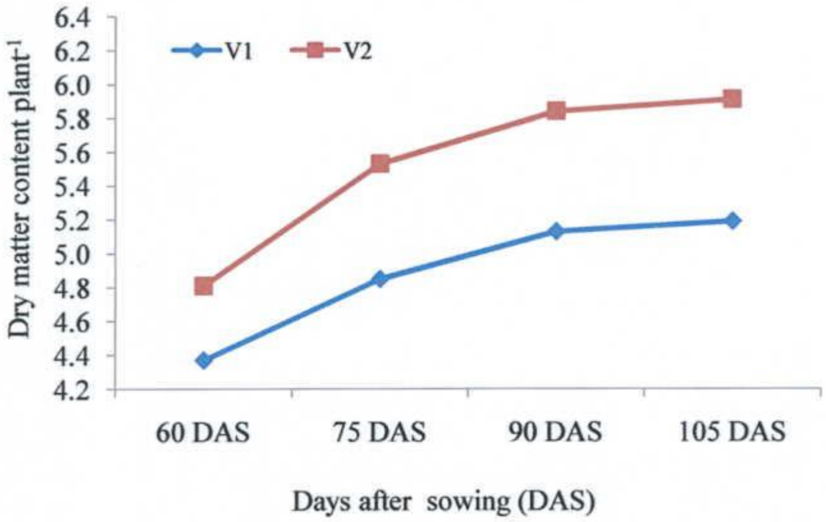
In a column, similar letter do not differ significantly at 0.05 level of probability

V_1: BARI chola 8; V_2: BARI chola 9

T_1: Control i.e., no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF)

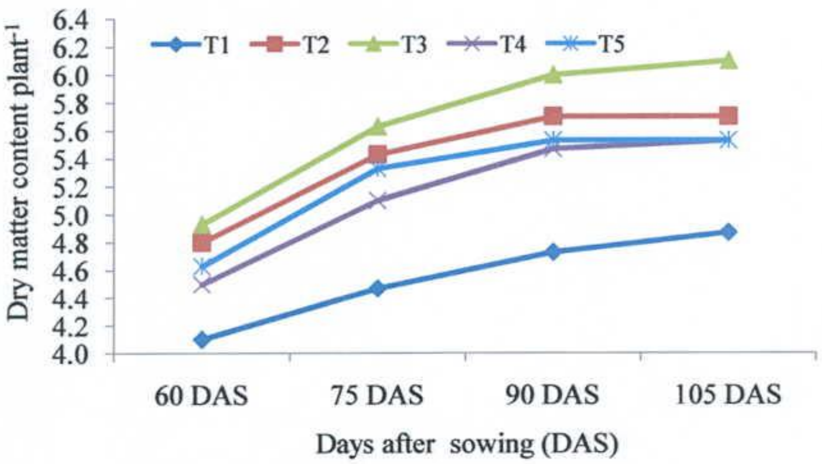
T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering

T_5: Kinetine spray before flowering



V_1: BARI chola 8; V_2: BARI chola 9

Figure 6. Effect of variety on dry matter content plant^{-1} of chickpea ($LSD_{0.05}$ = 0.436, 0.322, 0.497 and 0.272 at 60, 75, 90 and 105 DAS)



T_1: Control i.e. no spray at flowering and afterwards;
T_2: Supplemental irrigation before flowering (SIBF)
T_3: SIBF + Aqueous N before flowering;
T_4: PRH (a phytohormone) spray before flowering
T_5: Kinetine spray before flowering

Figure 7. Effect of supplementary treatments on dry matter content plant^{-1} of chickpea ($LSD_{0.05}$ = 0.242, 0.274, 0.391 and 0.373 at 60, 75, 90 and 105 DAS)

4.3.3 Interaction effect

Dry matter content plant^{-1} at 60, 75, 90 and 105 DAS varied significantly due th the interaction effect of chickpea varieties and different supplementary treatments (Table 3). At 60, 75, 90 and 105 DAS the maximum dry matter content plant^{-1} (5.23 g, 6.25 g, 6.57 g ad 7.02 g, respectively) was attained from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering) and the minimum dry matter content plant^{-1} (3.14 g, 3.83 g, 4.10 g and 4.25 g, respectively) was recorded from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

4.4 Flower dropping

4.4.1 Effect of variety

Significant variation was observed in terms of flower dropping of BARI chola 8 and BARI chola 9 (Table 4). The lower flower dropping (60.27%) was recorded from V_2 (BARI chola 9), whereas the higher flower dropping (64.98%) was recorded from V_1 (BARI chola 8). Aziz *et al.* (1960) reported 20-50% pod dropping in chickpea.

4.4.2 Effect of supplementary treatments

Flower dropping of chickpea showed statistically significant differences for different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones (Table 4). The lowest flower dropping (59.17%) was found from T_3 (SIBF + aqueous N before flowering), which was statistically similar (61.17%) to T_2 (supplemental irrigation before flowering-SIBF) and closely followed (62.63% and 62.70%, respectively) by T_5 (kinetine spray before flowering) and T_4 (PRH-a phytohormone spray before flowering), while the highest flower dropping (67.07%) was observed from T_1 (control). Hafiz (2000) reported that late supplementary foliar spraying with aqueous solution of 1% urea significantly yield components compared to the unsprayed control.

4.4.3 Interaction effect

Interaction effect of chickpea varieties and different supplementary treatments varied significantly in terms of flower dropping (Table 5). The lowest flower dropping (57.27%) was recorded from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering) and the highest flower dropping (71.20%) from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

Table 3. Interaction effect of variety and supplementary nitrogen, irrigation and hormone spray dry matter content plant^{-1} of chickpea

Treatments	Dry matter content plant^{-1} (g)			
	60 DAS	75 DAS	90 DAS	105 DAS
V_1T_1	3.14 d	3.83 f	4.10 e	4.25 e
V_1T_2	4.15 b	5.11 b-d	5.68 bc	6.08 b
V_1T_3	4.27 b	4.80 c-e	5.23 cd	5.47 cd
V_1T_4	3.65 c	4.57 de	5.33 bc	5.67 bc
V_1T_5	3.97 bc	4.73 de	5.35 bc	5.68 bc
V_2T_1	3.55 cd	4.40 e	4.66 de	5.05 d
V_2T_2	4.44 b	5.57 b	5.98 b	6.21 b
V_2T_3	5.23 a	6.25 a	6.75 a	7.02 a
V_2T_4	4.24 b	5.07 b-d	5.68 bc	5.86 bc
V_2T_5	4.39 b	5.37 bc	5.82 bc	6.04 b
$LSD_{(0.05)}$	0.471	0.550	0.624	0.490
Level of significance	0.05	0.05	0.05	0.01
CV(%)	6.63	6.40	6.60	4.94

In a column, similar letter do not differ significantly at 0.05 level of probability

V_1: BARI chola 8; V_2: BARI chola 9

T_1: Control i.e., no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF)

T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering

T_5: Kinetine spray before flowering

Table 4. Main effect of variety and supplementary nitrogen, irrigation and hormone spray on flower, pod & total dropping and pod remaining of chickpea

Treatments	Flower dropping (%)	Pod dropping (%)	Pod remaining (%)
Variety			
V_1	64.98 a	3.79 a	31.23 b
V_2	60.27 b	3.62 b	36.11 a
$LSD_{(0.05)}$	4.418	0.149	4.450
Level of significance	0.05	0.05	0.05
CV(%)	4.49	2.56	8.41
Supplementary treatments			
T_1	67.07 a	4.82 a	28.12 c
T_2	61.57 bc	3.27 c	35.17 ab
T_3	59.17 c	3.10 d	37.73 a
T_4	62.70 b	3.62 b	33.68 b
T_5	62.63 b	3.72 b	33.65 b
$LSD_{(0.05)}$	2.664	0.102	2.657
Level of significance	0.01	0.01	0.01
CV(%)	3.48	2.26	6.45

In a column, similar letter do not differ significantly at 0.05 level of probability

V_1: BARI chola 8; V_2: BARI chola 9

T_1: Control i.e., no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF)

T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering

T_5: Kinetine spray before flowering

Table 5. Interaction effect of variety and supplementary nitrogen, irrigation and hormone spray on flower, pod & total dropping and pod remaining of chickpea

Treatments	Flower dropping (%)	Pod dropping (%)	Pod remaining (%)
V_1T_1	71.20 a	4.97 a	23.83 e
V_1T_2	63.40 b-d	3.30 f	33.30 b-d
V_1T_3	61.07 b-e	3.13 gh	35.80 a-c
V_1T_4	64.33 bc	3.73 cd	31.93 cd
V_1T_5	64.90 b	3.80 c	31.30 d
V_2T_1	62.93 b-d	4.67 b	32.40 cd
V_2T_2	59.73 de	3.23 fg	37.03 ab
V_2T_3	57.27 e	3.07 h	39.67 a
V_2T_4	61.07 b-e	3.50 e	35.43 b-d
V_2T_5	60.37 c-e	3.63 de	36.00 a-c
$LSD_{(0.05)}$	3.767	0.149	3.758
Level of significance	0.05	0.05	0.05
CV(%)	3.48	2.26	6.45

In a column, similar letter do not differ significantly at 0.05 level of probability

V_1: BARI chola 8; V_2: BARI chola 9

T_1: Control i.e., no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF)

T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering

T_5: Kinetine spray before flowering

4.5 Pod dropping

4.5.1 Effect of variety

Pod dropping of BARI chola 8 and BARI chola 9 showed statistically significant variation under the present trial (Table 4). The lower pod dropping (3.62%) was observed from V_2 (BARI chola 9), while the higher pod dropping (3.79%) was found from V_1 (BARI chola 8). Aziz *et al.* (1960) reported 20-50% pod dropping in chickpea. Nayyar *et al*. (2006) reported that the pod setting stages appear to be the most sensitive stages to water stress.

4.5.2 Effect of supplementary treatments

Statistically significant variation was recorded for pod dropping of chickpea due to the application of different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones (Table 4). The lowest pod dropping (3.10%) was recorded from T_3 (SIBF + aqueous N before flowering), which was closely followed (3.27%) by T_2 (supplemental irrigation before flowering-SIBF), while the highest pod dropping (4.82%) was found from T_1 (control i.e., no spray at flowering and afterwards) which was closely followed (3.72% and 3.62%, respectively) by T_5 (kinetine spray before flowering) and T_4 (PRH-a phytohormone spray before flowering) and they were statistically similar.

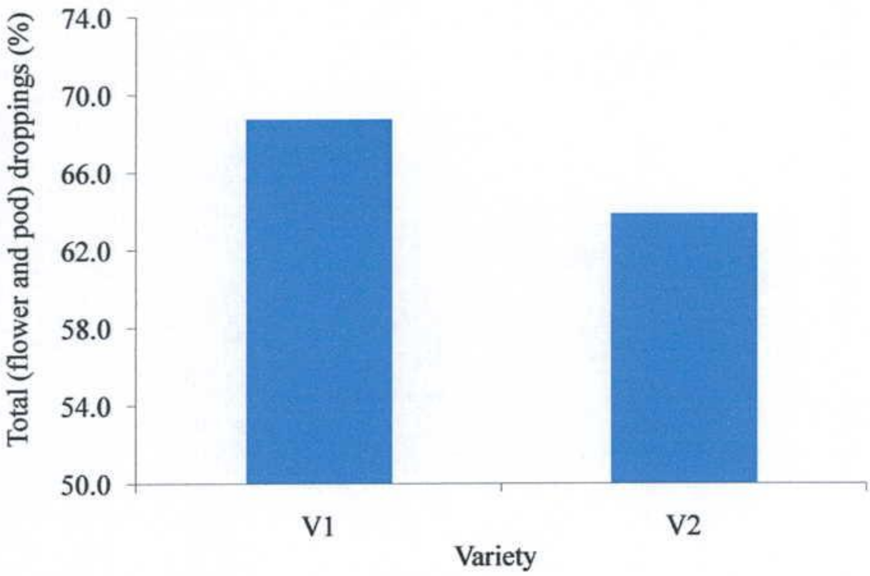
4.5.3 Interaction effect

Interaction effect of chickpea varieties and different supplementary treatments showed significant differences on pod dropping (Table 5). The minimum pod dropping (3.07%) was recorded from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering), whereas the maximum pod dropping (4.97%) from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

4.6 Total dropping

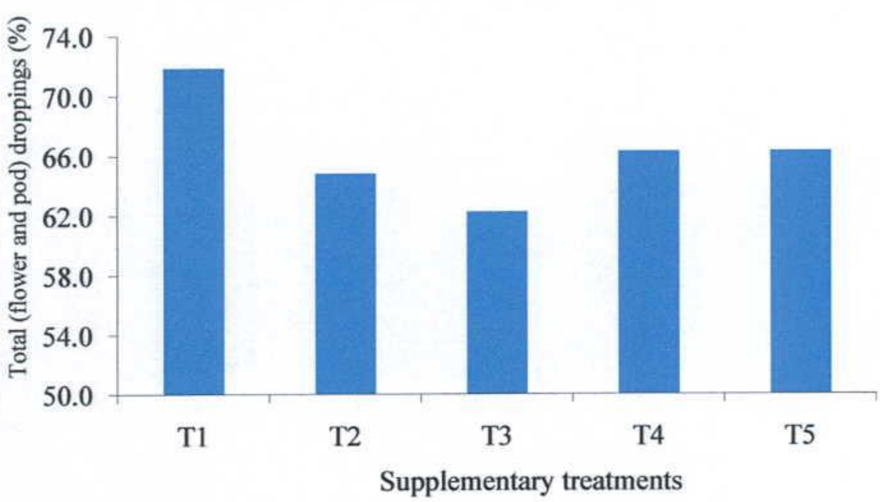
4.6.1 Effect of variety

Statistically significant variation was recorded in terms of total (flower and pod) dropping of BARI chola 8 and BARI chola 9 (Figure 8). The lower total dropping (63.89%) was observed from V_2 (BARI chola 9) and the higher (68.77%) was found from V_1 (BARI chola 8). Aziz *et al.* (1960) reported 20-50% flower and pod dropping in chickpea.



V_1: BARI chola 8; V_2: BARI chola 9

Figure 8. Effect of variety on total (flower and pod) dropping of chickpea (LSD0.05 = 4.450)



T_1: Control i.e. no spray at flowering and afterwards;
T_2: Supplemental irrigation before flowering (SIBF)
T_3: SIBF + Aqueous N before flowering;
T_4: PRH (a phytohormone) spray before flowering
T_5: Kinetine spray before flowering

Figure 9. Effect of supplementary treatments on total (flower and pod) dropping of chickpea (LSD0.05 = 2.657)

4.6.2 Effect of supplementary treatments

Total dropping of chickpea showed significant variation for different supplementary treatments (Figure 9). The lowest total dropping (62.27%) was found from T_3 (SIBF + aqueous N before flowering), which was statistically similar (64.83%) with T_2 (supplemental irrigation before flowering-SIBF) and closely followed (66.32% and 66.35%, respectively) by T_4 (PRH-a phytohormone spray before flowering) and T_5 (kinetine spray before flowering) and they were statistically similar, whereas the highest total dropping (71.88%) was observed from T_1 (control i.e., no spray at flowering and afterwards).

4.6.3 Interaction effect

Interaction effect of chickpea varieties and different supplementary treatments showed significant differences on total dropping (Figure 10). The lowest total dropping (60.33%) was observed from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering), while the highest total dropping (76.17%) was found from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

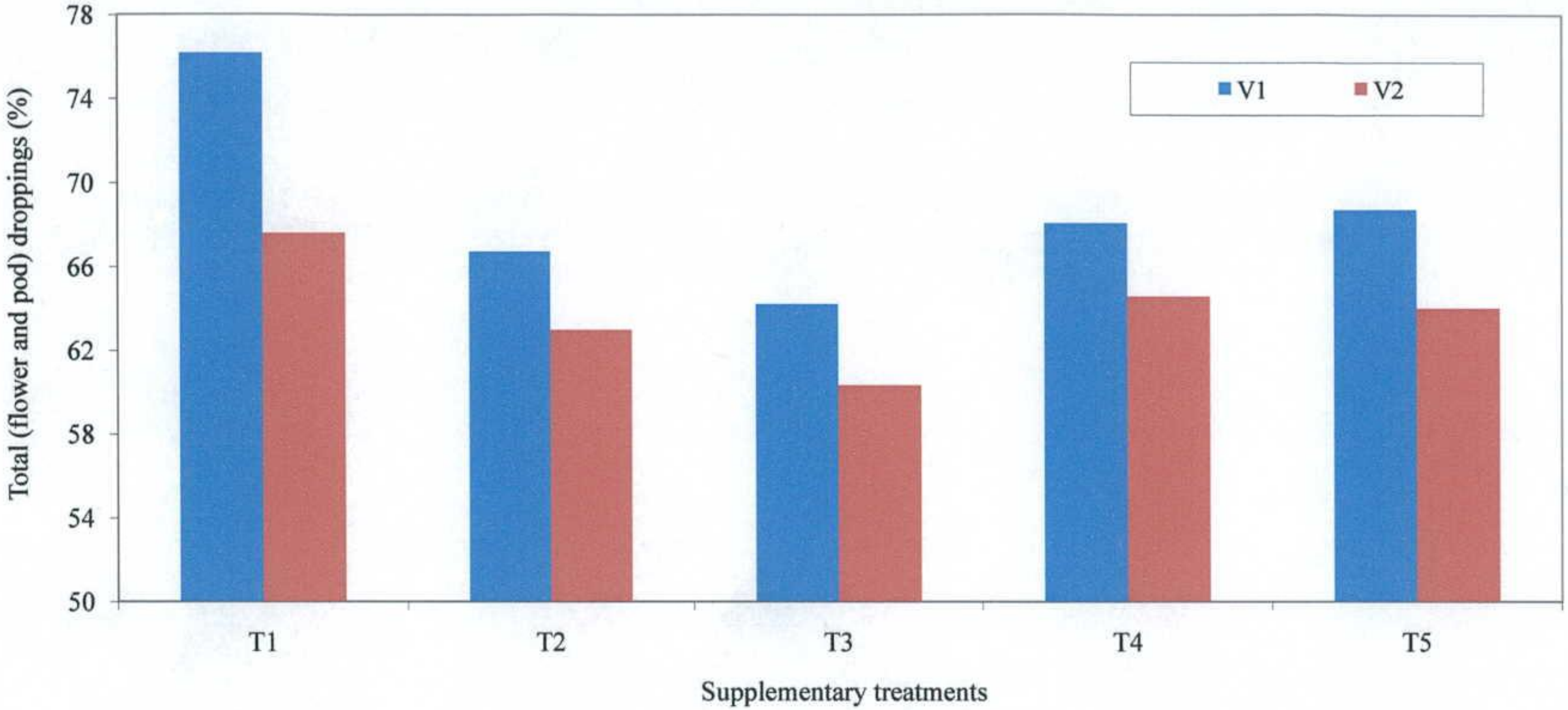
4.7 Pod remaining

4.7.1 Effect of variety

Significant variation was recorded for pod remaining of BARI chola 8 and BARI chola 9 (Table 4). The higher pod remaining (36.11%) was found from V_2 (BARI chola 9), while the lower pod remaining (31.23%) from V_1 (BARI chola 8).

4.7.2 Effect of supplementary treatments

Different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones showed significant variation in terms of pod remaining of chickpea (Table 4). The highest pod remaining (37.73%) was found from T_3 (SIBF + aqueous N before flowering), which was statistically similar (35.17%) with T_2 (supplemental irrigation before flowering-SIBF) and closely followed (33.68% and 33.65%, respectively) by T_4 (PRH-a phytohormone spray before flowering) and T_5 (kinetine spray before flowering) and they were statistically similar, while the lowest pod remaining (28.12%) was observed from T_1 (control i.e., no spray at flowering and afterwards).



V_1: BARI chola 8;
V_2: BARI chola 9

T_1: Control i.e. no spray at flowering and afterwards;
T_2: Supplemental irrigation before flowering (SIBF)
T_3: SIBF + Aqueous N before flowering;
T_4: PRH (a phytohormone) spray before flowering
T_5: Kinetine spray before flowering

Figure 10. Interaction effect of variety and supplementary treatments on total (flower and pod) dropping of chickpea ($LSD_{0.05}$ = 3.758)

4.7.3 Interaction effect

Chickpea varieties and different supplementary treatments varied significantly for pod remaining due to interaction effect (Table 5). The highest pod remaining (39.67%) was found from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering) and the lowest (23.83%) from V_1T_1 (BARI chola 8 and control).

4.8 Pods plant^{-1}

4.8.1 Effect of variety

Statistically significant variation was recorded in terms of pods plant^{-1} of BARI chola 8 and BARI chola 9 (Table 6). The maximum pods plant^{-1} (27.58) was found from V_2 (BARI chola 9), while the minimum (26.03) was observed from V_1 (BARI chola 8). Pods plant^{-1} varied for different varieties might be due to genetical and environmental influences as well as management practices. Mirzakhani *et al*. (2013) reported that the number of pods in the plant there were no significant differences between the different cultivars.

4.8.2 Effect of supplementary treatments

Pods plant^{-1} of chickpea showed significant variation for different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones (Table 6). The maximum pods plant^{-1} (28.52) was observed from T_3 (SIBF + aqueous N before flowering), which was statistically similar (27.57 and 26.75, respectively) with T_2 (supplemental irrigation before flowering-SIBF) and T_4 (PRH-a phytohormone spray before flowering) and closely followed (26.17) by and T_5 (kinetine spray before flowering), whereas the minimum (25.00) was recorded from T_1 (control i.e., no spray at flowering and afterwards). Hafiz (2000) reported that late supplementary foliar spraying with aqueous solution of 1% urea significantly increased yield components. Bicer *et al*. (2004) reported that number of pods plant^{-1} were higher under irrigated than rainfed conditions.

4.8.3 Interaction effect

Significant variation was observed due to the interaction effect of chickpea varieties and different supplementary treatments on pods plant^{-1} (Table 7). The maximum pods plant^{-1} (28.80) was found from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering) and the minimum pods plant^{-1} (24.57) from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

Table 6. Main effect of variety and supplementary nitrogen, irrigation and hormone spray on pods plant^{-1}, pod length, seeds pod^{-1}, weight of 1000-seed of chickpea

Treatments	Pods plant^{-1} (No.)	Pod length (cm)	Seeds pod^{-1} (No.)	Weight of 1000-seed (g)
Variety				
V_1	26.03 b	1.75 b	1.54 b	250.99 b
V_2	27.58 a	1.85 a	1.65 a	263.36 a
$LSD_{(0.05)}$	1.412	0.086	0.08	8.511
Level of significance	0.05	0.05	0.05	0.05
CV(%)	3.83	3.04	6.58	2.11
Supplementary treatments				
T_1	25.00 c	1.63 d	1.51 c	234.89 c
T_2	27.57 ab	1.89 b	1.64 ab	268.52 a
T_3	28.52 a	1.95 a	1.67 a	274.00 a
T_4	26.75 a-c	1.74 c	1.59 bc	248.84 bc
T_5	26.17 bc	1.79 c	1.56 bc	259.63 ab
$LSD_{(0.05)}$	1.897	0.055	0.077	14.79
Level of significance	0.01	0.01	0.01	0.01
CV(%)	5.78	2.49	3.97	4.70

In a column, similar letter do not differ significantly at 0.05 level of probability

V_1: BARI chola 8; V_2: BARI chola 9

T_1: Control i.e., no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF)

T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering

T_5: Kinetine spray before flowering

Table 7. Interaction effect of variety and supplementary nitrogen, irrigation and hormone spray on pods plant^{-1}, pod length, seeds pod^{-1}, weight of 1000-seed of chickpea

Treatments	Pods plant^{-1} (No.)	Pod length (cm)	Seeds pod^{-1} (No.)	Weight of 1000-seed (g)
V_1T_1	24.57 e	1.45 e	1.47 d	234.08 c
V_1T_2	26.68 a-e	1.90 ab	1.58 cd	261.63 ab
V_1T_3	28.24 a-c	1.93 a	1.60 bc	272.46 ab
V_1T_4	25.53 b-e	1.70 d	1.56 cd	236.54 c
V_1T_5	25.13 de	1.75 cd	1.51 cd	250.27 bc
V_2T_1	25.43 c-e	1.80 c	1.56 cd	235.71 c
V_2T_2	28.46 ab	1.88 ab	1.70 ab	275.42 a
V_2T_3	28.80 a	1.96 a	1.74 a	275.54 a
V_2T_4	27.96 a-d	1.79 c	1.62 bc	261.14 ab
V_2T_5	27.22 a-e	1.83 bc	1.62 bc	268.99 ab
$LSD_{(0.05)}$	2.683	0.077	0.110	20.92
Level of significance	0.05	0.01	0.01	0.05
CV(%)	5.78	2.49	3.97	4.70

In a column, similar letter do not differ significantly at 0.05 level of probability

V_1: BARI chola 8; V_2: BARI chola 9

T_1: Control i.e., no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF)

T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering

T_5: Kinetine spray before flowering

4.9 Pod length

4.9.1 Effect of variety

Pod length of BARI chola 8 and BARI chola 9 varied significantly under the present trial (Table 6). The longer pod (1.85 cm) was recorded from V_2 (BARI chola 9), whereas the shorter pod (1.75 cm) was found from V_1 (BARI chola 8). Different varieties responded differently for pod length to input supply, method of cultivation and the prevailing environment during the growing season.

4.9.2 Effect of supplementary treatments

Significant variation was recorded in terms of pod length of chickpea for different supplementary treatments (Table 6). The longest pods (1.95 cm) was found from T_3 (SIBF + aqueous N before flowering), which was followed (1.89 cm) by T_2 (supplemental irrigation before flowering-SIBF). On the other hand, the shortest pod (1.63 cm) was recorded from T_1 (control) which was followed (1.74 cm and 1.79 cm) by T_4 (PRH-a phytohormone spray before flowering) and T_5 (kinetine spray before flowering) and they were statistically similar. Bicer *et al.* (2004) reported that pod length were higher under irrigated than rainfed conditions.

4.9.3 Interaction effect

Interaction effect of chickpea varieties and different supplementary treatments showed significant differences on pod length (Table 7). The longest pod (1.96 cm) was found from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering), while the shortest pod (1.45 cm) was observed from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

4.10 Seeds pod^{-1}

4.10.1 Effect of variety

Statistically significant difference was observed in terms of seeds pod^{-1} of BARI chola 8 and BARI chola 9 (Table 6). The maximum seeds pod^{-1} (1.65) was recorded from V_2 (BARI chola 9) and the minimum seeds pod^{-1} (1.54) was recorded from V_1 (BARI chola 8). Different varieties responded differently for number of seeds pods^{-1} to input supply, method of cultivation and the prevailing environment during the growing season.

4.10.2 Effect of supplementary treatments

Different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones showed statistically significant variation in terms of seeds pod^{-1} of chickpea (Table 6). The maximum seeds pod^{-1} (1.67) was found from T_3 (SIBF + aqueous N before flowering), which was statistically similar (1.64) with T_2 (supplemental irrigation before flowering-SIBF) and closely followed (1.59 and 1.56) by T_4 (PRH-a phytohormone spray before flowering) and T_5 (kinetine spray before flowering), again the minimum seeds pod^{-1} (1.51) was observed from T_1 (control i.e., no spray at flowering and afterwards). Bicer *et al.* (2004) reported that number of seeds $pods^{-1}$ were higher under irrigated than rainfed conditions.

4.10.3 Interaction effect

Seeds pod^{-1} of chickpea showed significant differences due to the interaction effect of chickpea varieties and different supplementary treatments (Table 7). The maximum seeds pod^{-1} (1.74) was recorded from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering), whereas the minimum seeds pod^{-1} (1.47) from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

4.11 Weight of 1000-seed

4.11.1 Effect of variety

Statistically significant variation was recorded in terms of weight of 1000-seeds of BARI chola 8 and BARI chola 9 (Table 6). The maximum weight of 1000-seed (263.36 g) was found from V_2 (BARI chola 9), while the minimum weight of 1000-seed (250.99 g) was attained from V_1 (BARI chola 8). Mirzakhani *et al.* (2013) reported that weight of 100 seeds in the plant there were no significant differences between the different cultivars.

4.11.2 Effect of supplementary treatments

Weight of 1000-seed of chickpea showed significant variation for different supplementary treatments (Table 6). The maximum weight of 1000-seed (274.00 g) was recorded from T_3 (SIBF + aqueous N before flowering), which was statistically similar (268.52 g and 259.63 g, respectively) to T_2 (supplemental irrigation before flowering-SIBF) and T_5 (kinetine spray before flowering) and closely followed (248.84 g) by T_4 (PRH-a phytohormone spray before flowering), whereas the minimum weight of 1000-seed (234.89 g) from T_1 (control).

4.11.3 Interaction effect

Chickpea varieties and different supplementary treatments showed significant differences on weight of 1000-seed due to interaction effect (Table 7). The maximum weight of 1000-seed (275.54 g) was observed from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering) and the minimum weight of 1000-seed (234.08 g) from V_1T_1 (BARI chola 8 and control).

4.12 Shelling percentage

4.12.1 Effect of variety

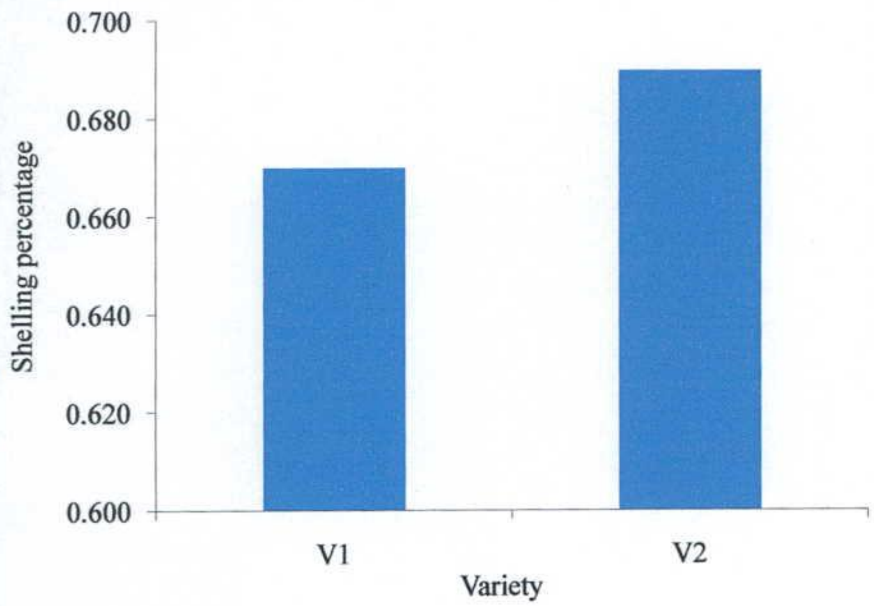
Shelling percentage of BARI chola 8 and BARI chola 9 varied significantly under the present trial (Figure 11). The higher shelling percentage (0.69) was recorded from V_2 (BARI chola 9) and the lower shelling percentage (0.67) was recorded from V_1 (BARI chola 8).

4.12.2 Effect of supplementary treatments

Statistically significant variation was recorded in terms of shelling percentage of chickpea for different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones (Figure 12). The highest shelling percentage (0.73) was found from T_3 (SIBF + aqueous N before flowering), which was statistically similar (0.70 and 0.69, respectively) to T_2 (supplemental irrigation before flowering-SIBF) and T_5 (kinetine spray before flowering) and closely followed (0.66) by T_4 (PRH-a phytohormone spray before flowering), while the lowest shelling percentage (0.64) was observed from T_1 (control i.e., no spray at flowering and afterwards). Hafiz (2000) reported that chickpea cultivars Giza 1, Giza 88 and Giza 195 and early soil application of nitrogen fertilizer up to 40 kg N ha^{-1} significantly increased shelling percentage.

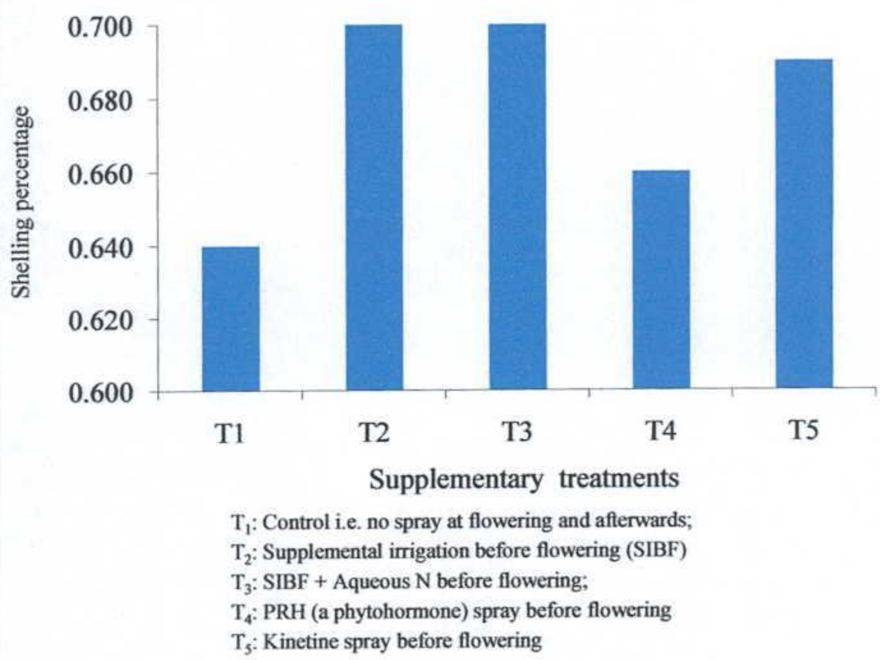
4.12.3 Interaction effect

Interaction effect of chickpea varieties and different supplementary treatments showed significant differences on shelling percentage (Figure 13). The highest shelling percentage (0.75) was recorded from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering), whereas the lowest shelling percentage (0.58) from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).



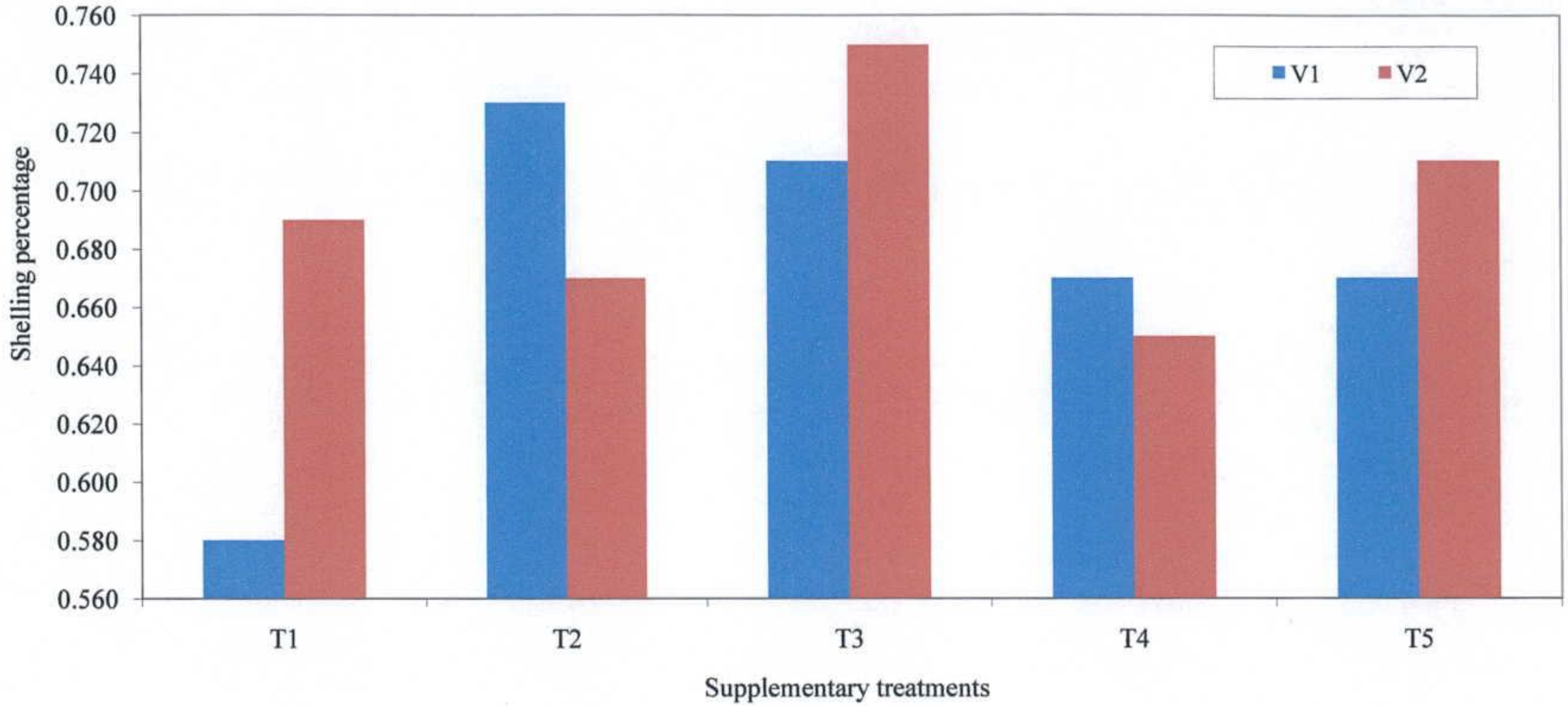
V_1: BARI chola 8; V_2: BARI chola 9

Figure 11. Effect of variety on shelling percentage of chickpea ($LSD_{0.05}$ = 0.016)



T_1: Control i.e. no spray at flowering and afterwards;
T_2: Supplemental irrigation before flowering (SIBF)
T_3: SIBF + Aqueous N before flowering;
T_4: PRH (a phytohormone) spray before flowering
T_5: Kinetine spray before flowering

Figure 12. Effect of supplementary treatments on shelling percentage of chickpea ($LSD_{0.05}$ = 0.055)



V_1: BARI chola 8; V_2: BARI chola 9

T_1: Control i.e. no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF)

T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering

T_5: Kinetine spray before flowering

Figure 13. Interaction effect of variety and supplementary treatments on shelling percentage of chickpea ($LSD_{0.05}$= 0.077)

4.13 Seed yield

4.13.1 Effect of variety

Statistically significant variation was recorded in terms of seed yield of BARI chola 8 and BARI chola 9 (Table 8). The higher seed yield (1.69 t ha^{-1}) was observed from V_2 (BARI chola 9), whereas the lower seed yield (1.43 t ha^{-1}) was found from V_1 (BARI chola 8). Varieties plays an important role in producing high yield of chickpea and yield also varied for different varieties might be due to genetical and environmental influences as well as management practices. Mukherjee and Singh (2005) reported that chickpea genotypes differed significantly with respect to grain yield.

4.13.2 Effect of supplementary treatments

Different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones showed significant variation for seed yield of chickpea (Table 8). The highest seed yield (1.84 t ha^{-1}) was recorded from T_3 (SIBF + aqueous N before flowering), which was statistically similar (1.71 t ha^{-1}) to T_2 (supplemental irrigation before flowering-SIBF) and closely followed (1.51 t ha^{-1} and 1.49 t ha^{-1}, respectively) by T_5 (kinetine spray before flowering) and T_4 (PRH-a phytohormone spray before flowering), while the lowest seed yield (1.25 t ha^{-1}) was attained from T_1 (control). It was revealed that supplementary spraying of nitrogen, irrigation and hormones ensured favorable condition for the growth of mungbean plant with optimum vegetative growth and the ultimate results was the highest yield. Fallah *et al.* (2005) reported that planting Greet palong with supplementary irrigation, may lead to a significant increase in grain yield under dryland conditions. Palta *et al.* (2005) reported that the potential to increase yields of chickpea by application of foliar nitrogen near flowering in environments in which terminal droughts reduce yield. Hafiz (2000) reported that late supplementary foliar spraying with aqueous solution of 1% urea significantly increased yield and yield quality compared to the unsprayed control. Mohammadi *et al.* (2006) reported that among phenological stages of chickpea, pod formation was the most sensitive to water deficit, and that under water limitation conditions chickpea yield could be improved by irrigation at this stage.

Table 8. Main effect of variety and supplementary nitrogen, irrigation and hormone spray on seed yield, stover yield, biological yield and harvest index of chickpea

Treatments	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Variety				
V_1	1.43 b	2.47 b	3.90 b	36.44 a
V_2	1.69 a	2.72 a	4.41 a	38.16 a
$LSD_{(0.05)}$	0.122	0.157	0.268	0.625
Level of significance	0.01	0.05	0.01	0.01
CV(%)	4.97	3.85	6.60	5.22
Supplementary treatments				
T_1	1.25 c	2.33 d	3.58 c	35.07 c
T_2	1.71 a	2.76 ab	4.47 a	38.17 ab
T_3	1.84 a	2.84 a	4.68 a	39.29 a
T_4	1.49 b	2.47 cd	3.96 b	37.48 a-c
T_5	1.51 b	2.60 bc	4.11 b	36.50 bc
$LSD_{(0.05)}$	0.186	0.201	0.335	2.384
Level of significance	0.01	0.01	0.01	0.05
CV(%)	9.73	6.33	6.60	5.22

In a column, similar letter do not differ significantly at 0.05 level of probability

V_1: BARI chola 8; V_2: BARI chola 9

T_1: Control i.e., no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF)

T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering

T_5: Kinetine spray before flowering

4.13.3 Interaction effect

Seed yield of chickpea varied significantly due to the interaction effect varieties and different supplementary treatments (Table 9). The highest seed yield (1.94 t ha^{-1}) was found from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering) and the lowest seed yield (1.19 t ha^{-1}) from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

4.14 Stover yield

4.14.1 Effect of variety

Stover yield of BARI chola 8 and BARI chola 9 showed statistically significant variation under the present trial (Table 8). The higher stover yield (2.72 t ha^{-1}) was observed from V_2 (BARI chola 9), while the lower stover yield (2.47 t ha^{-1}) was recorded from V_1 (BARI chola 8).

4.14.2 Effect of supplementary treatments

Statistically significant variation was recorded for stover yield of chickpea due to different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones (Table 8). The highest stover yield (2.84 t ha^{-1}) was found from T_3 (SIBF + aqueous N before flowering), which was statistically similar (2.76 t ha^{-1}) to T_2 (supplemental irrigation before flowering-SIBF) and closely followed (2.60 t ha^{-1}) by T_5 (kinetine spray before flowering). On the other hand, the lowest stover yield (2.33 t ha^{-1}) was found from T_1 (control i.e., no spray at flowering and afterwards) which was statistically similar (2.47 t ha^{-1}) to T_4 (PRH-a phytohormone spray before flowering). Singh and Smita (2006) reported that irrigation proved better in terms of straw yield.

4.14.3 Interaction effect

Interaction effect of chickpea varieties and different supplementary treatments showed statistically significant variation in terms of stover yield (Table 9). The highest stover yield (2.92 t ha^{-1}) was recorded from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering), whereas the lowest stover yield (2.11 t ha^{-1}) was observed from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

Table 9. Interaction effect of variety and supplementary nitrogen, irrigation and hormone spray on seed yield, stover yield, biological yield and harvest index of chickpea

Treatments	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1T_1	1.19 e	2.11 e	3.29 e	36.02 b-d
V_1T_2	1.55 cd	2.68 a-c	4.23 bc	36.68 a-d
V_1T_3	1.74 a-c	2.76 a-c	4.49 ab	38.60 ab
V_1T_4	1.32 de	2.33 de	3.66 de	36.17 b-d
V_1T_5	1.33 de	2.50 cd	3.84 cd	34.74 cd
V_2T_1	1.32 de	2.54 b-d	3.86 cd	34.12 d
V_2T_2	1.87 ab	2.85 ab	4.72 ab	39.66 ab
V_2T_3	1.94 a	2.92 a	4.86 a	39.97 a
V_2T_4	1.65 bc	2.61 a-d	4.26 bc	38.78 ab
V_2T_5	1.69 a-c	2.69 a-c	4.38 ab	38.25 a-c
$LSD_{(0.05)}$	0.263	0.284	0.474	3.371
Level of significance	0.05	0.01	0.05	0.05
CV(%)	9.73	6.33	6.60	5.22

In a column, similar letter do not differ significantly at 0.05 level of probability

V_1: BARI chola 8; V_2: BARI chola 9

T_1: Control i.e., no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF)

T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering

T_5: Kinetine spray before flowering

4.15 Biological yield

4.15.1 Effect of variety

Biological yield of BARI chola 8 and BARI chola 9 showed statistically significant variation under the present trial (Table 8). The higher biological yield (4.41 t ha^{-1}) was recorded from V_2 (BARI chola 9), while the lower (3.90 t ha^{-1}) was found from V_1 (BARI chola 8).

4.15.2 Effect of supplementary treatments

Statistically significant variation was recorded for biological yield of chickpea due to different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones (Table 8). The highest biological yield (4.68 t ha^{-1}) was observed from T_3 (SIBF + aqueous N before flowering), which was statistically similar (4.47 t ha^{-1}) to T_2 (supplemental irrigation before flowering-SIBF) and closely followed (4.11 and 3.96 t ha^{-1}) by T_5 (kinetine spray before flowering) and T_4 (PRH-a phytohormone spray before flowering), while, the lowest biological yield (3.58 t ha^{-1}) was recorded from T_1 (control i.e., no spray at flowering and afterwards).

4.15.3 Interaction effect

Interaction effect of chickpea varieties and different supplementary treatments showed statistically significant variation in terms of biological yield (Table 9). The highest biological yield (4.86 t ha^{-1}) was found from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering), whereas the lowest (3.29 t ha^{-1}) was obtained from V_1T_1 (BARI chola 8 and control i.e., no spray at flowering and afterwards).

4.16 Harvest index

4.16.1 Effect of variety

Harvest index of BARI chola 8 and BARI chola 9 showed statistically significant variation under the present trial (Table 8). The maximum harvest index (38.16%) was found from V_2 (BARI chola 9), while the minimum (36.44%) was recorded from V_1 (BARI chola 8).

4.16.2 Effect of supplementary treatments

Statistically significant variation was recorded for harvest index of chickpea due to different supplementary treatments that applied as supplementary nitrogen, irrigation and hormones (Table 8). The maximum harvest index (39.29%) was found from T_3 (SIBF + aqueous N before flowering), which was statistically similar (38.17% and 37.48%) to T_2 (supplemental irrigation before flowering-SIBF) and T_4 (PRH-a phytohormone spray before flowering), whereas the minimum (35.07%) was found from T_1 (control i.e., no spray at flowering and afterwards).

4.16.3 Interaction effect

Interaction effect of chickpea varieties and different supplementary treatments showed statistically significant variation in terms of harvest index (Table 9). The maximum harvest index (39.97%) was recorded from V_2T_3 (BARI chola 9 and SIBF + aqueous N before flowering), whereas the minimum (34.12%) was observed from V_2T_1 (BARI chola 9 and control i.e., no spray at flowering and afterwards).

Chapter V
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from 11 December, 2012 to 30 March, 2013 to study the influence of supplementary nitrogen, irrigation and hormones on growth, flower droppings and yield of chickpea. The variety BARI chola 8 and BARI chola 9 were used as the test crops. The experiment consists of two factors: Factor A: Chickpea variety (2) as V_1: BARI chola 8 and V_2: BARI chola 9, Factor B: Supplementary treatments (5 levels) as T_1: Control i.e., no spray at flowering and afterwards; T_2: Supplemental irrigation before flowering (SIBF); T_3: SIBF + Aqueous N before flowering; T_4: PRH (a phytohormone) spray before flowering and T_5: Kinetine spray before flowering. The two factors experiment was laid out in split-plot design with three replications. Data on different growth parameters, yield attributes and yield were recorded and statistically significant variation was recorded for different parameters.

At 60, 75, 90 and 105 DAS the taller plant (27.82 cm, 30.42 cm, 35.06 cm and 36.88 cm, respectively), maximum number of branches plant^{-1} (4.81, 5.53, 5.84 and 5.91, respectively), and maximum dry matter content plant^{-1} (4.37 g, 5.33 g, 5.78 g and 6.03 g, respectively) was recorded from V_2 (BARI chola 9), whereas the shorter plant (24.96 cm, 28.44 cm, 32.07 cm and 33.30 cm, respectively), minimum number of branches plant^{-1} (4.37, 4.85, 5.13 and 5.19, respectively) and minimum dry matter content plant^{-1} (3.83 g, 4.61 g, 5.14 g and 5.43 g, respectively) was recorded from V_1 (BARI chola 8) at same DAS. The lower flower dropping (60.27%), lower pod dropping (3.62%), lower total dropping (63.89%), higher pod remaining (36.11%), maximum pods plant^{-1} (27.58), longer pod (1.85 cm), maximum seeds pod^{-1} (1.65), maximum weight of 1000-seeds (263.36 g), higher shelling percentage (0.69), higher seed yield (1.69 t ha^{-1}), higher stover yield (2.72 t ha^{-1}), higher biological yield (4.41 t ha^{-1}) and maximum harvest index (38.16%) was recorded from V_2, whereas the higher flower dropping (64.98%), higher pod dropping (3.79%), higher total dropping (68.77%), lower pod remaining (31.23%), minimum pods plant^{-1} (26.03), shorter pod (1.75 cm), minimum seeds pod^{-1} (1.54), minimum weight of 1000-seeds (250.99 g), lower shelling percentage (0.67), lower seed yield (1.43 t ha^{-1}), lower stover yield (2.47 t ha^{-1}), lower biological yield (3.90 t ha^{-1}) and minimum harvest index (36.44%) was recorded from V_1.

At 60, 75, 90 and 105 DAS, the tallest plant (29.15 cm, 32.14 cm, 36.56 cm and 38.39 cm, respectively), maximum number of branches plant^{-1} (4.93, 5.63, 6.00 and 6.10, respectively), maximum dry matter content plant^{-1} (4.75 g, 5.53 g, 5.99 g and 6.25 g, respectively) was found from T_3 (SIBF + Aqueous N before flowering), while the shortest plant (22.78 cm, 26.23 cm, 28.66 cm and 29.84 cm, respectively), minimum number of branches plant^{-1} (4.10, 4.47, 4.73 and 4.87, respectively) and minimum dry matter content plant^{-1} (3.34 g, 4.11 g, 4.38 g and 4.65 g, respectively) was observed from T_1 (control i.e. no spray at flowering and afterwards) at same DAS. The lowest flower dropping (59.17%), the lowest pod dropping (3.10%), the lowest total dropping (62.27%), the highest pod remaining (37.73%), the maximum pods plant^{-1} (28.52), the longest pods (1.95 cm), the maximum seeds pod^{-1} (1.67), the maximum weight of 1000-seeds (274.00 g), the highest shelling percentage (0.73), the highest seed yield (1.84 t ha^{-1}), the highest stover yield (2.84 t ha^{-1}), higher biological yield (4.68 t ha^{-1}) and maximum harvest index (39.29%) was found from T_3, while the highest flower dropping (67.07%), highest pod dropping (4.82%), the highest total dropping (71.88%), the lowest pod remaining (28.12%), the minimum pods plant^{-1} (25.00), the shortest pod (1.63 cm), the minimum seeds pod^{-1} (1.51), the minimum weight of 1000-seeds (234.89 g), the lowest shelling percentage (0.64), the lowest seed yield (1.25 t ha^{-1}), the lowest stover yield (2.33 t ha^{-1}), lower biological yield (3.58 t ha^{-1}) and minimum harvest index (35.07%) was observed from T_1.

At 60, 75, 90 and 105 DAS the tallest plant (30.13 cm, 32.66 cm, 37.13 cm and 39.31 cm, respectively), the maximum number of branches plant^{-1} (5.00, 5.93, 6.47 ad 6.53, respectively) and the maximum dry matter content plant^{-1} (5.23 g, 6.25 g, 6.57 g ad 7.02 g, respectively) was found from V_2T_3 (BARI chola 9 and

SIBF + Aqueous N before flowering), while the shortest plant (21.13 cm, 24.13 cm, 25.00 cm and 25.94 cm, respectively), the minimum number of branches plant^{-1} (3.60, 3.80, 4.07 and 4.20, respectively) and the minimum dry matter content plant^{-1} (3.14 g, 3.83 g, 4.10 g and 4.25 g, respectively) was recorded from V_1T_1 (BARI chola 8 and control i.e. no spray at flowering and afterwards) at same DAS. The lowest flower dropping (57.27%), the lowest pod dropping (3.07%), the lowest total dropping (60.33%), the highest pod remaining (39.67%), the maximum pods plant^{-1} (28.80), the longest pod (1.96 cm), the maximum seeds pod^{-1} (1.74), the maximum weight of 1000-seeds (275.54 g), the highest shelling percentage (0.75), the highest seed yield (1.94 t ha^{-1}), the highest stover yield (2.92 t ha^{-1}), higher biological yield (4.86 t ha^{-1}) and maximum harvest index (39.97%) was recorded from V_2T_3 and the highest flower dropping (71.20%), the highest pod dropping (4.97%), the highest total dropping (76.17%), the lowest pod remaining (23.83%), the minimum pods plant^{-1} (24.57), the shortest pod (1.45 cm), the minimum seeds pod^{-1} (1.47), the minimum weight of 1000-seeds (234.08 g), the lowest shelling percentage (0.58), the lowest seed yield (1.19 t ha^{-1}), the lowest stover yield (2.11 t ha^{-1}) and lower biological yield (3.29 t ha^{-1}) was recorded from V_1T_1.

Considering the findings of the present experiment, following conclusions may be drawn:

1. BARI chola 9 cultivation with applying supplemental irrigation before flowering + aqueous N before flowering revealed maximum yield contributing characters and yield compared to the others.

2. Before recommendation of variety and supplementary treatments that applied as supplementary nitrogen, irrigation and hormones to optimize chickpea production further study is needed in different agro-ecological zones of Bangladesh for regional adaptability.

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Appendices

APPENDICES

Appendix I. Physical properties of the soils of the experimental field

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

Appendix II. Chemical properties of the soils of the experimental field

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

Appendix III. Monthly record of air temperature, relative humidity, rainfall, and sunshine of the experimental site during the period from December 2012 to March 2013

Month	*Air temperature (°c)		*Relative humidity (%)	Total Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
December, 2012	22.6	13.3	76	00	6.2
January, 2013	25.2	12.8	69	00	5.8
February, 2013	27.3	16.9	66	39	6.8
March, 2013	31.7	19.2	57	23	8.1

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix IV. Means square values for plant height of chickpea at different growth duration

Sources of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		30 DAS	60 DAS	90 DAS	110 DAS
Replication	2	0.654	0.612	2.896	5.431
Variety (A)	1	61.318*	29.528*	66.956*	95.921*
Error (a)	2	1.666	1.077	3.544	5.020
Supplementary treatments (T)	4	33.543**	29.003**	54.144**	66.355**
Interaction (A×T)	4	2.253*	4.395**	10.537**	9.901**
Error (b)	16	0.635	0.853	1.851	1.708

** Significant at 1% level; * Significant at 5% level;

Appendix V. Means square values for number of branches plant^{-1} at of chickpea at different growth duration

Sources of variation	Degrees of freedom	Mean square			
		Number of branches plant^{-1} at			
		30 DAS	60 DAS	90 DAS	110 DAS
Replication	2	0.025	0.025	0.009	0.021
Variety (A)	1	1.451**	3.464*	3.745*	3.888**
Error (a)	2	0.012	0.084	0.097	0.048
Supplementary treatments (T)	4	0.618**	1.210**	1.319**	1.189**
Interaction (A×T)	4	0.195**	0.278**	0.359*	0.351*
Error (b)	16	0.039	0.050	0.102	0.093

** Significant at 1% level; * Significant at 5% level;

Appendix VI. Means square values for dry matter content plant^{-1} of chickpea at different growth duration

Sources of variation	Degrees of freedom	Mean square			
		Dry matter content plant^{-1} (g)			
		30 DAS	60 DAS	90 DAS	110 DAS
Replication	2	0.019	0.116	0.137	0.048
Variety (A)	1	2.139*	3.929**	3.059*	2.754*
Error (a)	2	0.077	0.042	0.100	0.030
Supplementary treatments (T)	4	1.593**	1.813**	2.408**	2.440**
Interaction (A×T)	4	0.605*	0.252*	0.379*	0.523**
Error (b)	16	0.074	0.101	0.130	0.080

** Significant at 1% level; * Significant at 5% level;

Appendix VII. Means square values for flower, pod & total dropping and pod remaining of chickpea

Sources of variation	Degrees of freedom	Mean square			
		Flower dropping (%)	Pod dropping (%)	Total dropping (%)	Pod remaining (%)
Replication	2	0.162	0.001	0.147	0.147
Variety (A)	1	166.145*	0.208*	178.120*	178.120*
Error (a)	2	7.906	0.009	8.024	8.024
Supplementary treatments (T)	4	49.221**	2.703**	74.386**	74.386**
Interaction (A×T)	4	13.755*	0.016*	14.201*	14.201*
Error (b)	16	4.737	0.007	4.713	4.713

** Significant at 1% level; * Significant at 5% level;

Appendix VIII. Means square values for pods plant^{-1}, pod length, seeds pod^{-1}, weight of 1000-seed and shelling percentage of chickpea

Sources of variation	Degrees of freedom	Mean square				
		Pods plant^{-1} (No.)	Pod length (cm)	Seeds pod^{-1} (No.)	Weight of 1000-seed (g)	Shelling percentage (%)
Replication	2	0.925	0.0001	0.012	29.649	0.0001
Variety (A)	1	17.966*	0.081*	0.092*	1146.46*	0.004*
Error (a)	2	1.053	0.003	0.001	29.343	0.0001
Supplementary treatments (T)	4	10.770**	0.095**	0.024**	1475.94**	0.008**
Interaction (A×T)	4	20.966*	0.029**	0.026**	397.597*	0.006*
Error (b)	16	2.403	0.002	0.004	146.013	0.002

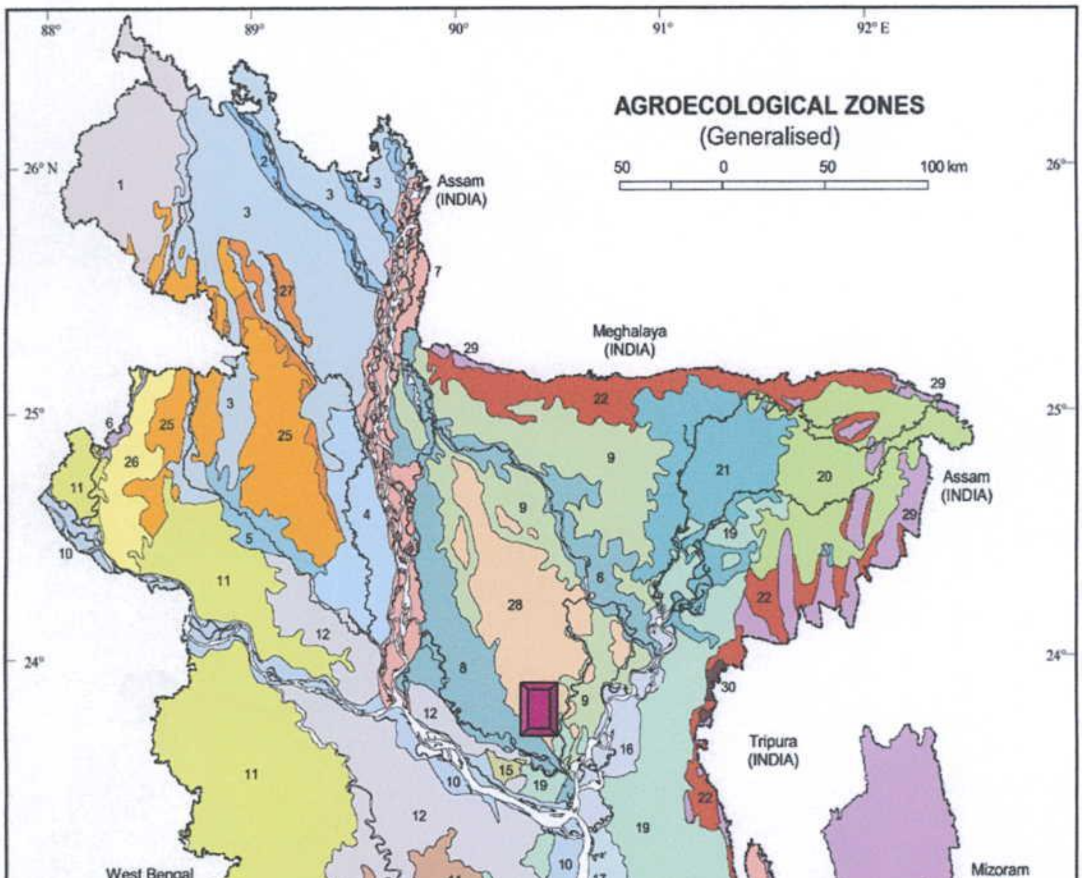
** Significant at 1% level; * Significant at 5% level;

Appendix IX. Means square values for seed yield, stover yield, biological yield and harvest index of chickpea

Sources of variation	Degrees of freedom	Mean square			
		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.005	0.003	0.011	1.262
Variety (A)	1	0.535**	0.456*	1.979**	21.987**
Error (a)	2	0.006	0.010	0.029	0.158
Supplementary treatments (T)	4	0.304**	0.264**	1.124**	15.539*
Interaction (A×T)	4	0.264*	0.270**	0.013*	7.065*
Error (b)	16	0023	0.027	0.075	3.793

** Significant at 1% level; * Significant at 5% level;

Appendix X. Photograph showing the location of the experimental site



Appendix XI. Photographs

Plate 1. Experimental field

Plate 2. Application of supplementary treatments.

Plate 3. Dropped flower

Plate 4. Scarecrow used for bird protection