YIELD AND QUALITY OF CHICKPEA AS AFFECTED BY SOWING DATES

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YIELD AND QUALITY OF CHICKPEA AS AFFECTED BY SOWING DATES

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CERTIFICATE

This is to certify that the thesis entitled **"YIELD AND QUALITY OF CHICKPEA AS AFFECTED BY SOWING DATES"** submitted to the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **SEED TECHNOLOGY**, embodies the result of a piece of bona fide research work carried out by **MD. YEASIN ALI**, Registration number: **14-06358** 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:
Dhaka, Bangladesh

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LIST OF SYMBOLS AND ABBREVIATIONS

@ = At the rate of

^{0}C = Degree Celsius

% = Percentage

BARI = Bangladesh Agricultural Research Institute

BAU = Bangladesh Agricultural University

BBS = Bangladesh Bureau of Statistics

BER = Bangladesh Economic Review

BINA = Bangladesh Institute of Nuclear Agriculture

cm = Centimeter

cv. = Cultivar (s)

df. = Degrees of freedom

etc. = Etcetera

FAO = Food and Agriculture Organization

ft = Feet (s)

g = Gram

hr = Hour (s)

Kg = Kilogram

CV% = Percentages of Co-efficient of Variance

et al. = And others

spp. = Species

J. = Journal

ml = milliliter

No. = Number

SAU = Sher-e-Bangla Agricultural University

USA = United States of America

var. = Variety

viz. = Namely

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ABSTRACT

A field experiment was conducted at the Agronomy research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2014 to June 2015 to observe the effect of sowing dates and variety on growth, yield and quality of chickpea. The experiment comprised of main plot: two chickpea varieties: BARI Chola-5 and BARI Chola-9 and sub-plots to be five different sowing dates: November 05, November 20, December 05, December 20 and January 04. The experiment was laid out in split- plot design with three replications. The results revealed significant variations in date to emergence, plant height, number of branches plant^{-1}, days to first flowering, days to maturity, number of pods plant^{-1}, pod length, seeds pod^{-1}, weight of 1000 seeds, seed yield, stover yield, biological yield, shelling percentage and harvest index due variety and sowing dates. Seed quality attributes viz germination percentage, vigor index, number of leaves per seedling, shoot length, root length and total dry matter content of seedling also varied due to variety and sowing time. Delayed sowing affected the chickpea plant growth, its yield and the quality of seed. In the case of varieties, more or less significant variation was observed in all parameters, here, BARI Chola-9 showed better performance over BARI Chola-5. Interaction of variety and sowing date significantly affected the seed yield. BARI Chola-9 sown on November 20 produced maximum seed yield (2.40 t/ha) and that the lowest seed yield (1.23 t/ha) in BARI Chola-5 for was found sown on January 04. The maximum weight of 1000 seeds, highest stover yield, harvest index, maximum germination percentage and vigor index were found when chickpea was sown

on 20 November and ensure the best performance. Irrespective of variety, delayed sowings showed lower performance on all parameters especially yield contributing parameters and yield of chickpea

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CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum* L.) belongs to the family Fabaceae. It is commonly known as gram and also the crop is variously known as chola, boot or botjam. Its production is 13,102,023 in metric tons in the worldwide (FAO, 2013). It is grown over 45 countries in all continent of the world. The large area of its adaptation is the Indian sub-continent. Two-third of the world production of chickpea comes from Indian subcontinent. The average yield of chickpea is 1.7 t ha^{-1} in Bangladesh which is very low compared to other countries of the world. Total production of pulse in Bangladesh is 378000 metric tons and Chickpea is cultivated 7000 ha of land with total production of chickpea is 17000 metric ton (BBS, 2015). In Bangladesh, chickpea is the third major pulse crop after lentil and grasspea. The area contributing is 12% of total pulse production of country (BBS, 2015). Chickpea plays an important role in the agro-economy and human health of Bangladesh. Also, it is an important crop for both human consumption and animal feed due to 17 - 31% protein in seeds and biological activity of its protein ranges between 52 - 78% (Ciftci, 2004; Khan, 1981; Kaul, 1982). It supplies about four times as much protein and eight times as riboflavin and the caloric value of it is equal to rice (Anonymous, 1966). Moreover, it is known as poor man's meat. Bangladesh Agricultural Research Institute (BARI) has developed several high yielding varieties of chickpea viz. BARI Chola-5, BARI Chola-6, BARI Chola-7, BARI Chola-8 and BARI Chola-9. Bangladesh Instituted of Nuclear Agriculture (BINA) has also developed chickpea varieties such as BINA Chola-1, BINA Chola-2, BINA Chola-3, and BINA Chola-4. These newly released varieties of chickpea can create a great opportunity to increase chickpea production in Bangladesh. Pulses mainly being the rabi seasonal crop is losing area under cultivation each year for increasing cultivation of wheat,

vegetable and high yielding boro rice due to increased irrigation facilities. The rapid growth of population has significant role in decreasing the cultivable land area year after year. So, we have no scope to increase production of pulses as well as chickpea horizontally in our country. The yield of chickpea in Bangladesh is lower than the other chickpea growing countries in the world. This mainly due to the use of traditional or low yielding varieties as well as adoption of poor management practices. In this situation the only way of increasing production vertically by means of using high yielding varieties, adjustment of planting time and using improved technologies. A number of agronomic practices have been found to influence the yield of pulse crop (Boztok, 1985). Sowing time had a marked effect on growth and development of crop (Mittel and Srivastava, 1964). Optimum sowing time provides more opportunity for growth and development and late hinders the growth and development with lowest yield potential (Gurung *et al.*, 1996). Early sown crop grows luxuriantly followed by less number of pods and seeds production thus limits yield. Late sowing also resulted in lower yield, the growth is hampered and the seed development period is shortened. Similar findings were pointed out by Yadav *et al.* (1998). Hence it is important to know the optimum sowing date of chickpea for having highest yield and better quality. With conceiving the above scheme in mind, the present research work was undertaken in order to fulfilling the following objectives:

- To identify the sustainable variety having highest yield and quality.
- To determine optimum sowing time of Chickpea.
- To study the combination effect of chickpea varieties and time of sowing on yield and quality of chickpea.

CHAPTER II

REVIEW OF LITERATURE

A number of research works have been reviewed to trace the effect of sowing time on yield and yield quality of chickpea varieties in diverse parts of the world. Information available, concerning to the present studies is cited below.

2.1 Effect of sowing date and variety on yield

2.1.1 Seed yield

Mubvuma (2015) studied that the effects of planting date on the growth and yield of chickpea. Two field experiments were undertaken using a split plot design with planting dates (early, medium and late, respectively) as main plots and chickpea cultivar (Range 1, Range 3, Range 4 and Range 5) as subplots. He reported that Grain yield was greater with early than medium and late planting probably due to longer duration of vegetative growth and seed filling period with early planting.

Husnain *et al.* (2015) observed that the maximum grain yield (1506.73 Kg ha-1) was observed from S_2 (29 November), which the minimum grain yield (1340.52 Kg ha-1) was found in S_1 (19 November), which statistically similar (1367.61 Kg ha-1) to S_3 (9 December).

Prasad *et al*., (2012) founded that Sowing on December 1 produced the highest seed (1.50 t/ha) while decrease in seed yield was 8.42 and 23.19% with delay in sowing to December 10 and December 20 respectively.

Mathews *et al.* (2011) reported that variation in grain yield with planting date has been reported in chickpea.

Kabir *et al*. (2009) was conducted that effect of sowing time and cultivars on the growth and yield performance of chickpea under rain fed condition. Three chickpea varieties viz., BARI Chola-2, BARI Chola-4, and BARI Chloa-6, and five different sowing times viz., 22 November , 2 December 2000, 12 December, 22 December and 1 January . Results revealed that the performance of BARI Chola-4 was the best in case of pods/plant yield and also harvest index among the varieties. He observed that seed yield was reduced consequently as the date of sowing was delayed. The late November sowing produced the highest seed yield and harvest index and also revealed that sowing date could be delayed up to early December to get satisfactory yield.

Ahmed *et al.* (2011) reported that grain yield production decreased with delay in sowing.

Tayyar *et al*. (2008) reported that based on 2 year data autumn planted chickpea resulted in 29 % higher seed yield than the spring planted crop.

Fallah (2008) showed that delay in planting from March 6 to April 5 significantly reduced grain yield.

Pezeshkpur *et al*. (2005) observed that early planting dates had higher yields of chickpea.

Regan *et al*. (2006) reported that seed yields varied widely depending on the time of sowing, location and seasonal conditions. Mean seed yields greater than 1000 kg/ha and up to 2000 kg/ha were achieved, but in some cases seed yields were less than 800 kg/ha. In the northern region, seed yield was almost doubled by sowing in early-May (1625 kg/ha) compared with late-June (754 kg/ha). In contrast to this, seed yields were generally lower in the southern regions and greater from late-June sowings (865 kg/ha) compared to earlier mid-May sowings (610 kg/ha).

He observed that the greater grain yields with early planting could be due to longer growing season and grain filling period.

Poras *et al.* (2002) conducted trial with treatment that comprised of 3 sowing dates, i.e. 4 December, 3 January and 3 April with 6 chickpea cultivars. Although seed yield in 4 December (34.1 g m^{-2}) and 3 January (32.3 g m^{-2}) increased compared to 3 April (29.6 g m^{-2}) but the differences were not significant.

Chaitanya and Chandrika (2003) observed that seed yield (0.54 t ha^{-1}) was observed with 1st November sown seeds which was significantly superior to all other dates of sowing. The lowest seed yield was recorded with December 1 sowing and it was at par with November 15 sowing.

Sharma and Sharma (2002) stated that the highest seed yield of 725 kg ha^{-1} was obtained from 25 November planted crop than delayed sown by 30 days results a decrease in grain yield up to 6.5 kg ha^{-1} day^{-1}.

Harpal *et al.* (2002) carried out field trials during 1999 and 2000 in Gurdaspur, Punjab, India where chickpea cultivars PBG 1 and GL 769 were sown on 10 October, 20 October, 30 October, 10 November and 20 November. They reported that GL 769 sown on 10 October gave highest grain yield (1410.00 kg ha^{-1}) in 1999 and (1414.27 kg ha^{-1}) in 2000 than other treatments.

Sugui F. P. and Sugui C. C. (2002) conducted experiment in Ilocos Norte, Philippines, during 1998-1999, to determine the best sowing date (15 October, 13 November, 15 January and 15 February) for chickpea cultivars ICCV 2 and ICCV 5. Seed yield was affected significantly by sowing date. The mean seed yield of two cultivars was highest (1670 kg ha^{-1}) for 15 November planting followed by 15 October (1237 kg ha^{-1}) and 15 December planting (1144 kg ha^{-1}).

Iliadis (2001) conducted experiment to increase seed yield of chickpea by changing sowing time from spring to autumn. Six chickpea cultivars were selected in two sowing seasons. The yield of autumn sowing cultivars was greater than spring sowing cultivars.

Patel *et al.* (1989) in their study observed that three chickpea cultivars were sown in Gujarat on 30 October, 15 or 30 November and 15 December 1994. Seed yield was highest with sowing on 15 November and lowest at the last sowing date.

Poniedizialek *et al.* (1999) conducted experiment on chickpeas during 1997-98 in the Krakow Area using 3 sowing dates from 17 April to 14 May. Yield decreased as sowing was delayed from 17 April to 14 May.

Bhattacharya and Pandey (1999) stated that different chickpea genotypes were grown under normal (30 October) and late (28 November) sowing dates. Normal sowing produced maximum seed yield than late sowing chickpea crop.

Desai and Intwala (1999) observed that 6 chickpea cajan cultivars were sown in the third week of October, first and third week of November. Seed yields were highest with sowing and decreased with delay in sowing.

Yadav *et al*. (1998) reported that forty chickpea (desi and kabuli) cultivars were sown in November and December in New Delhi. Delayed sowing decreased seed yield in both desi and kabuli types; however, the reduction in kabuli types was of highest order.

Borah (1998) carried out field trials in Assam during 1996-97 where chickpea were sown in 15 and 30 October, 15 November and 30 December. The maximum yield of chickpea was recorded in October sown crops.

Saini and Faroda (1997) in their field experiment, observed that chickpeas cv. H 68 were sown during the 3rd week in October or 1st or 3rd week in November. The optimum sowing date was 1st week in November, producing the highest seed yield of 2.76 t ha^{-1}.

Bejiga *et al*. (1997) working in Ethiopia, showed that varying sowing dates for chickpea affect yield. They indicated that early sowing increased yield of seed by 9.5% to 48% at Debre Zeit and 17.4% to 45% at Akai as compared to the third sowing date of late August.

Tiwari and Tripathi (1995) had sown in chickpea cv. JG 74 during 1st, 4th week in November and 2nd week in December. Delay sowing decreased seed yield.

Dixit *et al.* (1993) reported that chickpea cv. Ujjain 21 and Rad hey were grown at Powarkheda, Madhya Pradesh, India in the 1986-87. Winter seasons were sown on 5 or 26 October, 16 November and 7 or 28 December. Yield in both years was highest with sowing on 26 October and 16 November and lowest form 28 December.

Begum *et al.* (1992) conducted field trial with three sowing dates in November and December during 1986 in Bangladesh to evaluate the yield performance of 2 chickpea varieties viz. Hyprosola and G 97. They found that yield of late sown chickpeas were higher than early sown crops.

Poma *et al.* (1990) carried out field experiment with three chickpea lines sown in mid-December and at their successive 28-38 days intervals. They found average seed yield of three chickpea lines decreased with delayed sowing.

Dahiya *et al.* (1988) reported that *Cicer arietinum* cv. H 208 and C235 were sown 4 dates at 15 days intervals from 5 October to 19 November. The highest seed yield was 1.50 t ha^{-1} in 1983-84 and 1.36 t ha^{-1} in 1984-85 when sown on 20 October.

Auld *et al.* (1988) planted 10 cultivars in late April, early May and late May to determine the effect of planting date on yield components and seed yield. Planting in late April gave the highest seed yield.

Kumar *et al.* (1988) observed that chickpea were sown in early November, mid-November and early December. In general, yields were poor but the best yield (1.0-1.3 t ha^{-1}) was with mid-November sowing at Zainapora.

2.1.2 Stover yield

Husnain *et al.* (2015) showed that the highest straw yield (2339.03 Kg ha-1) was observed from S_2 (29 November), whereas the lowest straw yield (2007.65 Kg ha-1) was found in S_1 (19 November).

Prasad *et al*. (2012) observed that sowing on December 1 produced the highest biomass yields (6.70 t/ha).

Yadav *et al*. (1998) reported that forty chickpea (desi and kabuli) cultivars were sown in November and December in New Delhi. Delayed sowing reduces biomass production in both desi and kabuli types; however, the reduction in kabuli types was of highest order.

2.1.3 Harvest index

Akbar *et al*. (2011) to evaluate the effect of different sowing methods on yield and quality of two chickpea cultivars during the rabi season. They reported that the significant quality parameters, harvest index differences were observed among sowing methods and chickpea cultivars for yield and yield components.

2.2 Effect of sowing date and variety on yield attributes

2.2.1 Plant height

Kabir *et al*. (2009) observed that Chickpea varieties showed significant difference with respect to plant height and crop growth rate in different sowing times. The tallest plants (33.63 cm) were observed in early sowing in the last week of November, which was statistically significant over delay sowing at late December and at early January.

Shamsi (2009) Compared various planting dates showed that planting on November 6 had the highest plant height because of the increase in duration of the period of plant growth.

Rahemi and Soltani (2005) observed that plant height increase with high densities and early planting dates.

Chaitanya and Chandrika (2003) observed that the highest plant height (32.9 cm) was with 1 November sown seeds as compared to October 15, November 15 and December 1.

Allam (2002) reported that chickpea sowing 20th November gave taller plants.

2.2.2 Branches plant^{-1}

Husnain *et al.* (2015) observed that number of branches plant^{-1} of chickpea were significantly influenced by sowing time at 20, 40, 60 DAS and at harvest. The maximum number of branches plant-1 (1.42, 8.81, 18.09 and 19.98) were observed from S_2 (29 November), which was statistically similar (1.40, 8.65, 17.68 and 19.92) to that of S_3 (9 December) and the minimum number of branches plant^{-1} (1.35, 8.24, 17.30 and18.16) were found in S_1 (19 November) at same days after sowing.

Chaitanya and Chandrika (2003) observed that the number of primary branches per plant (3.4), number of secondary branches per plant (8.2) was observed with 1 November sown seeds.

Yadav *et al*. (1998) reported that forty chickpea (desi and kabuli) cultivars were sown in November and December in New Delhi. Delayed sowing reduction in number of branches in both desi and kabuli types; however, the reduction in kabuli types was of highest order.

2.2.3 Maturity date

Chaitany and Chandrika (2003) observed delayed sowings beyond October 15 decreased number of dates to maturity.

Rehman *et al,* (2015) conducted experiment on effect of different Sowing dates on growth and grain yield of chickpea (*Cicer arietinum* L.). Sowing dates had significant difference on days to flowering, and days to maturity, plant height, branches and pods per plant and 1000-seed weight and the maximum days to 90 % maturity were observed for cultivar Sanyasi (169 days) when sown on 15th October while minimum for cultivar DG-92 (122 days) when sown on 15th December. Grain yield was maximized for DG-92 (3.3 Mg ha-1) at sowing date of 15th November.

2.2.4 Pod plant^{-1}

Pandey *et al.* (2014) observed that crop sown on October 25 resulted into significantly more numbers of pod plant^{-1}followed by November 14 and December 4 sown chickpea crops.

Kambale *et al*. (2012) reported that number of pods plant^{-1} was significantly the higher (46.99) when crop was sown on 49th MSW (D_1). The lowest number of pods per plant (36.14) was found when crop was sown on 51st MSW (D_3).

Prasad *et al*. (2012) observed chickpea sown on December 1 produced maximum number of pods plant^{-1}, which were significantly higher than all other sowing dates and the lowest values were obtained in December 20 sowing.

Fallah (2008) showed that delay in planting from March 6 to April 5 significantly reduced number of pods plant^{-1}.

Chaitanya and Chandrika (2003) observed that the number of pods plant^{-1} (18.0) was observed with 1 November sown seeds.

Yadav *et al*. (1998) reported that forty chickpea (desi and kabuli) cultivars were sown in November and December in New Delhi. Delayed sowing reduction in pod number plant^{-1}in both desi and kabuli types; however, the reduction in kabuli types was of highest order.

Garg (1990) conducted field trials in Almora, Uttar Pradesh, India where chickpea cv. VL 86 and T_2 were sown on five dates between 5 October and 15 November. He observed pod damage was lowest in the early sown crop (5 October) and highest in the late sown crop (15 November).

Akbar *et al*. (2011) was observed that effect of different sowing methods on yield and quality of two chickpea cultivars during the rabi season. They reported that the significant quality parameters. With bed sowing method the chickpea cultivar Punjab 2008 produced greater number of pods per plant (81.49), number of grains per plant (98.49), grain yield (4.74 t ha^{-1}), biological yield (10.77 t ha^{-1}), harvest index differences were observed among sowing methods and chickpea cultivars for yield and yield components.

2.2.5 Seeds pod^{-1}

Husnain *et al.* (2015) observed that the maximum number of seeds pod^{-1} (1.88) was recorded from S_2 (29 November), whereas the minimum number of seeds pod^{-1} (1.61) was observed from S_1 (19 November).

Pandey *et al.* (2014) observed that crop sown on October 25 resulted into significantly more numbers of seed pod^{-1} followed by November 14 and December 4 sown chickpea crops.

Sadeghipour and Aghaei (2012) investigated that the effects of autumn and spring sowing dates on yield and yield components of chickpea varieties. They found that the longer growing period of autumn-sown chickpeas affected positively characters contributing to yield such as biomass, pods per plant, seed per pod, 1000-seeds weight and harvest index, which in turn contributed to increased seed yield.

Prasad *et al*. (2012) observed number of seed pod^{-1} remained unaffected due to dates of sowing and plant population.

Fallah (2008) showed that delay in planting from March 6 to April 5 significantly reduced number of grains pod^{-1}.

Chaitanya and Chandrika (2003) observed that the number of seeds pod^{-1} (1.24) was observed with 1 November sown seeds as compared to October 15, November 15 and December 1.

Yadav *et al*. (1998) reported that forty chickpea (desi and kabuli) cultivars were sown in November and December in New Delhi. Delayed sowing reduction in seeds pod^{-1} in both desi and kabuli types; however, the reduction in kabuli types was of highest order.

Poma and Zora (1990) reported that early sowing of chickpea on 49^{th} MSW produced significantly higher seeds pod^{-1} (12.75 g) than rest of sowing dates.

2.2.6 Pod length

Husnain *et al.* (2015) observed that the maximum pod length $plant^{-1}$ (3.06 cm) was recorded from S_2 (29 November), which is statistically similar (2.88 cm) to S_3 (9 December), whereas the minimum pod length $plant^{-1}$ (2.66 cm) was observed from S_1 (19 November).

2.2.7 Pod weight $plant^{-1}$

Kambale *et al*. (2012) reported that early sowing of chickpea on 49th MSW (D_1) produced significantly higher (16.19 g) pod weight per plant than rest of sowing dates, while the late sowing crop in 51st MSW recorded significantly the lowest pod weight per plant (12.49 g).

Yadav *et al*. (1998) reported that delayed sowing reduction in seed weight in both desi and kabuli types; however, the reduction in kabuli types was of highest order. Poma and Zora (1990) reported that late sown crop in 51st MSW recorded significantly the lowest seed weight per plant (9.24 g).

2.2.8 1000 seeds weight

Husnain *et al.* (2015) observed that significant differences were found for weight of 1000 seeds of chickpea due to sowing time. The highest weight of 1000 seeds (103.12 g) was recorded from S_2 (29 November), which statistically similar (102.28 g) to S_3, whereas the lowest weight of 1000 seeds (96.31g) was observed from S_1 (19 November).

Kaya *et al.* (2010) performed a field experiment on chick pea varieties with different sowing times to investigate the effect of sowing times. They reported that the significant differences were detected for cultivars, sowing dates and seed treatments. 1000 seed weight, harvest index, seed yield, respectively. Hundred seed weight, harvest index and seed yield were significantly affected from sowing dates and seed treatments**.**

Prasad (2012) observed 1000 seed weight remained unaffected due to dates of sowing and plant population.

Fallah (2008) showed that delay in planting from March 6 to April 5 significantly reduced number of grains per pod, 100-grain weight, grain yield and dry matter.

Nawaz *et al.* (1995) observed that 1000-seed weight was not influenced by the variation in sowing dates.

2.3 Effect of sowing date on yield quality

2.3.1 Seed germination

Husnain *et al.* (2015) observed that sowing time different a significantly in germination percentage. The maximum germination percentage (93.00) were observed from S_2 (29 November) and the minimum germination percentage (83.40) were found in S_1 (19 November). Auld *et al.* (1988) planted 10 cultivars in late April, early May and late May and observed slower seedling emergence.

Hernandez and Hill (1985) reported that seed yield decreased from 270 to 206 g/m^2 as sowing date was delayed. Reduction in seed yield was associated with reductions in the number of branches, pods and seeds per plant. A population level about 32 plants/m^2 appeared to be adequate for optimum seed yield.

2.3.2 Seed vigor index

Husnain *et al.* (2015) observed that the maximum vigor index (1761.00) was observed from S_2 (29 November) and the minimum (828.20) was found in S_1 (19 November).

2.3.3 Dry matter

Husnain *et al.* (2015) observed that significant differences were recorded for dry matter content in plant of chickpea due to different sowing time at 20, 40 and 60 DAS.

Ahmed *et al*. (2011) reported that total dry matter production decreased with delay in sowing which was reflected in grain yield.

Badani *et al*. (2010) was a field test conducted by during the winter season employed a split-plot design to know the influence of sowing date on yields of fresh-harvested chickpea. They found that the cultivar Zehavit was superior to cv. Bar in terms of all of these parameters, except final

dry yield. Thus, cv. Zehavit is the better cultivar for production of fresh-harvested chickpea, due to its ability to produce high yields of fresh seed with a lower percentage of waste.

Fallah (2008) showed that delay in planting from March 6 to April 5 significantly reduced number of grains per pod, 100-grain weight, grain yield and dry matter.

Shamsi (2009) observed among planting dates, date of November 6 with 2748 kg ha^{-1} had the highest biological yield, and dates of November 22 and December 6 with 2182 and 2127 kg ha^{-1} respectively, followed.

Hussain *et al.* (1997) observed the comparative, superior performance of early sowing to late sowing in TDM production.

CHAPTER III

MATERIALS AND METHODS

This chapter comprises a brief description on experimentation including duration, soil, climate, geographical region, land preparation, design, layout, intercultural operations, data collection and data analysis which are stated below.

3.1 Location of the experimental plot

The experiment was conducted at the central farm of the Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2014 to June, 2015. The site was 90.2^{o}N and 23.5^{o}E Latitude and at an altitude of 8.2 m from the sea level (Appendix I).

3.2 Characteristics of soil

The soil of the experiment was non- calcareous, dark gray, high land belonging to the Modhupur Tract (AEZ No-28). The soil texture was silty clay. The experimental site was a medium high land. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, and Dhaka and have been presented in Appendix II.

3.3 Climatic condition

The geographical location of the experimental area were under the sub-tropical monsoon climate, which is characterized by 3 distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October, heavy rainfall during Kharif season and scanty in the rabi season (October to March). There was no rainfall during the month of October, November, December and January. The average maximum temperature during the period of experiment was 31.82˚C and the average minimum temperature was 28.14^{o}C. Details of the meteorological data in respect of temperature,

rainfall and relative humidity during the period of the experiment were collected from Weather Station of Agargaon, Dhaka and have been presented in Appendix III.

3.4 Agro-ecological region

The research field belongs to the agro-ecological region of the Modhupur Tract (AEZ-28). The landscape comprises level upland, closely or broadly dissected terraces associated with either shallow or broad, deep valleys.

3.5 Experimental materials

"BARI Chola-5" and "BARI Chola-9", high yielding variety of chickpea developed by Bangladesh Agricultural Research Institute (BARI), Gazipur has been used as experimental material.

3.6 Experimental treatments

There were two chickpea varieties and five sowing dates included in the study. The experiment consisted of the following treatments:

A. Chickpea variety

- V_1- BARI Chola-5
- V_2- BARI Chola-9

B. Sowing date

- S_1–November 5
- S_2 - November 20
- S_3 – December 5
- S_4 - December 20
- S_5- January 4

3.7 Experimental design and layout

The experimental treatments were laid out in split-plot design with three replications where varieties were assigned in the main plot and sowing dates in the sub-plots. Total number of unit plots in the experiment was 2 × 5× 3 = 30. The unit plot size was 3.2 m × 2.0 m. The plot to plot distance was 0.5 m and from block to block distance was 1.0 m having a provision for an irrigation channel (Appendix IV).

3.8 Preparation of experimental land for chickpea

The land preparation was done as per treatment. For conventional tillage (CT) the experimental land was first opened with a power tiller. In case of stale seed bed technique, it is created by tilling the soil early, which encourages the weeds to germinate. After weed cover was established, the emerged weeds were killed by subsequent tillage before planting. The field layout was made on November as per design. Individual plots were cleaned by removing weeds and stubbles and finally leveled by ladder.

3.9 Fertilizer application

The plots were fertilized with urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum, $ZnSO_4$ and boric acid at the rate of 50, 90, 40, 110, 7 and 12 kg ha^{-1}, respectively. The whole amount of urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum, $ZnSO_4$ and boric acid were applied at the time of final land preparation.

3.10 Seed sowing

Seeds of BARI Chola-5 and BARI Chola-9 were sown on 5th November, 20th November 5th December, 20th December and 4th January of 2014 at the rate of 40 kg ha^{-1} with line sowing method. The depth of sowing was 6-7 cm and the seeds were covered with soil. Care was taken to protect the seedlings from birds for 20 days.

3.11 Intercultural operations

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the chickpea.

3.11.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening. Further irrigation was done when needed. Stagnant water was effectively drained out at the time of heavy rains.

3.11.2 Gap filling

Gap filling was done for all of the plots at 10 days after sowing (DAS) by same sources of seeds.

3.11.3 Weeding

Weeding's were done to keep the plots free from weeds, which ultimately ensured better growth and development. First weeding was done at 20 days after sowing (DAS), 2^{nd} and 3^{rd} weeding were done at 35 and 50 DAS respectively.

3.11.4 Plant protection

The plots were infested by pod borer which was successfully controlled by applying Cypermethrin at the rate of 1ml/one litter of water. There was no disease infestation on the crop.

3.12 Harvesting and processing

The crops were harvested at full maturity on 17^{th} March, 24^{th} March, 1^{st}April, 5^{th} April and 10^{th} April 2015 and carried to the threshing floor for processing. The crop was dried in the sun for four days, threshed and cleaned. Grain and straw were then dried in the sun for four days.

3.13 Sampling and data recording

For collecting data on plant characters, 5 plants were selected at random and uprooted from each plot prior to harvesting. The seed and straw yields were recorded plot-wise on 14% (app.) moisture basis as t ha^{-1}. The data on the following parameters were recorded.

Growth

- Date of emergence
- Plant height
- No. of branches/plant
- Days to flowering
- Days to maturity

Yield

- No. of pods per plant
- No. of seeds/pod
- Pod length
- 1000 seeds weight
- Seed yield
- Stover yield
- Shelling percentage
- Biological yield
- Harvest index

Seed Quality

- Germination percentage
- Vigor index
- Shoot length of seedling
- Root length
- No. of leaves per seedling
- Dry matter content of seedling

3.14.1 Growth, yield and yield contributing characters of chickpea

Date to emergence

It was recorded as the number of days from sowing until seedling emergence in each plot.

Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 60, 90 DAS (days after sowing) and at harvest. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the leaves.

Number of branches plant^{-1}

The number of branches plant^{-1} was counted at 30, 60, 90 DAS and at harvest from selected plants. The average number of branches plant^{-1} was determined.

Days to flowering

The flowering date was reported as the number of days from sowing until the crop initiate to bloom.

Days to maturity

The maturity days was reported as the number of days from sowing until the crop attained 95% maturity.

Days to harvesting

The harvesting days to harvesting was reported as the number of days from planting until 95% chickpea seed attains maturity.

Number of pods plant^{-1}

Numbers of total pods of selected 5 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.

Pod length

Pod length (cm) was taken of randomly selected ten pods and the mean length was expressed per pod basis.

Number of seeds per pod

The number of seeds pod^{-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.

1000-seeds weight

One thousand cleaned and dried seeds were counted randomly form each harvest sample and weighted by using a digital electric balance and the mean weight was expressed in gram.

Shelling percentage

The mass of seeds obtained from the pods that were randomly selected ten pods and calculated the shelling percentage by using the following formula:

Shelling percentage =

Seed yield

The plants were harvested inner 4 lines from 8 lines (3.2m × 2m) for taking seed yield. The seed were threshed from the plants, cleaned, dried and then weighed. The yield of seed (kg) plot^{-1} was adjusted at about 12% moisture content of seed and then it was converted to t ha^{-1}.

Stover yield

The stover yield was collected of inner 4 lines from each plot (3.2m × 2m) area. Stover obtained from harvest area was dried in open sun and weighed to record the final stover yield per plot and finally converted to ton per hectare.

Harvest Index

It denotes the ratio of economic yield (seed yield) to biological (seed yield + stover yield) and was calculated with following formula (Gardner *et al*., 1985).

Harvest index (%) =

3.14.2 Quality parameter of chickpea

The seeds of two varieties with different sowing dates were collected separately and their quality in germination, vigor and other growth parameters were assessed.

Germination percentage

Standard germination test was conducted in the laboratory. The 25 seeds from each treatment replicated three times were placed for germination on petridish and kept in germinator at 25°C for 7 days. The petridishes were monitored daily and water was applied when needed. The percentage of germination was calculated by following equation

Germination (%) =

Vigor index

The daily record of seed germination was kept starting from placement of seeds for germination. Vigor index was calculated by the following formula (Agrawal, 1991).

Vigor index = +

Number of leaves per seedling

The number of leaves per seedling was recorded from randomly selected 5 seedlings after 7 days germination. Data were recorded as the average of 5 seedlings from each petridishes**.**

Shoot length

Shoot length of seedling was recorded from randomly selected 5 seedlings after 7 days of germination and the mean number was expressed in cm.

Root length

Root length of seedling was recorded from randomly selected 5 seedlings after 7 days germination and the mean number was expressed in cm.

Dry weight of seedling

The seedlings obtained after standard germination test were used for seedling dry weight test. The root and radicals were detached from coleoptiles and were placed in tray, dried in oven at 72ºC for72 hours to measure dry weight (Akhtar *et al.*, 2010).

3.15 Statistical analysis

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique using STATISTIX-10 computer package program and the mean differences were adjudged by least significant difference (LSD) test at 5 % level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

This research was carried out to finding the yield and quality of chickpea as affected by variety and sowing date. The data on different growth, yield attributes and quality parameters were recorded. The results have been presented and discussed in different graphs, tables and possible interpretations given under the following headings:

4.1 Days to emergence

4.1.1 Effect of variety

Date of emergence significantly affected the chickpea variety at various days after sowing. The maximum number of plants emergence was found (10.67/m^2, at 4 DAS in BARI Chola-5 while minimum number was found (8.33/m^2) at 4 DAS in BARI Chola-9. Continously, maximum (42.89/m^2) and minimum (37.33/m^2) emergence was recorded from the seeds of BARI Chola-9 and BARI Chola-5 respectively at 10 days after sowing (Figure1). Auld *et al.* (1988) planted 10 cultivars in late April, early May and late May and observed slower seedling emergence.

V_1- BARI Chola-5 ; V_2- BARI Chola-9

Figure 1. Effect of variety on dates to emergence of chickpea ($LSD_{0.05}$ 2.06, 3.27, 4.34, 5.35, 2.58, 2.16 and 1.43 at 4, 5, 6, 7, 8, 9, and 10 DAS respectively)

4.1.2 Effect of sowing date

There was significant variation in time required for days to emergence but numerical minimum duration required. It was revealed that late sowing resulted in delayed emergence at various days after sowing. At 4 days after sowing, maximum number of emergence (12.83/m^2) was observed from S_2 wich was stastically similar with S_1. While minimum population (5.50/m^2) was recorded from S_5 that was stastically similar with S_4. At 5 DAS, the maximum number of plant emergence was recorded (21.50/m^2) for seed collected from S_1 that was stastically similar with S_2 and S_3 while the minimum were recorded (10.67/m^2) from S_5. Similarly, at 6 DAS maximum and

statistically similar number of seedling emergence was observed from S_1 and S_2, S_3. Where as the lowest number of seedling emergence was recorded when chickpea was sown those collected from late sowing dates of January 4. At 7 DAS maximum number of emergence (37.33/m^2) was observed from S_2 which was stastically similar with S_1. While minimum population (27.33/m^2) was recorded from S_5. The higher number of emergence (40.33/m^2) was observed from S_2 which was stastically similar with S_1. While the lowest number of emergence (31.5/m^2) was recorded from S_5 at 8 DAS. The higher number of emergence (43.33/m^2) was observed from S_2. While lowest number of emergence (34.33/m^2) was recorded from S_5 at 9 DAS. At 10 DAS the maximum number of emergence (44.83/m^2) was observed from S_2. While minimum number of emergence population (34.83/m^2) was recorded from S_5 **(**Table 1.). Lower population of chickpea recorded from December 20 to Janaury 04 sowing might be due to unfavourable condition including low temperature during their sowing dates of Janaury. Lower number of seedling emergence in delayed sown chickpea was also reported by Pandey *et al.*(2014).

Table 1. Effect of sowing date on number of population at different duration of chickpea

Sowing date	**Number of population/m^2 at different days after sowing**						
	4 DAS	5 DAS	6 DAS	7 DAS	8 DAS	9 DAS	10 DAS
S_1	12..33 a	21.50 a	31.41 a	36.50 a	39.33 a	41.33 b	42.50 b
S_2	12.83 a	20.16 a	28.67 a	37.67 a	40.33 a	43.33 a	44.83 a
S_3	9.83 b	21.33 a	28.91a	32.17 b	35.33 b	38.50 c	40.67 c
S_4	7.00 c	15.08 b	23.00 b	33.17 b	34.67 b	36.17 d	37.67 d
S_5	5.50 c	10.67 c	21.00 b	27.33 c	31.50 c	34.33 e	34.83 e
LSD **(0.0**5%)	1.56	1.71	3.29	2.67	3.01	1.7	1.68
CV (%)	13.49	7.89	10.09	6.51	3.34	3.70	3.42

In a column, similar letter do not differ significantly at 0.05 level of probability; S_1- November 05, S_2- November 20, S_3- December 05, S_4- December 20, S_5- January 04.

4.1.3 Interaction effect of variety and sowing date

Interaction between sowing time and variety showed significant variation in respect of emergence of chickpea at different days after sowing. At 4 DAS, maximum number of population (14.00/m^2) was found V_1S_1 which was stastically similar with V_1S_2 and V_2S_2. The minimum number of seedling emergence (4.00/m^2) was observed from the V_2S_5. The maximum number of seedling emergence (27.00/m^2) was recorded from V_1S_2 that was stastically similar with V_1S_3. The minimum number of seedlings (8.33/m^2) was produced from V_2S_5 that was stastically similar with V_2S_4 at 5 DAS. At 6 DAS, the maximum number of seedling emergence (35.66/m^2) was recorded from V_1S_3 that was stastically similar with V_1S_1. The minimum number of seedlings (11.33/m^2) was produced from V_2S_5. At 7 DAS, The maximum number of seedling emergence (41.00/m^2) was recorded from V_1S_1 that was stastically similar with V_1S_2. The minimum number of seedlings (21.00/m^2) was produced from V_2S_5. Consequently, the maximum number of emergence (48.33/m^2) was observed from V_1S_2 that was stastically similar with V_1S_1. The minimum number of seedlings (32.66/m^2) was produced from V_2S_5 (Table.2).

Table 2. Interaction effect of variety and sowing date on seedling emergence chickpea at different days after sowing (DAS)

Interactions	Number of population/m^2 at different days after sowing						
	4 DAS	5 DAS	6 DAS	7 DAS	8 DAS	9 DAS	10 DAS
V_1S_1	14.00 a	24.33 b	33.67 ab	41.00 a	43.00 a	44.67 ab	46.00 a
V_1S_2	14.00 a	27.00 a	30.67 bc	40.33 ab	44.00 a	46.67 a	48.33 a
V_1S_3	10.67 bc	24.67 ab	35.67 a	37.00 bc	39.33 b	42.33 bc	43.33 b
V_1S_4	7.66 de	21.33 c	28.00 c	34.67 c	35.67 cd	37.33 def	39.67 cd
V_1S_5	7.00 de	13.00 d	30.67 bc	33.67 c	35.67 cd	36.67 ef	37.00 ef
V_2S_1	10.67 bc	18.67 c	29.17 bc	32.00 c	35.67 cd	38.00 de	39.00 cde
V_2S_2	11.66 ab	13.33 d	26.67 cd	35.00 bc	36.67 bc	40.00 cd	41.33 bc
V_2S_3	9.00 cd	18.00 c	22.17 de	27.33 d	31.33 e	34.67 f	38.00 def
V_2S_4	6.33 e	8.83 e	18.00 e	31.67 c	33.67 d	35.00f	35.67 f
V_2S_5	4.00 f	8.33 e	11.33 f	21.00 e	27.33 f	32.00 g	32.67 g
$LSD_{(0.05\%)}$	2.21	2.43	4.65	3.76	4.25	2.40	2.38
CV (%)	13.49	7.89	10.09	6.51	3.34	3.70	3.42

In a column, similar letter do not differ significantly at 0.05 level of probability; V_1: BARI Chola-5; V_2: BARI Chola- 9, S_1- November 05, S_2- November 20, S_3- December 05, S_4- December 20, S_5- January 04.

4.2 Plant height

4.2.1 Effect of variety

Significant variation was recorded for plant height of chickpea due to sowing dates at 30, 60, 90 DAS and at harvest (Table 3). In comparing the varieties, BARI Chola-9 produced taller plant height than BARI Chola-5 in all growth durations. BARI Chola-9 exerted higher plant height (13.61cm) at 30 DAS while 10.66 cm plant height was noted for BARI Chola-5. The taller plant was recorded (37.51 cm) in BARI Chola-9 whereas the smaller were found (34.45 cm) in BARI Chola-5 at harvest.

Table 3. Effect of variety on plant height of chickpea at different days after sowing

Variety	Plant height (cm)			
	30 DAS	**60 DAS**	**90 DAS**	**At harvesting**
BARI Chola-5	10.66 b	24.03 b	29.86 b	34.45 b
BARI Chola-9	13.61 a	27.85 a	33.31 a	37.51 a
LSD (0.05%)	1.02	2.63	2.36	0.97
CV (%)	5.36	6.46	4.77	1.72

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

4.2.2 Effect of sowing date

The plant height of chickpea was significantly affected by different sowing dates. It was found that plant height of chickpea decreased with delayed sowing. The higher plant height was observed in November 20 sowing and the lower were recorded in January 04. At harvest, the highest plant height (41.40 cm) was recorded when sowing was done on November 20, whereas the lowest height (30.90 cm) was observed as sowing was delayed on January 4 (Figure 2). This finding was also supported by Shamsi (2009) who also reported decrease in plant height for late sowing of chickpea. Kabir *et al*. (2009) observed that the tallest plants were observed in early sowing in the last week of November, which was statistically significant over delay sowing at late December and at early January.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04.

Figure 2. Effect of sowing times on plant height of chickpea at different days after sowing ($LSD_{0.05}$ 0.93, 0.61, 0.83 and 0.97 at30, 60, 90 and at harvest respectively).

4.2.3 Combined effect of variety and sowing date

At 30 DAS, maximum plant height (15.50 cm) was observed from V_2S_1 treatment combination which was statistically similar with V_2S_2. On the other hand, minimum plant height (8.73 cm)

was noted for V_1S_5 that statistically similar with V_1S_4 (Table 4). There was more or less similar result for the interaction effect of sowing date and variety on plant height of chickpea at 60, 90 DAS and at harvest. It was revealed that maximum plant height is decreasing with delaying the sowing time for both of two varieties.

Table 4. Interaction effect of variety and sowing date on plant height of chickpea at different days after sowing (DAS)

Interaction	Plant height (cm)			
	30 DAS	**60 DAS**	**90 DAS**	**At harvesting**
V_1S_1	10.87 ef	25.80 d	33.49 bc	37.27 cd
V_1S_2	12.22 cd	27.43 b	33.58 bc	38.14 b
V_1S_3	11.53 de	25.07 cd	32.63 c	36.30 de
V_1S_4	9.95 fg	23.62 de	26.66 d	31.36 f
V_1S_5	8.73 g	18.27 f	22.96 e	28.20 g
V_2S_1	15.50 a	29.12 b	32.20 c	38.36 bc
V_2S_2	14.23ab	32.35 a	37.13 a	42.66 a
V_2S_3	13.59 bc	29.57 b	35.31 b	38.54bc
V_2S_4	12.85 cd	25..80 cd	33.40 b	35.04 e
V_2S_5	11.53 de	22.40 e	28.50 d	31.99 f
LSD (0.05%)	1.32	0.87	1.13	1.11
CV (%)	6.29	1.95	2.08	1.79

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

V_1: BARI Chola-5; V_2: BARI Chola- 9; S_1- November 05, S_2- November 20, S_3- December 05, S_4- December 20, S_5- January 04

4.3 Number of branches plant^{-1}

4.3.1 Effect of variety

Number of branches plant^{-1} of chickpea were none significantly influenced by chickpea variety at 30, 60, 90 DAS and at harvest. BARI Chola-5 produced the maximum number of branches per plants (8.66) and BARI Chola-9 produced the minimum number of branches per plant (8.09) at harvest. 0n other hand at harvesting time among all the treatments of BARI Chola-9 produced more number of branches per plant than BARI Chola-5 (Table 5). Chaitanya and Chandrika (2003) observed that the higher number of primary branches per plant, number of secondary branches per plant was observed with November sown seeds.

Table 5. Effect of variety on number of branches per plant of chickpea at different days after sowing (DAS)

Variety	No. of branches plant^{-1}			
	30 DAS	60 DAS	90 DAS	At harvest
BARI Chola-5	3.40	5.90	6.83	8.66
BARI Chola-9	3.80	6.61	6.97	8.09
LSD $_{(0.05\%)}$	NS	NS	NS	NS
CV (%)	7.16	9.42	3.72	3.89

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

4.3.2 Effect of sowing date

The pronounced effect of sowing date on number of branches per plant at various days after sowing was found. Early sowing date produced maximum number of branches per plant while that sown in late gave lower number of branches. The maximum numbers of branches plant^{-1} (4.03, 8.07, 8.66, 9.19) were observed from S_2 (30 DAS), S_1 (60 DAS), S_1 (90 DAS), at harvest and statistically similar S_1, S_2 in 90 DAS, at harvest. While the minimum number of branches plant^{-1} was found in S_5 sowing time. Similarly, among all of the treatments time of sowing S_1

found the best sown time in respect of the number of branches per plants (Figure 3). These results were in general agreement with the findings of Yadav *et al*. (1998).

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 3. Effect of sowing times on no. of branches per plant at different days after sowing ($LSD_{0.05}$ 0.21, 0.41, 0.67 and 0.69 at 30 DAS, 60 DAS, 90 DAS and at harvest respectively).

4.3.3 Combined effect of variety and sowing date

There was a significant differences observed between sowing time and variety on number of branches per plants of chickpea at 30, 60, 90 DAS and at harvest. At 30 DAS the highest number of branches plant^{-1} (4.20) was observed from V_2S_2, which was statistically similar with V_2S_3, V_1S_2 and the lowest number of branches plant^{-1} (3.03) were found in V_1S_5 which was statistically similar with V_2S_5, V_1S_4. At 60 DAS maximum number of branches per plant (8.52) was observed from V_2S_1 which statistically similar with V_1S_1. The minimum number of branches per plant (4.63) was recorded from V_1S_5 which was statistically similar with V_1S_4 and V_2S_5. At 90 DAS, maximum number of branch per plant (9.20) was observed from V_2S_1 which statistically similar with V_1S_2. The minimum number of branches per plant (4.08) was recorded from V_1S_5 which was statistically similar with V_2S_5. At harvest, maximum number of branches per plant (9.52) was observed from V_2S_1 which statistically similar with V_1S_1, V_2S_2 and V_1S_2. The minimum number of branches per plant (4.87) was recorded from V_1S_5 which was statistically similar with V_2S_5 (Table.6).

Table 6. Interaction effect of variety and sowing date on number of branches per plant of chickpea at different days after sowing (DAS)

Interaction	No of branches plant^{-1}			
	30 DAS	60 DAS	90 DAS	At harvesting
V_1S_1	3.60 bc	7.63 ab	8.13 b	8.86 a
V_1S_2	3.90 ab	6.93 cd	8.41 ab	8.58 a
V_1S_3	3.46 bcd	5.63 ef	6.40 c	6.87 b
V_1S_4	3.16 de	5.00 fg	6.40 c	6.21 bc
V_1S_5	3.03 e	4.63 g	4.08 e	4.87 d
V_2S_1	3.83 b	8.52 a	9.20 a	9.51 a
V_2S_2	4.20 a	7.46 ab	7.76 b	8.70 a
V_2S_3	3.90 ab	6.06 de	6.06 cd	6.73 b
V_2S_4	3.70 bc	5.73 ef	6.23 cd	6.16 bc
V_2S_5	3.40 cde	5.23 fg	5.36 de	5.33 d
LSD $_{(0.05\%)}$	0. 30	0.56	0.94	0.98
CV (%)	4.86	5.21	7.89	7.94

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

V_1: BARI Chola-5; V_2: BARI Chola- 9, S_1- November 05, S_2- November 20, S_3- December 05, S_4- December 20, S_5- January 04

4.4 Days to flowering

4.4.1 Effect of variety

Non-significant variation was observed for days to flowering between the two varieties. The maximum days to flowering (67.20 days) were observed in BARI Chola-9, while the minimum days to flowering (66.86 days) were observed in BARI Chola-5 (Table. 7).

Table 7. Effect of variety on flowering duration and maturity duration of Chickpea at difference DAS

Variety	Flowering duration (day)	Maturity duration (day)
BARI Chola-5	66.86	103.53
BARI Chola-9	67.20	106.20
LSD $_{(0.05\%)}$	NS	NS
CV (%)	3.14	8.19

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

4.4.2 Effect of sowing date

The time of sowing had a significant effect on days to flowering in chickpea. Maximum days to flowering were 75.50 days when chickpea was sown on November 5, whereas minimum days (60.50) required to flowering for sowing date of January 4 (Figure 4). Delayed sowing reduced the time to flowering due to high temperature during vegetative growth stage.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 4. Effect of sowing times on flowering duration of chickpea (LSD $_{(0.05)}$ 2.17)

4.4.3 Combined effect of variety and sowing date

Combined effect of variety and sowing date showed significant variation in dates to flowering .The highest days to flowering (75.66 days) was recorded from V_2S_1 and the lowest days to flowering (59.00 days) was observed from V_1S_5 and which is statistically similar withV_2S_5. Delayed sowing date significantly reduced time to flowering (Table 8).

Table 8. Interaction effect of variety and sowing date on flowering duration and maturity duration of chickpea

Interactions	Flowering duration (day)	Maturity duration (day)
V_1S_1	75.33 a	118.00 ab
V_1S_2	70.66 b	113.00 b
V_1S_3	66.33 cd	104.00 c
V_1S_4	63.00 e	95.00 d
V_1S_5	59.00 f	87.67 e
V_2S_1	75.66 a	121.33 a
V_2S_2	69.00 bc	115.33 b
V_2S_3	65.00 de	107.00 c
V_2S_4	64.33 de	96.33 d
V_2S_5	62.00 ef	91.00 de
LSD $_{(0.05\%)}$	3.07	5.50
CV (%)	2.65	3.04

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

V_1: BARI Chola-5; V_2: BARI Chola- 9

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04.

4.5 Days to maturity

4.5.1 Effect of variety

Days to maturity showed had a non-significant difference between chickpea varieties in this study. To mature BARI Chola-9 required 106.2 days while BARI Chola-5 needed 103.53 days (Table 7). Rehman *et al,* (2015) reported that the maximum days to 90 % maturity were observed for cultivar Sanyasi (169 days) when sown on 15th October while minimum for cultivar DG-92 (122 days) when sown on 15th December.

4.5.2 Effect of sowing date

Results revealed that delayed in sowing significantly affected the days to maturity. It was found that maturity date decreased with sowing date. Early sowing of November 05 required maximum

days to maturity (119.67) of chickpea, which was followed by November 20 with 114.17 days. The minimum days to maturity (89.33) were found for (January 04) sowing (Figure 5). Minimum day's required to flowering in late sowing might be due to higher temperature.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 5. Effect of sowing times on maturity duration of chickpea (LSD $_{(0.05)}$ 3.89)

4.5.3 Combined effect of variety and sowing date

Flowering and maturity duration plays a significant role in harvesting time for any crop. The interaction of variety and sowing date had significant effect on harvesting time (Table 8). Maximum maturity duration (121.33 days) was observed in BARI Chola-9 for first sowing (November 5) and minimum duration (87.67 days) was observed in January 4 sowing which was statistically similar with V_2S_5.

4.6 Number of pods plant^{-1}

4.6.1 Effect of variety

Total number of pods per plant of chickpea differed due to its varietal effect. The higher number of pods per plant (21.37) was obtained from BARI Chola-9 while the lower (19.15) from BARI Chola-5 (Table 9). Kambale *et al*. (2012) reported that number of pods plant^{-1} was significantly the higher when crop was sown on 49th MSW.

4.6.2 Effect of sowing date

Sowing date exhibited significant differences between them in respect of number of pods plant^{-1}. The maximum number of pods plant^{-1} (24.69) was recorded from S_1 which was statistically similar S_2 whereas the lower number of pods plant^{-1} (15.49) was found in S_5. (Figure 6) Prasad *et al*. (2012) reported chickpea sown on December 1 produced maximum number of pods plant^{-1},

which were significantly higher than all other sowing dates and the lower values were obtained in December 20 sowing.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04.

Figure 6. Effect of sowing times on number of pod per plant of chickpea (LSD $_{(0.05)}$ 1.96)

4.6.3 Combined effect of variety and sowing date

The number of pods per plant was significantly affected by the combined effect of variety and sowing date. BARI Chola-9 produced maximum number of pods per plant (26.94) when sowing was done on November 20 which was statistically similar V_2S_1 while BARI Chola-5 produced the lowest pods per plant (15.27) when sown on January 04, which was statistically similar with V_2S_5 and V_1S_4 (Table 10). This above result reconfirms the result of Prasad *et al*. (2012) and Fallah (2008).

4.7 Pod length

4.7.1 Effect of variety

Statistically significant differences were found for pod length of chickpea due to varietal effect. The maximum pod length (1.60 cm) was recorded from BARI Chola-9 whereas the minimum pod length (1.32 cm) was observed from BARI Chola-5 (Table 9).

4.7.2 Effect of sowing date

Pod length of chickpea differed significantly due sowing date. The maximum pod length (1.63 cm) was recorded from S_2, that statistically similar to S_3.The minimum pod length (1.21 cm) was found in S_5 (Figure 7).

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04.

Figure 7. Effect of sowing times on pod length of chickpea (LSD $_{(0.05)}$ 0.12)

4.7.3 Combined effect of variety and sowing date

Interaction between sowing date and variety showed significant variation in pod length. The maximum pod length (1.75 cm) was recorded from V_2S_2, that statistically similar with V_2S_3, V_2S_4 and V_2S_5. The minimum pod length (1.08 cm) was observed from V_1S_1 (Table10). The lower pod length with delayed sown dates reported by Husnain *et al.* (2015).

4.8 Number of seed per pods

4.8.1 Effect of variety

Chickpea varieties showed no significant effect on seed per pods. The maximum number of seeds pod^{-1} (1.19) was recorded from BARI Chola-5, whereas the minimum number of seeds pod^{-1} (1.17) was observed from BARI Chola-9 (Table 9).

4.8.2 Effect of sowing date

The number of seeds per pods significantly was affected by several sowing dates. Delayed sowing gradually decreased the seed number per pods of chickpea. The higher number of seeds pod^{-1} (1.38) was recorded from S_3, whereas the lower number of seeds pod^{-1} (1.11) was found S_4 which was at par with S_1, S_2 and S_5 (Figure 8). Higher temperature during grain filling stage might be possible reason of lower number of seeds per pods of chickpea with delayed sowing.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04.

Figure 8. Effect of sowing times on no. seed per pod of chickpea ($LSD_{(0.05)}$ 0.19)

4.8.3 Combined effect of variety and sowing date

Interaction between variety and sowing date significantly varied in number of seeds pod^{-1}. The higher number of seeds pod^{-1} (1.40) was recorded from V_1S_4 which the statistically similar (1.36) to V_2S_4. The lower number of seeds pod^{-1} (1.10) was observed from V_1S_3, and V_2S_2 that similar

V_1S_2, V_1S_5, V_2S_1, V_2S_3, and V_2S_5 to (Table 10). Pandey *et al.*, (2014) observed that crop sown on October 25 resulted into significantly more numbers of seed pod^{-1} followed by November 14 and December 4 sown chickpea crops.

4.9 Shelling percentage

4.9.1 Effect of variety

Chickpea varieties showed no significant effect on shelling percentage. The maximum shelling percentage was (17.80%) recorded by BARI Chola-9 compared to BARI Chola-5 (17.61%) (Table 9).

4.9.2 Effect of sowing date

The effect of sowing date on shelling percentage was found significant. Seed sowing on December 05 gave the highest shelling percentage (20.56%) while the lowest shelling percentage was (15.89%) for January 04 sowing which was statistically similar with S_4 and S_5 (Figure 9).

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04.

Figure 9. Effect of sowing dates on shelling percentages of chickpea (LSD $_{(0.05)}$ 1.21)

4.9.3 Combined effect of variety and sowing date

Combined effect of variety and sowing date showed significant variation of shelling percentage. The highest shelling percentage (22.17%) was recorded in BARI Chola-5 sown on December 05 which was followed by V_2S_1 (21.38%). However, the lowest shelling percentage (14.83%) was found in BARI Chola-9 with late sowing date of December 20 (Table 10).

Table 9. Effect of variety on yield parameters of chickpea

Variety	Pod plant^{-1}	Pod length	Seeds pod^{-1}	Shelling %
BARI Chola-5	19.15 b	1.32 b	1.19	17.61
BARI Chola-9	21.37 a	1.60 a	1.17	17.80
LSD (0.05%)	1.42	0.06	NS	NS
CV (%)	4.46	2.90	8.94	6.28

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

Table 10. Interaction effect of variety and sowing date on yield parameters of chickpea

Interaction	Pod plant^{-1}	Pod length (cm)	Seeds pod^{-1} (No.)	Shelling %
V_1S_1	24.06 b	1.08 d	1.20 bc	16.03 def
V_1S_2	21.68 c	1.42 bc	1.13 c	15.55 def
V_1S_3	18.97 d	1.32 c	1.10 c	22.17 a
V_1S_4	15.78 ef	1.44 bc	1.40 a	17.36 bcd
V_1S_5	15.27 f	1.35 bc	1.13 c	16.96 cde
V_2S_1	25.33 ab	1.35 bc	1.13 c	21.38 a
V_2S_2	26.94 a	1.75 a	1.10 c	18.78 bc
V_2S_3	21.55 c	1.67 a	1.13 c	18.96 b
V_2S_4	17.31 de	1.55 ab	1.36 ab	15.08 ef
V_2S_5	15.72 ef	1.66 a	1.13 c	14.83 f
LSD (0.05%)	1.68	0.21	0.18	1.90
CV (%)	4.79	8.56	8.94	6.28

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

V_1: BARI Chola-5; V_2: BARI Chola- 9

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04.

4.10. Thousand seeds weight

4.10.1 Effect of variety

Statistically significant differences were found for weight of 1000 seeds of chickpea due to varietal effect. The higher weight of 1000 seeds (222.50 g) was recorded from BARI Chola-9 whereas the lower weight of 1000 seeds (121.27 g) was observed from BARI Chola-5 (Table 11). Kaya *et al.* (2010) found that hundred seed weight, harvest index and seed yield were significantly affected from sowing dates and seed treatments**.**

4.10.2 Effect of sowing date

Weight of 1000 seeds of chickpea differed non-significantly due to several sowing times. As planting was delayed, gradual decrease of 1000-seeds weight observed. Results showed that the maximum 1000 seeds weight (178.17g) was recorded from S_2 that statistically similar with S_1 (November 5) whereas the minimum1000 seed weight (166.00 g) was found S_5 (Figure 10). The 1000 seed weight probably decreased due to delayed in sowing because the chickpea plants may not have got sufficient time to increase the seed size sufficiently because of longer photoperiod and higher temperature.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 10. Effect of sowing times on 1000 seeds weight of chickpea ($LSD_{0.05}$ 4.94)

4.10.3 Combined effect of variety and sowing date

Interaction between variety and sowing date showed significant variation in weight of 1000 seeds. The highest weight of 1000 seeds (232g) was recorded from V_2S_2, that statistically similar to V_2S_1. The lowest weight of 1000 seeds (118.67 g) was observed from V_1S_5, that statistically

similar to V_1S_1, V_1S_2, V_1S_3 and V_1S_4 (Table 12). Nawaz *et al.* (1995) observed that 1000-seed weight was not influenced by the variation in sowing dates.

4.11 Seed yield

4.11.1 Effect of variety

Seed yield showed significant differences between two varieties. The maximum seed yield (2.09 t ha^{-1}) was observed from BARI Chola-9, while the minimum seed yield (1.67 t ha^{-1}) was found in BARI Chola-5 (Table 11).

4.11.2 Effect of sowing date

Seed yield of chickpea varied significantly due to sowing date. It was observed that seed yield of chickpea gradually decreased with the delay of sowing. The highest seed yield (2.18 t ha^{-1}) was observed from S_2 and the lowest seed yield (1.53 t ha^{-1}) was found in S_5 (Figure 11). Lower seed yield of chickpea for delayed sown might be due to the shorter grain filling period as a result of higher temperatures at grain filling stage. The lowest grain yield recorded in the late planting plots was probably due to the observed shorter duration of vegetative growth (Mubvuma, 2015).

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 11. Effect of sowing times on seed yield of chickpea ($LSD_{(0.05)}$ 0.03)

4.11.3 Combined effect of variety and sowing date

Chickpea variety and sowing date significantly affected the grain yield. The maximum Seed yield (2.4 t/ha) was obtained from BARI Chola-9 sown on November 20 whereas, the minimum yield (1.23 t/ha) was produced by BARI Chola-5 for January 4 sowing. It was clear that both of high yielding chickpea varieties sown on January produced low pods, which ultimately resulted in lower seed yield (Table 12).

This result was in agreement with Mathews *et al.* (2011) who noted that early sowing of chickpea had maximum contribution in seed yield. In earlier, Tayyar *et al*. (2008) observed that each day delay in sowing of chickpea after 20th November decreased grain yield.

4.12 Stover yield

4.12.1 Effect of variety

Result showed that the stover yield of chickpea was significantly influenced by variety. The maximum stover yield (4.39 t/ha) was produced by BARI Chola-9 while BARI Chola-5 produced the lower stover yield (3.58 t/ha) (Table 11).

4.12.2 Effect of sowing date

Stover yield of chickpea were significantly influenced by the sowing dates. The highest stover yield (4.57 t/ha) was observed from S_2, whereas the lowest stover yield (3.43 t/ha) was found in S_5 (Figure 12). Prasad *et al*. (2012) observed that sowing on December 1 produced the highest biomass yields. Yadav *et al*. (1998) also reported that early sowing of chickpea produced higher stover yield due to more number of pods per plant.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 12. Effect of sowing dates on stover yield of chickpea ($LSD_{(0.05)}$ 0.07)

4.12.3 Combined effect of variety and sowing date

Result revealed that interactive effect of variety and sowing date significantly affected the total amount of stover. BARI Chola-9 sown on November 20 produced maximum stover yield (5.10 t/ha), while the lowest stover yield (2.93 t/ha) was observed in V_1S_5 treatment (Table 12). However it was clear that both high yielding varieties produced maximum amount of stover in

early sowing as the environmental condition was suitable for plant growth and gets enough time for maturation of the plant.

4.13 Biological yield

4.13.1 Effect of variety

Finding revealed that varietal effect of chickpea in respect of biological yield was significant. The higher biological yield (6.48 t/ha) was recorded by BARI Chola-9, while BARI Chola-5 produced the lower biological yield (5.25 t/ha) (Table11).

4.13.2 Effect of sowing date

Biological yield of chickpea were significantly influenced by the time of sowing. The highest biological yield (6.75 t/ha) was observed from S_2, whereas the lowest biological yield (4.95 t/ha) was found in S_5 (Figure 13). Prasad *et al*. (2012) observed that sowing on December 1 produced the highest biological yields. Yadav *et al*. (1998) also reported that early sowing of chickpea produced higher biological yield due to more number of pods per plant.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 13. Effect of sowing dates on biological yield of chickpea ($LSD_{(0.05)}$ 0.09)

4.13.3 Combined effect of variety and sowing date

Combined effect of variety and sowing date showed significant variation in the production of biological yield. BARI Chola-9 sown on November 20 produced maximum biological yield (7.50 t/ha), while the lowest biological yield (4.16 t/ha) was observed in V_1S_5 treatment (Table 12).

4.14 Harvest index

4.14.1 Effect of variety

Significantly variation was observed for harvest index between the two varieties. The higher harvest index (32.30 %) was exerted by BARI Chola-9, while BARI Chola-5 produced the lower harvest index (31.51 %) (Table 11).

4.14.2 Effect of sowing date

Harvest index of chickpea were significantly influenced by the time of sowing. The highest harvest index (32.64 %) was observed from S_3 which was statistically similar with S_1. The lowest harvest index (30.66 %) was found in S_5 (Figure 14). Prasad *et al*. (2012) observed that sowing on December 1 produced the highest harvest index. Yadav *et al*. (1998) also reported that early sowing of chickpea produced higher harvest index due to more number of pods per plant.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 14. Effect of sowing dates on harvest index of chickpea ($LSD_{(0.05)}$ 0.41)

4.14.3 Combined effect of variety and sowing date

Result revealed that interactive effect of variety and sowing date significantly affected the harvest index. BARI Chola-9 sown on December 05 produced maximum harvest index (32.92 %) which was statistically similar with V_2S_1, V_1S_2 and V_1S_3, while the lowest harvest index (29.49 %) was observed in V_1S_5 treatment (Table 12).

Table 11. Effect of variety on 1000 seeds weight (g), seed yield (t/ha), stover yield (t/ha), biological yield (t/ha) and harvest index of chickpea

Variety	1000 seeds weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
BARI Chola-5	121.27 b	1.67 b	3.58 b	5.25 b	31.51 b
BARI Chola-9	222.50 a	2.09 a	4.39 a	6.48 a	32.30 a
LSD (0.05%)	6.69	0.04	0.15	0.19	0.29
CV (%)	2.56	2.38	1.31	2.04	0.59

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

Table 12. Interaction effect of variety and sowing date on 1000 seeds weight (g), seed yield (t/ha), stover yield (t/ha), biological yield (t/ha) and harvest index of chickpea

Interaction	1000 seeds weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
V_1S_1	123.67 e	1.92 c	4.02 de	5.94 de	32.34 bcd
V_1S_2	124.33 e	1.95 c	4.06 de	6.01 d	32.45 abc
V_1S_3	121.00 e	1.74 e	3.64 f	5.38 e	32.36 abcd
V_1S_4	118.67 e	1.47 f	3.30 g	4.77 g	30.91 e
V_1S_5	118.67 e	1.23 g	2.93 h	4.16 h	29.49 f
V_2S_1	229.00 ab	2.18 b	4.48 b	6.66 b	32.75 ab
V_2S_2	232.00 a	2.40 a	5.10 a	7.50 a	32.02 cd
V_2S_3	223.00 bc	2.13 b	4.35 c	6.49 c	32.92 a
V_2S_4	216.67cd	1.93 c	4.11 d	6.05 d	31.98 cd
V_2S_5	213.33d	1.83 d	3.92 e	5.75 e	31.84 d
LSD (0.05%)	6.99	0.05	0.10	0.13	0.57
CV (%)	2.35	1.42	1.49	1.26	1.04

V_1: BARI Chola-5; V_2: BARI Chola- 9

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

4.15 Germination percentage

4.15.1 Effect of variety

Statistically significant variation was recorded in terms of germination rate of chickpea. In the experiment, BARI Chola-9 recorded higher germination rate (92.0%) whereas 86.00% germination was showed in BARI Chola-5 (Table 13).

4.15.2 Effect of sowing date

The germination rate was significantly affected by time of sowing. The maximum germination rate were recorded (98%) from the sowing date of November 20 and minimum were found (65%) from the sowing date of January 4, on the other hand statistically similar were November 05 and December 05 (Figure 15). The low temperature during late sowing period and lower seed weight period have congenial reason of decreasing the rate of germination of chickpea seeds collected from late sown condition. These results were in line with the findings of Auld *et al.* (1988) who planted 10 cultivars in late April, early May and late May and observed slower seedling emergence.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 15. Effect of sowing dates on germination percentage of chickpea (LSD $_{(0.05)}$ 2.31)

4.15.3 Combined effect of variety and sowing date

Significant interactive effect of variety and sowing date on germination was observed. The maximum germination rate was observed (99.33%) for the seeds of V_1S_2 treatment and lower germination rate were resulted (49.00%) for the seeds of V_1S_5 treatment (Table 14).

4.16 Vigor index

4.16.1 Effect of variety

There was a non-significant varietal effect found in respect of vigor index in chickpea. The maximum vigor index were found (36.26) in BARI Chola-9 whereas the minimum were found (35.80) in BARI Chola-5 (Table 13).

4.16.2 Effect of sowing date

Sowing date had significant effect on vigor index of chickpea. The maximum vigor index (38.17) was recorded in S_2 which was statistically similar with S_1. The minimum vigor index (33.83) was recorded in S_5 (Figure 16).

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 16. Effect of sowing dates on vigor index of chickpea ($LSD_{(0.05)}$ 0.84)

4.16.3 Combined effect of variety and sowing date

In case of vigor index variety and sowing date interactions were significant. The maximum vigor index (38.33) was recorded at V_2S_2 which was statistically similar with V_1S_2 and V_2S_1.The minimum vigor index (33.00) was recorded at V_1S_5 (Table 14). This finding was supported by Husnain *et al.* (2015) who reported that the maximum vigor index was obtained from early and the minimum was found in delayed sowing.

4.17 Shoot length

4.17.1 Effect of Variety

The effect of variety in respect of shoot length was found significant. BARI Chola-9 produced the higher shoot length (7.82 cm) whereas the lower length (6.17 cm) was found in BARI Chola-5 seeds (Table 13).

4.17.2 Effect of sowing date

The shoot length of chickpea seeds collected from different sowing dates had a significant effect in respect of shoot length. It was observed that shoot length of chickpea gradually decreased with the seeds of delayed sowing. Chickpea seeds were collected from November 20 sowings produced the highest shoot length (8.06 cm) which was statistically similar with the sowings time of November 5 and December 5. The minimum shoot length (4.55 cm) were found from the seeds collected from sowing date of January 4 (Figure 17).

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 17. Effect of sowing dates on shoot length of chickpea seedling ($LSD_{(0.05)}$ 1.02)

4.17.3 Combined effect of variety and sowing date

In respect to shoot length, the interaction effect of variety and sowing date was found significant. Maximum shoot length (8.84 cm) was recorded at V_2S_2 that statistically followed by V_2S_3, V_2S_1 and V_1S_1, whereas the lowest shoot length (2.77 cm) was recorded at V_1S_5 treatment (Table 14).

4.18 Root length

4.18.1 Effect of variety

The varietal effect on root length was found significant through the maximum (5.83 cm) and minimum (3.96 cm) root length was found in BARI Chola-9 and BARI Chola-5 respectively (Table 13).

4.18.2 Effect of sowing date

The different sowing dates had a significant effect on root length of chickpea seedling. Results indicated that early sown seeds (November 20) produced the highest root length (6.38 cm) and seeds of late sowing (January 04) exerted the lowest root length of 3.78 cm (Figure 18).

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 18. Effect of sowing dates on root length of chickpea seedling ($LSD_{(0.05)}$ 0.27)

4.18.3 Combined effect of variety and sowing date

Interaction between variety and sowing date significantly affected the root length of chickpea. It was shown that the maximum root length 7.04 cm was found in V_2S_2 treatment (Table 14). On the other hand, the lowest root length (2.98 cm) was found in V_1S_4 treatment which was statistically similar with the treatment V_1S_5.

4.19 Number of leaves per seedling

4.19.1 Effect of variety

Chickpea seedling was significantly affected by variety on number of leaves per seedling. BARI Chola-9 produced the higher number of leaves per seedling (4.06) while BARI Chola-5 gave lower number of leaves (3.33) per seedling (Table 13).

4.19.2 Effect of sowing date

The number of leaves per seedling was significantly differed because of sowing dates (Figure 19). It was revealed that early sowing seeds produced maximum number of leaves per plant compared to delay sowing seeds. The maximum number of leaves per seedling (3.83) was recorded in S_1 that was statistically similar with the seeds of November 20, December 20 and December 5 sowing. The lowest number of leaves per seedling (3.60) was found in January 04 sown seeds.

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 19. Effect of sowing dates on number of leaves per seedling of chickpea ($LSD_{(0.05)}$ 0. 19)

4.19.3 Combined effect of variety and sowing date

Interactive effect of varieties and sowing date remained significant in respect of number of leaves per seedling. BARI Chola-9 sown on December 20 produced maximum number of leaves per seedling (4.23), which was statistically similar with November 5, November 20 and December 5 sown seeds whereas minimum numbers of leaves per seedling (3.06) were resulted in V_1S_3 treatment that was at par with V_1S_4 treatment (Table 14).

4.20 Dry matter of seedling

4.20.1 Effect of variety

Significant differences were recorded for dry matter content in chickpea plant due to different varieties. BARI Chola-9 showed the maximum (0.95 g) whereas the minimum (0.42 g) showed by BARI Chola-5 (Table 13).

4.20.2 Effect of sowing date

Dry weight of chickpea seedling was affected significantly by the seeds of different sowing dates. Seeds of early sowing date gave higher seedling weight compared to the seeds of late sowing date. The maximum dry matter in chickpea plant (0.75 g) was recorded from S_2, which were statistically similar with S_1 and S_3 while the lowest dry matter content in plant was found (0.58) in S_5 treatment (Figure 20).

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

Figure 20. Effect of sowing dates on dry weight of chickpea seedling ($LSD_{(0.05)}$ 0.07)

4.20.3 Combined effect of variety and sowing date

Interaction of sowing date and variety was significant different on total dry matter of chickpea. The highest dry matter (1.03 g) was observed from V_2S_1 which was par at in the treatment combination of V_2S_2 and V_2S_3 whereas the lowest dry matter (0.37 g) were found in V_1S_5 which was par at in the treatment combination of V_1S_1, V_1S_2, V_1S_3 and V_1S_4 (Table 14). Ahmed *et al*. (2011) reported that total dry matter production decreased with delay in sowing which was reflected in seed yield.

Variety	Germination (%)	Vigor index	Shoot length (cm)	Root length (cm)	No. of leaves seedling^{-1}	Dry matter content (g seedling^{-1})
BARI Chola-5	86.00 b	35.80	6.17 b	3.96 b	3.33 b	0.42 b
BARI Chola-9	92.00 a	36.26	7.82 a	5.83 a	4.06 a	0.95 a
LSD $_{(0.05\%)}$	4.89	NS	0.88	0.16	0.27	0.08
CV (%)	3.50	4.73	8.05	2.39	6.18	7.65

Table 13. Effect of variety on germination, vigor, shoot length, root length, no. of leaves and dry matter content of chickpea seedling

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

Table 14. Interaction effect of variety and sowing date on germination, vigor, shoot length, root length, no. of leaves and dry matter content of chickpea seedling

Interactions	Germination (%)	Vigor index	Shoot length (cm)	Root length (cm)	No. of leaves seedling^{-1}	Dry matter content (g)
V_1S_1	95.00 bc	37.00 bc	7.76 abc	3.48 f	3.60 cd	0.44c
V_1S_2	99.33 a	38.00ab	7.28 bcd	5.71 c	3.43 de	0.47 c
V_1S_3	94.33 bc	36.33cd	6.83 cd	4.40 e	3.06 f	0.42 c

V_1S_4	92.33 c	34.66 e	6.21 d	2.98 g	3.16 ef	0.39 c
V_1S_5	49.00 e	33.00 f	2.77 e	3.26 fg	3.40 de	0.37 c
V_2S_1	94.66 bc	37.66 ab	8.23 ab	6.25 b	4.06 ab	1.03 a
V_2S_2	96.66 ab	38.33 a	8.84 a	7.04 a	4.00 abc	1.02a
V_2S_3	96.00 ab	35.66de	8.80 a	6.42 b	4.13 ab	0.99 a
V_2S_4	91.66 c	35.00 e	6.88 bcd	5.13 d	4.23 a	0.95 a
V_2S_5	81.00 d	34.66e	6.33 cd	4.30 e	3.90 bc	0.77b
LSD $_{(0.05\%)}$	3.27	1.18	1.44	0.38	0.28	0.09
CV (%)	2.12	1.90	11.95	4.51	4.28	7.90

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

V_1: BARI Chola-5; V_2: BARI Chola- 9

S_1- November 05; S_2- November 20; S_3- December 05; S_4- December 20; S_5- January 04

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during November 2014 to June 2015 to study the effect of variety and sowing date on growth, yield and seed quality of Chickpea. The experiment was laid out in split plot design with three replications. This experiment comprised as main plot- variety viz V_1- BARI Chola-5 and V_2- BARI Chola-9 assigned in main plots and sowing dates viz S_1 - November 05, S_2 - November 20, S_3–December 05, S_4 - December 20 and S_5- January 04 in subplots.

Observations were made on growth parameters such as plant height, number of branches per plant, days to flowering, days to maturity, yield parameters such as number of pods per plant, number of seeds/pod, pod length, 1000 seeds weight, seed yield, stover yield, shelling percentage, biological yield and harvest index. Seed quality characteristics of harvested seeds such as days to emergence, germination percentage, vigor index, shoot length, root length, number leaves per seedling and dry matter content of seedlings were recorded and the analyses were carried out using STATISTIX-10 computer package program. The mean differences were compared by least significant difference test (LSD) at 5 % level of significance.

Findings showed that individual effect of sowing date was significant on all selected parameters. Varietal effect was also observed significant except in respect of number of branches, days to flowering, days to maturity, shelling percentage. However, interaction of variety and sowing date significantly affected all growth, yield and quality contributing parameters of chickpea.

The highest plant height was recorded (42.66 cm) from V_2S_2 at harvest while minimum height of 28.20 cm was found from V_1S_5. At harvest, maximum number of branches per plant (9.51) was

observed from V_2S_1 which was statistically similar with V_1S_1, V_2S_2 and V_1S_2. The minimum number of branches per plant (4.87) was recorded from V_1S_5 which was statistically similar with V_2S_5. Similarly, V_1S_1 and V_2S_1 treatments showed highest flowering duration (75.33 and 75.66 days), whereas the lowest flowering duration (59.00 days) was observed from V_1S_5 treatment which was statistically similar with V_2S_5.

A general trend was observed that delaying in sowing date decreased the average number of days to maturity. The maximum maturity was recorded (121.33 days) from V_2S_1 treatment while V_1S_5 exerted minimum (87.67 days).

BARI Chola-9 produced maximum number of pods per plant (26.94) when early seed sowing was done on November 5 which was statistically similar to V_2S_1 while BARI Chola-5 produced the lower pods per plant (15.27) when delayed seed sown on January 04, which was statistically similar with V_2S_5 and V_1S_4. The longer pod length (1.75 cm) was found in BARI Chola-9 sown on 20 November and the lower (1.08 cm) in BARI Chola-5 for sowing date of 5th November. Again, V_2S_2 treatment showed the higher 1000- seed weight (232g) which was statistically similar with the treatment V_2S_1, while the lower 1000- seed weight (118.67 g) in the treatment of V_1S_5 which was statistically similar with the treatment V_1S_1, V_1S_2 and V_1S_4. Results revealed that BARI Chola-9 sown on early time (November 20) produced maximum seed yield (2.40 t ha^{-1}) while the lower (1.23 t ha^{-1}) seed yield was recorded for the BARI Chola-5 when sowing was done on January 04. Maximum stover yield (5.10 t ha^{-1}) was recorded from V_2S_2 whereas the minimum stover yield (2.93t ha^{-1}) was recorded from V_1S_5 treatment. BARI Chola-9 sown on December 05 produced maximum harvest index (32.92 %) which was statistically similar with V_1S_2 and V_1S_3, while the lowest harvest index (29.49 %) was observed in V_1S_5 treatment. However it was clear that both high yielding varieties produced maximum seed of yield, stover

yield, and harvest index as the environmental condition was suitable for plant growth and gets enough time for maturation of the plant.

The treatment V_1S_2 recorded maximum germination rate (99.33%) and the maximum vigor index (38.33) was recorded from the treatment V_2S_2. BARI Chola-9 produced the maximum shoot length (8.85 cm) sown on November 20 and BARI Chola-5 produced the lower shoot length (2.77 cm) when sowing was done on January 04. Maximum root length (6.38 cm) was observed in BARI Chola-9 for 20th November while minimum length was (3.78 cm) observed in BARI Chola-5. In addition, maximum dry matter content of seedling (1.03 g) was recorded from V_2S_1 treatment which was statistically similar with V_2S_2 whereas minimum dry matter content of seedling (0.37 g) was found from V_1S_5.

BARI Chola-9 showed better performance than BARI Chola-5. Both early and delay sowing affected the chickpea plant growth, yield and seed quality. Maximum result found in case of sowing date 20 November than others. Interaction of variety and sowing date significantly affected the seed yield. BARI Chola-9 sown on November 20 produced maximum seed yield and the lower in BARI Chola-5 for sowing on January 04.

Considering the results of the present experiment, further studies in the following areas are suggested:

- Studies of similar nature could be carried out in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of zonal adaptability.
- Other varieties with different management practice might be included in further studies.

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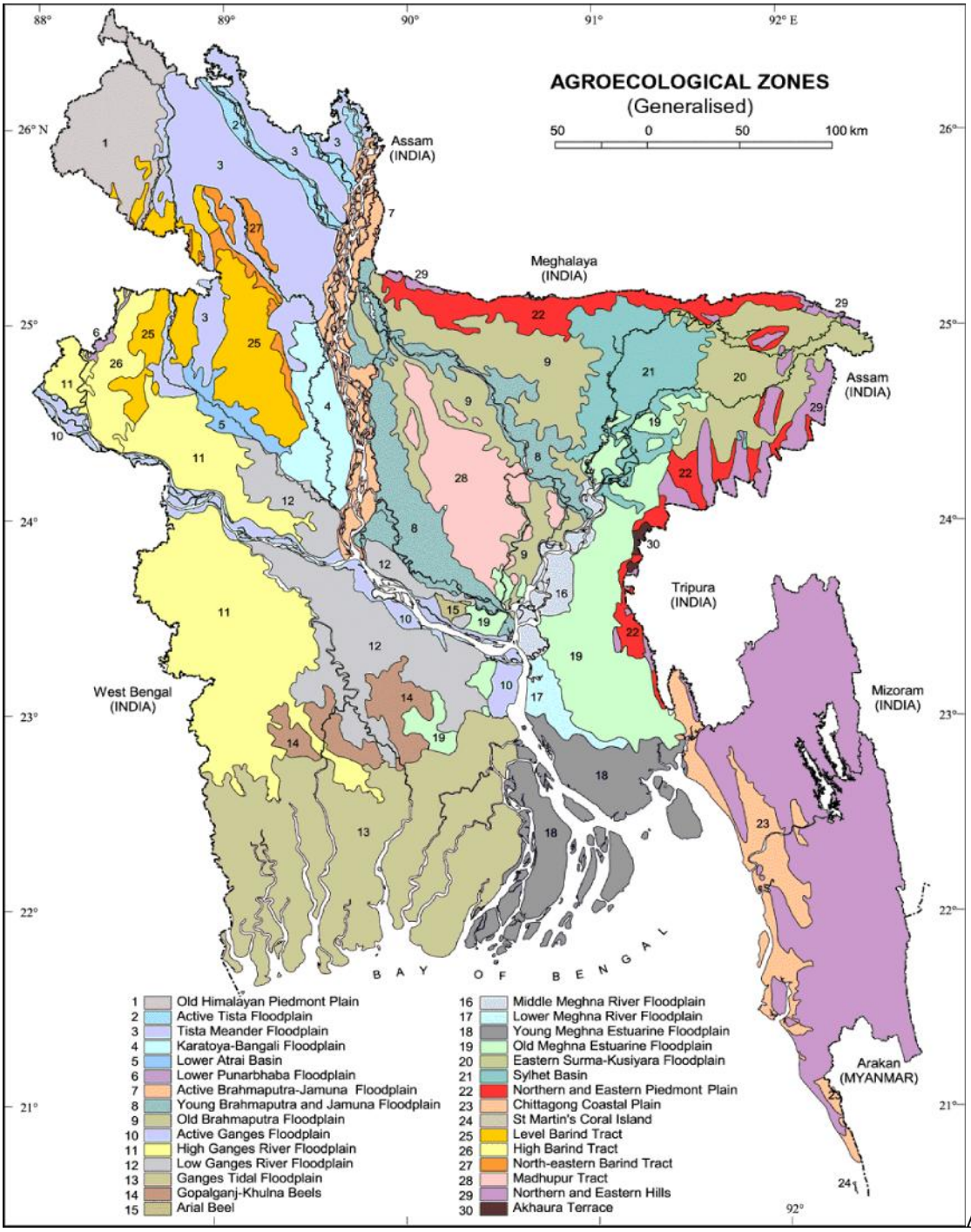
APPENDICES



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

=Experimental site

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

Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.54
Total nitrogen (%)	0.027
Phosphorus	6.3 µg/g soil
Sulphur	8.42 µg/g soil
Magnesium	1.17 meq/100 g soil
Boron	0.88 µg/g soil
Copper	1.64 µg/g soil
Zinc	1.54 µg/g soil
Potassium	0.10 meg/100g soil

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

Appendix III. Monthly average air temperature, rainfall and relative humidity of the experimental site during the period from October 2014 to March 2015

Months	Air temperature (°C)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
October, 2014	25.82	16.04	78	00
November, 2014	22.40	13.50	74	00
December, 2015	24.50	12.40	68	00
January, 2015	27.10	16.70	67	30
February, 2015	31.40	19.60	54	11
March, 2015	33.5	22.6	61	16.04

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargaon, Dhaka- 1207

APENDIX IV: Layout of experimental field

North

North

0.5 m

3.2 m						
2 m	V_2S_3 .5 m		V_1S_5		V_2S_1	
	V_2S_4		V_1S_2		V_2S_3	
	V_2S_2		V_1S_3		V_2S_4	
		1 m				
	V_2S_5		V_1S_1		V_2S_2	
	V_2S_1		V_1S_4		V_2S_5	
	1 m					
	V_1S_2		V_2S_5		V_1S_1	
	V_1S_4		V_2S_3		V_1S_5	
	V_1S_1		V_2S_2		V_1S_3	
	V_1S_5		V_2S_4		V_1S_2	
	V_1S_3		V_2S_1		V_1S_4	

25 m

11.6 m

R_1

R_2

R_3

Plot size: 3.2 m × 2.0 m; Replication: 3; Between replication: 1.0 m; Plot spacing: 50 cm

Main plot: Variety- BARI Chola-5, BARI Chola-9 Subplot: sowing time (5): 05 November (S_1), 20 November (S_2), 05 December (S_3), 20 December (S_4), 04 January ($S_{5)}$

Appendix V. Mean square values for date of emergence of chickpea

Sources of variation	Degrees of freedom	Mean square values for date of emergence at different days after sowing						
		4 DAS	5 DAS	6 DAS	7 DAS	8 DAS	9 DAS	10 DAS
Replication	2	2.80	0.53	0.90	18.23	0.23	1.63	0.10
Variety	1	40.83*	556.01*	790.50*	472.0*	326.71*	235.20*	229.63*
Error (a)	2	1.73	4.38	7.63	11.63	2.70	1.90	0.833
Sowing date	4	62.26*	135.0*	115.7*	99.28*	78.13*	80.89*	93.21*
Variety Sowing date	4	1.08*	25.75*	61.98*	21.61*	10.20*	6.78*	3.05*
Error (b)	16	1.64	1.96	7.20	4.72	1.47	2.05	1.83

* Significant at 5% level

Appendix VI. Mean square values for plant height of chickpea at different days after sowing

Sources of variation	Degrees of freedom	Mean square values for plant height at different days after sowing			
		30	**60**	**90**	**At harvest**
Replication	2	0.06	0.25	1.59	0.30
Variety	1	65.26*	109.48*	89.02*	70.31*
Error (a)	2	0.42	2.81	2.27	0.38
Sowing date	4	11.18*	79.00*	87.22*	115.87*
Variety Sowing date	4	0.10*	1.74*	14.35*	2.83*
Error (b)	16	0.58	0.25	0.43	0.41

* Significant at 5% level

Appendix VII. Mean square values for number of branches/plant of chickpea at different days after sowing

Sources of variation	Degrees of freedom	Mean square values for no. of branches/plant at different days after sowing			
		30	**60**	**90**	**At harvest**
Replication	2	0.02	0.60	0.15	0.18
Variety	1	1.08 NS	3.04 NS	0.13 NS	0.33 NS
Error (a)	2	0.06	0.35	0.06	0.07
Sowing date	4	0.57*	10.36*	12.72*	17.46*
Variety Sowing date	4	0.01*	0.04*	0.68*	0.16*
Error (b)	16	0.03	0.10	0.29	0.32

* Significant at 5% level NS = Non significant

Appendix VIII. Mean square values for days to flowering, days to maturity, days to harvesting of Chickpea

Sources of variation	Degrees of freedom	Mean square	
		Days to flowering	Days to maturity
Replication	2	41.03	24.03
Variety	1	0.83 NS	53.33 NS
Error (a)	2	4.43	27.33
Sowing date	4	203.11*	947.78*
Variety Sowing date	4	5.58 *	1.08 *
Error (b)	16	3.15	10.13

* Significant at 5% level NS = Non significant

Appendix IX. Mean square values for number of pods per plant, pod length, shelling percentage, 1000-seed weight of chickpea

Sources of variation	Degrees of freedom	Mean square			
		No. of pods per plant	Pod length	Shelling percentage	1000 seed weight (g)
Replication	2	1.26	0.025	0.22	29.2
Variety	1	36.98*	0.58*	0.25 NS	77317.6*
Error (a)	2	0.817	0.001	3.16	19.2
Sowing date	4	108.89*	0.153*	22.49*	167.4*
Variety Sowing date	4	5.18*	0.007	21.96*	42.0*
Error (b)	16	0.94	0.01	0.99	16.3

* Significant at 5% level NS = Non significant

Appendix X. Mean square values for seed yield, stover yield, biological yield and harvest index of chickpea

Sources of variation	Degrees of freedom	Mean square			
		Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.00091	0.015	0.02	0.08
Variety	1	1.41*	4.84*	11.48*	4.72*
Error (a)	2	0.00061	0.0091	0.014	0.035
Sowing date	4	0.41*	1.22*	3.03*	4.23*
Variety Sowing date	4	0.023*	0.08*	0.18*	1.57*
Error (b)	16	3.16	0.004	0.005	0.11

* Significant at 5% level

Appendix XI. Mean square values for germination percentage vigor index, shoot length of seedling, root length, dry weight of seedling of chickpea

Sources of variation	Degrees of freedom	Mean square					
		Germination percentage	Vigor index	Shoot length of seedling	Root length	Number of leaves	Dry weight of seedling
Replication	2	5.70	0.03	0.33	0.05	0.11	0.002
Variety	1	270.00*	1.63*	20.33*	26.02*	4.03*	2.144*
Error (a)	2	9.70	0.23	0.31	0.013	0.05	0.002
Sowing date	4	1107.08*	18.78*	13.49*	6.62*	0.04*	0.028
Variety Sowing date	4	320.42*	1.05*	2.28*	0.70*	0.14*	0.009*
Error (b)	16	3.57	0.46	0.69	0.048	0.025	0.002

* Significant at 5% level