GROWTH AND YIELD OF CHICKPEA AS INFLUENCED BY DIFFERENT MICRONUTRIENTS

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CERTIFICATE

This is to certify that the thesis entitled **" GROWTH AND YIELD OF CHICKPEA AS INFLUENCED BY DIFFERENT MICRONUTRIENTS"** submitted to the ***Faculty of Agriculture***, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE (M.S.) IN AGRONOMY***, embodies the results of a piece of bona fide research work carried out by ***MD. SABBIR MAHMUD***, Registration. No. 11-04725, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

(Prof. Dr. Md. Jafar Ullah)

Dated: **Professor**

Dhaka, Bangladesh **Supervisor**

DEDICATED TO

MY

BELOVED PARENTS

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GROWTH AND YIELD OF CHICKPEA INFLUENCED BY DIFFERENT MICRONUTRIENTS

ABSTRACT

An experiment was conducted at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2011 to March, 2012 to find out the influence of the different micronutrient application to chickpea crops for increased seed yield. The treatment were designed with two factors i. Cultivars; V_1= BARI Chola-6 and V_2= BARI Chola-9 and ii. Micronutrient application; F_0= Control (No fertilization), F_1= Recommended NPK + all (B,S,Zn,Mg) +Zypsum in soil, F_2= Recommended NPK + B,S,Zn,Mg (Sprey), F_3=Recommended NPK + 3 without B (Sprey), F_4= Recommended NPK + 3 without S (Sprey), F_5= Recommended NPK + 3 without Zn (Sprey), F_6= Recommended NPK + 3 without Mg (Sprey). The experiment was laid out in randomized complete block design with three replications. Results revealed that cultivars had significant effect on yield attributes and yield of chickpea. BARI Chola-6 gave maximum pods plant^{-1} (30), 1000-seed weight (117.44 g), harvest index (43.97%) as well as seed yield (1.72 t ha^{-1}) whereas BARI Chola-9 which showed lowest grain yield. In case of micronutrient application, significant variations were observed in yield attributes and yield of chickpea. F_1 () gave higher pods plant^{-1} (45.98), 1000-seed weight (122.3 g), harvest index (46.39%) as well as seed yield (2.19 t ha^{-1}) while control gave minimum yield. Out of 14 treatment combinations, BARI Chola-6 cultivated with Recommended NPK + all (B,S,Zn,Mg) +Zypsum in soil performed the best results in terms of growth and yield. The maximum pods plant^{-1} (55.57), seeds pod^{-1} (2.21), 1000-seed weight (124.3 g), harvest index (48.45 %) as well as seed yield (2.51 t ha^{-1}) were recorded in V_1F_1 () while V_2F_0 $_{()}$ minimum results.

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LIST OF ABBREVIATIONS

%	=	Percent
AEZ	=	Agro Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimetre
cv.	=	Cultivar (s)
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.	=	And Others
FAO	=	Food and Agriculture Organization
g	=	Gram
ha^{-1}	=	per Hectare
HYV	=	High Yielding Variety
plant^{-1}	=	per plant
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
t/ha	=	Tonne per Hectare

CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and the third largest produced food legume globally, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). Chickpea is grown in more than 50 countries (89.7% area in Asia, 4.3% in Africa, 2.6% in Oceania, 2.9% in Americas and 0.4% in Europe) (Gaur *et al*., 2010). The other major chickpea producing countries include India, Pakistan, Turkey, Iran, Myanmar, Australia, Ethiopia, Canada, Mexico and Iraq. Chickpea is a temperate crop though it is well adapted in tropical and sub-tropical conditions (Kay, 1979). In the tropics and sub-tropics, chickpea is normally sown in the post monsoon i.e. during rabi season. In Bangladesh, chickpea is grown on well drained alluvial to clay loam soils having pH ranging from 6.0 to 7.0.

Chickpea is an important source of protein for millions of people in the developing countries, particularly in South Asia, who are largely vegetarian either by choice or because of economic reasons. In addition to having high protein content (20-22%), chickpea is rich in fiber, minerals (phosphorus, calcium, magnesium, iron and zinc) and β-carotene. Its lipid fraction is high in unsaturated fatty acids. Chickpea plays a significant role in improving soil fertility by fixing the atmospheric nitrogen. Chickpea meets 80% of its nitrogen (N) requirement from symbiotic nitrogen fixation and can fix up to 140 kg N ha^{-1} from air. It leaves substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improve soil health and fertility. Because of its deep tap root system, chickpea can withstand drought conditions by extracting water from deeper layers in the soil profile (Gaur *et al*., 2010).

Chickpea is one of the most important pulse crops in Bangladesh after grasspea and lentil occupying third position (BBS, 2008). The area coverage under pulses is about 233000 hectare while the contribution of chickpea is about 8233 hectare with seed production of 6605 metric ton (BBS, 2010). It contributes about 20% of the pulses. The average yield of chickpea is 0.76 mt ha^{-1} (BBS, 2008). Even though, the acreage of chickpea cultivation in Bangladesh is decreasing due to less return as compared to cereal crops and also due to increase in area under boro rice, maize and potato. The increasing gap between production and demand of pulse in Bangladesh has resulted in chronic problem of malnutrition mainly due to protein deficiency. The expansion in area under chickpea is not possible as it will have a direct impact on other major crops. So, proper management should be adopted to rise per hectare yield of chickpea. The yield of chickpea in Bangladesh is lower than the other chickpea growing countries in the world. This is mainly due to the use of traditional or low yielding varieties as well as adoption of poor management practices. A considerable variation of yield may be found with use of suitable varieties (Ullah *et al.,* 2002).

Despite its importance, few studies have been conducted to analyses the application of micronutrients to chickpea. Although the chickpea is a rustic edible plant, widespread deficiencies and/or imbalances of mineral nutrients in the soils along with limited moisture supply are considered major environmental stresses leading toward yield loss in chickpea (Khan, 1998). Chickpea is mainly cultivated as a rainfed crop and water stress often affects both the productivity and the yield stability of the chickpea. Rainfed soils are generally degraded with poor native fertility. Micronutrients play an important role in increasing legume yield through their effects on the plant itself, on the nitrogen-fixing symbiotic process and the effective use of the major and secondary nutrients, resulting in high legume yields. The magnitude of yield losses due to nutrient deficiency also varies among the nutrients (Ali *et al*., 2002). Micronutrient availability for the plant depends, among other factors, texture, organic matter and, mainly, soil pH.

The main micronutrient that limits chickpea productivity is zinc (Zn) (Ahlawat *et al*., 2007). Boron (B) may cause yield losses up to 100% (Ahlawat *et al*., 2007). In general, each tonne of chickpea grain removes 38 g of Zn from the soil, and it is estimated that 35 g of B and 1.5 g of Mo are removed from the soil as well (Ahlawat *et al*., 2007).

Among micronutrients, Zn deficiency is perhaps the most widespread (Roy *et al*., 2006; Ahlawat *et al*., 2007) and is common among chickpea-growing regions of the world. Chickpea is generally considered sensitive to Zn deficiency (Khan, 1998), although there are differences in sensitivity to Zn deficiency between varieties (Khan, 1998; Ahlawat *et al*., 2007). A comparison between several crop species has shown that chickpea is more sensitive to Zn deficiency than cereal and oil seeds (Tiwari and Pathak, 1982). The critical Zn concentrations in soils vary from 0.48 mg kg^{-1} to 2.5 mg kg^{-1} depending on soil type (Ahlawat *et al*., 2007). Zn deficiency decreases crop yield and delays crop maturity. Also, Zn deficiency reduces water use and water use efficiency (Khan *et al*., 2004) and also reduces nodulation and nitrogen fixation (Ahlawat *et al*., 2007), which contributes to a decrease in crop yield.

Boron (B) which also limits chickpea productivity is a less important factor than Zn (Ahlawat *et al*., 2007). B, in acidic soils, has been shown to be a major reducer of chickpea yields in some regions (Srivastava *et al*., 1997). In comparison with others crops, the response of the crop to the application of B is higher in chickpea than in some cereals (Wankhade *et al*., 1996); although differences between chickpea cultivars concerning B deficiency have also been observed (Ahlawat *et al*., 2007). The application of B is important when the concentration of B in the soil is less than 0.3 mg kg^{-1} (Ahlawat *et al*., 2007). B deficiency also causes flower drop and, subsequently, poor podding of chickpeas (Srivastava *et al*., 1997) and poor yields.

In general, about 97% soils of Bangladesh ais deficient in Sulphur. Use of non-judicious chemical fertilizers, intensive cultivation of modern rice, higherr cropping intensity and limited use of organic matter are the most probable reasons for S deficiency. Recently farmers of Bangladesh are being adviced to use S containg fertilizer along with urea for higher yield (Anon., 1997).

Gypsum is used on these soils to improve soil structure but the responses are often short-lived (Jaywardane and Chan., 1994) and economically unsustainable. While gypsum is an excellent kick-starter, gains in crop production

Foliar fertilization and soil application are effective practices for the implementation of some micronutrients (Roy *et al*., 2006). Zn, B, S, Mo and Gypsum application results are controversial according to literature reports (Yanni, 1992; Braga and Vieira, 1998; Johansen *et al*., 2007; Shil *et al*., 2007). Also, nutrient interaction in crop plants affects yield of annual crops, this nutrient interaction can be positive, negative or neutral (Fageria *et al*., 1997). Soil, plant and climatic factors can influence interaction.

This work was conducted to determine the effect of foliar spray of B, S, Zn, Mo and Gypsum applications in soil on chickpea production with the following objectives.

- To compare the growth and yield of chickpea cultivars in the field.
- To determine the effect of micronutrient applications on growth and yield of chickpea.
- To study the combined effect of variety and micronutrient applications on the growth and yield of chickpea.

CHAPTER II

REVIEW OF LITERATURE

Chickpea is an important pulse crop in Bangladesh which can contribute largely in the national economy. In Bangladesh, chickpea crop is generally grown without fertilizer. However, there is evidence that the yield of chickpea can be increased substantially by using fertilizers (Dahiya *et al.*, 1989 and Katare *et al.*, 1984). Information related to fertilizer managements of chickpea were reviewed and presented in the following heads.

2.1. Effect of variety on growth and yield

2.1.1. Plant height

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its vicinity.

Kabir *et al.* (2009) conducted a study to see the effect of sowing time and cultivars on the growth and yield performance of chickpea under rainfed condition. The varieties showed significant difference in case of plant height and insignificant in case of total dry matter production and crop growth rate. BARI Chola-4 produced the tallest plants (32.30 cm) being closely followed by BARI Chola-2 (30.9 cm). The shortest plants (29.26 cm) were found in BARI Chola-6.

(Aliloo *et al.,* 2012) conducted an experiment to study the effects of foliar spraying of aqueous solutions 2 and 4% urea at two stages (before and after flowering) and 20 kg/ha urea application in soil (three-weed after sowing) on growth, yield and yield components of cultivars (Azad and ILC 482) under rain-fed conditions. Pant height of Azad cultivar was significantly higher than that of ILC 482.

2.1.2. Branches plant^{-1}

Nutrients help in initiation buds in plant. These buds ultimately become active branches from where leaves as the photosynthetic organ and the flowering nodes are developed. Thus it plays a vital role in increasing the crop yield.

Das (2006) showed that the total number of branches across the varieties BU Chola-1, BARI Chola-6 and BARI Chola-7 averaged from 13.78 to 15.98. BARI Chola-6 produced the highest and BARI Chola-7 produced the lowest number of branches plant^{-1}.

2.1.3. Total dry weight plant^{-1}

Das (2006) showed total dry matter is the sum of the dry matter accumulated in the various components of the plant namely leaf, petiole, stem and the reproductive parts of the plant. The pattern of dry matter production in the varieties BU Chola-1, BARI Chola-6 and BARI Chola-7 is almost similar.

2.1.4. Nodules plant^{-1}

Das *et al.* (2009) reported the number of nodules plant^{-1} across the varieties to be ranged from 5.13 to 9.88, the highest number of nodules plant^{-1} was found in the variety BARI Chola-6 and the lowest number of nodules were observed in the variety BU Chola-1.

Bhuiyan *et al.* (2009) conducted a study at a Regional Agricultural Research Station (RARS), Rahmatpur, Barisal, Bangladesh for two consecutive rabi seasons in 2002-03 and 2003-04 with a view to assessing the effect of *Rhizobium* inoculation on four cultivars of chickpea. Four chickpea cultivars, namely BARI Chola-3, BARI Chola-4, BARI Chola-5 and BARI Chola-6, were used in these trials. The variety BARI Chola-3 produced significantly higher nodule numbers (42.6).

Eusuf Zai *et al.* (1999) found significantly more nodules in variety BARI Chola-6.

2.1.5. Nodule dry weight

Das *et al.* (2009) conducted an experiment to study the effects of applied phosphorus fertilizer doses on the nodulation and yield in chickpea (*Cicer arietinum* L.) and showed variation in nodule dry weight plant^{-1} in the different varieties was observed. The dry weight of nodule plant^{-1} was 8.49 mg and 6.63 mg in BARI Chola-7 and 4.17 mg in the BU Chola-1 respectively.

Solaiman *et al.* (2007) conducted an experiment at the research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh to study the response of five chickpea (*Cicer arietinum* L) varieties to Rhizobium inoculant and mineral nitrogen on nodulation, nitrogen fixation, dry matter production, nitrogen (N) uptake, yield and quality of the crop. Among the treatments, Barichola-5 performed best in recording number and dry weight of nodules.

2.1.6. Pods plant^{-1}

Ali *et al.* (2010) experimented the performance of six brown chickpea (*Cicer arietinum* L.) genotypes viz. 90261, 93127, 97086, 98004, 98154 and Bittal-98 was tested under four NP levels (0-0, 12- 30, 24-60, 30-90 kg ha^{-1}) at Agronomic Research Institute, AARI, Faisalabad, Pakistan during 2006-07 and 2007-08. There was a linear increase in yield of all genotypes from 0-0 to 24-60 kg NP level. The differences among varietal means were non-significant during first year but significant during second year. However, on the basis of average of two years, genotype 98004 expressed comparatively more pods per plant (77.58).

2.1.7. Seeds pod^{-1}

Das (2006) showed the average number of seed pod^{-1} across the varieties to be ranged from 1.20 to 1.42 pod^{-1}. The BARI Chola-7 produced the highest and BU Chola-1 produced the lowest number of seed pod^{-1} respectively.

2.1.8. 1000-seed weight

Karasu *et al.* (2009) reported that the effects of cultivars were statistically significant at 1% probability level on the 1000 seed weight. While maximum 1000 seed weight was obtained from Canıtez- 87 cultivar (498.2 g) and popular local genotype Yerli (497.9 g), ILC-114 line had fewer 1000 seed weight (446.8 g).

2.1.9. Seed yield

Bhuiyan *et al.* (2009) conducted a trial at a Regional Agricultural Research Station (RARS), Rahmatpur, Barisal, Bangladesh for two consecutive rabi seasons in 2002-03 and 2003-04 with a view to assessing the effect of *Rhizobium* inoculation on four cultivars of chickpea. Four chickpea cultivars, namely BARI Chola-3, BARI Chola-4, BARI Chola-5 and BARI Chola-6, were used in these trials. The seed yields of the BARI Chola-5 and BARI Chola-6 variety (1.80 t/ha and 1.85 t/ha) were increased by 20.0% and 19.4% over uninoculated treatments for two consecutive rabi seasons in 2002-03 and 2003-04.

Das (2006) showed that the average yield ha^{-1} among the varieties was 608.18 kg in BU Chola-1, 641.87 kg in BARI Chola-6 and 661.16 kg in BARI Chola-7 respectively.

Kabir *et al.* (2009) found that the heaviest seed weight was observed in BARI Chola-6 and lowest seed weight was observed in BARI Chola-4, which was statistically at par with BARI Chola-2, which might be due to genotypic variation. The highest seed yield per plant was found in BARI Chola-4, which was statistically similar with BARI Chola-2.

2.1.11. Harvest index

Das *et al.* (2009) stated that the highest harvest index (37.68 %) was found in the variety BARI Chola-7 and the lowest (36.28 %) in the variety BARI Chola-6.

2.2. Effect of micronutrient on growth and yield

2.2.1. Plant height

Tahir1 *et al.* (2013) conducted a field study at Agronomic Research Area, University of Agriculture, Faisalabad to evaluate the production potential of mungbean (*Vigna radiata* L.) in response to sulphur and boron. In this experiment the genotype NIAB Mung-2006 was sown in first week of March. The treatments comprised four sulphur levels i.e. 0, 12, 24 and 36 kg ha^{-1} (Factor A) and three boron levels i.e. 0, 4 and 8 kg ha^{-1} (Factor B). Gypsum was used as sulphur source and boric acid for boron. Experiment was laid out in Randomized Complete Block Design (RCBD) in factorial arrangement with three replications. It appeared that sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1} significantly increased plant height (58.30 cm). Maximum net income was also obtained by application of sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1}.

Farhad *et al.* (2010) conducted a field experiment at Sher-e-Bangla Agricultural University Farm, Dhaka 1207 during the period from December 2008 to April 2009 to study the role of potassium and sulphur on the growth, yield and oil content of soybean (*Glycine max* var. BARI Soybean-5). The experimental soil was clay loam in texture having pH of 6.3. The experiment included four levels of potassium viz. 0, 20, 40 and 70 kg K ha 1 and four levels of sulphur viz. 0, 10, 20 and 40 kg S ha^{-1}. Sulphur fertilizer also had significant effect on yield and yield attributes of soybean. Application of sulphur @ 20 kg ha^{-1} produced the highest plant height, seed yield, 1000-seed weight and straw yield. On the other hand, in all the cases the lower response was found from the control treatment.

Bozoglu *et al*. (2007) set a trial on neutral pH soil, the Zn × Mo interaction had no significant effect on the chickpea growth was not recorded. Shil *et al*. (2007) found that there was an interaction effect of B and Mo but the interaction was only for plant height.

Hosseini *et al*. (2007) showed the interaction effect of Zn and B on plant growth, when the availability of Zn and B is low, has also been documented in other crops.

Johansen *et al*. (2007) reported that micronutrient application could improve the growth of chickpea.

Masood Ali and Mishra (2001) reported that foliar application of boron and molybdenum brought significant improvement in plant height in chickpea.

Pandian *et al*. (2001) reported that application of basal dose of fertilizer along with 2 per cent DAP sprayed twice registered higher plant height (73.5 cm) and net return per rupee invested in greengram.

Ramesh and Thirumurugan (2001) stated that foliar applications of 2% DAP and 1 % KCl along with benzyladenine 25 ppm had significantly increased the plant height in soybean.

Srivastava and Srivastava, (1994) reported that foliar spray of 2 per cent DAP twice with recommended dose of fertilizer recorded the maximum plant height of chickpea.

2.2.2. Branches plant^{-1}

Tomer *et al.* (1997) observed that plant growth of mustard increased with increase in S rates**.**

2.2.3. Total dry weight plant^{-1}

Bhanavase and Patil, 1994; Johansen *et al*. (2007) reported that the plant growth was affected by the Mo application; at maturity result in greater total DM production.

Ahlawat *et al*. (2007) found that the DM production increase, with increased Mo supply, was mostly due to the increase in the number of pods (including seeds) per plant, due to more flower production. The treatments influenced dry water (DW) partitioning between plant organs.

Khan *et al*. (2000) showed that the growth and yield characteristics were found to be affected by the Zn application. The soil Zn application increased plant growth.

Brennan *et al*. (2001) reported that at maturity plants that were fertilized with Zn had a greater total production of DM. The DM production increase, with increased Zn supply, was mostly due to the increase in the number of pods (including seeds) per plant. The roots treatments influenced the DW partitioning between plant organs.

Ahlawat, 1990 reported that the plant growth was also found to be affected by the B application; at maturity plants fertilized with B had greater total DM production, plant growth increases when the availability of B improves.

2.2.4. Pods plant^{-1}

Tahir1 *et al.* (2013) conducted a field study at Agronomic Research Area, University of Agriculture, Faisalabad to evaluate the production potential of mungbean (*Vigna radiata* L.) in response to sulphur and boron. In this experiment the genotype NIAB Mung-2006 was sown in first week of March. The treatments comprised four sulphur levels i.e. 0, 12, 24 and 36 kg ha^{-1} (Factor A) and three boron levels i.e. 0, 4 and 8 kg ha^{-1} (Factor B). Gypsum was used as sulphur source and boric acid for boron. Experiment was laid out in Randomized Complete Block Design (RCBD) in factorial arrangement with three replications. It appeared that sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1} significantly increased number of pods plant^{-1} (21.33). Maximum net income was also obtained by application of sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1}.

Valenciano *et al.* (2010) set a experiment to find out the response of chickpea to the applications of Zn, B and Mo was studied in pot experiments with natural conditions and acidic soils in northwest Spain from 2006 to 2008 following a factorial statistical pattern (5 × 2 × 2) with three replicates. Five concentrations of Zn (0, 1, 2, 4 and 8 mg Zn pot^{-1}), two concentrations of B (0 and 2 mg B pot^{-1}), and two concentrations of Mo (0 and 2 mg Mo pot^{-1}) were added to the pots. Chickpea responded to the Zn, B and Mo applications. There were differences between soils. The Zn, B and Mo applications improved seed yield, mainly due to the number of pods per plant.

2.2.5. Seeds pod^{-1}

2.2.6. 1000-seed weight

Tahir1 *et al.* (2013) conducted a field study at Agronomic Research Area, University of Agriculture, Faisalabad to evaluate the production potential of mungbean (*Vigna radiata* L.) in response to sulphur and boron. In this experiment the genotype NIAB Mung-2006 was sown in first week of March. The treatments were comprised of four sulphur levels i.e. 0, 12, 24 and 36 kg ha^{-1} (Factor A) and three boron levels i.e. 0, 4 and 8 kg ha^{-1} (Factor B). Gypsum was used as sulphur source and boric acid for boron. Experiment was laid out in Randomized Complete Block Design (RCBD) in factorial arrangement with three replications. It appeared that sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1} significantly increased 1000-seed weight (35 g). Maximum net income was also obtained by application of sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1}.

Farhad *et al.* (2010) conducted a field experiment at Sher-e-Bangla Agricultural University Farm, Dhaka 1207 during the period from December 2008 to April 2009 to study the role of potassium and sulphur on the growth, yield and oil content of soybean (*Glycine max* var.BARI Soybean-5). The experimental soil was clay loam in texture having pH of 6.3. The experiment included four levels of potassium viz. 0, 20, 40 and 70 kg K ha^{-1} and four levels of sulphur viz. 0, 10, 20 and 40 kg S ha^{-1}. Sulphur fertilizer also had significant effect on yield and yield attributes of soybean. Application of sulphur @ 20 kg ha^{-1} produced the highest plant height, seed yield, 1000-seed weight and straw yield. On the other hand, in all the cases the lesser response was found from the control treatment.

Chaubey *et al.* (2000) reported that number of primary branches, pod $plant^{-1}$, plant height, 100-kernel weight of groundnut were significantly higher by the application of sulphur.

Singh and Yadav (1997) stated sulphur significantly increased the 1000-seed weight in mungbean. Dubey *et al*. (1997) reported that sulphur enhanced the branches plant^{-1}, seed capsule^{-1} and 1000 grain weight of lentil.

Chowdhury *et al*. (1995) reported that number of effective tiller hill^{-1} and 1000 grain weight of rice were increased by sulphur.

2.2.7. Seed yield

EL-Kader and Mona (2013) conducted an experiment during the summer seasons of 2011 and 2012 on peanut (*Arachis hypogaea* L.) cv. (Giza 6) grown in a sandy soil at a farm at El-Quassasin region, Ismailia Governorate, Egypt, to study the effect of sulfur (S) application at rate of 200kg/fed, foliar spraying with Zn, B and their combinations on yield and its components as well as seed quality and some chemical contents of seeds. The experiment was designed in complete randomized blocks with three replicates. Results indicated that, application of sulfur (S) and foliar spraying with micronutrient (Zn and B) together had the significant effect on peanut seed yield and its attributes as well as seed quality. The highest values of available Zn and B were obtained due to the application of sulfur (S).

Tahir1 *et al*. (2013) conducted a field study at Agronomic Research Area, University of Agriculture, Faisalabad to evaluate the production potential of mungbean (*Vigna radiata* L.) in response to sulphur and boron. In this experiment the genotype NIAB Mung-2006 was sown in first week of March. The treatments comprised four sulphur levels i.e. 0, 12, 24 and 36 kg ha-1 (Factor A) and three boron levels i.e. 0, 4 and 8 kg ha^{-1} (Factor B). Gypsum was used as sulphur source and boric acid for boron. Experiment was laid out in Randomized Complete Block Design (RCBD) in factorial arrangement with three replications. It appeared that sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1}

significantly increased seed yield (1200 kg ha^{-1}). Maximum net income was also obtained by application of sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1}.

Valenciano *et al*. (2010) set an experiment to find out the response of chickpea to the applications of Zn, B and Mo was studied in pot experiments with natural conditions and acidic soils in northwest Spain from 2006 to 2008 following a factorial statistical pattern (5 × 2 × 2) with three replicates. Five concentrations of Zn (0, 1, 2, 4 and 8 mg Zn pot^{-1}), two concentrations of B (0 and 2 mg B pot^{-1}), and two concentrations of Mo (0 and 2 mg Mo pot^{-1}) were added to the pots. Chickpea responded to the Zn, B and Mo applications. The Zn, B and Mo applications improved seed yield, mainly due to the number of pods per plant. This was the yield component that had the most influence on, and the most correlation with seed yield. The highest seed yield was obtained from the Zn4 × B2 × Mo2 treatment (4.00 g $plant^{-1}$) while the lowest was obtained from the Zn0 × B0 × Mo treatment (2.31 g $plant^{-1}$).

Farhad *et al.* (2010) conducted a field experiment at Sher-e-Bangla Agricultural University Farm, Dhaka 1207 during the period from December 2008 to April 2009 to study the role of potassium and sulphur on the growth, yield and oil content of soybean (*Glycine max* var.BARI Soybean-5). The experimental soil was clay loam in texture having pH of 6.3. The experiment included four levels of potassium viz. 0, 20, 40 and 70 kg K ha^{-1} and four levels of sulphur viz. 0, 10, 20 and 40 kg S ha^{-1}. Sulphur fertilizer also had significant effect on yield and yield attributes of soybean. Application of sulphur @ 20 kg ha^{-1} produced the highest plant height, seed yield, 1000-seed weight and straw yield. On the other hand, in all the cases the lower response was found from the control treatment.

Ahlawat *et al*. (2007) set an experiment in Mo-deficient chickpea, the flowers produced were found to be less in number, smaller in size and many of them failed to open or to mature, consequently leading to lower seed yield.

Khan *et al*. (2004) Zn deficiency decreases crop yield and delays crop maturity. Also, Zn deficiency reduces water use and water use efficiency and also reduces nodulation and nitrogen fixation (Ahlawat *et al*., 2007), which contributes to a decrease in crop yield.

Mondal *et al*. (2003) reported that sulphur was found to significantly increase the seed yield.

Tabatabaei, (1986) showed the role of sulfur in increasing seed yield in addition to its direct role in plant nutrition may be due to improving soil reaction and it was that sulfur application caused an increase in the absorbable phosphorous of the soil. Similar finding was also reported by Sarkar *et al.,* (2000).

Sarker *et al.* (2000) conducted a field experiment to find out the effect of sulphur and boron fertilization on yield of soyabean. He found that grain yield showed a significant variation for different sulphur level. He reported that grain yield increased with S and B application up to 30 kg ha^{-1}.

2.2.8. Stover yield

Tahir1 *et al.* (2013) conducted a field study at Agronomic Research Area, University of Agriculture, Faisalabad to evaluate the production potential of mungbean (*Vigna radiata* L.) in response to sulphur and boron. In this experiment the genotype NIAB Mung was sown in first week of March. The treatments comprised four sulphur levels i.e. 0, 12, 24 and 36 kg ha-1 (Factor A) and three boron levels i.e. 0, 4 and 8 kg ha-1 (Factor B). Gypsum was used as sulphur source and boric acid for boron. Experiment was laid out in Randomized Complete Block Design (RCBD) in factorial arrangement with three replications. It appeared that sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1} significantly increased biological yield (7688 kg ha^{-1}). Maximum net income was also obtained by application of sulphur at 24 kg ha^{-1} and boron at 4 kg ha^{-1}.

Farhad *et al.* (2010) conducted a field experiment a at Sher-e-Bangla Agricultural University Farm, Dhaka 1207 during the period from December 2008 to April 2009 to study the role of potassium and sulphur on the growth, yield and oil content of soybean (*Glycine max* var.BARI Soybean-5). The experimental soil was clay loam in texture having pH of 6.3. The experiment included four levels of potassium viz. 0, 20, 40 and 70 kg K ha^{-1} and four levels of sulphur viz. 0, 10, 20 and 40 kg S ha^{-1}. Sulphur fertilizer also had significant effect on yield and yield attributes of soybean. Application of sulphur @ 20 kg ha^{-1} produced the highest plant height, seed yield, 1000-seed weight and straw yield. On the other hand, in all the cases the lower response was found from the control treatment.

Sarker *et al.* (2000) conducted a experiment to find out the effect of sulphur and boron fertilization on yield of soyabean. He found that higher straw yield was recorded due to sulphur application. He also showed that straw yield positively influenced by Boron application. Interaction effect of Sulphur and Boron also significantly influenced on straw yield.

Bhuiyan *et al.* (1998) reported that Boron produced higher straw yield on lentil.

Tomer *et al*. (1997) observed that straw yields of mustard increased with increase in S rates. He also showed that boron has significantly influence on straw yield.

2.2.9. % Harvest index (HI)

Valenciano *et al.* (2010) set an experiment to find out the response of chickpea to the applications of Zn, B and Mo was studied in pot experiments with natural conditions and acidic soils in northwest Spain from 2006 to 2008 following a factorial statistical pattern (5 × 2 × 2) with three replicates. Five concentrations of Zn (0, 1, 2, 4 and 8 mg Zn pot^{-1}), two concentrations of B (0 and 2 mg B pot^{-1}), and two concentrations of Mo (0 and 2 mg Mo pot^{-1}) were added to the pots. Chickpea responded to the Zn, B and Mo applications. There were differences between soils. The mature plants fertilized with Zn, with B and with Mo had a greater total dry matter production. Harvest Index (HI) was improved with the Zn application and with the Mo application. The highest HI was obtained with the Zn4× B2 × Mo2 treatment (60.30%) while the smallest HI was obtained with the Zn0 × B0 × Mo0 treatment (47.65%).

Ahlawat *et al*. (2007) reported that with the increase in the application of Mo, HI increased, the increase in HI was mainly attributed to the increase in seed production.

Johnson *et al.* (2005) carried out a field experiment over two seasons to compare soil fertilization and micronutrient seed priming as methods of improving Zn and B nutrition of each crop. Micronutrient treatments were evaluated for their effect on grain yield and grain micronutrient content. Soil B fertilization increased B content of the grain of lentil (*Lens culinaris*), chickpea (*Cicer arietinum*), increasing the yield of chickpea only.

Tripathi *et al*. (1997) said that HI increased with an increase in the application of Zn but decreased when 8 mg of Zn were applied to each pot, (). High Zn applications also decreased the plant yield slightly.

Ganie *et al*. (2014) conducted an experiment during *Kharif* 2011 to study the effect of sulphur and boron application on nutrient content and uptake pattern of N, P, K, S and B in French bean. The result showed that increase in application of sulphur led to an increase in the concentration and in turn uptake of N, P, K, S and B in pods, seeds as well as stover were increased up to 45 Kg/ha. However, the increase in nutrient concentration and uptake parameters with the increase in sulphur from 30 Kg/ha to 45 Kg/ha showed no significant difference. Owing to boron application was also found increase in N, P, K, S and B concentration and their uptake by the crop. The interaction effect between sulphur and boron significantly and synergistically increased N, P, K, S and B content and uptake of french bean at pod picking stage as well as harvesting stage. However, it was found that higher levels of sulphur and boron showed antagonistic effect on nutrient content and uptake of French bean at pod picking stage as well as harvesting stage. The study suggested that soil application of sulphur and boron in inceptisols of Kashmir valley increased the availability of primary nutrients in addition to sulphur and boron causing their absorption by French bean plant.

CHAPTER III

MATERIALS AND METHODS

This chapter has been written on different resources, cultural managements, data collection and statistical analysis required in this experiment. The experiment was conducted during the period from November, 2011 to March, 2012 to study the response of chickpea varieties to different micro-nutrients managements. The details materials and methods of this experiment are presented below under the following headings:

3.1. Experimental site

The present research work conducted at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka. The experimental area was situated at $23^0$77′ N latitude and $90^0$33′ E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004).

3.2. Soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment (Edris *et al.*, 1979).

3.3. Climate

The climate of experimental site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October.

3.4. Planting materials

The crop used in this study was two cultivars of chickpea viz., BARI Chola-6 and BARI Chola-9. BARI Chola-6 and BARI Chola-9 varieties have been developed by the Bangladesh Agricultural Research Institute (BARI) for cultivation in this country. The seeds were collected from BARI, Joydebpur, Gazipur. The seeds were healthy, pulpy, well matured and free from mixture of other seeds, weed seeds and extraneous materials.

3.5. Land preparation

Power tiller was used for the preparation of the experimental field. Then it was exposed to the sunshine for 5/6 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed and deep ploughing was done to obtain good tilth, which was necessary to get better yield of this crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubble were removed from the experimental field. The plots were spaded one day before planting and the fertilizers were incorporated thoroughly as per treatment before planting according to fertilizers recommendation guide (BARC, 2011).

3.6. Fertilizers application

Urea, Triple super phosphate (TSP) and Muriate of potash (MoP) were used as a source of nitrogen, phosphorous and potassium, respectively in the experimental plot.

The applied fertilizers were mixed properly with soil in the plot using a spade.

Fertilizer	Dose (kg ha^{-1})
N	32
P	28
K	48
S	24
Zn	3.0
B	1.5
Mo	0.6

Source: *BARC, 2012.*

During land preparation TSP, MoP and half of urea used as basal dose, rest of urea applied in two split. The micro nutrients were applied according to treatment.

3.7. Treatments of the experiment

The experiment consisted of two factors as follows:

Factor A: Cultivar-2

V_1= BARI Chola-6

V_2= BARI Chola-9

Factor B: Micronutrient-7

F_0= Control (No fertilizer)

F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil

F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray

F_3= F_2 without B

F_4= F_2 without S

F_5= F_2 without Zn

F_6= F_2 without Mg

3.8. Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (Factorial) with three replications. Each block was divided into 14 plots where 14 treatment combinations were allotted at random. The unit plot size was 4 m × 2.5 m. The space between two blocks and two plots were 1.5 m and 0.50 m, respectively.

3.9. Sowing of seeds in the field

Seeds were sown on 17th November 2012. Row to row and plant to plant distances were 40 cm and 10 cm, respectively. Seeds were placed at about 2-3cm depth from the soil surface.

3.10. Intercultural operations

3.10.1. Thinning

Emergence of seedling was completed within 10 days after sowing. Over crowded seedling were thinned out two times. First thinning was done after 15 days of sowing which was done to remove unhealthy and lineless seedlings. The second thinning was done 10 days after first thinning.

3.10.2. Weeding

First weeding was done at 20 DAS and then second weeding at 40 DAS.

3.10.3. Irrigation

The irrigation was done as per requirement. Water application was continued till soil saturation.

3.10.4. Disease and pest management

The research field looked nice with normal green plants. The field was observed time to time to detect visual difference among the treatments and any kind of infestation. The experimental crop was not infected with any disease and no fungicide was used. Hairy caterpillars attacked the young plants and accumulated on the lower surface of leaves where they usually sucked juice of green leaves. Borers also attacked the pods. To control these pests, the infected leaves were removed from the stem and destroyed together with insects by hand picking. Beside, spraying Pyriphos to control these insects. The insecticide was sprayed two times at seven days interval.

3.11. Harvesting and threshing

Harvesting of the crop was done after 120 days of sowing for data collection when about 80% of the pods attained maturity. After germination 2 m^2 area from middle portion of each plot was marked for harvest at maturity. The harvested plants of 2 m^2 of each treatment were brought to the cleaned threshing floor and separated pods from plants by hand and allowed them for drying well under bright sunlight.

3.12. Sampling and data collection

The data of the different parameters of chickpea were collected from randomly selected ten plant samples which were collected from each plot excluding border lines. The sample plants were uprooted carefully from the soil. Plant height, branches plant^{-1}, above ground dry weight, nodules plant^{-1} and nodule dry weight plant^{-1} were recorded form selected plants at an interval of 20 days started from 20 DAS (for plant height) and 40 DAS (for others) up to harvest. Yield and yield contributing parameters were recorded from the remarked plants from the central part (2m^2) of the plots. A brief outline of the data recording on morpho-physiological and yield contributing characters are given below.

3.12.1. Plant height (cm)

Plant height was measured in centimeter by a meter scale at harvest period from the ground surface to the top of the main shoot and the mean height was expressed in cm.

3.12.2. Branches plant^{-1} (no.)

Number of branches per plant was counted from selected plants. The average number of branches per plant was determined.

3.12.3. Total dry weight plant^{-1} (g)

The plant dry matter was taken by oven dry method. Collected plants including roots, stem and leaves was oven dried at 70˚ C for 72 hours then transferred into desiccator and allowed to cool down to the room temperature and final weight was taken and converted into total dry matter per plant.

3.12.4. Nodules plant^{-1} (no.)

Nodules were collected from ten randomly selected plants. The nodules per plant were calculated from their mean values.

3.12.5. Nodule dry weight plant^{-1} (g)

Counted nodules were dried in an oven and the nodule dry weight plant^{-1} was measured.

3.12.6. Pods plant^{-1} (no.)

The pods from the branches of the selected ten plants were counted and the number of pods per plant was calculated from their mean values.

3.12.7. Seeds pod^{-1} (no.)

Number of seeds per pod was recorded from the selected 20 pods at the time of harvest. The seed per pod was calculated from their mean values.

3.12.8. 1000-seed weight (g)

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

3.12.9. Seed yield and stover yield (t ha^{-1})

The seed weight was taken from the selected plants having threshed properly and then yield was expressed in kg per hectare. Stover weight was taken without seed and converted to kg per hectare.

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

The summation of economic yield (grain yield) and biomass yield (stover yield) was considered as biological yield. Biological yield was calculated by using the following formula:

Biological yield= Grain yield + Stover yield (dry weight basis)

3.12.11. Harvest index (%)

It is the ratio of economic yield (grain yield) to biological yield and was calculated with the following formula:

$$\% \text{ Harvest index (HI)} = \frac{\text{Economic yield}}{\text{Biologicalyield}} \times 100$$

3.13. Statistical analysis

The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program designed by (Fread, 1986). The mean values for all the parameters were analyzed by Duncan’s Multiple Range Test (DMRT) at 5% levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises presentation and discussion of the results obtained from a study to investigate the influence of different micronutrients on the growth, development and yield of chickpea variety cv. BARI Chola-5 and BARI Chola-9. The results of the growth and yield characters of the production of the crop as influenced by different micronutrient treatments have been presented and discussed in this chapter.

4.1 Plant height (cm)

4.1.1 Effect of variety

Plant height varied significantly due to variety treatments (Figure 1). Plant height increased with days after sowing. It was observed that BARI Chola-6 (V_1) produced the highest plant height at 40, 60, 80 and 100 DAS and BARI Chola-9 (V_2) produced the lowest plant height at 40, 60 80 and 100 DAS. Result shows that BARI Chola-6 (V_1) produced 19.57%, 9.88 %, 3.55 % and 11.78 % more plant height at 40, 60 80 and 100 DAS respectively than BARI Chola-9 (V_2).

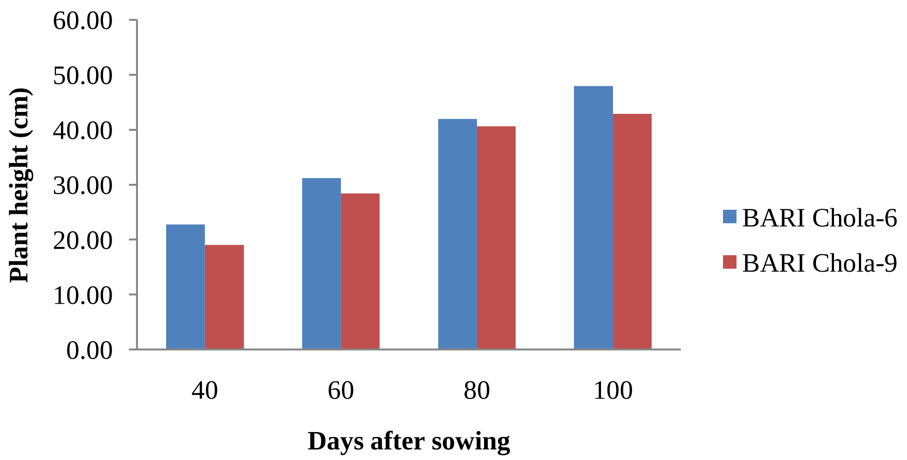


Figure 1. Effect of variety on the plant height of chickpea at different days after sowing

[SE value = 0.68, 0.49, 0.73 and 0.65 at 40, 60, 80 and 100 DAS, respectively]

4.1.2 Effect of micronutrients

Plant height varied significantly due to various micronutrient treatments (Figure 2). It was observed that at 40 DAS F_2 produced the highest (23.58 cm) plant height which was statistically similar with F_1, F_3, F_4 and F_5. At 60 DAS, F_2 produced the highest (33.42 cm) plant height which was statistically similar with F_1. At 80 DAS, F_2 produced the highest (46.36 cm) plant height which was statistically similar with F_1 and F_4. At 100 DAS, F_2 produced the highest (50.28 cm) plant height which was statistically similar with F_1. Application of Zn, B along with other fertilizers resulted in increased plant height, which was reported by Valenciano *et al.* (2010). Control plant produced the lowest plant height at 40, 60 80 and 100 DAS. Almost similar results were obtained by Kaisher *et al.* (2010). Such result might be due to the fact that sulphur is involved in chlorophyll formation which enhanced vegetative growth resulting in increased plant height. The increase in plant height may be due to boron which is involved in development and differentiation of tissue, enhance plant growth and ultimately plant height is increased. Yang *et al.* (1998) observed that seedling height was increased by boron application.

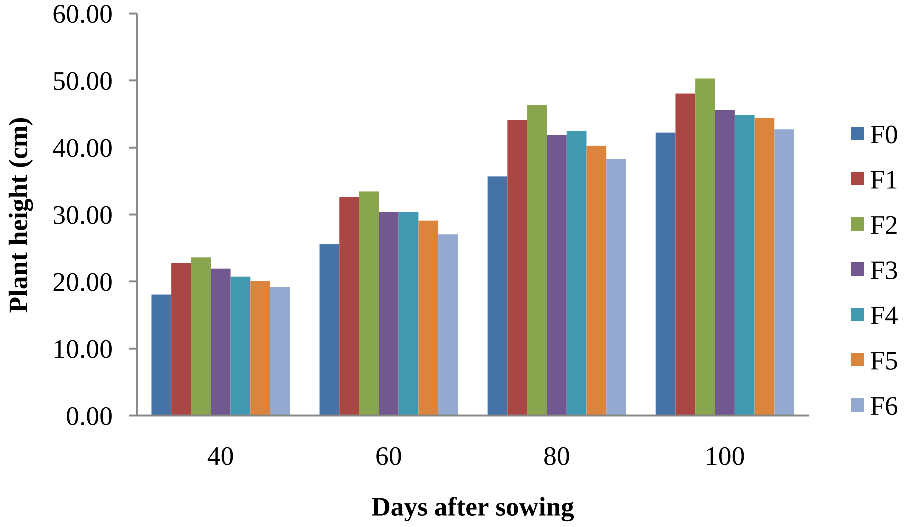


Figure 2. Effect of micronutrients on the plant height of chickpea at different days after sowing

[SE value = 1.28, 0.92, 1.38 and 1.22 at 40, 60, 80 and 100 DAS, respectively]

4.1.3 Interaction effect of variety and micronutrients

Plant height did not vary significantly due to various treatment combinations of variety and micronutrients (Table 1). Numerically, the treatment combination of V_1F_2 produced the highest plant height at 40, 60, 80 and 100 DAS. However, the treatment combination of V_2F_0 produced the lowest plant height at 40, 60, 80 and 100 DAS.

Table 1. Interaction effect of variety and micronutrient on the plant height of chickpea at different days after sowing

Treatments	Days after sowing			
	40	**60**	**80**	**100**
V_1F_0	19.88	25.66	36.33	43.99
V_1F_1	25.04	33.84	44.89	50.91
V_1F_2	24.84	34.66	47.50	52.23
V_1F_3	24.06	32.40	43.35	48.85
V_1F_4	22.75	32.39	42.95	47.75
V_1F_5	21.61	31.25	40.13	47.62
V_1F_6	21.21	28.04	38.66	44.40
V_2F_0	16.26	25.47	35.04	40.48
V_2F_1	20.57	31.29	43.33	45.24
V_2F_2	22.31	32.17	45.23	48.33
V_2F_3	19.81	28.33	40.38	42.29
V_2F_4	18.76	28.33	41.99	41.93
V_2F_5	18.50	26.95	40.39	41.09
V_2F_6	17.09	26.06	37.92	41.00
SE	ns	ns	ns	ns
CV (%)	14.98	7.55	8.16	6.59

V_1=BARI Chola-6, V_2=BARI Chola-9, F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

4.2 Number of branches

4.2.1 Effect of variety

Number of branches of chickpea varied significantly due to variety treatments (Figure 3). Number of branches of chickpea increased with days after sowing. It was observed that BARI Chola-9 (V_2) produced the highest number of branches at 40, 60, 80, 100 DAS and at harvest. However, BARI Chola-6 (V_1) produced the lowest plant height at 40, 60, 80, 100 DAS and at harvest. Result shows that BARI Chola-9 (V_2) produced 27.86 %, 22.33 %, 22.82 %, 16.57 % and 16.13 % more branches at 40, 60 80, 100 DAS and at harvest respectively than BARI Chola-6 (V_1).

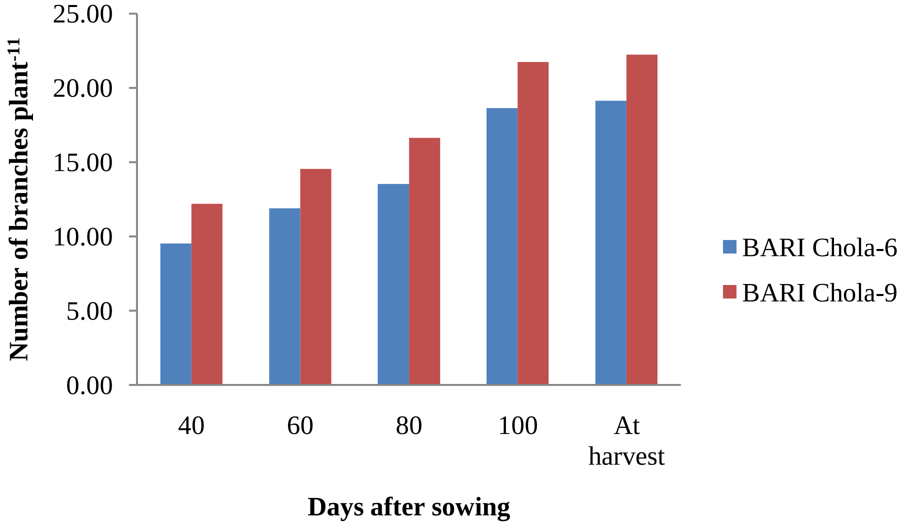
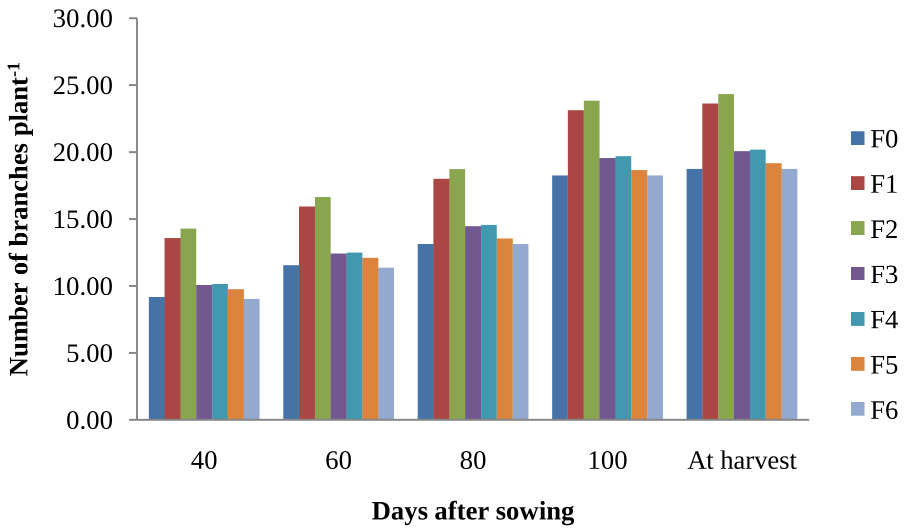


Figure 3. Effect of variety on the number of branches of chickpea at different days after sowing

[SE value = 0.84, 1.58, 0.93, 0.93 and 0.93 at 40, 60, 80, 100 DAS and at harvest, respectively]

4.2.2 Effect of micronutrients

Number of branches of chickpea did not varied significantly due to various micronutrient treatments (Figure 4). Numerically F_2 produced the highest number of branches of chickpea at 40, 60, 80 and 100 DAS. At harvest, F_1 produced the highest number of branches numerically. It may be due to sulphur, which is involved chlorophyll formation, seed formation and vegetative growth and thereby increase the number of pod bearing branches. These results are in agreement with Singh and Yadav, (1997). Valenciano *et al.* (2010), Khan *et al*., 2004 and Ahlawat *et al*. (2007) also found similar results.



F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

Figure 4. Effect of micronutrients on the number of branches of chickpea at different days after sowing

[SE value = 1.58, 1.58, 1.74, 1.74 and 1.74 at 40, 60, 80, 100 DAS and at harvest, respectively]

4.2.3 Interaction effect of variety and micronutrients

Number of branches did not vary significantly due to various treatment combinations of variety and micronutrients (Table 1). Numerically, the treatment combination of V_2F_2 produced the highest number of branches at 40, 60, 80, 100 DAS and at harvest. However, V_1F_3 produced the lowest number of branches at 40 and 60 DAS. At 80,100 DAS and at harvest the treatment combination of V_1F_6 produced the lowest number of branches of chickpea.

Table 2. Interaction effect of variety and micronutrient on the number of branches of chickpea at different days after sowing

Treatments	Days after sowing				
	40	60	80	100	At harvest
V_1F_0	8.207	10.57	11.69	16.80	17.30
V_1F_1	13.09	15.45	17.53	22.64	23.14
V_1F_2	13.89	16.25	18.33	23.44	23.94
V_1F_3	6.923	9.283	11.23	16.34	16.84
V_1F_4	9.393	11.75	13.83	18.94	19.44
V_1F_5	8.013	10.37	11.17	16.28	16.78
V_1F_6	7.213	9.573	10.99	16.10	16.60
V_2F_0	10.14	12.50	14.58	19.69	20.19
V_2F_1	14.06	16.42	18.50	23.61	24.11
V_2F_2	14.70	17.06	19.14	24.25	24.75
V_2F_3	13.23	15.59	17.67	22.78	23.28
V_2F_4	10.86	13.22	15.30	20.41	20.91
V_2F_5	11.50	13.86	15.94	21.05	21.55
V_2F_6	10.83	13.19	15.27	20.38	20.88
SE	ns	ns	ns	ns	Ns
CV (%)	35.7	29.33	28.21	21.07	20.56

V_1=BARI Chola-6, V_2=BARI Chola-9, F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

4.3 Number of nodules plant^{-1}

4.3.1 Effect of variety

Number of nodules plant^{-1} of chickpea varied significantly due to variety treatments (Figure 5). It was observed that BARI Chola-6 (V_1) produced the highest number of nodules plant^{-1} at 60, 80, 100 DAS and at harvest. However, BARI Chola-9 (V_2) produced the lowest number of nodules plant^{-1} at 60, 80, 100 DAS and at harvest. Result shows that BARI Chola-6 (V_1) produced 35.2 %, 28.88 %, 17.33 %, and 20.79 % more nodule plant^{-1} at 60 80, 100 DAS and at harvest respectively than BARI Chola-9 (V_2).

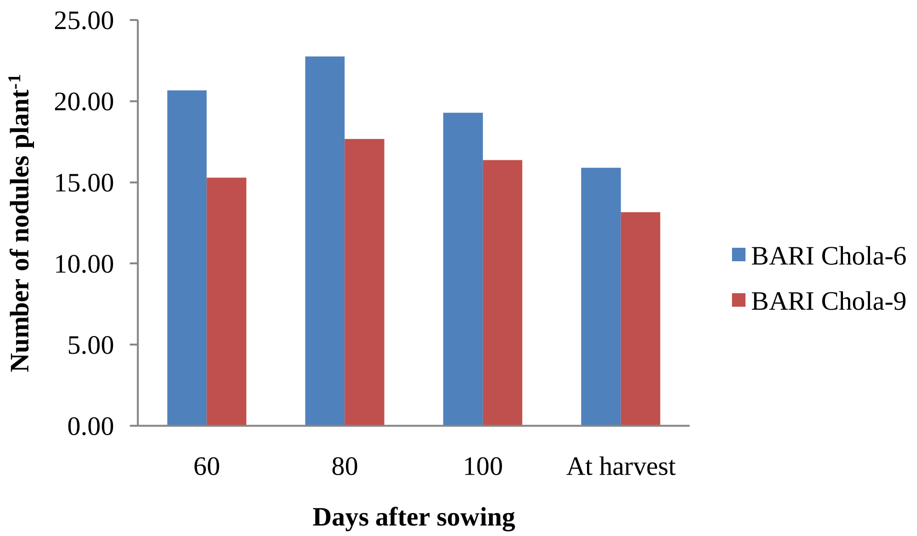
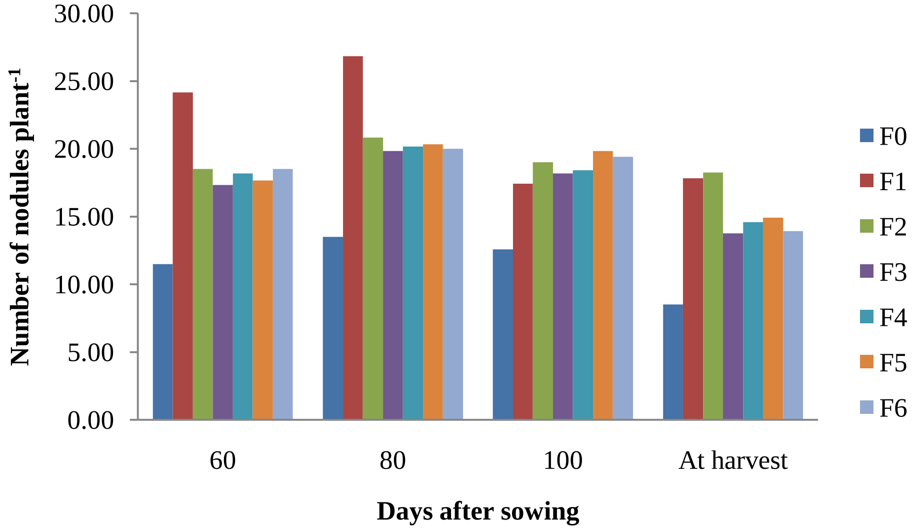


Figure 5. Effect of variety on the number of nodules plant^{-1} of chickpea at different days after sowing

[SE value = 0.51, 0.53, 0.19 and 0.19 at 60, 80, 100 DAS and at harvest, respectively]

4.3.2 Effect of micronutrients

Number of nodules plant^{-1} of chickpea varied significantly due to various micronutrient treatments (Figure 6). It was observed that F_2 produced the highest number of nodules plant^{-1} of chickpea at 60, 80 and 100 DAS. However, at 60, 80, 100 DAS and at harvest the lowest number of nodules plant^{-1} was observed from F_0. It may be due to combination of sulphur and boron which positively affect root nodulation in green gram. These results are in line with Wu and Harper, (1990). Valenciano *et al.* (2010) and Ahlawat *et al*. (2007) also reported the same.



F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

Figure 6. Effect of micronutrients on the number of nodules plant^{-1} of chickpea at different days after sowing

[SE value = 0.95, 0.96, 0.35 and 0.37 at 60, 80, 100 DAS and at harvest, respectively]

4.3.3 Interaction effect of variety and micronutrients

Number of nodules plant^{-1} did not varied significantly due to various treatment combinations of variety and micronutrients at 60 and 80 DAS, however, significant variation observed on 100 DAS and at harvest (Table 3). At 60 and 80 DAS numerically, the treatment combination of V_1F_1 produced the highest Number of nodules plant^{-1}. At harvest V_1F_1 produced the highest number of nodules plant^{-1} which was statistically similar with V_1F_2.

Table 3. Interaction effect of variety and micronutrient on the number of nodules plant^{-1} of chickpea at different days after sowing

Treatments	Days after sowing			
	60	80	100	At harvest
V_1F_0	13.33	15.33	14.33 f	9.33h
V_1F_1	28.00	30.33	14.83 f	19.00 a
V_1F_2	21.67	23.33	20.17 c	18.67 a
V_1F_3	20.00	22.00	19.83 c	13.50 ef
V_1F_4	20.67	23.00	21.67 ab	17.67 ab
V_1F_5	20.00	22.67	22.83 a	17.67 ab
V_1F_6	21.00	22.67	21.33bc	15.50 cd
V_2F_0	9.667	11.67	10.83 g	7.667 i
V_2F_1	20.33	23.33	20.00 c	16.67 bc
V_2F_2	15.33	18.33	17.83 d	17.83 ab
V_2F_3	14.67	17.67	16.50 de	14.00 de
V_2F_4	15.67	17.33	15.17ef	11.50 g
V_2F_5	15.33	18.00	16.83 d	12.17 fg
V_2F_6	16.00	17.33	17.50 d	12.33 fg
SE	ns	ns	0.49	0.53
CV (%)	12.89	11.96	4.76	6.3

V_1=BARI Chola-6, V_2=BARI Chola-9, F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

4.4 Nodules dry weight (g)

4.4.1 Effect of variety

Nodules dry weight of chickpea varied significantly due to variety treatments (Figure 7). It was observed that BARI Chola-6 (V_1) produced the highest nodules dry weight at 60, 80 and 100 DAS. However, BARI Chola-9 (V_2) produced the highest nodules dry weight at harvest. Result shows that BARI Chola-6 (V_1) produced 31.67 %, 27.67 % and 19.29 %, more nodule dry weight at 60 80, and 100 DAS respectively than BARI Chola-9 (V_2).

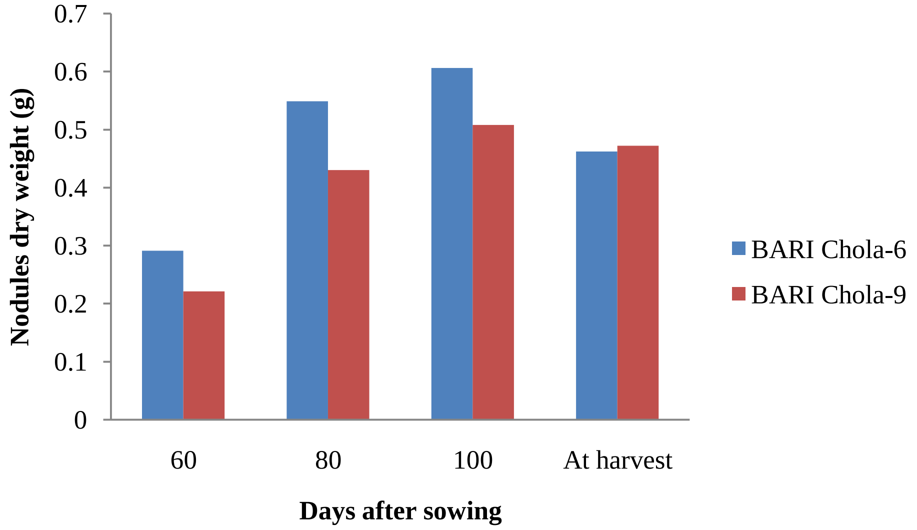
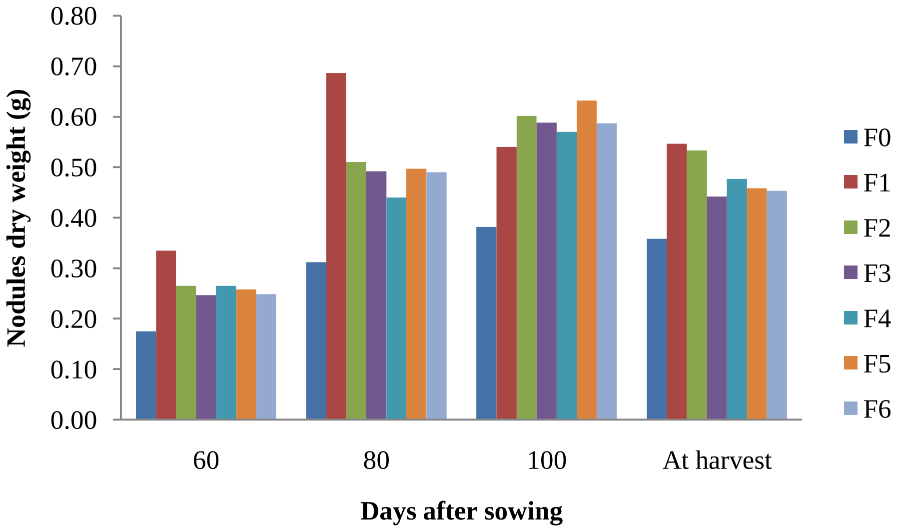


Figure 7. Effect of variety on the nodules dry weight of chickpea at different days after sowing

[SE value = 0.009, 0.016, 0.01 and 0.013 at 60, 80, 100 DAS and at harvest, respectively]

4.4.2 Effect of micronutrients

Nodules dry weight of chickpea varied significantly due to various micronutrient treatments (Figure 8). It was observed that F_1 produced the highest nodules dry weight of chickpea at 60, 80 DAS and at harvest. However, the lowest nodules dry weight was observed from F_0 at 60, 80, 100 DAS and at harvest



F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

Figure 8. Effect of micronutrients on the nodules dry weight of chickpea at different days after sowing

[SE value = 0.02, 0.03, 0.02 and 0.03 at 60, 80, 100 DAS and at harvest, respectively]

4.4.3 Interaction effect of variety and micronutrients

Nodules dry weight did not varied significantly in all the days after sowing except 100 DAS due to various treatment combinations of variety and micronutrients (Table 4). Numerically, the treatment combination of V_1F_1 produced the highest number of branches at 60, 80 DAS and at harvest. However, numerically the treatment combination of V_2F_0 produced the lowest nodules dry weight at 60, 80,100 DAS and at harvest. Significant result was found at 100 DAS; the maximum dry weight was recorded from V_1F_5 which was statistically similar to V_1F_3, while the minimum result recorded in V_2F_0.

Table 4. Interaction effect of variety and micronutrient on the nodules dry weight (g) of chickpea at different days after sowing

Treatments	Days after sowing			
	60	**80**	**100**	**At harvest**
V_1F_0	0.21	0.36	0.42 f	0.37
V_1F_1	0.39	0.76	0.44ef	0.54
V_1F_2	0.30	0.58	0.64 bc	0.53
V_1F_3	0.29	0.57	0.71 ab	0.44
V_1F_4	0.30	0.46	0.64 bc	0.46
V_1F_5	0.27	0.56	0.74 a	0.44
V_1F_6	0.27	0.56	0.65 b	0.45
V_2F_0	0.14	0.26	0.34 g	0.35
V_2F_1	0.28	0.61	0.64 bc	0.55
V_2F_2	0.23	0.44	0.57 cd	0.53
V_2F_3	0.20	0.42	0.46ef	0.44
V_2F_4	0.23	0.42	0.50 de	0.49
V_2F_5	0.24	0.43	0.52 de	0.48
V_2F_6	0.23	0.42	0.52 de	0.45
SE	ns	ns	0.03	Ns
CV (%)	17.10	15.64	8.37	12.82

V_1=BARI Chola-6, V_2=BARI Chola-9, F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

4.5 Number of pod plant^{-1}

4.5.1 Effect of variety

Number of pod plant^{-1} of chickpea varied significantly due to variety treatments (Table 5). It was observed that BARI Chola-6 (V_1) produced the highest (30.00) number of pod plant^{-1} and BARI Chola-9 (V_2) produced the lowest (24.70) number of pod plant^{-1}. This result showed that BARI Chola-6 produced 21% more numbers of pod plant^{-1} than BARI Chola-9 (V_2). Bhuiyan *et al.* (2008) also found significant variation in number of pod plant^{-1} using various chickpea varieties however, Khatun *et al.* (2010) found contrasting results.

4.5.2 Effect of micronutrients

Number of pod plant^{-1} of chickpea varied significantly due to various micronutrients treatments (Table 5). It was observed that F_1 produced the highest (45.98) number of pod plant^{-1} and F_0 produced the lowest (17.43) number of pod plant^{-1} which was statistically similar with F_3. Results showed that 10% more pod found in F_3 treatment. It may be due to boron, which is involved in flower and grain formation and thereby increase number of seeds per pod. Minimum numbers of seeds per pod were found with no boron application. These results are in line with Kaisher *et al.* (2010). Valenciano *et al.* (2010), Khan *et al.*, 2004 and Ahlawat *et al*. (2007) found similar results.

4.5.3 Interaction effect of variety and micronutrients

Significant variation was observed in the number of pod plant^{-1} of chickpea due to various treatment combinations of variety and micronutrients (Table 5). It was observed that the treatment combination of V_1F_1 produced the highest (55.57) number of pod plant^{-1} and the treatment combination of V_2F_0 produced the lowest (14.80) number of pod plant^{-1} which was statistically similar with V_1F_0 and V_2F_3.

4.6 Number of seed pod^{-1}

4.6.1 Effect of variety

Number of seed pod^{-1} of chickpea varied significantly due to variety (Table 5). It was observed that BARI Chola-6 (V_1) produced the highest (2.02) number of seed pod^{-1} and BARI Chola-9 (V_2) produced the lowest (1.91) number of seed pod $^{-1}$. Khatun *et al.* (2010) and Bhuiyan *et al.* (2008) found similar results.

4.6.2 Effect of micronutrients

Number of seed pod^{-1} of chickpea varied significantly due to various micronutrients treatments (Table 5). It was observed that F_1 produced the highest (2.15) number of seed pod^{-1} which was statistically similar with F_2, F_3, F_4, F_5 and F_6. However, F_0 produced the lowest (1.53) number of seed pod^{-1}. Valenciano *et al.* (2010), Khan *et al*., 2004 and Ahlawat *et al*. (2007) found similar results

4.6.3 Interaction effect of variety and micronutrients

No significant variation was observed on the number of seed pod^{-1} of chickpea due to various treatment combinations of variety and micronutrients (Table 5). Numerically the highest (2.21) number of seed pod^{-1} was observed from the treatment combination of V_1F_1 and the lowest (1.50) number of seed pod^{-1} from the treatment combination of V_2F_0.

4.7 1000-seed weight (g)

4.7.1 Effect of variety

1000-seed weight of chickpea varied significantly due to variety treatments (Table 5). It was observed that BARI Chola-6 (V_1) produced the highest (117.44 g) 1000-seed weight and BARI Chola-9 (V_2) produced the lowest (115.40 g) 1000-seed weight. This result showed that BARI Chola-6 (V_1) produced 1. 76% more 1000 seed weight than BARI Chola-9 (V_2). Thousand-seed weight ranged from 110-120 g in BARI Chola-5, 140-150 g in BARI Chola-6, and 250-260 g in BARI Chola-8 was observed by Bakr *et al.* (2002). Khatun *et al.* (2010) and Bhuiyan *et al.* (2008) reported the same.

4.7.2 Effect of micronutrients

1000-seed weight of chickpea varied significantly due to various micronutrients treatments (Table 5). It was observed that F_1 produced the highest (122.30 g) 1000-seed weight of chickpea and F_0 produced the lowest (110.3 g) 1000-seed weight. Results showed that 10.87% more 1000 seed weight found in F_3 treatment. The increase in 1000-seed weight might be due to positive effect of sulphur and boron on seed weight and size. These results are in line with Kaisher *et al*. (2010).Valenciano *et al.* (2010), Khan *et al*., 2004 and Ahlawat *et al.* (2007) earlier reported that 1000 seed weight was significantly affected due to various micronutrient treatments.

4.7.3 Interaction effect of variety and micronutrients

Significant variation was observed on the 1000-seed weight of chickpea due to various treatment combinations of variety and micronutrients (Table 6). It was observed that the treatment combination of V_1F_1 produced the highest (124.30 g) 1000-seed weight which was statistically similar with V_1F_2. However, the treatment combination of V_1F_0 produced the lowest (110.20 g) 1000-seed weight which was statistically similar with V_1F_3, V_2F_0, V_2F_5 and V_2F_6.

Table 5. Interaction effect of variety and micronutrient on the pod numbers plant^{-1}, number of seed pod^{-1} and 1000-seed weight of chickpea

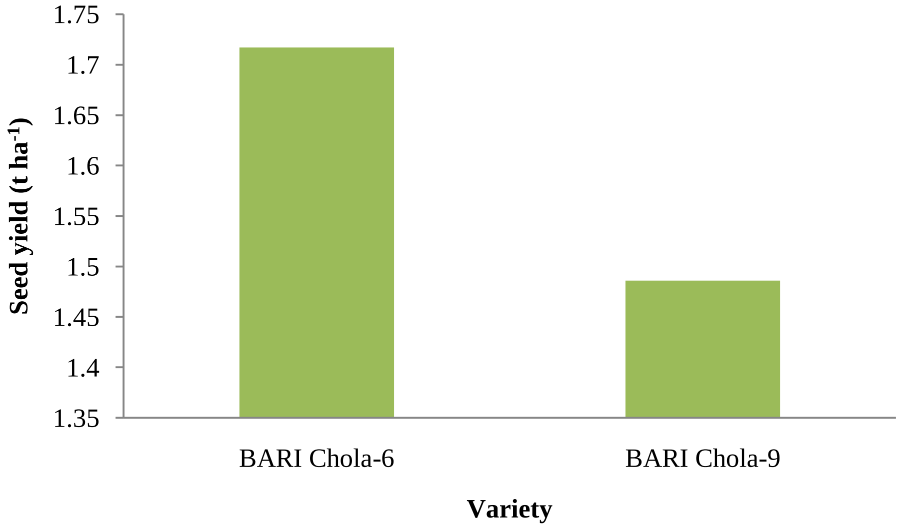
Treatments	Pod numbers plant^{-1}	Number of seed pod^{-1}	1000 seed weight (g)
Effect of variety			
V_1	29.99	2.02	117.44
V_2	24.7	1.91	115.40
SE	0.95	0.05	0.51
Effect of Micro nutrients			
F_0	19.33d	1.53b	110.3 c
F_1	33.48 a	2.15 a	122.3 a
F_2	29.18b	2.07 a	120.0 a
F_3	23.56 cd	1.95 a	115.9b
F_4	25.73bc	2.05 a	115.2b
F_5	26.72b	2.01 a	115.4b
F_6	25.82bc	2.01 a	115.8b
SE	1.78	Ns	0.96
Interaction effect of variety and micronutrients			
V_1F_0	20.07 de	1.56 bc	110.2e
V_1F_1	35.57 a	2.21 a	124.3 a
V_1F_2	28.90 bc	2.18 a	120.6 ab
V_1F_3	25.13 cd	1.98 a	113.0 de
V_1F_4	25.70 cd	2.08 a	115.7 cd
V_1F_5	27.10 cd	2.11 a	119.2 bc
V_1F_6	27.50 cd	2.03 a	119.1 bc
V_2F_0	19.80 e	1.51 c	110.4 e
V_2F_1	31.45 b	2.08 a	120.2 b
V_2F_2	29.47 bc	1.96 a	119.4 bc
V_2F_3	22.00 e	1.92 ab	118.9 bc
V_2F_4	25.77 cd	2.03 a	114.7 d
V_2F_5	26.33 cd	1.91 ab	111.7 de
V_2F_6	24.13 cd	2.00 a	112.6 de
SE	2.52	Ns	1.35
CV (%)	15.95	10.93	2.01

V_1=BARI Chola-6, V_2=BARI Chola-9, F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

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

4.8.1 Effect of variety

Seed yield of chickpea varied significantly due to variety treatments (Figure 9). It was observed that BARI Chola-6 (V_1) produced the highest (1.72 t ha^{-1}) seed yield and the other variety BARI Chola-9 (V_2) which produced the lowest (1.49 t ha^{-1}) seed yield. This result showed that BARI Chola-6 (V_1) produced 15 % more seed yield than BARI Chola-9 (V_2). Khatun *et al.* (2010) and Bhuiyan *et al.* (2008) reported seed yield significantly influenced by chickpea variety.

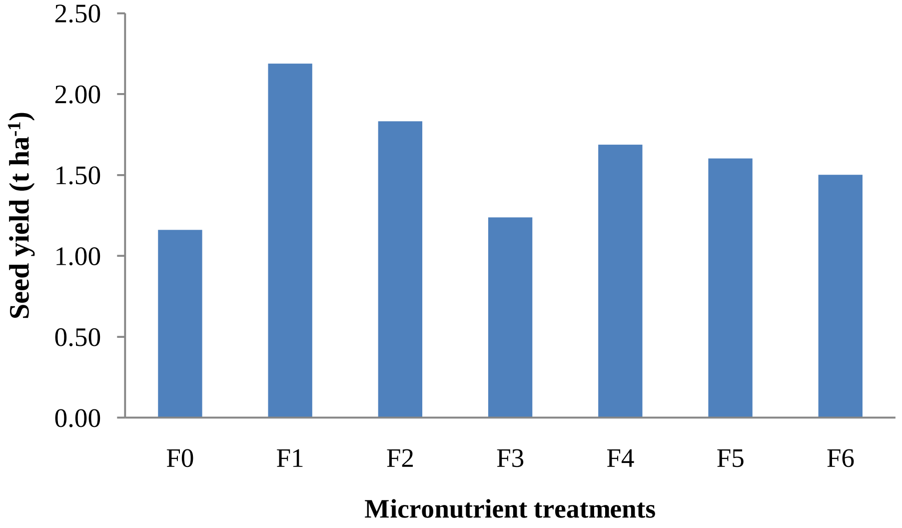


V_1=BARI Chola-6, V_2=BARI Chola-9,

Figure 9. Effect of variety on the seed yield of chickpea [SE value = 0.62]

4.8.2 Effect of micronutrients

Seed yield of chickpea varied significantly due to various micronutrients treatments (Figure 10). It was observed that the F_1 treatments produced the highest seed yield (2.19 t ha^{-1}) and F_0 produced the lowest (1.16 t ha^{-1}) seed yield which was statistically similar with F_3 and F_6. Result showed that F_1 produced 88.62 % more seed yield than control. Chickpea responded to the Zn, B and Mg applications. The Zn and B applications improved seed yield, mainly due to the number of pods $plant^{-1}$. Valenciano *et al.* (2010) and Johnson *et al.* (2005) reported the same.



F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

Figure 10. Effect of micronutrients on the seed yield of chickpea [SE value = 0.11]

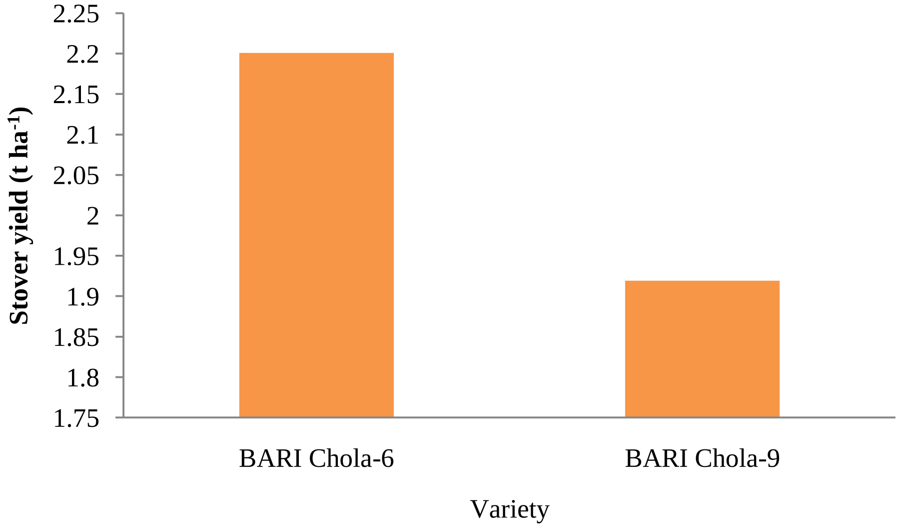
4.8.3 Interaction effect of variety and micronutrients

Significant variation was observed on the seed yield of chickpea due to various treatment combinations of variety and micronutrients (Table 6). It was observed that the treatment combination of V_1F_1 produced the highest (2.51 t ha^{-1}) seed yield and the treatment combination of V_1F_0 produced the lowest (1.04 t ha^{-1}) seed yield which was statistically similar with V_1F_3, V_2F_0, V_2F_3, V_2F_4, V_2F_5 and V_2F_6.

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

4.9.1 Effect of variety

Stover yield also varied significantly due to variety treatments (Figure 11). It was observed that the BARI Chola-6 (V_1) produced the highest (2.20 t ha^{-1}) stover yield and BARI Chola-9 (V_2) produced the lowest (1.92 t ha^{-1}) stover yield. Result showed that BARI Chola-6 (V_1) produced 14.69 % more stover yield than BARI Chola-9 (V_2). Khatun *et al.* (2010) and Bhuiyan *et al.* (2008) also found significant variation of stover yield due to various chickpea variety.

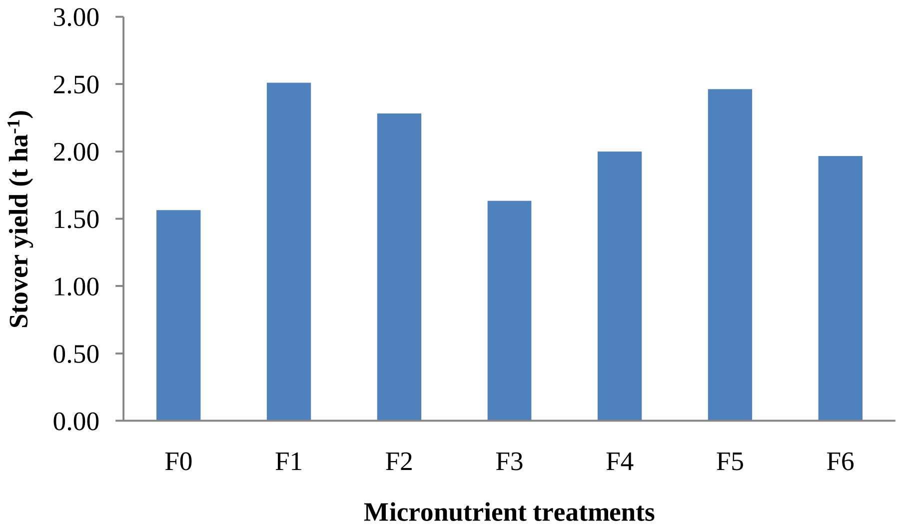


V_1=BARI Chola-6, V_2=BARI Chola-9

Figure 11. Effect of variety on the stover yield of chickpea [SE value = 0.07]

4.9.2 Effect of micronutrients

Various micronutrients treatments had significant effect on the stover yield of chickpea (Figure 12). It was observed that F_1 produced the highest (2.51 t ha^{-1}) stover yield which was statistically similar with F_2 and F_5. However, the lowest (1.57 t ha^{-1}) stover yield was observed from F_0 which was statistically similar with F_3 and F_6. Result showed that F_1 produced 60.38 % more stover yield than control. Sarker *et al.* (2000), Bhuiyan *et al.* (1998), observed higher stover yield formation due to application of B, Zn and S.



F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

Figure 12. Effect of micronutrients on the stover yield of chickpea [SE value = 0.14]

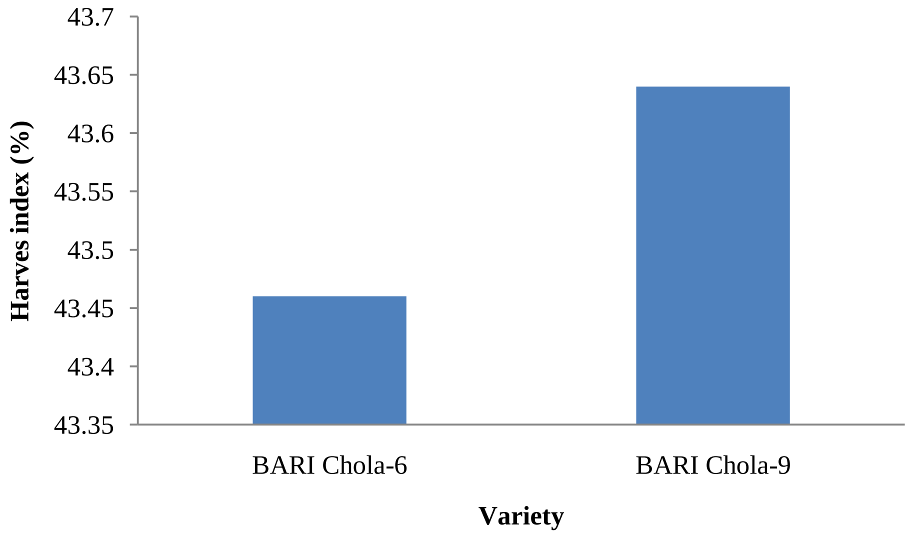
4.9.3 Interaction effect of variety and micronutrients

Stover yield varied significantly due to various treatment combinations of variety and micronutrients (Table 6). It was observed that the treatment combination of V_1F_1 produced the highest (2.67 t ha^{-1}) stover yield which was statistically similar with V_1F_2, V_1F_4, V_1F_5, V_1F_6, V_2F_1 and V_2F_5. However, the lowest (1.55 t ha^{-1}) stover yield was observed from V_1F_0 which was statistically similar with V_1F_3, V_2F_0, V_2F_2, V_2F_3, V_2F_4 and V_2F_6.

4.10 Harvest index (%)

4.10.1 Effect of variety

Harvest index did not vary significantly due to variety treatments (Figure 13). It was observed the BARI Chola-9 (V_2) produced the highest (43.64 %) harvest index numerically while BARI Chola-6 (V_1) produced the lowest (42.46 %) harvest index numerically. This result showed that BARI Chola-6 (V_2) produced 0.41 % more harvest index than BARI Chola-9 (V_2). However, Bhuiyan *et al.* (2008) reported significant variation of harvest index due to various chickpea variety.

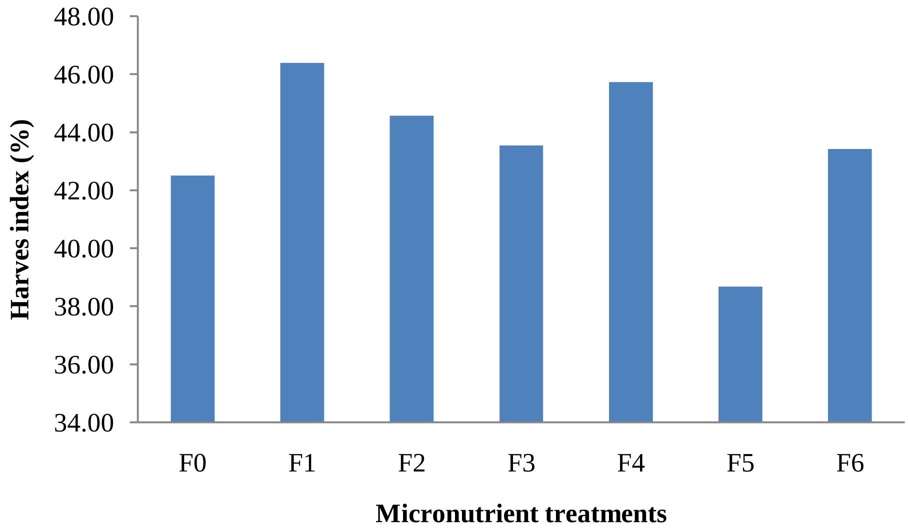


V_1=BARI Chola-6, V_2=BARI Chola-9

Figure 13. Effect of variety on the harvest index of chickpea [SE value = 1.06]

4.10.2 Effect of micronutrients

Harvest index did not varied significantly due to various micronutrients treatments (Figure 14). Numerically, the F_1 produced the highest (46.39 %) harvest index and F_5 produced the lowest (38.68 %) harvest index. Application of micronutrients increases the harvest index of chickpea. Result showed that F_1 produced 9.13 % more harvest index than control. Valenciano *et al.* (2010), Ahlawat *et al*. (2007) and Tripathi *et al*. (1997) reported the same.



F_0= Control (No fertilization), F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

Figure 14. Effect of micronutrients on the harvest index of chickpea

[SE value = 1.99]

4.10.3 Interaction effect of variety and micronutrients

Various treatment combinations had no significant variation over the harvest index of chickpea (Table 6). However, numerically the highest (48.6 %) harvest index was observed from V_1F_1 and the lowest (36.36 %) from V_2F_5.

Table 6. Interaction effect of variety and micronutrient on the seed yield, stover yield and harvest index of chickpea

Treatments	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Harvest index (%)
V_1F_0	1.040 g	1.547e	40.31 ab
V_1F_1	2.507 a	2.670 a	48.45 a
V_1F_2	2.017 b	2.543 ab	44.23 ab
V_1F_3	1.153 fg	1.620 de	42.44 ab
V_1F_4	1.857 b-d	2.210 a-d	45.75 ab
V_1F_5	1.787 b-e	2.537 ab	41.01 ab
V_1F_6	1.660 b-f	2.280 a-c	42.04 ab
V_2F_0	1.280 e-g	1.583 de	44.72 ab
V_2F_1	1.870 bc	2.350 a-c	44.33 ab
V_2F_2	1.647 b-f	2.020 b-e	44.91 ab
V_2F_3	1.323 d-g	1.647 de	44.65 ab
V_2F_4	1.517 b-g	1.790 c-e	45.71 ab
V_2F_5	1.420 c-fg	2.390 a-c	36.36 b
V_2F_6	1.343 c-g	1.650 de	44.80 ab
SE	0.16	0.19	ns
CV (%)	17.59	16.28	11.21

V_1=BARI Chola-6, V_2=BARI Chola-9, F_0= Control (No fertilization),
F_1= Recommended NPK and gypsum, B, S, Zn, and Mg in soil, F_2= Recommended NPK and gypsum in soil and B, S, Zn and Mg as spray, F_3= F_2 without B, F_4= F_2 without S, F_5= F_2 without Zn, F_6= F_2 without Mg.

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was carried out at the research field of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka from November, 2012 to March 2013 to study the response of different micronutrients on chickpea varieties. Two varieties of chickpea (V_1: BARI Chola-6 and V_2: BARI Chola-9) and seven micronutrient treatments (F_0= Control (No fertilization), F_1= Recommended NPK + all (B,S,Zn,Mg) + Zypsum in soil, F_2= Recommended NPK + B,S,Zn,Mg (Sprey), F_3=Recommended NPK + 3 without B (Sprey), F_4= Recommended NPK + 3 without S (Sprey), F_5= Recommended NPK + 3 without Zn (Sprey), F_6= Recommended NPK + 3 without Mg (Sprey) were used in this experiment.

The data on crop growth and yield parameters like plant height, number of branches plant^{-1}, number of nodule plant^{-1}, Nodule dry weight, Number of pod plant^{-1}, 1000-seed weight, Seed yield, Stover yield and Harvest index (%). Collected data were statistically analyzed for the evaluation of best micronutrient treatments for cheickpea variety and the best combination. Summary of the results and conclusion have been described in this chapter.

Results showed that variety had significant effect on growth parameters. The rapid increase of plant height was observed from 40 days to 100 days after sowing of growth stages which was the highest (47.97 cm) in the BARI Chola-6 (V_1) and smallest (42.91 cm) in BARI Chola-9 (V_2) at harvesting stage. Conversely, F_2= Recommended NPK + B,S,Zn,Mg (Sprey) and Control (F_0) were marked as tallest (47.81 cm) and shortest (39.58 cm) plant respectively at harvesting stage in terms of As levels. In combination of variety and micronutrients, V_1F_2 generated tallest (52.23 cm) plant whereas V_2F_0 produced shortest (40.48 cm) at harvesting stage.

Considering the varieties, BARI Chola-9 (V_2) produced the maximum number of branches (22.24) and minimum (19.15) from BARI Chola-6 (V_1) at

Regarding on micronutrient application, F_2= Recommended NPK + B,S,Zn,Mg (Sprey) produced maximum number of branches (24.34) whereas minimum (18.75) from control produced. In combination V_2F_2 gave maximum branches (24.75) while V_1F_4 produced minimum (16.60) at harvesting stage.

Considering the number of nodules plant^{-1} of chickpea BARI Chola-6 (V_1) produced the highest number of nodules plant^{-1} whereas lowest produced from BARI Chola-9 (V_2) at harvest. Regarding micronutrient application, F_2= Recommended NPK + B,S,Zn,Mg (Sprey) produced maximum number of nodule plant^{-1} whereas minimum from control treatment. In combination V_1F_2 gave maximum branches (18.67) while V_1F_4 produced minimum (9.33) at harvesting stage.

Considering the varieties, BARI Chola-9 (V_2) produced the highest nodules dry weight while minimum produced from BARI Chola-6 (V_1) at harvest. Regarding on micronutrient application, F_1 produced highest nodules dry weight of chickpea while the lowest was observed from F_0 at harvest. In combination V_1F_1 gave maximum nodules dry weight (0.54) while V_1F_0 produced minimum (0.37) at harvesting stage.

Considering the varietal characteristics, the maximum pod number plant^{-1} (29.99), seed pod^{-1} (2.02) and 1000-seed weight (117.44 g) was generated by BARI Chola-6 (V_1) and the minimum number of pod plant^{-1} (24.7), seed pod^{-1} (1.92) and 1000-seed weight (115.40 g) was produced by BARI Chola-9 (V_2). Whereas observing different micronutrients treatments, F_1= Recommended NPK + all (B,S,Zn,Mg) +Zypsum in soil 1 generated the maximum pod number plant^{-1} (45.98), seed pod^{-1} (2.15) and 1000-seed weight (122.3 g) whereas control produced the minimum pod number plant^{-1}, seed pod^{-1} and 1000-seed weight. In combination V_1F_1 generated utmost pod number plant^{-1} (55.57), seed pod^{-1} (2.21) and 1000-seed weight (124.3 g) whereas the minimum number recorded from V_2F_0 treatment combination.

Considering the varietal characteristics, the maximum seed yield (1.72 t ha^{-1}) and stover yield (2.20 t ha^{-1}) was generated by BARI Chola-6 (V_1) and the minimum seed yield (1.49 t ha^{-1}), and stover yield (1.92 t ha^{-1}) was produced by BARI Chola-9 (V_2) but maximum harvest index (43.64 %) recorded on BARI Chola-9 (V_2) while minimum (42.46%) from BARI Chola-6 (V_1). Whereas observing different micronutrients treatments, F_1= Recommended NPK + all (B,S,Zn,Mg) +Zypsum in soil generated the maximum seed yield (2.19 t ha^{-1}), stover yield (2.51 t ha^{-1}) and harvest index (46.39 %) whereas control produced the minimum seed yield (1.16 t ha^{-1}), stover yield (1.57 t ha^{-1}) and harvest index (38.68 %). In combination V_1F_1 generated maximum seed yield (2.507 t ha^{-1}), stover yield (2.67 t ha^{-1}) and harvest index (48.45 %) whereas the minimum number recorded from V_2F_0 treatment combination.

Considering the results of the present experiment, it may conclude that different micronutrient positively influenced the entire physiology, growth and yield of chickpea. The treatment F_1= Recommended NPK + all (B,S,Zn,Mg) +Zypsum in soil produced the maximum yield which was statistically similar to F_2= Recommended NPK + B,S,Zn,Mg (Sprey). It was also observed that BARI Chola-6 (V_1) showed maximum result in all growth and yield parameters.

So, it may be recommended that BARI Chola-6 (V_1) variety with F_1= Recommended NPK + all (B,S,Zn,Mg) +Zypsum in soil better for growth and yield of chickpea.

However, to reach a specific recommendation, this trait could be replicated at different agro ecological zones of Bangladesh for validating the present results.

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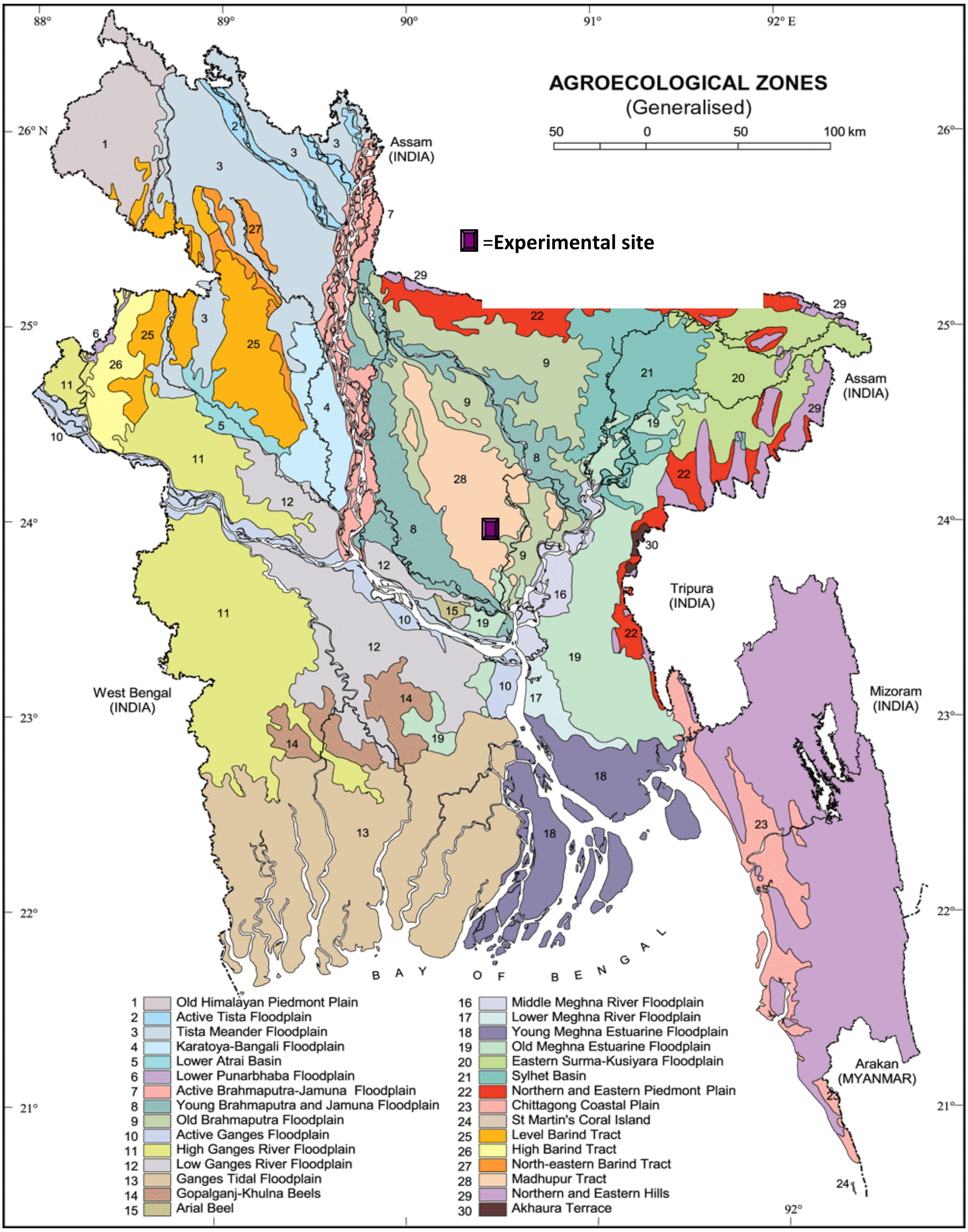
APPENDICES

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



Appendix II: Physical and chemical properties of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

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

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

Appendix III. Means square values for plant height of chickpea at different days after sowing

Sources of variation	DF	Mean square values at different days after sowing				
		40	**60**	**80**	**100**	**At harvest**
Replication	2	10.13	0.07	3.79	14.57	13.34
Variety (A)	1	145.824 *	82.628 *	19.448 ns	268.281 *	300.215 *
Fertilizer (B)	6	23.662 *	47.33 *	76.87 *	49.66 *	49.107 *
A x B	6	0.717 ns	3.266 ns	1.659 ns	2.959 ns	10.586 ns
Error	26	9.81	5.05	11.36	8.97	9.85
CV (%)		14.98	7.55	8.16	6.59	7.12

*Significant at 5% level

^{ns}- Non significant

Appendix IV. Means square values for no of branches of chickpea at different days after sowing

Sources of variation	DF	Mean square values at different days after sowing				
		40	**60**	**80**	**100**	**At harvest**
Replication	2	16.71	16.71	11.97	11.98	11.99
Variety (A)	1	74.081 *	74.081 *	100.255 *	100.255 *	100.255 *
Fertilizer (B)	6	27.73 ns	27.73 ns	32.51 ns	32.51 ns	32.51 ns
Variety (A) x Fertilizer (B)	6	5.768 ns	5.768 ns	6.942 ns	6.942 ns	6.942 ns
Error	26	15.03	15.03	18.11	18.11	18.11
CV (%)		35.7	29.33	28.21	21.07	20.56

*Significant at 5% level

ns- Non significant

Appendix V. Means square values for number of nodules per plant of chickpea at different days after sowing

Sources of variation	DF	Mean square values at different days after sowing			
		60	**80**	**100**	**At harvest**
Replication	2	3.167	6.643	8.042	1.089
Variety (A)	1	304.024 *	272.595 *	88.595 *	78.72 *
Fertilizer (B)	6	81.357 *	89.484 *	36.056 *	62.248 *
Variety (A) x Fertilizer (B)	6	2.468 ns	1.706 ns	22.345 *	8.748 *
Error	26	5.372	5.848	0.721	0.839
CV (%)		12.89	11.96	4.76	6.3

*Significant at 5% level

ns- Non significant

Appendix VI. Means square values for nodules dry weight of chickpea at different days after sowing

Sources of variation	DF	Mean square values at different days after sowing			
		60	**80**	**100**	**At harvest**
Replication	2	0.002	0	0.019	0.007
Variety (A)	1	0.051 *	0.149 *	0.101 *	0.001 ns
Fertilizer (B)	6	0.013 *	0.073 *	0.041 *	0.024 *
Variety (A) x Fertilizer (B)	6	0.001 ns	0.003 ns	0.033 *	0.001 ns
Error	26	0.002	0.006	0.002	0.004
CV (%)		17.10	15.64	8.37	12.82

*Significant at 5% level

ns- Non significan

Appendix VII. Means square values for yield and yield contributing characters of chickpea at different days after sowing

Sources of variation	DF	Pod numbers plant^{-1}	Number of seed pod^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harves index (%)
Replication	2	32.633	0	17.72	0.11	0.02	25.86
Variety (A)	1	294.42 *	0.12 *	43.64 *	0.56 *	0.84 *	0.34 ns
Fertilizer	6	500.28*	0.24 *	87.59 *	0.74 *	0.85 *	38.64 ns
Variety (A) x Fertilizer (B)	6	73.62 *	0.01 ns	31.19 *	0.15 *	0.11 *	17.69 ns
Error	26	19.02	0.05	5.48	0.08	0.11	23.84
CV (%)		15.95	10.93	2.01	17.59	16.28	11.21

*Significant at 5% level

^{ns}- Non significant