EFFECT OF NITROGEN AND ZINC ON GROWTH AND YIELD OF BARI CHHOLA-2 (*Cicer arietinum* L.)

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CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF NITROGEN AND ZINC ON GROWTH AND YIELD OF BARI CHHOLA-2 (Cicer arietinum L.)*** *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*** *in* ***SOIL SCIENCE,*** *embodies the result of a piece of bona fide research work carried out by* ***MD. ABU SHAEID*** *Registration No.* ***11-04421*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:

Place: Dhaka, Bangladesh

(Prof. Mst. Afrose Jahan)
Supervisor

DEDICATED TO

MY BELOVED PARENTS

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ABSTRACT

This experiment was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, during the period from November, 2015 to April, 2016 to study the effect of nitrogen and zinc on growth and yield of chickpea (*Cicer arietinum* L.*)*. In experiment, the treatment consisted of four Nitrogen levels viz. N_0 = No nitrogen (Control), N_1 = 10 kg ha^{-1}, N_2 = 20 kgha^{-1}, N_3 = 30 kgha^{-1} and three Zinc levels viz. Zn_0 = No Zinc (Control), Zn_1 = 4.0 kgha^{-1}, Zn_2 = 8.0 kgha^{-1}. The experiment was laid out in a two factors randomized complete block design (RCBD) with three replications. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed that a significant variation among the treatments in respect of majority of the observed parameters. The tallest plant was found in the 20 kg N ha^{-1}. The maximum number of branches plant^{-1}, pods plant^{-1} was recorded from the 20 kg N ha^{-1}. The highest seed yield (2.10 ton ha^{-1}) was recorded from the 20 kg N ha^{-1}. The highest plant height was produced from 8.0 kg Zn ha^{-1}. The highest number of branches of chickpea, number of pods plant^{-1} was obtained from 8.0 kg Zn ha^{-1} treatment. It was observed that the 8.0 kg Zn ha^{-1} treatments produced the highest seed yield (2.08 t ha^{-1}). Significant variation was observed on the seed yield of chickpea due to various treatment combinations of N and Zn. It was observed that the treatment combination of 20 kg N ha^{-1} with 8.0 kg Zn ha^{-1} produced the highest (2.25 t ha^{-1}) seed yield. The combined use of 20 kg N/ha and 8 kg Zn ha^{-1} along with recommended doses of other fertilizer would be beneficial to increase the seed yield of chickpea variety BARI Chhola-2 (Baral).

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LIST OF ABBREVIATION AND ACRONYMS

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

CHAPTER I

INTRODUCTION

Chickpea (*Cicerarietinum L.*) is one of the most important grain legumes as it ranks third in the world after dry bean (*Phaseolus vulgaris L.*) and field pea (*Pisumsativum L.*). Chickpea is a significant contributor to agricultural sustainability due to its nitrogen fixation. Chickpea (*Cicerarietinum L*) is a grain legume crop grown for its nutritional value because of high protein contents. It is considered as an economical source of quality vegetable protein in human diet. Farmers have a wrong notion that chickpea being a legume crop, does not need any nutrition and usually they grow it on the marginal land, without applying any fertilizer. The yield gap of chickpea may be attributed to improper agro-technology used by the farmers. Yield gap can be abridged, by adopting the advanced production technology accompanying with the use of inoculums, balanced nutrition, weed management and high yielding varieties. Application of phosphorus to the legumes also improves the seed yield considerably (Hussain, 1983). Further, Raut and Kohire (1991) reported that seed yield of chickpea was increased significantly with Rhizobium and phosphorus application. Patel and Patel (1991) also observed that nitrogen application as a starter dose along with phosphorus and seed inoculation has beneficial effect on yield of chickpea crop. Tippannavar and Desai (1992) studied that seed inoculation with Rhizobium increased the nodule number, seed yield and plant dry weight. Shah *et al*. (1994) found that increase in number of nodules, and seed yield due to be seed inoculation.

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 $mtha^{-1}$(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 pulses 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).

Chickpea is mainly produced in arid or semiarid environments (Canci and Toker, 2009a, b). Due to several morphological and physiological advantages, the crop can effectively cope with drought conditions (Serraj et al., 2004; Cutforth *et al*., 2009; Zaman-Ullah*et al*., 2011). Chickpea is of high importance in human diets in many areas of the world. Additionally, chickpea grains can be used as energy and protein-rich feed in animal diets and chickpea straw as forage for ruminants (Bampidis and Christodoulou, 2011). Chickpea yields, yield components and protein contents are affected by production system and fertilization regime (Caliskan *et al*, 2013).

Chickpea meets 80% of its nitrogen for essential growth element requirement from symbiotic nitrogen fixation. N_2 fixation in chickpea range from 10 to 176 kg $ha^{-1}season^{-1}$, depending on method of cultivation, cultivar, presence of appropriate rhizobia and environment at variable (Bcek *et al*., 1991). There are evident that nitrogen application becomes helpful to increase the seed yield (Chaudhari *et al*., 1998; Khan *et al*., 1992). Nitrogen is most useful element for pulse crops as a component of protein (BARC, 1997). Fertilizer management especially with nitrogen, phosphorus and sulphur produced seeds with high level of protein and amino acids in chickpea (Gupta and Singh, 1982).

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 ton 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 oilseeds (Tiwari and Pathak, 1982). The critical Zn concentrations in soils vary from 0.48 mg $kg^{-1}$to 2.5 $mgkg^{-1}$depending on soil type (Ahlawat *et al*., 2007) and according to Ankerman and Large (1974) soils have low Zn availability when there is less than to 1.1 $mgkg^{-1}$of Zn (DTPA extraction). 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. In neutral to alkaline soils. Zn deficiencies can be encountered (Roy et al., 2006), Zn solubility decreases markedly above pH 6.0-6.5 (Sims, 2000). Zn uptake is positively correlated with the amount of organic matter in the soil and negatively correlated with the phosphorus (P) concentration in the soil (Sillanpää, 1972; Hamilton *et al*., 1993;Ahlawat *et al*., 2007). Soils that have a higher concentration of sand and a lower concentration of organic matter produced lower crop yields which lead to poor Zn utilization (Singh and Ram, 1996).

The basal application of nitrogen could not be helpful in the plant when it requires during its life cycle though fixed is seemed to be utilized. It is believed that rhizobium bacteria are using plants dry matter for their energy requirement that may be a back drop of pulse production (Uddin, 2010). Considering the above facts the present work was conducted to evaluate the effect of nitrogen and zinc on growth and yield of BARI Chola-2 (*cicerarietinum*L.) with the following objectives:

1. To find out the effect of N and Zn on growth and yield of Chickpea.
2. To find out the optimum doses of N and Zn for higher yield of Chickpea

CHAPTER II
REVIEW OF LITERATURE

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

2.1. Effect of nitrogen on growth and yield

Dhima *et al.* (2015) conducted experiment in northern Greece to investigate the effect of nitrogen fertilization and irrigation on productivity of three Greek chickpea varieties ("Amorgos", "Serifos", "Andros"). Chickpea, grown under irrigation regime (30 + 30 mm of water) and fertilized with 50 kg N ha^{-1} before planting and with 40 kg N ha^{-1} at blossom growth stage, produced more total dry biomass and seed yield as compared with that grown under non-irrigated conditions and fertilized with 50 kg N ha^{-1} before planting only. In particular, irrigation and nitrogen fertilization at blossom growth stage increased total dry weight of chickpea by 18.3% and 18.5%, respectively, as compared with that of non-irrigated and fertilized with N before planting. The corresponding increase of seed yield was 30.5% and 20%, respectively. The total dry biomass of "Amorgos" was 10% and 13% greater than that of "Serifos" and "Andros", while its respective seed yield increase was 5% and 16%.

Namvar*et al.* (2011) conducted experiment in Iran to study the effects of organic and inorganic nitrogen on growth indices and yield components of chickpea (*Cicer arietinum* L.) cv. ILC 482. Experimental factors were comprised of inorganic nitrogen fertilizer at four levels (0, 50, 75 and 100 kg ha^{-1}) in the main plots applied in the urea form, and two levels of inoculation with *Rhizobium* bacteria (with and without inoculation) as sub plots. Application of N and *Rhizobium* inoculation continued to have positive effect on growth indices and yield components of chickpea. Lower levels of nitrogen application and noninoculated plants showed less growth indices including total dry matter (TDM), leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) while the highest values of these indices were observed at the high levels of nitrogen application and inoculated plants. The highest plant height, number of primary and secondary branches, number of pods per plant and number of grains per plant were obtained from the highest level of nitrogen fertilizer (100 kg urea ha^{-1}) and *Rhizobium* inoculation. Application of 75 and 100 kg urea ha^{-1}showed no significant difference in these traits. Moreover, the highest grain yield was recorded in the inoculated plants that were treated with 75 kg urea ha^{-1}. The results indicated that the application of suitable amounts of nitrogen fertilizer (i. e. between 50 and 75 kg urea ha^{-1}) as a starter can be beneficial in improving growth, development and total yield of inoculated chickpea.

Neeraj and Pandey (2008) showed that the application of 25 kg nitrogen with 30 cm row spacing was significantly better to harvest the maximum production from chickpea from per unit area, whereas, the minimum yield and net income was found with control and 50 cm row spacing.

Kumar *et al.* (2005) reported that dry weight of chickpea plants responded favorably to nitrogen fertilizer application under normal and water stressed conditions. He also noted that in order to get the best out of the limited moisture, it is essential that nutrient requirements of dry land crops be adequately met. An application of 20 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1}resulted in a significantly higher seed yield, growth and yield contributing traits.

Srinivasarao *et al* (2004) investigated the available nutrient status in sub-soil layers (15-30 and 30-45 cm) in relation to that of surface soils of profiles collected from pulse growing regions of India. He reported higher nutrient contents (N, P, K) between top two layers and that many pulse crops like chickpea, pigeon pea and mung bean were deep rooted extending the root system beyond 15 cm hence substantially utilizing nutrients from deep layers to increase seed yield. A review of work done on fertilizer requirements under dry land conditions proves that the fertilizer application rates and planting population densities are tools to optimize the soil nutrients, moisture availability and seed yield (Kumar, 2005). In soils deficient in nitrogen, application of nitrogen fertilizer to crops will bring considerable increase in the productivity (Umrani, 1995).

Shri *et al.* (2004) reported that in Central Uttar Pradesh plant height, number of pods per plant, number of grains per pod, shelling percentage, pods yield was maximum with 25 kg N.

Nitrogen (N) plays a big role in all metabolic processes. It forms an important constituent of cell structures and is indispensable for the transfer of genetic information. Akram *et al.* (2004) remarked that the addition of even small amounts of nitrogen (N) into agricultural lands can increase the growth and yield of crops effectively. Although N accounts for 78% of the air volume, its availability is relatively poor because only few plants (pulses) can utilize it directly from the atmosphere. Consequently the supply of available N often becomes inadequate especially during the critical growing periods of plants. Hence it has been a long time challenge for agriculturalists to maintain soil N at levels that are adequate for optimum crop production (Krishna *et al.,* 2004). Applications of nitrogen increase the source capacity, namely, leaf area, Leaf area index (LAI), early canopy closure and the rate of photosynthesis (Doughton *et al.,* 1993).

Muhammad *et al.* (2004) conducted a field experiment on clay soil during the rainy season of 1990 to study the response of chickpea cultivars to nitrogen, phosphorus and *Rhizobium* inoculation. They observed that seed yield increased with the application of nitrogen fertilizer up to 20 kg N ha^{-1}in combination with phosphorus fertilizer up to 40 kg P_2O_5 and inoculation with *Rhizobium.*

Krishna *et al.* (2004) conducted a field experiment on sandy loam soil during the kharif (monsoon) season of 1986 at Hisar, Hariana, India, with chickpea.

Treatments 0, 50 or 100% of the recommended N and P fertilizers (20 kg N as Urea and 40 kg P_2O_5 ha^{-1}as single super phosphate) were tested. They found that chickpea receiving the recommended dose gave the highest seed yield.

Raut and Sabale (2003) used four different types of NPK fertilizer (25:50:0, 31.2:60.7:27, 47.45:80.33:33.45 and 126:138:52.8) and reported that number of branches/m^2, dry matters/ha, harvest index (HI), stovers and grain yields increased with increasing fertilizer rates. Lopez *et al.* (2004) reported that chickpea crop seems incapable of meeting nitrogen demands by fixation and does not even supply an equivalent quantity of 50 kg/ha of nitrogen fertilizer. There is no work done for Naivasha area, therefore, there is need to determine the optimum fertilizer level for optimal growth of desi chickpea in the dry land of Naivasha- Kenya.

Jain *et al.* (2003) found optimum accumulation of DM in leaf, stem and petiole of chickpea with 30 kg N ha^{-1}.

Takankhar *et al.* (1998) conducted a field trial to evaluate the response of chickepa to sulphur fertilization under different levels of nitrogen and phosphorus. Greengram cv. Gujrarat 2 and K 851 were given 10 kg N + 20 kg P_2O_5 ha^{-1} or triple these rates and 0, 10, 20 or 30 kg sulphurha-1as gypsum. Seed yield was 1.20 and 1.24 t ha^{-1} in Gujrarat 2 and K 851, respectively and was increased with the increase in fertilizer rate up to 20 kg N + 40 kg P_2O_5 ha^{-1}.

Reddy and Ahlawat (1998) found that a starter dose of 30-35 kg N ha^{-1} applied at the time of sowing result in better initial growth & development of chickpea. A positive response to increasing level of N up to 40 kg ha^{-1} has been observed at Ropar and Patiala districts in Punjab, India.

Patra *et al.* (1998) noticed increased plant height of chickpea over control with 20 kg N along with 40 kg P ha^{-1}.

Nandan and Prasad (1998) also reported highest plant height at 40kg N ha^{-1}. Sardana and Varma (1987) carried out a study in New Delhi, India in 1983-84.

They found that application of N. phosphorus and potassium fertilizers in combination resulted significant increase in plant height of chickpea.

Maliwal *et al.* (1998) reported that N fertilizer influenced proportionally on the dry matter of chickpea. Irrespective of N levels DM increased progressively till 90 DAE. The rate of dry matter production of chickpea was higher during 50 to 70 DAE.

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

Bahr (1997) conducted a field experiment on N in combination with phosphorus fertilizer to chickpea. They reported that application of 40 kg N ha^{-1}increased plant height.

Paikaray *et al.* (1996) in a study observed the application of 30 kg N ha^{-1}fertilizers significantly increased that plant height of chickpea.

Sabale (1995) found the number of branches per plant in pea significantly increased with increasing N levels from 0 to 36.8 kg ha^{-1}. The highest number of branches per plant was obtained at 36.8 kg N ha^{-1} and the lowest at 0 kg N ha^{-1}.

Mishra (1995) reported that N deficient chickpea plants were shorter and got less branches $plant^{-1}$ than the plants grown with applied N. The tallest plant and higher number of branches $plant^{-1}$ was obtained by 30 kg N ha^{-1}.

Kurhade and Nagre (1995) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of chickpea cultivars. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg P_2O_5 ha^{-1} resulted in the maximum seed yield (1112.96 kg ha^{-1}) and harvest index (41.88%). They also observed that number of flowers $plant^{-1}$ was found to be significantly higher by varying levels of nitrogen and phosphorus and pod length was significantly affected by both nitrogen and phosphorus application.

Kasole *et al.* (1995) carried out an experiment on chickpea cultivars, which was grown in pots in podzolic soil with 7 levels of N (0, 25, 50, 100, 200, 400 and 500 kg ha^{-1}). They noted that application of N up to 200 kg ha^{-1} increased the total dry matter and with use of higher rates decreased, the total dry matter decreased.

Kosgey *et al.* (1993) observed dry matter accumulation with increase in levels of N at all growth stages. The split application of N fertilizer increased the rate of photosynthetic accumulation, leaf dry weight; stem dry weight which finally resulted in increased DM production by plant at each stage of growth of chickpea.

Yadav *et al.* (1992) carried out an experiment under glass house condition in Mohendergrah district, India and found that nitrogen application significantly increased the dry matter yield of chickpea. In another study, Jain *et al.* (2003) using different levels of nitrogen found a significant increase in dry matter production of chickpea with 60 kg N ha^{-1}.

Khan *et al.* (1992) reported that the application of 20 kg N + 50 kg P_2O_5 ha^{-1} in chickpea produced significantly higher number of pods $plant^{-1}$.

Vadavia *et al.* (1991) noticed that application of 20 kg N ha^{-1} and 40 kg P ha^{-1}increased plant height of chickpea significantly over no N and P application.

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

Babar *et al.* (1991) suggested a starter dose of 20kg N ha^{-1} along with 50kg P2O5 ha^{-1}as basal for optimum plant height for chickpea.

Bhopal and Singh (1990) conducted an experiment with the semi dwarf garden pea cv. Lincoln, which received N at the rate of 0, 20, 40 and 60 kg ha^{-1} , P_2O_5 at

0, 30, 60 and 90 kg ha^{-1} increased green pod yield. Further addition of nitrogen (60 kg ha^{-1}) tended to decrease the yield.

Sharma *et al.* (1989) carried out a field experiment on chickpea in Assam, India and reported that combined application of N and phosphorus significantly increased the dry weight of plants.

Katyal (1989) reported that application of 20 kg N, 40 kg P_2O_5 and 30 kg K_2O ha^{-1} resulted in 36.4 and 10.4 per cent more dry matter production in the first and second year over control, respectively.

Dahiya *et al.* (1989) reported the increase in plant height of chickpea using N and P at the rate of 18-27 and 46-69 kg ha^{-1}, respectively.

Arvadia and Patel (1988) observed stimulatory effect of nitrogen or phosphorus alone at the rate of 25 kg ha^{-1} on the growth of chickpea plants. They also reported appreciable increase in the plant height than those in control plots. Application of phosphorus alone at the rate of 50 kg ha^{-1} did not show any significant effect on plant height over 25 kg P ha^{-1}.

Maurya *et al.* (1987) studied the effect of N levels (0, 30, 60 or 90 kg ha^{-1}) on the rate of growth and yield performance of chickpea at Dilhi, India in 1988. They observed that N above the rate of 40 kg N ha^{-1} reduced the dry matter yield. They also noted that applied N at the levels above 40 kg ha^{-1} reduced the nodule dry weight and the seed yield consequently.

Srivastava and Varma (1982) showed that N application at the rate of 15 kg ha^{-1} increased the number of green leaves in pea plants.

Mudholker and Ahlawat (1979) reported that the use of recommended dose of NPK plus compost increased the seed yield of chickepa by 83 - 87%.

Dutt (1979) found that split application of 40 kg N ha^{-1} increased the number of leaves of lentil.

2.2 Effect of zinc on the growth and yield of chickpea

Hidoto *et al*. (2017) conducted experiment at three locations with Zn deficient soils in southern Ethiopia during 2012 and 2013 cropping seasons to evaluate the effects of Zn fertilization strategies and varietal differences on Zn content and plant performance of chickpea (*Cicer arietinum* L.). Zinc foliar application increased grain Zn content by 21 and 22% over Zn soil application and seed priming, respectively. Effects of Zn application strategies on gain and straw Zn contents were consistent across locations. The grain Zn concentration varied among the varieties ranging from 34 mg kg^{-1} for Mastewal to 42 mg kg^{-1} for the Landrace and variety Arerti.

Zn application strategies did not affect the growth and yield parameters, except for pod bearing branches. Foliar Zn application and appropriate variety selection are potential approaches for Zn bio fortification in chickpea.

Krishna and George (2017) conducted experiment to study the effect of levels of phosphorus and zinc on growth and yield of *Kabuli* Chickpea (*Cicer kabulium L.*) var. Pusa-1088. The experiment consisted of twelve treatment combinations comprising of four levels of Phosphorus (@ 40, 50, 60 and 70 kg P ha^{-1}) along with three levels of Zinc (@ 0, 15 and 20 kg ZnSO4 ha^{-1}) in combination with basal application of Nitrogen and Potassium each @ 20 and 40 kg ha^{-1}. The experimental results revealed that Soil application (Basal) of Phosphorus and Zinc @ 70 kg P, 20 kg ZnS04 ha^{-1}recorded significantly higher dry weight (35.00 g $plant^{-1}$), more no. of branches (19.5 $plant^{-1}$), pods $plant^{-1}$ (55.99), grains pod^{-1} (1.45) and maximum Seed index (44.86 g)and seed yield (3387 kg ha^{-1}). The interaction of Phosphorus and Zinc was significant for all the major parameters. These results suggested that the application of P and Zn to *Kabuli* Chickpea affect its yield significantly and also found that P fertilizer @ 70 kg $ha^{-1}$and ZnSO4 @ 20 kg ha^{-1}proved effective for optimum production.

Hossain *et al*. (2016) conducted experiment at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the period from November 2013 to April 2014 to study the effect of boron and zinc on the growth and yield of chickpea. Five levels of boron viz. 0, 1, 2, 3 and 4 kg B ha^{-1} and four levels of zinc viz. 0, 2, 4 and 6 kg Zn ha^{-1} were used as treatments. Effect of Zinc on total dry matter was significant at 20, 30, 40, 50 and 60 DAS but not significant at 70 and 80 DAS.The maximum total dry matter was recorded from 4 kg Zn ha^{-1}. Effect Zinc on crop growth rate was not significant. Application of boron showed significant effect on the yield attributes and yield of chickpea. Zinc showed significant effect on almost all the yield attributes and yield of chickpea. The highest seed yield (1.742 t ha^{-1}) was obtained from 4 kg Zn ha^{-1} and lowest one (1.325 t ha^{-1}) was found in control treatment. Therefore, the combination of 3 kg B $ha^{-1}$with 4 kg Zn ha^{-1} may be recommended for better plant growth and higher yield of chickpea.

Pathak *et al*. (2012) conducted experiment to study the effect of zinc foliar application on improving plant yield and seed zinc content for human consumption, chickpea plants were raised in refined sand culture with deficient (0.2 µM) and sufficient (1µM) supply of zinc under glass-house conditions. Prior to initiation of the reproductive phase, zinc was applied as 0.1% ZnSO4 foliar spray to both zinc sufficient and deficient plants. The plants exposed to different zinc treatments were studied for pollen and stigma structure and their involvement in fertilization and seed yield. Zinc deficiency induces flower abortion, pollen, and ovule infertility leading to low seed set and ultimately its yield. Foliar application of ZnSO4 to zinc deficient plants at the time of initiation of flowering partially reverses the adverse effect of zinc deficiency on pollen-stigma morphology, pollen fertility, and greatly enhanced seed yield of plants. Zinc foliar application improved not only the boldness and vigor of seeds in zinc-deficient plants, but also the seed zinc content in zinc-deficient seeds as well as the sufficient ones.

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.

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.

Akay (2011) studied the effect of zinc fertilizer applications on different chickpea varieties and the most suitable zinc application dose were investigated under the field conditions in May to September of 2003 and 2004. Zinc was applied to the soil at four doses 0, 0.5, 1.0 and 1.5 kg da^{-1} before sowing. The values of P, phytic acid and Zn contents in the seed and the Zn content in the leaf of ILC-482 variety were found to be higher when compared with other varieties. According to correlation test results, there were significant ($P < 0.05$) differences among the described criteria. Significant correlations were observed between phosphorus content in seed and grain yield (r= 0.75*); total chlorophyll content of leaves and grain yield (r= 0.78*); total chlorophyll content of leaves and phytic acid (r= 0.93**); total chlorophyll content of leaves and phosphorus content in seed (r= 0.72*) particularly in ILC -482 variety. The application of zinc fertilizer did not provide a significant increase in the yield. However, significant increases were observed in phosphorus, phytic acid and zinc content in the seed and the chlorophyll concentration in the leaf through zinc fertilizer application at a dose of 1.0 kg da^{-1} ($P < 0.01$).

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 mgBpot^{-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.

Khan *et al*. (1998) conducted two glasshouse experiments using Zn-deficient siliceous sandy soil to determine the response of chickpea to Zn nutrition and to diagnose Zn status in plant tissue. In Experiment 1, two genotypes of desi chickpea (Dooen and Tyson) were grown at five Zn levels (0, 0.04, 0.2, 1.0 and 5.0 mg kg^{-1} of soil). After 4 weeks, no difference in growth and no visible symptoms of Zn deficiency were detected. After 6-8 weeks of growth, chlorosis of younger leaves and stipules occurred in the Zn_0 treatment, with shoot dry weight being only 24% of that recorded at the highest Zn level. Root growth increased from 0.52 g/plant when no Zn was applied to 1.04 g/plant in the treatment with 0.2 mg Zn kg^{-1}of soil; no response to further increase of Zn fertilization occurred. Zinc concentration in the whole shoot increased significantly with increased in Zn application. The critical Zn concentration in the shoot tissue, associated with 90% of maximum growth, was 20 mg kg^{-1} for both genotypes at flowering stage.In the second experiment, two genotypes of desi chickpea (Tyson and T-1587) were grown at three Zn levels (0, 0.5 and 2.5 mg kg^{-1} of soil) under two moisture regimes (field capacity 12% w/w, and water stress 4% w/w). Shoot growth was influenced by both Zn supply and water stress. The effect of water stress was severe in the 0.5 and 2.5 mg Zn treatments where shoot dry matter was reduced 52 and 46%, respectively. T-1587 was less sensitive to Zn deficiency and produced higher shoot dry weight than Tyson in the Zn_0 treatment. Zinc concentration in shoots increased from 5 mg kg^{-1} when no Zn was applied to 40 mg kg^{-1} at the highest Zn level. The critical Zn concentration in shoots was 21 mg kg^{-1}.The results of the two experiments showed that the critical concentration for Zn did not differ amongst the three cultivars used and was not affected by soil moisture. Similar studies should be undertaken with a wider number of genotypes to discover if a critical concentration of 20-21 mg kg^{-1} in the shoot can be used to diagnose the Zn status of chickpea genotypes.

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.

Sangwan and Raj (2004) conducted experiment during rabi 1991-92 to 1995-96 (5 seasons) at Dryland Research Farm of CCS Haryana Agricultural University, Hisar located in an aridclimate to evaluate the effect of Zn appreciation to soil (0, 5, 10 and 15 kg Zn/ha) on chickpeayield under dryland conditions. The grain yield of chickpea increased significantly with variouslevels of Zn application when compared with the control. Application of 15 kg Zn/ha gavesignificantly highest yield over lower levels but there was no significant difference between 5& 10 and 10 & 15 Zn/ha except in the year 1992-93 and 1994-95. A mean grain yield increaseof 35% was observed with zinc fertilization over control.

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, 2015 to April, 2016 to effect of nitrogen and zinc on growth and yield of chickpea(*CicerarietinumL.)*. 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 Sher-e-Bangla Agricultural University, Dhaka. The experimental area is located at 23.41° N and 90.22° E latitude and at an altitude of 8.6 m from the sea level.

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 to analyze soil according to Edris *et al.*, (1979) and the soil characterizes.

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 cultivar of chickpea BARI Chhola-2 (Baral) variety has 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 whole amount of fertilizers were incorporated thoroughly before planting according to fertilizers recommendation guide (BARC, 2005) except nitrogen. Nitrogen was used as per treatments.

3.6. Fertilizers

Phosphorus, potash and sulphur fertilizers were applied as basal during final land preparation. Nitrogenous and zinc fertilizer was applied as per treatment.

Fertilizer	Dose (kg ha^{-1})
P	40
K	20
S	10

3.7. Treatments of the experiment

The experiment was consisted of two treatment factors as follows:

Factor A: Urea fertilizer

1. N_0 = No Nitrogen (Control)
2. N_1 = 10 kg N ha^{-1}
3. N_2 = 20 kg N ha^{-1}
4. N_3 = 30 kg N ha^{-1}

Factor B: Zinc oxide fertilizer

1. Zn_0 = No Zinc (Control)
2. Zn_1 = 4.0 kg Zn ha^{-1}
3. Zn_2 = 8.0kg Zn ha^{-1}

3.8 Treatment combinations

There are 12 treatment combinations of different N and Zn doses used in the experiment under as following:

1. N_0Zn_0	7. N_2Zn_0
2. N_0Zn_1	8. N_2Zn_1
3. N_0Zn_2	9. N_2Zn_2
4. N_1Zn_0	10. N_3Zn_0
5. N_1Zn_1	11. N_3Zn_1
6. N_1Zn_2	12. N_3Zn_2

3.9. Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (Factorial) with three replications. Each block was divided into 12 plots where 12 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. The layout of the experiment is presented in Appendix II.

3.10. Sowing of seeds in the field

Seeds were sown on 15th November 2015. 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.

3.11. Intercultural operations

3.11.1. Thinning

Emergence of seedling was completed within 10 days after sowing (DAS). Overcrowded 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.

3.11.2. Weeding

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

3.11.3. Irrigation

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

3.11.4. 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.

3.12. 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 areas from middle portion of each plot were marked for harvest at maturity. The harvested plants of 2 m^2 of each treatment were brought to the cleaned threshing floor and pods were separated from plants by hand and allowed them for drying well under bright sunlight.

3.13. Crop 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.

3.13.1. 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.

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

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

3.13.3. 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.

3.13.4 Thousand seed weight (g)

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

3.13.5. Seed yield (t ha^{-1})

The seed weight was taken from the selected plants having threshed properly and then yield was expressed in ton per hectare.

3.13.6Stover yield

Stover yield was determined from the central 5 m length of all 6 inner rows of each plot. After threshing, the sub-sample was oven dried to a constant weight and finally converted to t ha^{-1}.

3.13.7Biological yield

The biological yield was calculated with the following formula-

Biological yield= Grain yield + Straw yield

3.14 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil samples of each plot was air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.15 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. pH, organic matter S and Mo contents. The soil samples were analyzed by the following standard methods as follows:

3.15.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 as described by Page *et al.*, 1982.

3.15.2 Organic matter

Organic carbon in soil sample was determined by wet oxidation method. The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.16. 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

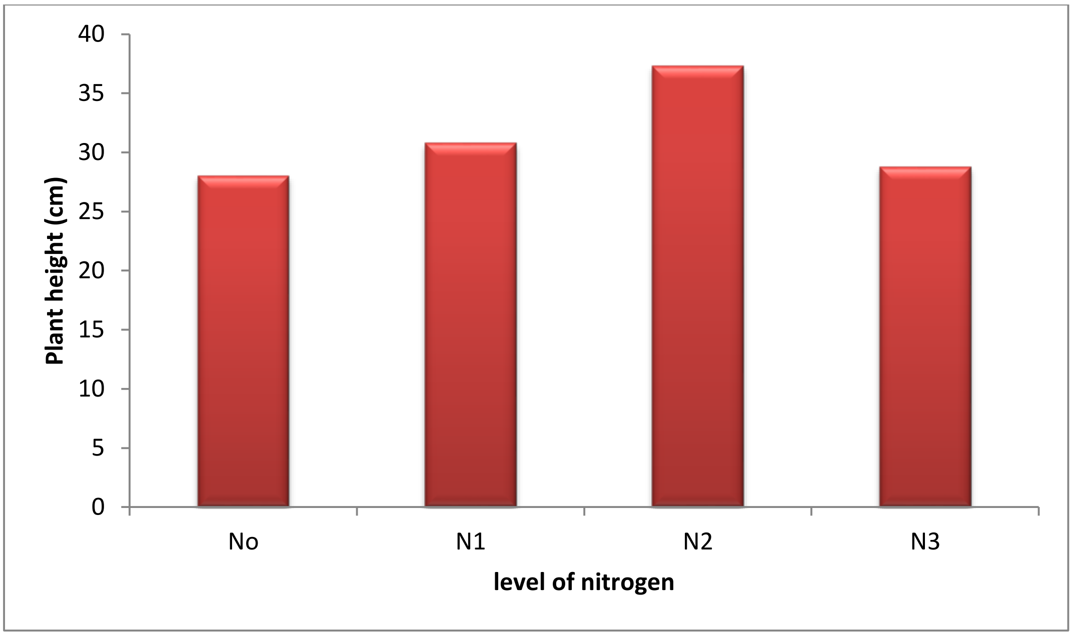
RESULTS AND DISCUSSION

This chapter comprises presentation and discussion of the results obtained from a study to effect of nitrogen and zinc on growth and yield of chickpea (*cicerarietinum*L.). The results of the growth and yield characters of the production of the crop as influenced by different nitrogen and zinc treatments have been presented and discussed in this chapter.

4.1 Plant height (cm)

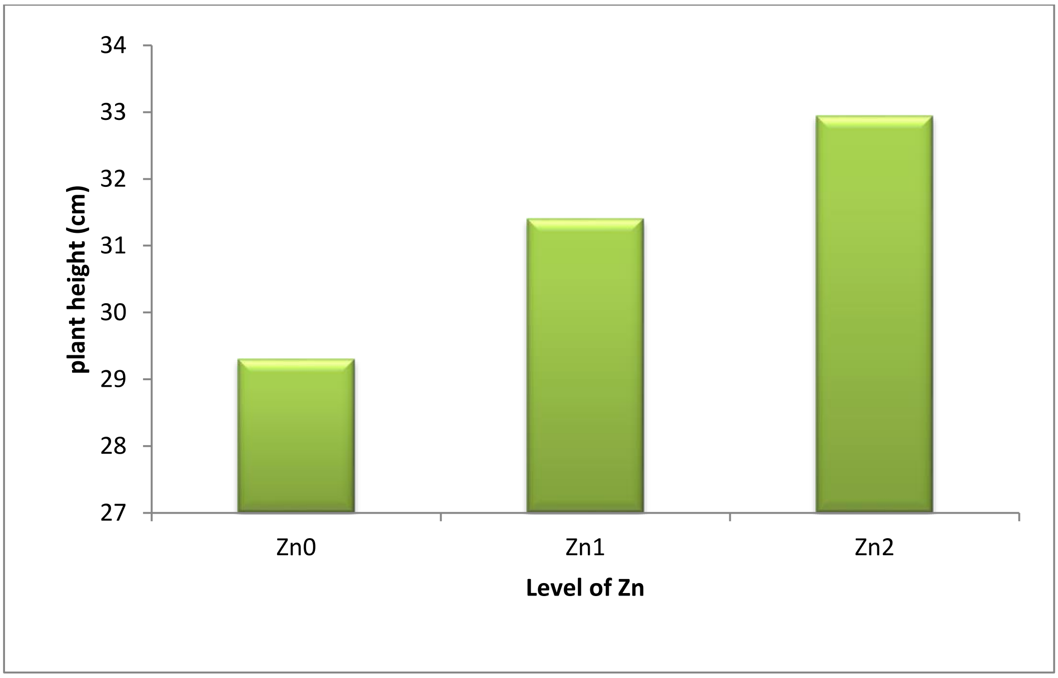
Different nitrogen application showed significant differences on plant height at harvest (fig. 1). The tallest plant (37.31 cm) was found in N_2 (20 kg N ha^{-1}). The shortest plant (28.00 cm) was observed in N_0 (No fertilizer). Similarly Patra*et al.* (1998) noticed increased plant height of chickpea over control with 20 kg N along with 40 kg P ha^{-1}. Rathore and Patel (1991) noticed that application of 18 kg N along with 46 kg P ha^{-1} increased plant height of chickpea over no N application. Chaudhari*et al.* (1998) found a positive effect of nitrogen at the rate of 20 and 40 kg ha^{-1} on increased in chickpea plant height.

Plant height varied significantly due to different level of Zinc (Figure 2). It was observed that Zn_2 produced the highest (32.94 cm) plant height. On other hand, Zn_0produced the shortest (29.30 cm) plant height. 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).



N_0 = No nitrogen (Control), N_1 = 10 kg N ha^{-1}, N_2 = 20 kg N ha^{-1}, N_3 = 30 kg N ha^{-1}

Fig. 1. Effect of different levels of nitrogen on plant height of chickpea



Zn_0 = No Zinc (Control), Zn_1 = 4.0 kg Zn $ha^{-1,}$ Zn_2 = 8.0kg Zn ha^{-1}

Fig. 2. Effect of different levels of zinc on plant height of chickpea

Plant height varied significantly due to various treatment combinations of nitrogen and zinc (Table 1). Numerically, the treatment combination of N_2Zn_2 produced the highest plant height (40.00 cm). However, the treatment combination of N_0Zn_0 produced the lowest plant height (26.44 cm).

4.2. Branches plant^{-1}

Number of branches plant^{-1} showed significant variation for different nitrogen application (Figure3). The maximum number of branches plant^{-1} was recorded from N_2 (8.82), which were statistically similar with N_3 treatment. The minimum number of branches plant^{-1}(4.80) was recorded from N_0treatment. Chaudhari*et al.* (1998) found a positive effect of nitrogen at the rate of 20 and 40 kg ha^{-1} on increased in chickpea number of primary and secondary branches plant^{-1}. Vadavia*et al.* (1991) reported that application of 20 kg N ha^{-1} and 40 kg P ha^{-1} increased number of branches plant^{-1} of chickpea. Mishra (1995) reported that N deficient chickpea plants were shorter and got less branches plant^{-1} than the plants grown with applied N. The tallest plant and higher number of branches plant^{-1} was obtained by 30 kg N ha^{-1}.

Number of branches of chickpea varied significantly due to different zinc treatments (Figure 4). The highest number of branches of chickpea (7.82) was obtained from Zn_2 treatment. Thelowest number of branches (6.18) was produced from Zn_0 (control) treatment. It may be due to zinc, which is involved 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.

Table 1. Combined effect of different level of nitrogen and Zinc on plant height and number of branch per plant of chickpea

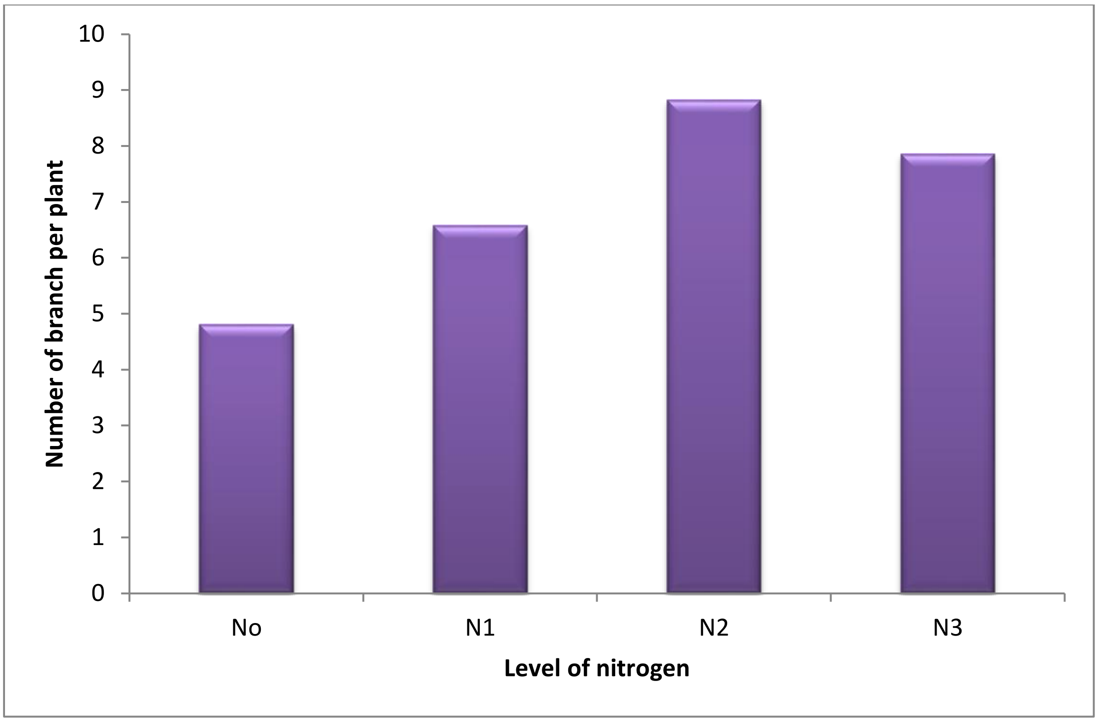
Treatment	Plant height (cm)		number of branch per plant	
N_0Zn_0	26.44	e	3.93	f
N_0Zn_1	27.55	de	5.07	ef
N_0Zn_2	30.00	cde	5.40	e
N_1Zn_0	29.11	de	5.67	de
N_1Zn_1	31.55	cd	6.73	cd
N_1Zn_2	31.66	cd	7.33	bc
N_2Zn_0	34.33	bc	7.80	bc
N_2Zn_1	37.60	ab	8.67	b
N_2Zn_2	40.00	a	10.00	a
N_3Zn_0	27.33	de	7.33	bc
N_3Zn_1	28.89	de	7.70	bc
N_3Zn_2	30.11	cde	8.53	b
$LSD_{(0.05)}$	4.02		1.22	
CV (%)	7.6		10.27	

N_0 = No nitrogen (Control) Zn_0 = No Zinc (Control)

N_1 = 10 kg N ha^{-1} Zn_1 = 4.0 kg Zn ha^{-1}

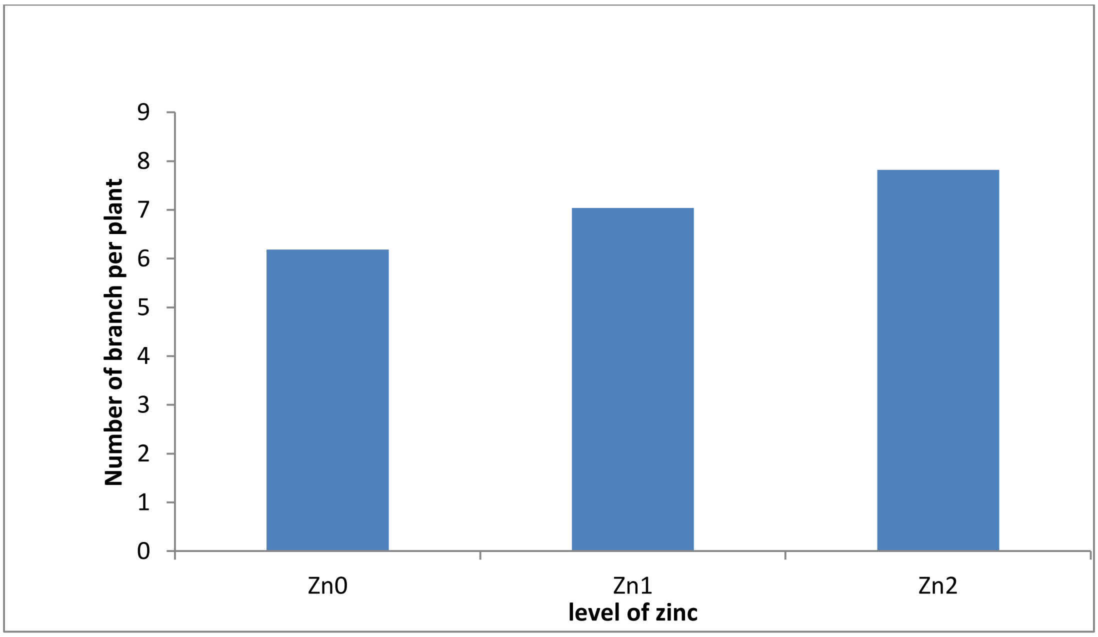
N_2 = 20 kg N ha^{-1} Zn_2 = 8.0kg Zn ha^{-1}

N_3 = 30 kg N ha^{-1}



N_0 = No nitrogen (Control), N_1 = 10 kg N ha^{-1}, N_2 = 20 kg N ha^{-1}, N_3 = 30 kg N ha^{-1}

Fig. 3 Effect of different levels of nitrogen number of branch per plant of chickpea



Zn_0 = No Zinc (Control), Zn_1 = 4.0 kg Zn ha^{-1}, Zn_2 = 8.0kg Zn ha^{-1}

Fig 4. Effect of different levels zinc on number of branch per plant of chickpea

A significant variation in the number of branch per plant was found between the N and Zn (table 1). The maximum number of branch per plant (10.00) was found in combined use of 20 kg N and 8 kg Zn, treatment, whereas the lowest number of leaves per plant (3.93) was found in control treatment.

4.3 Number of pods plant^{-1}

Number of pods plant^{-1} showed significant variation for different nitrogen application (Table2). The highest pods plant^{-1}(69.29) was recorded from N_2treatment. On the other hand, for different nitrogen level, the lowest pods plant^{-1}(27.44) was recorded from N_0 (No fertilizer). Patra*et al.* (1998) noticed that number of pods plant^{-1} of chickpea increased over control with 20 kg N along with 40 kg P ha^{-1}. Rathore and Patel (1991) observed that maximum number of pods plant^{-1} when chickpea was provided with 18 kg N along with 46 kg P ha^{-1}. Chaudhari*et al.* (1998) found a positive effect of nitrogen at the rate of 20 and 40 kg ha^{-1} on increase in chickpea pods per plant and protein content in seed over control. Karadavut and Ozdemir (2001) found that *Rhizobium* inoculation and 30 kg N ha^{-1} significantly increased pods plant^{-1}. Vadavia*et al.* (1991) found that number of pods plant^{-1} of chickpea increased following application of 20 kg N ha^{-1} and 40 kg P ha^{-1}.

The effect of Zn was significantly influenced on Number of pod plant^{-1} (Table.3). The highest number of pod plant^{-1} (52.42) was obtained from Zn_2, 8 kg Zn/ha and the lowest number of pod plant^{-1} (38.00) was obtained from the control, Zn_0. It was observed that with the increase of Zn number of pod plant^{-1}also increase. It may be due to zinc 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 zinc 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.

Significant variation was observed in the number of pod plant^{-1} of chickpea due to various treatment combinations of N and Zn (Table 4). It was observed that the treatment combination of N_2Zn_2 produced the highest (77.33) number of pod plant^{-1}, which was statistically similar with $N_2Zn_1$and the treatment combination of N_0Zn_0 produced the lowest (23.6) number of pod plant^{-1}.

Table 2. Effect of different level of nitrogen on the yield of chickpea

Treatment	**Number of effective pod per plant**		**1000 seed weight (g)**		**Yield (t/ha)**	
N_o	27.44	d	108.8	b	1.74	b
N_1	36.64	c	111.3	b	1.95	ab
N_2	69.29	a	115.3	a	2.10	a
N_3	48.02	b	111.5	b	2.01	a
LSD $_{(0.05)}$	8.857		3.834		0.26	
CV (%)	7.27		8.89		8.89	

N_0 = No nitrogen (Control), N_1 = 10 kg N ha^{-1}, N_2 = 20 kg N ha^{-1}, N_3 = 30 kg N ha^{-1}

Table 3. Effect of different level of Zinc on the yield of chickpea

Treatment	**Number of effective pod per plant**		**1000 seed weight (g)**		**Yield (t/ha)**	
Zn_0	38.00	b	110.6	b	1.73	b
Zn_1	45.63	ab	112.9	a	2.04	a
Zn_2	52.42	a	111.6	ab	2.09	a
LSD $_{(0.05)}$	10.31		1.478		0.30	
CV (%)	7.27		8.89		8.89	

Zn_0 = No Zinc (Control), Zn_1 = 4.0 kg Zn ha^{-1}, Zn_2 = 8.0kg Zn ha^{-1}

Table 4. Combined effect of different levels of nitrogen and zinc on yield of chickpea

Treatment	Number of effective pods per plant	Thousand seed weight (g)	Yield (t/ha)
N_0Zn_0	23.60 h	107.70 e	1.51 e
N_0Zn_1	26.13 gh	109.20 cde	1.84 bcd
N_0Zn_2	32.60 fgh	109.50 cde	1.88 bcd
N_1Zn_0	29.60 gh	110.00 cde	1.64 de
N_1Zn_1	36.20 efg	111.50 bcde	2.06 abc
N_1Zn_2	44.13 de	112.30 bcde	2.16 ab
N_2Zn_0	58.13 b	113.00 abcd	1.82 cd
N_2Zn_1	72.40 a	115.90 ab	2.23 a
N_2Zn_2	77.33 a	117.00 a	2.25 a
N_3Zn_0	40.67 def	111.70 bcde	1.95 abcd
N_3Zn_1	47.80 cd	114.00 abc	2.03 abc
N_3Zn_2	55.60 bc	108.70 de	2.05 abc
$LSD_{(0.05)}$	9.58	4.20	0.29
CV (%)	7.27	8.89	8.89

N_0 = No Nitrogen (Control)
N_1 = 10 kg N ha^{-1}
N_2 = 20 kg N ha^{-1}
N_3 = 30 kg N ha^{-1}

Zn_0 = No Zinc (Control)
Zn_1 = 4.0 kg Zn ha^{-1}
Zn_2 = 8.0kg Zn ha^{-1}

4.4 Thousand Seed weight

Thousand seed weight showed significant variation due to different doses of nitrogen application (table 2). The highest thousand seed weight (115.30 g) was recorded from N_2 (20 kg N ha^{-1}). On the other hand, for different nitrogen application techniques, the lowest thousand seed weight (108.80 g) was recorded from N_0 (No fertilizer), which was statistically similar with $N_3$and N_1treatment. Patra*et al*. (1998) reported that when 20 kg N along with 40 kg P ha^{-1}were applied, it increased 1000-seed weight of chickpea over control. Rathore and Patel (1991) reported that application of 18 kg N ha^{-1}along with 40 kg P ha^{-1}increased 1000-seed weight. Vadavia*et al*. (1991) found that seed weight increase following application of 20 kg N $ha^{-1}$and 40 kg P $ha^{-1}$of chickpea. Javiya*et al*. (1989) found that plant height of chickpea was significantly increased by the application of N fertilizer at 50 kg ha^{-1}.

Thousand seed weightof chickpea varied significantly due to various zinc treatments (Table 3). It was observed that the Zn_2 treatments produced the highest thousand seed weight(112.90 g). The lowest seed yield (110.60 g) was obtained from Zn_0 (control). Chickpea responded to the Zn applications. 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.

Significant variation was observed on the thousand seed weightof chickpea due to various treatment combinations of N and Zn (Table 4). It was observed that the treatment combination of N_2Zn_2 produced the highest (117.00 g) thousand seed weight and the treatment combination of N_0Zn_0 produced the lowest (107.70g).

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

Seed yield showed significant variation due to different doses of nitrogen application (Table 2). The highest seed yield (2.10 ton ha^{-1}) was recorded from N_2 (20 kg N ha^{-1}), which was statistically similar with N_3 treatment. On the other hand, the lowest seed yield (1.13 ton ha^{-1}) was recorded from N_0 (control). Vadavia*et al.* (1991) found significant higher seed yield of chickpea following application of 20 kg ha^{-1} N and 40 kg P ha^{-1}. Application of 20 kg N ha^{-1} increased seed yield of chickpea reported by Subba Rao *et al.* (1986). Shamim and Naimat (1987) reported that application of 10 kg N + 75 kg P_2O_5 ha^{-1} to *Cicerarietinum*cv. C-727 increases seed yields cover uninoculated seed from 583 to 878 kg ha-1. Tomar and Sharma (1985) obtained highest seed yield in chickpea of two consecutive years with the application of N, P and K at the rate of 20, 40 and 20 kg ha^{-1} respectively over control. Similar result was obtained by Rawal and Yadava (1986) using those fertilizers at the same rate.

Seed yield of chickpea varied significantly due to different Zn treatments (Table 3). Themaximum seed yield (2.08 t ha^{-1}) was obtained from Zn_2 treatment, which was statistically similar with Zn_1 treatmentandZn_0 produced the lowest (1.71 t ha^{-1}) seed yield. Chickpea responded to the Zn. The Zn 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.

Significant variation was observed on the seed yield of chickpea due to various treatment combinations of N and Zn (Table 4). It was observed that the treatment combination of N_2Zn_2 produced the highest (2.25 t ha^{-1}) seed yield, which was statistically similar with N_2Zn_1 and the treatment combination of N_0Zn_0 produced the lowest (1.51 t ha^{-1}).

4.6. Stover yield

The stover yield per hectare was significantly affected by different nitrogen application (Table 5). The maximum stover yield per hectare (1.03 tons) was observed in N_2.The lowest yield per hectare (0.74 ton) was observed from N_0.

Subba-Rao *et al.* (1986) also reported that the rate of 20 kg N ha^{-1} was most effective in increasing straw yield of chickpea. Karadavut and Ozdemir (2001) stated the application of *Rhizobium sp.* and 30 kg N ha^{-1} on 3 chickpea cultivars in the winter season of 1995-96 and 1996-97 significantly increased straw yield.

Different Zn treatments had not significant effect on the stover yield of chickpea (Table 6). The maximum stover yield per hectare (0.95 ton) was obtained from Zn_2 treatment and the minimum (0.79 ton) was obtained in Zn_0 treatment (Table 6). Sarker*et al.* (2000), Bhuiyan*et al.* (1998), observed higher stover yield formation due to application of Zn.

Combined effect of different N and Zn had a significant variation on seed yield per hectare (table 7). The highest seed yield per hectare (1.12 ton) was obtained from N_2Zn_2treatment while the lowest (0.69 ton) from N_0Zn_0combination (Table 8).

4.7. Biological yields

A significant increase in biological yield was found in chickpea due to different N level. The highest biological yield of 3.13 t ha^{-1} was observed in treatment N_2 and the lowest (2.48) from N_0 (Table 5).

There was significant variation in biological yield due to the different level of Zn. The maximum biological yield (3.01 t ha^{-1}) was obtained from Zn_2 treatment and the minimum (2.54 t ha^{-1}) was obtained in Zn_0 treatment (Table 6).

Combined effect of different N and Zn had a significant variation on biological yield. The highest biological yield (3.37 t ha^{-1}) was obtained from N_2Zn_2 treatment while the lowest (2.2 t ha^{-1}) from N_0Zn_0 (Table 7).

Table 5. Effect of different levels of nitrogen on stover yield and biological yield of chickpea

Treatment	Stover yield (t/ha)	Biological yield (t/ha)
N_o	0.75 b	2.48 b
N_1	0.82 ab	2.77 ab
N_2	1.03 a	3.13 a
N_3	0.87 ab	2.88 ab
LSD $_{(0.05)}$	0.25	0.46
CV (%)	9.88	10.21

N_0 = No nitrogen (Control), N_1 = 10 kg N ha^{-1}, N_2 = 20 kg N ha^{-1}, N_3 = 30 kg N ha^{-1}

Table 6. Effect of different levels of zinc on stover yield and biological yield of chickpea

Treatment	Stover yield (t/ha)	Biological yield (t/ha)
Zn_0	0.79 b	2.54 b
Zn_1	0.85 b	2.89 ab
Zn_2	0.95 a	3.01 a
LSD $_{(0.05)}$	0.9	0.37
CV (%)	9.88	10.21

Zn_0 = No Zinc (Control), Zn_1 = 4.0 kg Zn $ha^{-1,}$$Zn_2$ = 8.0kg Zn ha^{-1}

Table 7. Combined effect of different levels of nitrogen and zinc stover yield and biological yield of chickpea

Treatment	Stover yield (t/ha)		Biological yield (t/ha)	
N_0Zn_0	0.69	d	2.20	e
N_0Zn_1	0.73	cd	2.57	cde
N_0Zn_2	0.79	cd	2.67	cde
N_1Zn_0	0.80	cd	2.44	de
N_1Zn_1	0.80	cd	2.86	abcd
N_1Zn_2	0.85	bcd	3.01	abc
N_2Zn_0	0.94	abc	2.75	bcd
N_2Zn_1	1.03	ab	3.26	ab
N_2Zn_2	1.12	a	3.37	a
N_3Zn_0	0.73	cd	2.77	bcd
N_3Zn_1	0.85	bcd	2.88	abcd
N_3Zn_2	1.03	ab	2.98	abcd
$LSD_{(0.05)}$	0.19		0.49	
CV (%)	9.88		10.21	

N_0 = No Nitrogen (Control)

N_1 = 10 kg N ha^{-1}

N_2 = 20 kg N ha^{-1}

N_3 = 30 kg N ha^{-1}

Zn_0 = No Zinc (Control)

Zn_1 = 4.0 kg Zn ha^{-1}

Zn_2 = 8.0kg Zn ha^{-1}

CHAPTER V
SUMMARY AND CONCLUSION

This experiment was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, during the period from November, 2015 to April, 2016 to effect of nitrogen and zinc on growth and yield of chickpea (*Cicer arietinum* L.*)*. In experiment, the treatment consisted of four Nitrogen fertilizer viz. N_0 = No nitrogen (Control), N_1 = 10 kg ha^{-1}, N_2 = 20 kgha^{-1}, N_3 = 30 kgha^{-1} and three different Zinc fertilizer viz. Zn_0 = No Zinc (Control), Zn_1 = 4.0 kgha^{-1}, Zn_2 = 8.0kgha^{-1}. The experiment was laid out in a two factors randomized complete block design (RCBD) with three replications.

Results showed that a significant variation was observed among the treatments in respect majority of the observed parameters. The collected data were statistically analyzed for evaluation of the treatment effect.

In the study, it was observed that the plant height was significantly affected due to the different Nitrogen. The tallest plant (37.31 cm) was found from N_2 (20 kg N ha^{-1}). Plant height varied significantly due to different level of Zinc. It was observed that Zn_2 produced the highest (32.94 cm) plant height. Plant height varied significantly due to various treatment combinations of nitrogen and zinc. The treatment combination of N_2Zn_2 produced the highest plant height (40.00 cm).

Number of branches plant^{-1} showed significant variation for different nitrogen application. The maximum number of branches plant^{-1} was recorded from N_2 (8.82). The highest number of branches of chickpea (7.82) was obtained from Zn_2 treatment. A significant variation in the number of branch per plant was found between the N and Zn. The maximum number of branch per plant (10.00) was found in combined use of 20 kg N and 8 kg Zn, treatment.

Number of pods plant^{-1} showed significant variation for different nitrogen application. The highest pods plant^{-1} (69.29) was recorded from N_2 treatment. The effect of Zn was significantly influenced on Number of pod plant^{-1}. The highest number of pod plant^{-1} (52.42) was obtained from $Zn_{2,}$ 8 kg Zn/ha.

Significant variation was observed in the number of pod plant^{-1} of chickpea due to various treatment combinations of N and Zn (Table 5). It was observed that the treatment combination of N_2Zn_2 produced the highest (77.33) number of pod plant^{-1}.

Thousand seed weight showed significant variation for different nitrogen application. The highest thousand seed weight (115.30 g) was recorded from N_2 (20 kg N ha^{-1}). Thousand seed weight of chickpea varied significantly due to various zinc treatments. It was observed that the Zn_2 treatments produced the highest thousand seed weight (112.90 g). Significant variation was observed on the thousand seed weight of chickpea due to various treatment combinations of N and Zn. It was observed that the treatment combination of N_2Zn_2 produced the highest (117.00 g) thousand seed weight

Seed yield showed significant variation for different nitrogen application. The highest seed yield (2.10 ton ha^{-1}) was recorded from N_2 (20 kg N ha^{-1}). Seed yield of chickpea varied significantly due to various zinc treatments. It was observed that the Zn_2 treatments produced the highest seed yield (2.08 t ha^{-1}). Significant variation was observed on the seed yield of chickpea due to various treatment combinations of N and Zn. It was observed that the treatment combination of N_2Zn_2 produced the highest (2.25 t ha^{-1}) seed yield and the treatment combination of N_0Zn_0 produced the lowest (1.51 t ha^{-1}).

The stover yield per hectare was significantly affected by different nitrogen application (Table 8). The maximum stover yield per hectare (1.03 tons) was observed in N_2. Different Zn treatments had not significant effect on the stover yield of chickpea (Figure 12). The maximum stover yield per hectare (0.95 ton) was obtained from Zn_2 treatment. Combined effect of different N and Zn had a significant variation on seed yield per hectare. The highest seed yield per hectare (1.12 ton) was obtained from N_2Zn_2 treatment.

A significant increase in biological yield was found in chickpea due to different N level. The highest biological yield of 3.13 t ha^{-1} was observed in treatment N_2. There was significant variation in biological yield due to the different level of Zn. The maximum biological yield (3.01 t ha^{-1}) was obtained from Zn_2

treatment. Combined effect of different N and Zn had a significant variation on biological yield. The highest biological yield (3.37 t ha^{-1}) was obtained from N_2Zn_2 treatment

Considering the above results, it may be summarized that growth, seed yield contributing parameters of chickpea are positively correlated with N and Zn application. Therefore, the present experimental results suggest that the combined use of 20 kg N/ha and 8 kg Zn/ha along with recommended doses of other fertilizer would be beneficial to increase the seed yield of chickpea variety BARI Chhola-2 (Baral) under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

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

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

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APPENDIX

Appendix: **Soil characteristics of experimental farm of Sher-e-Bangla Agricultural University are analyzed by soil Resources Development Institute (SRDI), Farmgate, Dhaka.**

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Farm, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	**N/A**

Source: SRDI

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
pH	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (µgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40
Available B (µgm/gm soil)	0.13
Available Zn (µgm/gm soil)	0.94
Available Cu (µgm/gm soil)	1.93
Available Fe (µgm/gm soil)	240.9
Available Mn (µgm/gm soil)	50.6

Source: SRDI