EFFECT OF ZINC AND BORON ON GROWTH AND YIELD OF BARI JHAR SHEEM-1 (*Phaseolus vulgaris* L.)

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CERTIFICATE

This is to certify that the thesis entitled **‘Effect of Zinc and Boron on Growth and Yield of BARI Jhar Sheem-1’** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Soil Science**, embodies the result of a piece of bonafide research work carried out by**SamiaFardus**, Registration number: **10-04135** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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ABSTRACT

The experiment was conducted during the period from December, 2015 to February 2016 at the farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to study the effect of Zn and B on growth and yield of BARI Jhar Sheem-1. The experiment comprised of two factors; Factor A: Levels of Zn (3 levels) Zn_1: 0 kg Zn ha^{-1}(control), Zn_2: 1.5 kg Zn ha^{-1}, Zn_3: 3 kg Zn $ha^{-1}$and Factor B: Levels of B (3 levels) B_1: 0 kg B ha^{-1}(control), B_2: 1 kg B $ha^{-1}$and B_3: 2 kg B ha^{-1}. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. For different levels of Zn at harvest, the tallest plant (30.11cm) was recorded from Zn_3, whereas the shortest plant (23.38cm) was found from Zn_1. The highest pod yield (11.77 t ha^{-1}) was recorded from Zn_3, whereas the lowest (8.56 t ha^{-1}) from $Zn_{1.}$ The longest pod (14.26 cm) was observed from Zn_3, while the shortest pod (12.56 cm) was found from Zn_1 (0 kg Zn ha^{-1}). The highest stover yield (6.53 t ha^{-1}) was attained from Zn_3. The lowest stover yield (3.50 t ha^{-1}) was found from Zn_1. In consideration of different level of B at harvest, the tallest plant (27.58cm) was recorded from B_3, while the shortest plant (26.12cm) from B_1. The longest pod (13.72 cm) was obtained from B_3, while the shortest pod (13.13 cm) was recorded from B_1. The highest pod yield $hectare^{-1}$(11.49 ton) from B_3, while the lowest pods yield(9.29 t ha^{-1}) from B_1. The highest stover yield (5.72 t ha^{-1}) was observed from B_3, whereas the lowest stover yield (4.89 t ha^{-1}) was found from B_2(1 kg B ha^{-1}). In the combination of Zn and B at harvest, the tallest plant (30.81cm) was observed from $Zn_3B_2$and the shortest plant (22.13cm) from Zn_1B_1.The longest pod (14.60 cm) was recorded from Zn_3B_3, whereas the shortest pod (12.33 cm) was observed from Zn_1B_1. The highest pod yield(12.57 t ha^{-1}) was found from $Zn_3B_2$and the lowest pod yield (7.63 t ha^{-1}) from Zn_1B_2. The highest stover yield (7.43 t ha^{-1}) was obtained from the treatment combination of 3 kg Zn ha^{-1} and 2 kg B ha^{-1}. The lowest stover yield (3.37 t ha^{-1}) was obtained from the Zn_1B_1. Findings revealed that application of 3kg Zn ha^{-1}along with 2kg B $ha^{-1}$and 3kg Zn ha^{-1}along with 1kg B ha^{-1}showed statistically same pod yield and other yield contributing characters.

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CHAPTER I

INTRODUCTION

Bush bean (*Phaseolus vulgaris* L.) belongs to the family Fabaceae (Leguminosae) and sub family Papiolionaceae which is derived from a wild species *Phaseolus arborigenesis* originated from southern Mexico and Middle America (Ahlawal *et al.,* 1989) is the second legume vegetable in the world and newly introduced as winter vegetables in Bangladesh. It is also referred as to French bean, Common bean, Snap bean, Green bean, Kidney bean, Haricot bean, Pinto bean, Raj bean, Navy bean, Pole bean, Wax bean, String bean, and Dwarf bean (George 1985; Salunkhe *et al*. 1987; Tindall, 1988). In Bangladesh it is called Jhar seem or Farashi seem (Rashid, 1993). It is becoming popular for its tender pods and shelled beans. The green pods and dry seeds are used in preparations with fish, meat and other vegetables as well. The dry seeds are also used in various curry preparations.

It is widely cultivated in the temperate and subtropical regions and also in many parts of the tropics (Purseglove, 1987). It grows intensively five major continental areas: Eastern Africa, North and Central America, South America, Eastern Asia and Western and South Eastern Europe. In FAO statistics the genus of *Phaseolus* occupied 27.08 million hectares of the World's cropped area. Production of dry pods was about 18.94 million tons with an average yield of 699kg/ha (FAO, 2000). Brazil is the largest bush bean producing country in the world. In our country it is cultivated in Sylhet, Cox's Bazaar, and Chittagong Hill Tracts in limited scale.

It is an excellent vegetable which is rich in proteins, carbohydrates, fats, fiber, thiamin, vitamins and minerals such as calcium, phosphorous, iron, riboflavin, niacin, folic acid and zinc (Broughton *et al.,* 2003). Immature pods are mostly marketed as fresh. After harvest plants can be fed to sheep, horses and cattle. Recently Jhar Sheem cultivation is gaining popularity because of its demand for export.

The productivity of bush bean at farmers' field is low due to the lack of knowledge about sowing time, poor fertility management (Saini and Negi, 1996). Suitable temperature for bush bean growth and development is ranging from 19-27^{0} C. In our country bush bean grows successfully in winter season due to optimum temperature. Two bush bean varieties (BARI Jhar Sheem-1 and BARI Jhar Sheem-2) for rabi season have developed by Bangladesh Agricultural Research Institute.

It is short durated crop and yield is comparatively high. It can fit well in intercropping with maize, sunflower, wheat and sugarcane (Frances *et al*., 1986). Seventeen essential elements are required by crop plants for optimal growth and development. These minerals, when required in relatively high amounts, are called macronutrients or, in trace amounts, micronutrients. While micronutrients are required in relatively smaller quantities for plant growth, they are as important as macronutrients. Micronutrients often act as cofactors in enzyme systems and participate in redox reactions, in addition to having several other vital functions in plants. Most importantly, micronutrients are involved in the key physiological processes of photosynthesis and respiration (Marschner, 1995; Mengel *et al.*, 2001) and their deficiency can impede these vital physiological processes thus limiting yield gain. Micro nutrient availability for the plant depends on soil texture, soil organic matter and soil pH. The soils of different parts of Bangladesh are more or less deficient in boron and zinc which causes poor yield of bush bean.

As a micronutrient importance of Zn in crop production has increased in recent years (Fageria, 2006), considered the most yield-limiting micronutrient (Duffy, 2007; Fageria and Baligar, 2005). Zn is an essential micronutrient involved in a wide variety of physiological processes and it plays an important role in several plant metabolic processes; it activates several enzymes such as alcohol dehydrase, phospholipase, carbonic anhydrase, alkaline phosphatase, carboxypeptidase (Coleman, 1991), RNA polymerase (Romheld and Marschner, 1991) and is involved in protein synthesis and carbohydrate, nucleic acid and lipid metabolism (Marshner, 1986; Pahlsson, 1989).

However, like other heavy metals when Zn is accumulated in excess in plant tissues, it causes alterations in vital growth processes such as photosynthesis and chlorophyll biosynthesis (Doncheva *et al*., 2001) and membrane integrity (De Vos *et al*., 1991). Within plants Zn seems to affect the capacity for water uptake and transport (Barcelo and Poschenrieder, 1990; Kasim, 2007; Disante *et al*., 2010) and to reduce the adverse effects of short periods of heat stress (Peck and McDonald, 2010) or of salt stress (Tavallali *et al*., 2010). Since Zn is required for the synthesis of tryptophan (Brown *et al*., 1993; Alloway, 2004), which is a precursor of IAA, this metal also has an active role in the production of auxin, an essential growth hormone (Brennan, 2005). An excess of Zn has been reported to have a negative effect on mineral nutrition (Chaoui *et al*., 1997). Zinc (Zn) deficiency is a major yield-limiting factor in several Asian countries (Rehman *et al.*, 2012). Zn riched seeds performes better to seed germination, seedling growth and yield of crops (Cakmak *et al*., 1996).

Boron ranks third place among micronutrients in its concentration in seed and stem as well as its total amount after zinc. The principal role of B in plant cell wall and membrane constancy (Bassil *et al*., 2004). Application of B as boric acid increase the plant height, net assimilation rate, relative growth rate and leaf area index (Kalyani *et al*., 1993). It plays a vital role in physiological process of plants such as cell maturation, cell elongation and cell division, pod and seed formation and metabolic process such as hormone development, carbohydrate, protein and nucleic acid metabolism, indole acetic acid cell wall synthesis, membrane integrity and function, cytokinins synthesis and phenol metabolisms (Dell and Huang, 1997; Tanaka and Fujiwar, 2008) and also essential for sugar translocation, movement of growth regulator within the plant and normal growth of pollen grains (Hamasa and Putaiah, 2012). Application of B is enhanced metabolic activity and photosynthetic activity of plants (Lalit Bhatt *et al*., 2004; Sathya *et al*., 2009). Due to B deficiency plants manifest restricted growth of terminal buds with necrosis, shortened internodes and in severe stress of boron deficient plants develop chlorosis, drop flower buds and fail to develop seeds. The leaves become thickened, deformed and brittle; petiol and stem may crack and root may discoloration and rot. Ahmed *et al.* 2012 observed that deficiency B cause prominent reduction of growth, nodulation, yield percentage vigour and viability in legume. Increasing the uptake and reutilization of N, P, K, Na, Ca and other by application of B (Yaseen *et al.*, 2004). Some parts of Bangladesh are more or less deficient in B which causes poor yield. Boron would be more effective when it will be used with Zn fertilizer (Valenciano *et al.*, 2010).

Moreover, farmers are unaware about the use of micronutrient in Jhar Sheem cultivation. So, attention should be given to increasing yield through optimum doses of micronutrients as B and Zn. Hence, an experiment was conducted with different levels of Zn and B application for Jhar Sheem cultivation with the following objectives:

- To assess the effect of Zn and B on growth and yield of BARI Jhar Sheem-1.
- To optimize the suitable dose of Zn and B as micronutrients on growth and yield of BARI Jhar Sheem-1.

CHAPTER II

REVIEW OF LITERATURE

Recently Bush bean (*Phaseolus vulgaris* L.) is one of the most important legume vegetables in the World. Researches on various aspects of its production technology have been carried out worldwide. Many research works have been done in different parts of the world to study the effect of the boron and Zn on the growth and yield of Jhar Sheem. It has been recently introduced in Bangladesh. However, a very few research works have been carried out on Jhar Sheem production under Bangladesh conditions. The literature on the effect of "Zinc (Zn)" and "Boron (B)" as micronutrient on growth and yield are presented in this chapter. However, in the recent, many micronutrients are used for the observation of vegetative growth. But, the literature on the use of different concentrations of "Zn and B" on Jhar Sheem are meager. Some of the important findings related to the present study are reviewed in this chapter.

2.1 Influence of zinc on growth and yield of related crops

An experiment was conducted by Kumar *et al*. (2014) to evaluate the effect of organic, inorganic and biofertlizers on growth, yield and economics of Jhar Sheem. The seed inoculation with biofertilizers + zinc @ 5 kg ha^{-1} gave the significantly higher growth and yield attributes; seed yield (10.73 and 11.97 q ha^{-1}), stover yield (19.65 and 21.15 q ha^{-1}).

Pandey *et al*. (2012) were studied the effects of Zn deficiency on antioxidant responses of two pea (*Pisum sativum* L.) genotypes, a Zn-efficient IPFD-99-13 and Zn-inefficient KPMR-500, grown in sand culture. In the pea genotype KPMR-500, Zn deficiency decreased dry matter yield, tissue Zn concentration, and antioxidant enzyme activities stronger than in the genotype IPFD-99-13. Zinc deficiency produced oxidative damage to pea genotypes due to enhanced accumulation of TBARS and H_2O_2 and decreased activities of antioxidant enzymes (Cu/Zn superoxide dismutase (SOD), catalase (CAT), peroxidase (POD), and ascorbate peroxidase (APX)). In the leaves of IPFD-99-13 genotype, the higher activity of ROS-scavenging enzyme, e.g., SOD, CAT, POD, and glutathione reductase, and antioxidants, such as ascorbate and non-protein thiols, led to the lower accumulation of H_2O_2 and lipid peroxides. These results suggest that, by maintaining an efficient antioxidant defense system, the IPFD-99-13 genotype shows a lower sensivity to Zn deficiency than the KPMR-500 genotype.

El Sayed Hameda *et al*. (2012) were conducted two field experiments were carried out at EI-Bramoon Agricultural Research Farm of Mansoura Horticultural Research Station. The investigated effects of foliar spray with some microelements (Fe, Zn and Mn, 100 ppm) at different fertilizer sources (FYM, mineral fertilizer and control) and bio-fertilization with Rhizobium as well as their interactions on yield and yield components and chemical constituents of pea plant (*Pisum sativum*, L.) cv. Master-B. The foliar spraying pea plants with a mixture of microelements significantly increased yield components expressed as plant height, pod length, pod weight, number of green seeds/pod, weight of 100-green seed, seed index (1000-dry seed weight) and chemical constituents such as NPK, carbohydrates (%) and protein (%) of green seeds of pea plant in both seasons. The fertilization with FYM was the most reliable treatment compared with chemical fertilizer and control treatments.

An experiment was conducted by Alam *et al*. (2010) to evaluate the performance of different fertilizer treatment on garden pea varieties under farmers' field condition in the medium high land under irrigated situation at the Farming System Research and Development (FSRD) site, Elenga, Tangail during two consecutive years. Three verities viz. BARI Motor shuti-1 BARI Motor shuti-2 and BARI Motor shuti-3 were considered as first factor treatment. The second factor was fertilizer combination T_1:N_{50} P_{26} K_{42} S_{12} & T_2: N_{50} P_{26} K_{42} S_{12} + $B_{2.5}Mo_{2.5}$ $Zn_{2.5}$ kg/ha. BARI Motor shuti-1 and BARI motor shuti-2 along with the fertilizer dose N^{50}, P^{26} K^{42} S^{12} and 2.5 kg/ha of each Mo, B & Zn, produced the highest pod yield of 12.35 t/ha and 8.51 t/ha during 2006-07 and 2007-08 respectively.

An experiment was conducted by Stoyanova and Doncheva (2002) to study the influence of succinate treatment on Zn toxicity was investigated using plant growth and mineral uptake as stress indicators. In the presence and absence of 0.2 mM Na-succinate, Pea plants (*Pisum sativum* L., cv. Citrine) were treated with various Zn concentrations (0.67 to 700 mM Zn). Plants pre-treated with succinate and then exposed to Zn exhibited higher dry root, stem and leaf weight than the plants treated with Zn alone. Lower Zn translocation in aboveground parts seemed to result from Zn complexing by organic anion in the roots. This probably caused less Zn transport to the stems and leaves and suggested that succinate has potential for complexing with Zn and may play a role in tolerance to high Zn levels.

There were two field experiments conducted at Giza Experimental Station, ARC, Egypt by Rizk and Abdo (2001) to investigate the response of mungbean (*Vigna radiata*) with some micronutrients. Two cultivars of mungbean (V-2010 and VC-1000) were used in those investigations. Zn (0.2 or 0.4 g/l), Mn (1.5 or 2.0 g/l), B (3.0 or 5.0 g/l) and a mixture of Zn, Mn, and B (0.2, 1.5 and 3.0 g/l, respectively), in addition to distilled water as control were sprayed once at 35 days after sowing (DAS). All treatments increased significantly, yield and its components especially Zn (0.2 g/l) which showed a highly significant increase in all characters under investigation compared to the control. All adopted treatments increased significantly protein percentage in seeds of the two mungbean cultivars in both seasons. Among the treatments of micronutrients, B gave the highest percentage of crude protein.

2.2 Influence of boron on growth and yield of related crop

Green pod yield of French bean increased with increase in P application and with up to 1 kg B ha^{-1} was noted by Singh *et al.* (1994). Application of more than 1 kg B caused a toxic effect.

An experiment was carried out by Moghazy *et al*. (2014) to study the influence of a foliar application with boron and five levels of combinations between compost manure and mineral nitrogen fertilizer as well as their interaction on growth, yield and chemical composition of pea cv. Master B. The vegetative growth traits of green pea, i.e., plant length, number of leaves, number of branches, fresh weight per plant, relative growth rate, yields and its components had high significant values by foliar spraying with boron.

In the pea field the most effective treatment for improving quality and increasing yield that foliar spray with boron (boric acid 17% B) at 50 ppm with application of nitrogen fertilizer in compost form at 2.5 ton fed^{-1} and inorganic N-fertilizer at 60 kg fed^{-1} .

Boron deficiency was established as the dominant nutritional problem causing flower and pod abortion. There were no formations of pods or grains in the absence of B in pea were reported by Banu (2003).

Kumar *et al.* (2002) observed that mungbean was grown in solution culture to study the effect of B deficiency on leaf expansion and intercellular airspaces. Different B concentrations were supplied just after initiation of the second trifoliate leaf because this is the first leaf whose growth depends on the exogenous B supply. The proportion of the spongy mesophyll region comprising airspaces in B-deficient leaves was less than 50% of that observed in leaves of plants supplied with sufficient B.

An experiment was conducted in sandy loan calcareous soil in Uttar Pradesh, India during 1995-96 to study the effect of B application on yield of pea (cv. Rachma) and black gram (cv. Pv-19). Application of B up to 4 kg borax ha^{-1} significantly increased the grain yield of black gram and pea (Singh, R. *et al.* 2002).

Eguchi (2000) conducted a pot experiment on soybean using B deficient alluvial soil and found that the leaves remained green during the harvesting stage in the B deficient plot. Delay of maturity and decrease yield to 67% than B treated plot.

A foliar treatment of B at different rates was carried out by Hermantarajan *et al.* (2000) and observed that application of 50 μg g^{-1} B significantly influenced plant height, root length, total dry matter production, and seed yield of soybean than 100 μg g^{-1} B.

Abhijit *et al.* (1999) reported that boron in the form of borax @ 5 kg ha^{-1} increased significantly the growth and yield of yellow sarson.

Sakai *et al.* (1999) conducted a field experiment in calcareous soil to evaluate the direct and residual effects of different levels of B (0, 4, 16, 32 and 64 kg borax ha^{-1}) and FYM (0, 2.5 and 5 t ha^{-1}) alone or in combinations on maize-lentil cropping system. Increasing levels of B up to 16 kg borax ha^{-1} significantly increased and higher level decreased the yield of first corp. B uptake by corps increased due to available B in post-harvest soil.

The average grain yield of chickpea and other legume crops was 0.1 t ha^{-1} when B was not applied while the yield was 1.4 t ha^{-1} by the application of B 0.5 kg ha^{-1} was observed by Srivastava *et al*. (1999). Further, Tisdale *et al*. (1999) also observed that plant growth, flowering and fruit development were also restricted by a shortage of B & Plants require B for nodule formation in legumes.

A pot experiment with mungbean cv. PDM 54 was conducted by Verma and Mishra (1999) that boron was applied for seed treatment, soil application (basally or at flowering) or foliar spraying. It increased yield and growth parameters with the best results in terms of seed yield/plant when the equivalent of 5 kg borax/ha was applied at flowering stage.

A pot experiment with non calcareous soil in India was conducted by Panwar *et al.* (1998) that chickpeas seed yield was reduced by 4.4% and 61% after application of 0.8 and 0.2 mg B kg^{-1} soil, respectively. 0.2% foliar application of B was increased dry matter & straw yield was less affected by high level of B. Several field trials have been conducted by the OFRD scientists of BARI, Joydebpur to see the response of legume crop to B fertilizer. They observed good response of crop on B application (BARI, 1998).

Srivastava *et al.* (1997) conducted an experiment in a field in B deficient soil, chickpeas cv. Kalika were given complete fertilizer or the complete fertilizer minus each of the trace elements. In the experiment without application of B it was observed that flower abortion was the highest and no seed was produced.

In three different places in Nepal a diagnostic nutrient trial with chickpea was conducted by Srivastava *et al.* (1997) & observed that B deficiency was established as the dominant nutritional problem causing flower and pod abortion. No pods or grains were formed in the absence of applied B. Optimally correct the syndrome was got by the application of 0.5 kg B ha^{-1} .

Talashikar and Chavan (1996) observed that pod production of groundnut was enhanced significantly with the addition of B by 44%.

A field experiment was carried out by Islam *el al.* (1995) on grey floodplain soils at Bogra, Bangladesh. They reported that the yield of chickpea obtained was 14% higher from 2 kg B.

An experiment on the effect of B, Zn and Mo on morphological characters in lentil was conducted by Sinha *et al.* (1994) and showed that primary branch plant^{-1} and pods plant^{-1} increased significantly due to application of B.

Application of B increased the number of pods plant^{-1} and grain yield in a susceptible chickpea variety, Kalika reported by Srivastava (1994). Nitrate reductase activity was lower when there was a B deficiency, especially when NO_3 was present in the medium.

The application of 1 kg B ha^{-1} to peas and soybeans and treating seeds with the equivalent of 50 g ammonium molybdate ha^{-1} increased nodule weight atmospheric N fixation and seed yield (Posypanov *et al.*,1994).

Application of B fertilizers at transplanting time Lin and Deng, (1992) observed that NR activity in leaves was increased. Roy *et al.* (1992) observed that soil application of 20 kg borax ha^{-1} increased seed yield of lentil, while soil application of 3 kg Na-molybdate ha^{-1} gave only small (about 14%) increases.

Luo *et al.* (1990) observed that B fertilizer application increased branches plant^{-1}, pods plant^{-1} in groundnut. The application of B fertilizer promoted the uptake of N, P and K in groundnut.

On the contrary, application of B decreased the uptake of Ca, K, P (Singh *et al*., 1990). Buzetti *et al.* (1990) observed that when soybean cv. porana was treated with 0, 0.2, 0.4, 0.6 or 0.8 pg g^{-1} B pot^{-1}, soybean DM and seed yield pot^{-1} increased up to approx. 0.3 pg g^{-1} B and decreased at higher B rates.

An experiment was conducted by Dwivedi, *et al.* (1990) in sandy loam acid Alfisol with different cropping sequence to study the direct and residual effect of B. He stated that B at 1.0 kg ha^{-1} increased yields at all the cropping sequence an increasing B rates increased B contents in plants and seeds.

Field trials at 7 sites in North Bihar were carried out by Sakai *et al.* (1990) that seed yield of chickpea increased from 1.4 t ha^{-1} with no B to 1.79 t ha^{-1} with 3 kg B ha^{-1}. The yield response to B application was greater on low B soils.

The possible effects of B on nitrate reductase (NR) activity were via the metabolism of nucleic acids and proteins (Kastori and Petrovic, 1989). The effect of variable levels of B-supply on nitrate reductase activity (NR) indicated that, both deficiency and high toxic levels of B-decreased the total N content and the activity of nitrate reductase in roots and shoots of sunflower plants.

Yang *et al*. (1989) observed that application of B, N and K promoted growth, CO_2 assimilation, and NR activity in rape seed leaves. B application increased nodule weight, nodule number and dry weight of groundnut (Kulkami *et al.*, 1989).

Sakal *et al*. (1988) reported that application of 2.0 and 2.5 kg B ha^{-1} increased grain yields of black gram and chickpea by 63% and 38%, respectively and a synergistic relationship between B and K was found in Black gram.

Rerkasem *et al.* (1987) reported that application of 20 kg borax ha^{-1} increased seed yield in black gram (*Vigna mungo)* while 10 kg borax ha^{-1} increased dry matter yield, the number of nodules $plant^{-1}$, the number of pods $plant^{-1}$ and the number of seeds pod^{-1} in green gram (*Vigna radiata).*

Howeler *et al.* (1987) reported that yield of bean was nearly doubled with the application of 1 kg B ha^{-1}.

B application increased nodule weight of groundnut observed by Kanzaria and Patel (1985). Application of 11.2 kg borax ha^{-1} gave maximum yield of groundnut, whereas at a lower dose of 5.6 kg ha^{-1} was found optimal (Saxena and Mehlotra, 1985).

Dutta *et al.* (1984) reported that application of 1 Kg B ha^{-1} increased in leaf area ratio, leaf area index, number of leaves $plant^{-1}$, number of branches $plant^{-1}$, number of pods $plant^{-1}$ mungbean.

Singh and Singh (1984) reported that the uptake of N, Na and B by grain and stover increased significantly with the application of boron in barley.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from December, 2015 to February, 2016 to study the effect of Zn and B on growth and yield of BARI Jhar Sheem-1. This chapter includes materials and methods that were used in conducting the experiment are presented below under the following headings:

3.1 Experimental site

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

3.2 Soil

The soil of the experimental site is under Tejgaon series which belongs to the Agro-ecological zone, Madhupur Tract (AEZ-28), which falls into Deep Red Brown Terrace Soils. Soil samples were collected from the experimental plots to a depth of 0-15 cm from the surface before initiation of the experiment and analyzed in the laboratory. The soil was having a texture of Silty Clay Loam with pH 6.2. The morphological characteristics of the experimental field and physical and chemical properties of initial soil are given in Table 1.

3.3 Climate

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

Table 1. Characteristics of experimental field soil as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Exprimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	31
% Silt	39
% clay	29
Textural class	Silty-Clay Loam
pH	6.2
Organic carbon (%)	0.78
Organic matter (%)	1.187
Total N (%)	0.06
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.12
Available S (ppm)	14.40

3.4 Planting material

The test crop was used as the variety BARI Jhar Sheem-1. The seeds were collected from the Horticulture Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. BARI Jhar Sheem-1 was the released variety of Jhar Sheem, which was recommended by the National Seed Board. Green pod of this variety may harvest within 70-75 days as green pods and highest pod yield of 12-15 t ha^{-1} may be harvested if cultivate following modern technology.

3.5 Land preparation

The land was irrigated before ploughing. After having 'zoe' condition the land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 4 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 1st and 7th December, 2015, respectively. Experimental land was divided into unit plots following the design of experiment.

3.6 Treatments of the experiment

The experiment comprised of two factors

Factor A: Levels of Zinc (3 levels)

Zn_1=0 kg Zn ha^{-1}

Zn_2=1.5 kg Zn ha^{-1}

Zn_3 =3 kg Zn ha^{-1}

Factor B: Levels of Boron (3 levels)

B_1=0 kg B ha^{-1}

B_2=1 kg B ha^{-1}

B_3=2 kg B ha^{-1}

There will be (3X3) = 9 different treatment combinations such as: Zn_0B_0, Zn_0B_1, Zn_0B_2, $Zn_{1.5}B_0$, $Zn_{1.5}B_1$, $Zn_{1.5}B_2$, Zn_3B_0, Zn_3B_1, Zn_3B_2.

3.7 Fertilizer application

Zinc and Boron fertilizers were applied in required amounts of as per treatments and all other fertilizers were applied in the whole plots as basal dose according to the fertilizer recommendation guide (BARC, 1997). Urea, Triple Super Phosphate (TSP), Muriate of Potash (MoP), Gypsum, Zinc Sulphate and Boric acid were used as a source of Nitrogen, Phosphorous, Potassium, Gypsum, Sulphur, Zn and B respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation and Zn & B were applied as per treatment.

3.8 Experimental design and layout

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 20 m × 15 m was divided into 3 replications. Different combination of Zn and B were assigned randomly to each replication as per design of the experiment. The size of the each unit plot was 4 m × 1.6 m. The space between two replications and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

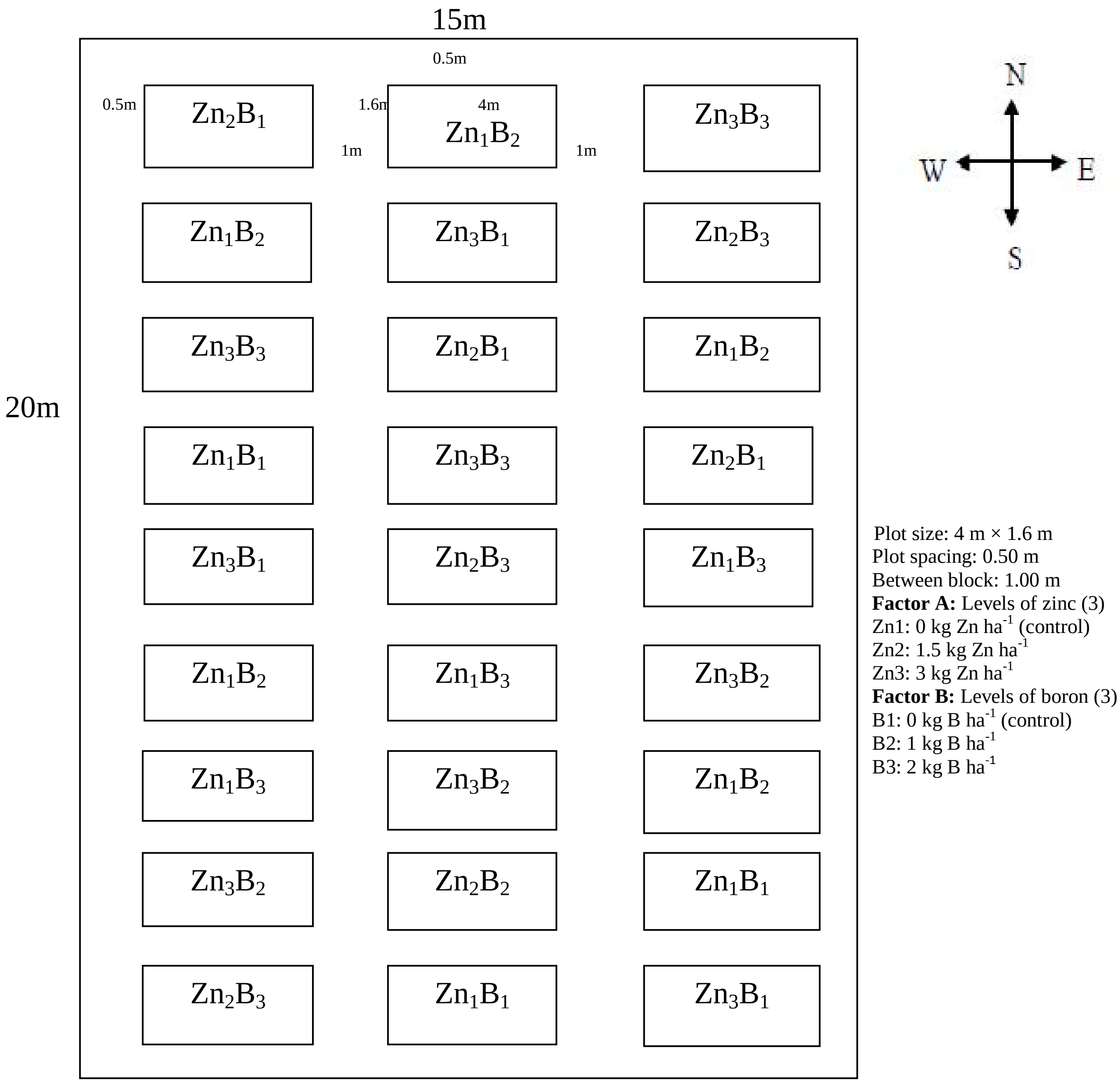

Figure1: Layout of the experimental plot

3.9 Sowing of seeds

Two seeds were sown in each hill at a depth of 3.0 cm. The seeds were covered with pulverized soil just after sowing and gently pressed with hand. The sowing was done on 8 December, 2015.

3.10 Intercultural operations

3.10.1 Gap filling

During seed sowing, few seeds were sown in the border of the plots. Seedlings were transferred to fill up the gap where seeds failed to germinate. Seedling of about 15 cm height were transplanted from border rows with roots plunged 5 cm below the soil in the hills in the evening and when watering was done to protect the seedling from wilting. All gaps were filled up within two weeks after germination of seeds.

3.10.2 Thinning of seedlings

After 15 days of sowing one healthy plant per hill was kept and remaining one was plucked.

3.10.3 Weeding

The experimental plots were kept weed free by hand weeding. Weeding were done three times as and when necessary and to break the crust. It also helped in soil moisture conservation**.**

3.10.4 Irrigation

Irrigation was done whenever necessary. The young plants were irrigated by watering can. Beside this, irrigation was given five times at an interval of 10 days depending on soil moisture content.

3.10.5 Plant protection

a). Insect pests

Some plants were attacked by insect pests (Aphids) at the early stage of growth and attacked by white fly at flowering and fruit setting stage. Ripcord was sprayed at the rate of 2ml/ litter at an interval of 15days.

b). Diseases

Seedlings were attacked by damping off and root rot and Dithane M-45 was sprayed at the rate of 2ml/L at an interval of 15 days. Some plants were attacked by bean common mosaic virus (BCMV), which is an important disease of bush bean. These plants were removed from the plots and destroyed.

3.11 Harvesting

Immature green pods were harvested at tender stage, suitable for use as vegetable through hand picking and weighed to estimate the yield of fresh pod. At harvest, pods were nearly full-size, with the seeds still small (about one quarter developed) with firm fresh (Swiader *et al*., 1992). Three times harvest were done. First harvest was done at 60 days after sowing.

3.12 Crop sampling and data collection

Five plants from each treatment were randomly selected and marked with sample card. Plant height, were recorded from selected plants at 10 days interval started from 20 DAS to 60 DAS and final harvesting of pod at 70 DAS.

3.13 Post – harvest operation

The sample plants were harvested separately for determining yield and yield components. The harvested crop was cleaned, dried, shelled and finally dried plot by plot separately to collect necessary data on various aspects.

3.14 Collection of data

Five plants were selected at random in such a way that the border effect could be avoided. The details of data recording are given below

i. Plant height (cm)

ii. Pod length (cm)

iii. Pod diameter (cm)

iv. Number of pods plant^{-1}

v. Weight of 100 pods (g)

vi. Pod Yield (ton/ha)

vii. Stover yield (ton/ha)

viii. Initial and post harvest soil pH, organic matter, total N, available P, available S, exchangeable K, available Zn and B.

3.15 Procedure of data collection

3.15.1 Plant height (cm)

Five plants were selected randomly for measuring the heights from the base of the plant to the tip of the tallest leaf. The height of plants was recorded in cm and the mean values of 5 plants for each plot were determined.

3.15.2 Length of green pod (cm)

Five pods were selected randomly from each plants for measuring the length were using centimeter scale and mean value was calculated and was expressed in centimeter (cm).

3.15.3 Diameter of green pod (cm)

Diameter of green pods of five randomly selected pods from each plots were measured in cm and the mean value was calculated.

3.15.4 Number of pods per plant

The number of pods per plant from five randomly selected sample plants of each plot were counted, averaged and recorded at the time of final harvest.

3.15.5 Weight of 100 pods (gm)

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

3.15.6 Pod yield (t/ha)

Green pods were harvested at regular interval from each unit plot and their weight was recorded. As harvesting was done at different interval and the total pod weights were recorded in each unit plot and expressed in kilogram (kg). The green pod yield per plot was finally converted to yield per hectare and was expressed in tone (t).

3.15.7 Stover yield (t/ha)

After separating the pods from the plants and drying the harvested plants in the sun, total weight of stover of each plot was taken in kilograms and converted into tons per hectare.

3.16 Collection and analysis of soil sample

Soil samples were collected at 0- 15 cm soil depths after the harvesting of crop from five locations of each experimental plot. Three samples of each plot were mixed together made a composite sample and analyzed for soil texture, soil pH, organic matter, total nitrogen, available phosphorus, exchangeable potassium, available sulphur, Zn and B**.**

3.16.1 Particle size analysis of soil

Hydrometer method was used for particle size analysis of the soil (Bouyoucos, 1927). The textural class was determined using Marshell's Triangular co-ordinate as designated by USDA (1951).

3.16.2 Soil pH

The glass electrode pH meter was used to determine the pH of the soil samples. The ratio of soil and water in the solution was maintained 1: 2.5 (Jackson, 1973).

3.16.3 Organic carbon (%)

Walkley estimated soil organic carbon and Black's wet oxidation method as outlined by Jackson (1973).

3.16.4 Organic matter (%)

Soil organic matter content was calculated by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724 as described by Piper (1942). % organic matter = % organic carbon × 1.724

3.16.5 Total nitrogen (%)

Micro Kjeldhal method used for determining total nitrogen in the soil samples (Page *et al.*, 1982) .The procedure was – digestion of soil sample by conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 10:1:0.1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Black, 1965).

3.16.6 Available phosphorus (ppm)

Available phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was measured spectrophotometrically after development of blue colour (Black, 1965).

3.16.7 Exchangeable potassium (meq/100g soil)

Exchangeable potassium in the soil samples was extracted in the normal ammonium acetate at pH 7.0 (Black, 1965) and was determined by using a flame photometer.

3.16.8 Available sulphur (ppm)

Available S in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Page *et al.*, 1982). The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

3.16.9 Available Zinc

Available Zn content was determined by extracting the soil with $ZnCl_2$ solution as described by Page *et al*., 1982. The digested Zn was determined by developing turbidity by adding $ZnCl_2$ solution. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths.

3.16.10 Available Boron

For available B, the extractant composed of $CaH_4(PO_4)_2$, HCl and phenol was used. Boron concentration was measured by adding 2 ml Curcumin solution plus 0.5 ml concentrated H_2SO_4 and 15 ml Methanol (Meth: water = 3:2) solution before taking reading. The concentration in the soil extract was read at 555 nm wave length in a double beam spectrophotometer (Model No. 200-20, Hitachi, Japan).

3.17 Statistical analysis

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

CHAPTER IV

RESULT AND DISCUSSION

The experiment was conducted to study the effect of zinc and boron on growth and yield of BARI Jhar Sheem-1. Data on different growth parameter, yield and characteristics of post harvest soil was recorded. The analyses of variance (ANOVA) of the data on different recorded parameters are presented in Appendix I-II. The findings of the experiment have been presented and discusses with the help of table and graphs and possible interpretations were given under the following headings:

4.1 Yield contributing characters and yield of bush bean:

4.1.1 Effect of Zinc

4.1.1.1 Plant height (cm)

Plant height of BARI Jhar Sheem-1 was significantly increased by different levels of Zn application (Fig.-2) (Appendix III). The tallest plant (30.11 cm) was produced with 3 kg Zn ha^{-1} and shortest plant (23.38 cm) was found in control treatment. It was observed that plant height increased gradually with the increment of Zn doses up to 3 kg Zn ha^{-1}. Zinc ensured the availability of other macro and micro nutrients that created a favorable condition for the growth of Jhar Sheem with optimum vegetative growth and the ultimate results was the tallest plant.

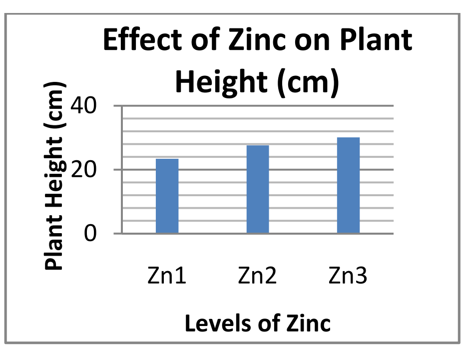

Figure 2: Effect of Zinc on Plant Height (cm)

4.1.1.2 Pod length (cm)

Pod length showed statistically significant variation for BARI Jhar Sheem-1 due to different levels of Zn application (Appendix I). The longest pod (14.26 cm) was recorded from Zn_3 (3 kg Zn ha^{-1}), which were closely followed (13.40 cm) by Zn_2 (1.5 kg Zn ha^{-1}), while the shortest pod (12.56 cm) was found from Zn_1 (0 kg Zn ha^{-1}) (Fig.-3) (Appendix III).

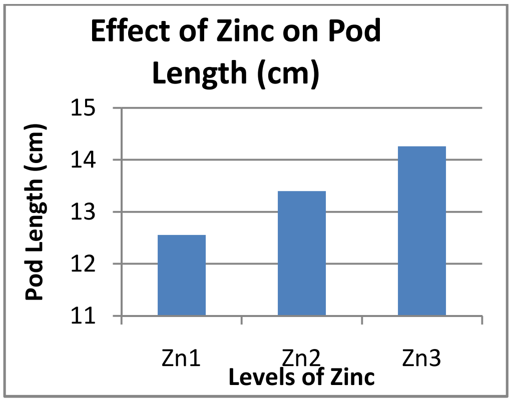

Figure 3: Effect of Zinc on Pod Length (cm)

4.1.1.3 Diameter of green pod (cm)

Diameter of green pod was found statistically non significant due to the application of different Zinc levels (Fig.-4) (Appendix III). The highest diameter of green pods (3.289 cm) was recorded from the treatment of Zn_3 (3kg Zn ha^{-1}). The lowest diameter of green pods (3.233 cm) was found in the control treatment Zn_1 (0 kg Zn ha^{-1}).

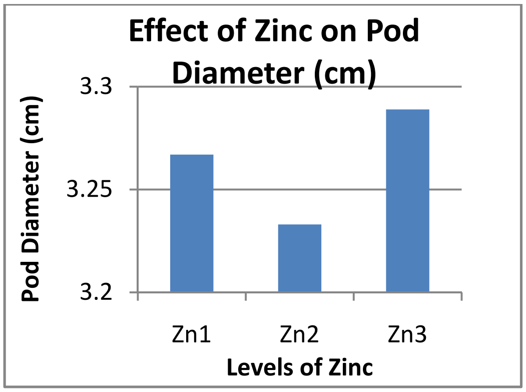

Figure 4: Effect of Zinc on Pod Diameter (cm)

4.1.1.4 Number of pods plant^{-1}

Statistically significant variation was recorded due to different levels of Zn on number of pods plant^{-1} of BARI Jhar Sheem-1 (Appendix I). The maximum number of pod plant^{-1} (69.19) was found from Zn_3 (3 kg Zn ha^{-1}). On the other hand, the minimum number of pods plant^{-1} (42.30) was recorded from Zn_1 (0 kg Zn ha^{-1}) (Fig.-5) (Appendix III).

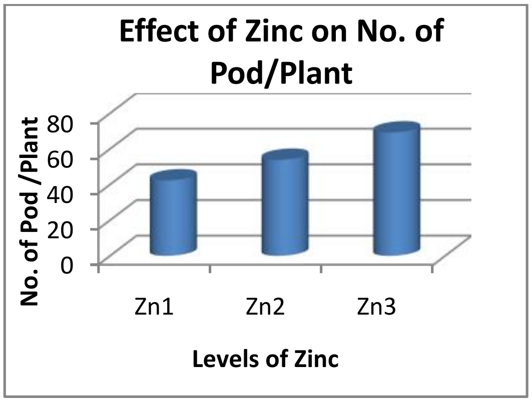

Figure 5: Effect of Zinc on No. of Pod/Plant

4.1.1.5 Weight of 100 pods (gm)

Statistically significant variation was recorded due to different levels of Zn in terms of weight of 100 pods of BARI Jhar Sheem-1 (Appendix I). The highest weight of 100 pods (492.7 g) was observed from Zn_3 (3kg Zn ha^{-1}), which were statistically identical (436.2 g) with Zn_2 (1.5 kg Zn ha^{-1}), whereas the lowest weight of 100 pods (372.1 g) was observed from Zn_1 (0 kg Zn ha^{-1}) (Fig.-6) (Appendix III).

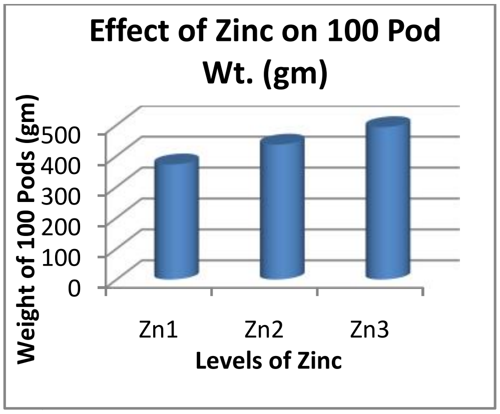

Figure 6: Effect of Zinc on 100 Pod Wt. (gm)

4.1.1.6 Pod yield (t/ha)

The pod yield of bush bean per hectare was significantly influenced by different levels of Zn (Fig.-7) (Appendix III). The maximum yield of green pod (11.77 t/ha) was recorded with the application of treatment Zn_3 (3 kg Zn ha^{-1}), which was significantly different with other treatments and the minimum yield of green pod (8.556 t/ha) was found from the control treatment where no Zinc was applied. The results are in agreement with that of Chandel *et al.* (2002), Singh and Verma (2002), Tewari and Singh (2000).

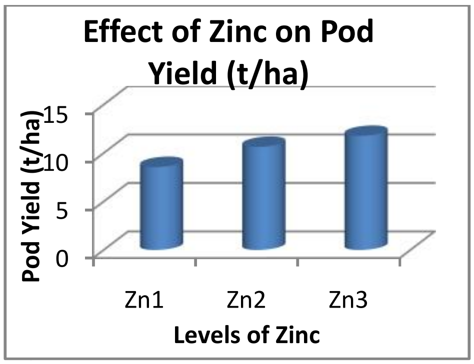

Figure 7: Effect of Zinc on Pod Yield (t/ha)

4.1.1.7 Stover yield (ton/ha)

Stover yield $plant^{-1}$ of BARI Jhar Sheem-1 varied significantly due to different levels of Zinc (Appendix I). The highest stover yield ha^{-1} (6.531 ton) was attained from Zn_3 (3 kg Zn ha^{-1}). The lowest stover yield ha^{-1} (3.501 ton) was found from Zn_0 (0 kg Zn ha^{-1}) (Fig.-8) (Appendix III).

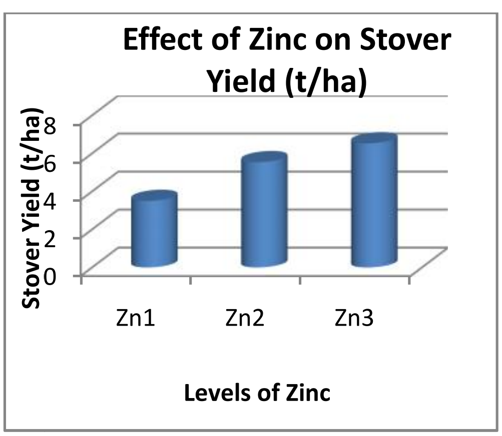

Figure 8: Effect of Zinc on Stover Yield (t/ha)

4.1.2 Effect of Boron

4.1.2.1 Plant height

There was non significant difference among the different levels of boron in respect of plant height (Fig.-9) (Appendix IV). Plant height increased with increasing levels of boron up to higher level. The tallest plant (27.58 cm) was produced with 2 kg B ha^{-1} and shortest plant (26.12 cm) was found in control treatment. It was revealed that with the increase of B fertilizer, plant height increased up to the highest level of boron that was applied.

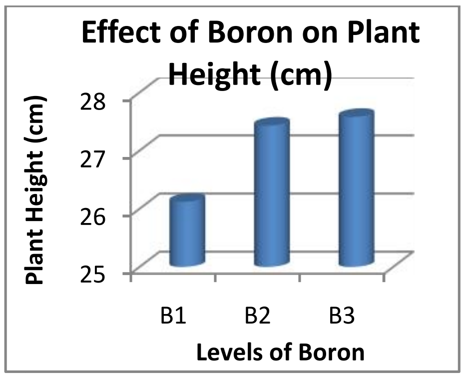

Figure 9: Effect of Boron on Plant Height (cm)

4.1.2.2 Pod length (cm)

Statistically non significant variation was recorded in terms of pod length of BARI Jhar Sheem-1 due to different levels of boron (Appendix I). The longest pod (13.72 cm) was obtained from B_3 (2 kg B ha^{-1}) which were statistically similar (13.36 cm) with B_2(1kg B ha^{-1}) and the shortest pod (13.13 cm) was recorded from B_1 (0 kg B ha^{-1}) (Fig.-10).

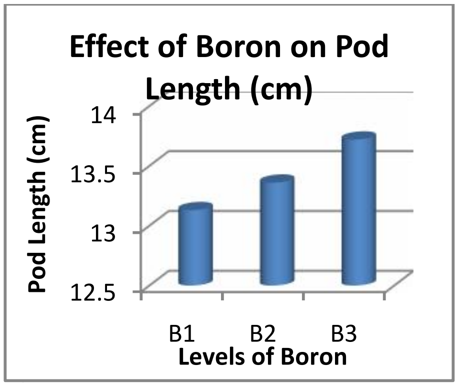

Figure 10: Effect of Boron on Pod Length (cm)

4.1.2.3 Diameter of green pod (cm)

Boron had non significant effect on diameter of green pod (Fig.-11) (Appendix IV). The highest diameter of green pods (3.30 cm) was recorded from the treatment of 1kg B/ha which was statistically similar with that of 2 kg B ha^{-1}. The lowest diameter of green pod (3.21cm) was obtained in the control treatment.

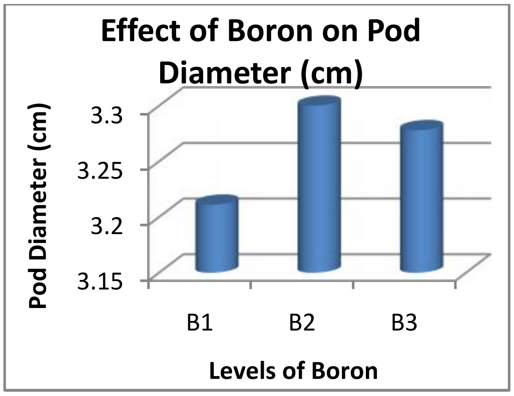

Figure 11: Effect of Boron on Pod Diameter (cm)

4.1.2.4 Number of pods plant^{-1}

Different levels of boron showed non significant variation in terms of number of pod plant^{-1} of BARI Jhar Sheem-1 (Appendix I). The maximum number of pods plant^{-1} (58.08) was found from B_3 (2 kg B ha^{-1}) and the minimum number of pods plant^{-1} was found from B_1 (0 kg B ha^{-1}) (Fig.-12) (Appendix IV). Sinha *et al.* (1994) reported that pods plant^{-1} increased significantly due to application of B.

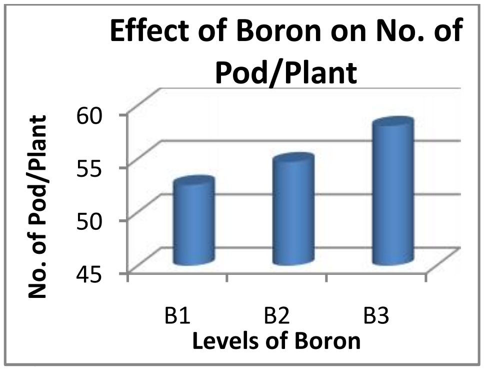

Figure 12: Effect of Boron on No. of Pod/Plant

4.1.2.5 Weight of 100 pods (gm)

Different levels of B varied significantly for weight of 100 pods of BARI Jhar Sheem-1 under the present trial (Appendix I). The highest weight of 100 pods (480.7 g) was recorded from B_3 (2 kg B ha^{-1}). The lowest weight of 100 pods (398.5 g) from B_1 (0 kg B ha^{-1}) which was statistically similar with B_2 (1 kg B ha^{-1}) (Fig.-13) (Appendix IV).

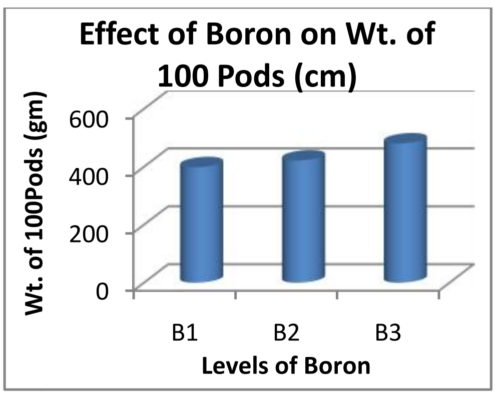

Figure 13: Effect of Boron on Wt. of 100 Pods (gm)

4.1.2.6 Pod yield (t/ha)

Pod yield was significantly influenced by different levels of B. The highest pod yield of bush bean per hectare (11.49 t/ha) was obtained when the crop was fertilized with 2kg B/ha and the lowest pod yield of bush bean per hectare (9.289 t/ha) was obtained in the control treatment (Fig.-14) (Appendix IV).

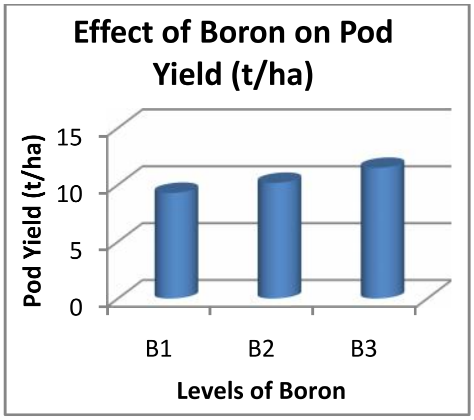

Figure 14: Effect of Boron on Pod Yield (t/ha)

4.1.2.7 Stover yield (ton/ha)

Statistically significant variation was recorded in terms of stover yield ha^{-1} of BARI Jhar Sheem-1 due to different levels of Boron (Appendix I). The highest stover yield ha^{-1} (5.728 ton) was observed from B_3 (2 kg B ha^{-1}). The lowest stover yield ha^{-1} (4.891 ton) was found from B_2 (1 kg B ha^{-1}) which was similar with B_1 (0kg B ha^{-1}) (Fig.-15) (Appendix IV).

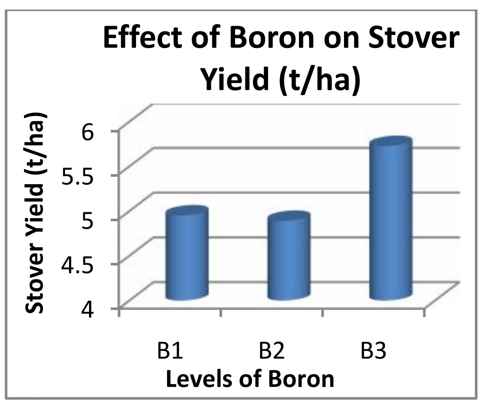

Figure 15: Effect of Boron on Stover Yield (t/ha)

4.1.3 Interaction effect of Zinc and Boron

4.1.3.1 Plant height (cm)

The treatment combinations of Zn and B had significant effect on plant height (Fig.-16) (Appendix V). The tallest plant (30.81 cm) was found in Zn_3B_1 treatment statistically similar with Zn_3B_2, Zn_3B_3 and Zn_2B_3. The shortest plant (22.13 cm) was observed in the control treatment. The second highest plant (29.79 cm) was observed in the treatment of Zn_3B_2. These results revealed that higher dose of Zinc and Boron were influential nutrients for increasing the plant height.

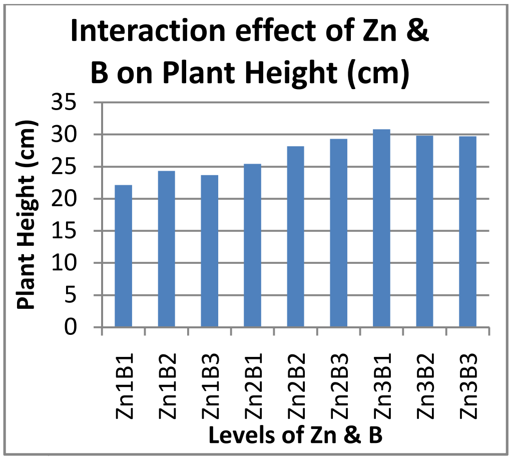

Figure 16: Interaction effect of Zn & B on Plant Height (cm)

4.1.3.2 Pod length (cm)

Interaction effects of different levels of Zn and B influenced non significantly the pod length of BARI Jhar Sheem-1 (Appendix I). The longest pod (14.60 cm) was recorded from Zn_3B_3 (3 kg Zn ha^{-1} and 2 kg B ha^{-1}), whereas the shortest pod (12.33 cm) was observed from Zn_1B_1 (0kg Zn ha^{-1} and 0kg B ha^{-1}) and Zn_1B_3 treatment combination (Fig.-17) (Appendix V).

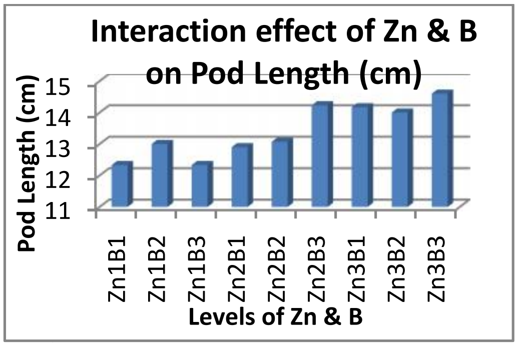

Figure 17: Interaction effect of Zn & B on Pod Length (cm)

4.1.3.3 Diameter of green pod (cm)

The interaction effect of different doses of Zn and B on diameter green pod was found to be non significant (Fig.-18) (Appendix V). The highest diameter of green pod (3.47 cm) was obtained from the treatment combination of Zn_3B_2 (3 kg Zn ha^{-1} and 1 kg B ha^{-1}), which was statistically similar with that of Zn_2B_3. The lowest diameter of green pod (3.13 cm) was obtained from Zn_2B_2 which was similar with Zn_3B_1 and the control treatment.

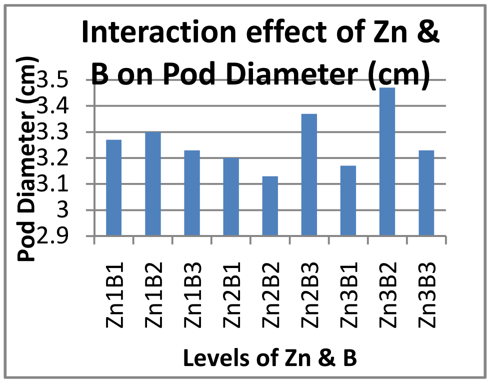

Figure 18: Interaction effect of Zn & B on Pod Diameter (cm)

4.1.3.4 Number of pods $plant^{-1}$

Number of pods $plant^{-1}$ of BARI Jhar Sheem-1 varied significantly due to the interaction effect of different levels of Zn and B (Appendix I). The maximum number of pods $plant^{-1}$ (74.45) was found from Zn_3B_3 (3 kg Zn ha^{-1} and 2 kg B ha^{-1}) which closely similar with (66.89) Zn_3B_2 and (66.22) Zn_3B_1 while the minimum number (40.22) was found from Zn_1B_1 (0 kg Zn ha^{-1} and 0 kg B ha^{-1}) treatment combination (Fig.-19) (Appendix V).

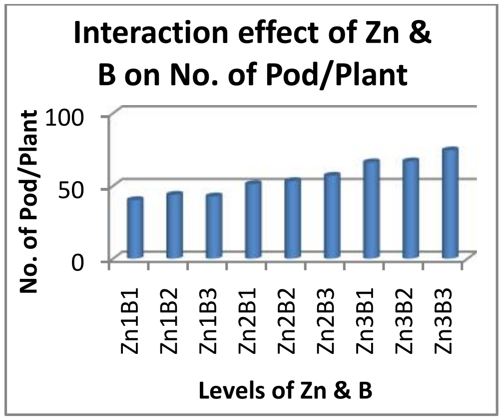

Figure 19: Interaction effect of Zn & B on No. of Pod/Plant

4.1.3.5 Weight of 100 pods (gm)

Weight of 100 pods of BARI Jhar Sheem-1 showed significant difference due to interaction effect of different levels of Zn and B (Appendix I). The highest weight of 100 pods (529.6 g) was observed from Zn_3B_3 (3 kg Zn ha^{-1} and 2 kg B ha^{-1}) and the lowest weight (326.6 g) from Zn_1B_2 (0 kg Zn ha^{-1} and 1 kg B ha^{-1}) treatment combination which was similar with Zn_1B_1 (0kg Zn ha^{-1} and 0kg B ha^{-1}) (Fig.-20) (Appendix V).

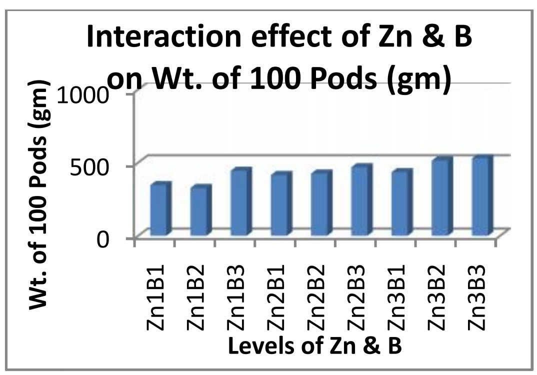

Figure 20: Interaction effect of Zn & B on Wt. of 100 Pods (gm)

4.1.3.6 Pod yield (t/ha)

Different treatment combinations of Zn and B influenced significant effect on pod yield (Fig.-21). The highest pod yield (12.57 t/ha) was recorded from the treatment combination of Zn_3B_2 (3kg Zn ha^{-1} and 1kg B ha^{-1}) which was significantly similar with Zn_3B_3 and Zn_2B_3 treatments. The lowest pod yield (7.63 t/ha) was in the Zn_1B_2 (0kg Zn ha^{-1} and 1kg B ha^{-1}) which was similar with the control treatment.

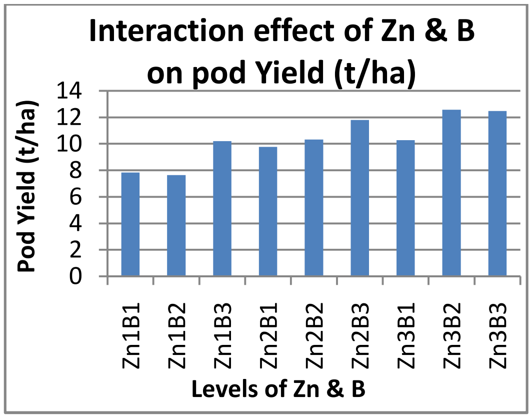

Figure 21: Interaction effect of Zn & B on Pod Yield (t/ha)

4.1.3.7 Stover yield (ton/ha)

Different treatment combinations of Zn and B had significant effect on stover yield (Fig.-22). The highest stover yield (7.427 t/ha) was obtained from the treatment combination of 3 kg Zn ha^{-1} and 2 kg B ha^{-1}. The lowest stover yield (3.373 t/ha) was obtained from the control treatment which was similar with Zn_1B_2 and closely similar with Zn_1B_3.

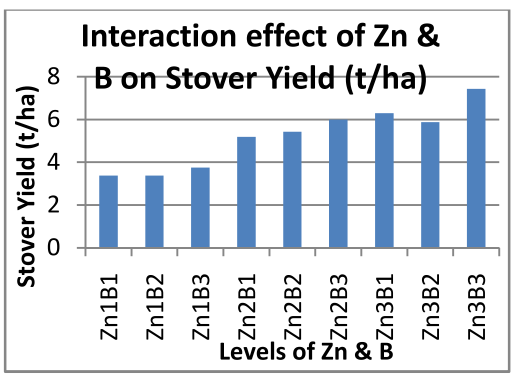

Figure 22: Interaction effect of Zn & B on Stover Yield (t/ha)

4.2 pH, organic matter, N, P, K, S, Zn and B in post harvest soil

4.2.4.1 pH

Different levels of Zn showed statistically non significant variation in terms of pH in post harvest soil (Appendix II). The highest pH in post harvest soil (6.144) was observed from Zn_2 (1.5 kg Zn ha^{-1}), while the lowest pH (5.967) was found from Zn_1 (0 kg Zn ha^{-1}) (Table 2).

Statistically non significant variation was recorded for pH in post harvest soil due to different levels of B (Appendix II). The highest pH in post harvest soil (6.222) was recorded from B_2 (1 kg B ha^{-1}) which was statistically similar (6.056) with B_1 (0 kg B ha^{-1}), whereas the lowest pH (5.959) from B_3 (2 kg B ha^{-1}) (Table 3).

Interaction effect of different levels of Zn and B showed non significant variation on pH in post harvest soil (Appendix II). The highest pH in post harvest soil (6.367) was observed from Zn_2B_2 (1.5 kg Zn ha^{-1} and 1 kg B ha^{-1}) and the lowest pH in post harvest soil (5.9) was found from Zn_1B_1 (0 kg Zn ha^{-1} and 0 kg B ha^{-1}) treatment combination (Table 4).

4.2.4.2 Organic matter

Different levels of Zn showed statistically non significant differences for organic matter in post harvest soil due to (Table 2). Data revealed that the highest organic matter in post harvest soil (1.637%) was observed from Zn_2 (1.5 kg Zn ha^{-1}), while the lowest organic matter in post harvest soil (1.511%) from Zn_1 i.e. 0 kg Zn ha^{-1}.

Organic matter in post harvest soil varied non significantly for different levels of B (Table 3). The highest organic matter in post harvest soil (1.709%) was found from B_3 (2kg B ha^{-1}), whereas the lowest organic matter in post harvest soil (1.377%) was recorded from B_1 (0 kg B ha^{-1}).

Statistically non significant variation was recorded due to the interaction effect of different levels of Zn and B in terms of organic matter in post harvest soil (Appendix II). The highest organic matter in post harvest soil (1.883%) was obtained from Zn_3B_3 (3 kg

Zn ha^{-1} and 2 kg B ha^{-1}), while the lowest organic matter in post harvest soil (1.263%) was found from Zn_3B_1 (3 kg Zn ha^{-1} and 0 kg B ha^{-1}) treatment combination (Table 4).

4.2.4.3 Total nitrogen

A statistically non significant variation was observed in the total N content in the post harvest soil. The highest total N content (0.069%) was observed in Zn_3 (3kg Zn ha^{-1}) and the lowest value of 0.063% in control (Table 2).

Statistically non significant variation was observed in total N content of the post harvest soil (Table 3). The highest total N content (0.071%) was observed in B_3 (2kg B ha^{-1}) and the minimum value (0.063%) was found in the control treatment.

The effect of combined applications of different doses of Zn and B resulted non significant variations in nitrogen content in the post harvest soil (Table 4). The higher total N content of the post harvest contents (0.076 %) were recorded in the treatment combination of Zn_3B_3 (3kg Zn ha^{-1} and 2kg B ha^{-1}) and the lowest value of 0.060% in Zn_1B_2, Zn_1B_3, Zn_2B_1, Zn_3B_1.

4.2.4.4 Available phosphorus

The effect of application of Zn at different levels showed no significant differences in respect of P content in soil after harvest (Table 2). The highest P content (23.01ppm) was recorded in Zn_2 (1.5kg Zn ha^{-1}) and the lowest P content (22.33ppm) was found in the control treatment.

Statistically significant variation was not observed due to the application of B at different doses on the content of available P of the post harvest soil (Table 3). The highest P content (22.85ppm) was observed in B_2 (1kg B ha^{-1}) and the minimum value (22.52ppm) was found in the B_3 (2kg B ha^{-1}).

The effect of combined application of Zn and B showed no significant differences in respect of P content in soil after harvest (Table 4). The highest P content (23.41ppm) was observed in Zn_2B_1 (1.5kg Zn ha^{-1} and 0k B ha^{-1}) and the minimum value (20.90ppm) was found in the control treatment.

4.2.4.5 Exchangeable potassium

The effect of application of Zn showed no significant differences in respect of K content in soil after harvest (Table 2). The highest K content was (0.13%) found in Zn_2 (1.5kg Zn ha^{-1}) and the lowest K content (0.121%) was found in the control treatment.

Statistically significant variation was not observed in K content of the post harvest soil with the application of various levels of B (Table 3). The highest K content (0.13%) was observed in B_3 (2kg B ha^{-1}) and the minimum value (0.118%) was found in the control treatment.

The effect of combined application of Zn and B showed no significant differences in respect of K content in soil after harvest (Table 4). The highest K content (0.14%) was observed in Zn_2B_3 (1.5kg Zn ha^{-1} and 2kg B ha^{-1}) which was similar with Zn_3B_2 (3kg Zn ha^{-1} and 1kg B ha^{-1}) and the minimum value (0.11%) was found in the control treatment.

4.2.4.6 Available sulphur

The effect of application of Zn showed significant differences in respect of S content of soil after harvest (Table 2). The highest S content (13.09ppm) was recorded in Zn_3 (3kg Zn ha^{-1}) and the lowest S content (9.103ppm) was found in the control treatment.

Statistically significant variation was observed in B content in respect of the post harvest soil (Table 3). The highest S content in (11.78ppm) was observed in B_3 (2kg B ha^{-1}) and the minimum value (10.46ppm) was found in the control treatment.

The effect of combined application of zinc and boron showed significant differences in respect of S content of soil after harvest (Table 4). The highest S content (13.38ppm) was observed in Zn_3B_3 (3kg Zn ha^{-1} and 2kg B ha^{-1}) and the minimum value (8.50ppm) was found in the control treatment.

Table 2: Effect of Zn on the soil pH, Organic matter, N, P, K, S, Zn and B concentration in the soil after bush bean harvest

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me/100gm)	Available S (ppm)	Available Zn (ppm)	Available B (ppm)
Levels of Zinc								
Zn_1	5.967	1.511	0.063	22.33	0.121	9.103c	0.210c	0.209c
Zn_2	6.144	1.637	0.067	23.01	0.130	11.54b	0.346b	0.338b
Zn_3	6.122	1.606	0.069	22.57	0.123	13.09a	0.611a	0.370a
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	1.085	0.316	0.0547
CV(%)	-	-	-	-	-	9.66	9.43	14.47

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Zn_1=0 kg Zn ha^{-1}, Zn_2=1.5 kg Zn ha^{-1}, Zn_3=3 kg Zn ha^{-1}

Table 3: Effect of B on the soil pH, Organic matter, N, P, K, S, Zn and B concentration in the soil after bush bean harvest

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me/100gm)	Available S (ppm)	Available Zn (ppm)	Available B (ppm)
Levels of Boron								
B_1	6.056	1.377	0.063	22.54	0.118	10.46b	0.342c	0.143c
B_2	6.222	1.668	0.064	22.85	0.127	11.50ab	0.386b	0.370b
B_3	5.959	1.709	0.071	22.52	0.130	11.78a	0.438a	0.573a
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	1.085	0.316	0.0547
CV(%)	-	-	-	-	-	9.66	9.43	14.47

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

B_1=0 kg B ha^{-1}, B_2=1 kg B ha^{-1}, B_3=2 kg B ha^{-1}

Table 4: Interaction effect of Zn and B on the soil pH, Organic matter, N, P, K, S, Zn and B concentration in the soil after bush bean harvest

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me/100gm)	Available S (ppm)	Available Zn (ppm)	Available B (ppm)
Zn_1B_1	5.900	1.467cd	0.070	20.90	0.110	8.850b	0.1767g	0.130c
Zn_1B_2	6.067	1.500cd	0.060	22.81	0.120	8.907b	0.2067fg	0.3267b
Zn_1B_3	5.933	1.567bc	0.060	23.29	0.133	9.553b	0.2467f	0.560a
Zn_2B_1	6.100	1.400cd	0.060	23.41	0.130	9.843b	0.3167e	0.180c
Zn_2B_2	6.367	1.833ab	0.063	22.67	0.120	12.38a	0.333de	0. 3667b
Zn_2B_3	5.967	1.677abc	0.076	22.95	0.140	12.41a	0.3867d	0.5867a
Zn_3B_1	6.167	1.263d	0.060	23.32	0.113	12.67a	0.533c	0.120c
Zn_3B_2	6.233	1.670abc	0.070	23.07	0.140	13.23a	0.6167b	0.4167b
Zn_3B_3	5.967	1.883a	0.076	21.31	0.116	13.38a	0.6833a	0.5733a
$LSD_{(0.05)}$	NS	0.2998	NS	NS	NS	1.879	0.0547	0.0948
CV(%)	-	10.96	-	-	-	9.66	9.43	14.47

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Zn_1=0 kg Zn ha^{-1} B_1=0 kg B ha^{-1}

Zn_2=1.5 kg Zn ha^{-1} B_2=1 kg B ha^{-1}

Zn_3=3 kg Zn ha^{-1} B_3=2 kg B ha^{-1}

4.2.4.7 Available Zinc

Available Zinc in post harvest soil showed statistically significant variation due to different levels of Zn application (Appendix II). The highest available zinc in post harvest soil (0.611ppm) was observed from Zn_3 (3 kg Zn ha^{-1}), while the lowest available zinc (0.210ppm) was found from Zn_1 (0 kg Zn ha^{-1}) (Table 2).

The variation was significant for available Zn in post harvest soil due to different levels of B (Appendix II). The highest available zinc in post harvest soil (0.438ppm) was recorded from B_3 (2kg B ha^{-1}), whereas the lowest available zinc (0.342ppm) from B_1 (0 kg B ha^{-1}) (Table 3).

Interaction effect of different levels of zinc and boron showed significant variation on available zinc in post harvest soil (Appendix II). The highest available zinc in post harvest soil (0.6833ppm) was observed from Zn_3B_3 (3kg Zn ha^{-1} and 2kg B ha^{-1}) and the lowest available zinc in post harvest soil (0.1767ppm) was found from Zn_1B_1 (0 kg Zn ha^{-1} and 0 kg B ha^{-1}) treatment combination (Table 4).

4.2.4.8 Available Boron

Different levels of Zn showed statistically non significant variation in terms of available B in post harvest soil (Appendix II). The highest available boron in post harvest soil (0.389ppm) was found from Zn_1 (0kg Zn ha^{-1}), whereas the lowest available B (0.370ppm) was observed from Zn_3 (3 kg Zn ha^{-1}) (Table 2).

Available boron in post harvest varied significantly due to different levels of B (Appendix II). The highest available B in post harvest soil (0.573ppm) was obtained from B_3 (2kg B ha^{-1}), while the lowest available B (0.143ppm) was recorded from B_1 (0 kg B ha^{-1}) (Table 3).

Interaction effect of different levels of Zn and B showed significant variation on available boron in post harvest soil (Appendix II). The highest available B in post harvest soil (0.5867ppm) was found from Zn_2B_3 (1.5 kg Zn ha^{-1} and 2kg B ha^{-1}) which was similar with (0.560ppm) was found in Zn_1B_3 (0kg Zn ha^{-1} and 2kg B ha^{-1}) and (0.5733ppm) was found in Zn_3B_3 (3kg Zn ha^{-1} and 2kg B ha^{-1}). On the other hand, the lowest available boron in post harvest soil (0.120ppm) was recorded from Zn_3B_1 (3kg Zn ha^{-1} and 0 kg B ha^{-1}) treatment combination which was similar with (0.130ppm) Zn_1B_1 (0kg Zn ha^{-1} and 0kg B ha^{-1}) and (0.180ppm) Zn_2B_1 (1.5kg Zn ha^{-1} and 0kg B ha^{-1}) (Table 4).

CHAPTER V

SUMMERY AND CONCLUSION

The experiment was conducted during the period from December, 2015 to February 2016 at the farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to study the effect of zinc and boron on growth and yield of BARI Jhar Sheem-1. The variety BARI Jhar Sheem-1 was used as the test crop. The soil of the experimental field was silty clay loam in texture belonging to the Tejgoan soil series of the Madhupur Tract (Agro ecological zone AEZ -28). The selected plot was a medium high land that remained fallow during the previous summer. The experiment comprised of two factors; Factor A: Levels of zinc (3 levels)- Zn_1: 0 kg Zn ha^{-1} (control), Zn_2: 1.5 kg Zn ha^{-1}, Zn_3: 3 kg Zn ha^{-1} and Factors B: Levels of boron (3 levels)- B_1: 0 kg B ha^{-1} (control), B_2: 1 kg B ha^{-1} and B_3: 2 kg B ha^{-1}. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 6.4 m^2 (4 m x 1.6m) and the space between block and between plots were 1m and 0.5m respectively. Seeds were shown in the plot 8 December, 2015. Intercultural operations were done as when necessary. From each unit plot 5 plants were randomly selected to record data on growth and yield attributes. Data on different growth parameters, yield and nutrient of post harvest soil was recorded and statistically significant variation was observed different level of zinc and boron. Data were analyzed using the computer package M- STAT and the difference between means was compared by LSD test. At the time of final land preparation soil sample and after harvest soil sample were taken for chemical analysis and to assess the nutrient status. Results of the samples were also statistically analyzed. The individual and combined effects of Zinc (Zn) and Boron (B) on growth, yield and nutrient stratus of soil of bush bean were studied.

Data on plant characters were recorded at different stages. Zinc and Boron fertilization at different levels individually influenced plant characters. The individual and interaction effects of Zn and B on growth, yield and nutrient content were found positive. Both the growth and yield increased with increasing zinc and boron.

Plant height was significantly influenced by different level of Zn. The tallest plant (30.11 cm) was produced with 3 kg Zn ha^{-1} and shortest plant (23.38 cm) was found in control treatment. The longest pod (14.26 cm) was recorded from Zn_3 (3 kg Zn ha^{-1}), which were closely followed (13.40 cm) by Zn_2 (1.5 kg Zn ha^{-1}), while the shortest pod (12.56 cm) was found from Zn_1 (0 kg Zn ha^{-1}). The highest diameter of green pods (3.289 cm) was recorded from the treatment of Zn_3 (3kg Zn ha^{-1}). The lowest diameter of green pods (3.233 cm) was found in the control treatment Zn_1 (0 kg Zn ha^{-1}). The maximum number of pod $plant^{-1}$ (69.19) was found from Zn_3 (3 kg Zn ha^{-1}). On the other hand, the minimum number of pods $plant^{-1}$ (42.30) was recorded from Zn_1 (0 kg Zn ha^{-1}). The highest weight of 100 pods (492.7 g) was observed from Zn_3 (3kg Zn ha^{-1}), which were statistically identical (436.2 g) with Zn_2 (1.5 kg Zn ha^{-1}), whereas the lowest weight of 100 pods (372.1 g) was observed from Zn_1 (0 kg Zn ha^{-1}). The maximum yield of green pod (11.77 t/ha) was recorded with the application of 3 kg Zn ha^{-1}, which was significantly different with other treatments and the minimum yield of green pod (8.556 t/ha) was found from the control treatment where no Zinc was applied. The highest stover yield ha^{-1} (6.531 ton) was attained from Zn_3 (3 kg Zn ha^{-1}). The lowest stover yield ha^{-1} (3.501 ton) was found from Zn_0 (0 kg Zn ha^{-1}). The highest pH in post harvest soil (6.144) was observed from Zn_2 (1.5 kg Zn ha^{-1}), while the lowest pH (5.967) was found from Zn_1 (0 kg Zn ha^{-1}). Different levels of zinc showed statistically non significant differences for organic matter in post harvest soil. Data revealed that the highest organic matter in post harvest soil (1.637%) was observed from Zn_2 (1.5 kg Zn ha^{-1}), while the lowest organic matter in post harvest soil (1.511%) from Zn_1 i.e. 0 kg Zn ha^{-1}. A statistically non significant variation was observed in the total N, P, K content in the post harvest soil. The highest total N content (0.069%) was observed in Zn_3 (3kg Zn ha^{-1}) and the lowest value of 0.063% in control. The highest P content (23.01%) was recorded in Zn_2 (1.5kg Zn ha^{-1}) and the lowest P content (22.33%) was found in the control treatment. The highest K content was (0.13%) found in Zn_2 (1.5kg Zn ha^{-1}) and the lowest K content

(0.121%) was found in the control treatment. The highest S content (13.09%) was recorded in Zn_3 (3kg Zn ha^{-1}) and the lowest S content (9.103%) was found in the control treatment. The highest available Zn in post harvest soil (0.611 ppm) was observed from Zn_3 (3 kg Zn ha^{-1}), while the lowest available Zn (0.210 ppm) was found from Zn_1 (0 kg Zn ha^{-1}). The highest available B in post harvest soil (0.389 ppm) was found from Zn_1 (0kg Zn ha^{-1}), whereas the lowest available B (0.370 ppm) was observed from Zn_3 (3 kg Zn ha^{-1}).

In consideration of different level of B, plant height increased with increasing levels of B up to higher level. The tallest plant (27.58 cm) was produced with 2 kg B ha^{-1} and shortest plant (26.12 cm) was found in control treatment. Statistically non significant variation was recorded in terms of pod length of BARI Jhar Sheem-1 due to different levels of B. The longest pod (13.72 cm) was obtained from B_3 (2 kg B ha^{-1}) which were statistically similar (13.36 cm) with B_2 (1kg B ha^{-1}) and the shortest pod (13.13 cm) was recorded from B_1 (0 kg B ha^{-1}). B had non significant effect on diameter of green pod. The highest diameter of green pods (3.30 cm) was recorded from the treatment of 1kg B/ha which was statistically similar with that of 2 kg B ha^{-1}. The lowest diameter of green pod (3.21cm) was obtained in the control treatment. The maximum number of pods $plant^{-1}$ (58.08) was found from B_3 (2 kg B ha^{-1}) and the minimum number of pods $plant^{-1}$ was found from B_1 (0 kg B ha^{-1}). The highest weight of 100 pods (480.7 g) was recorded from B_3 (2 kg B ha^{-1}). The lowest weight of 100 pods (398.5 g) from B_1 (0 kg B ha^{-1}) which was statistically similar with B_2 (1 kg B ha^{-1}). The highest pod yield of bush bean per hectare (11.49 t/ha) was obtained when the crop was fertilized with 2kg B/ha and the lowest pod yield of bush bean per hectare (9.289 t/ha) was obtained in the control treatment. The highest stover yield ha^{-1} (5.728 ton) was observed from B_3 (2 kg B ha^{-1}). The lowest stover yield ha^{-1} (4.891 ton) was found from B_2 (1 kg B ha^{-1}) which was similar with B_1 (0kg B ha^{-1}). Statistically non significant variation was recorded for pH, organic matter in post harvest soil due to different levels of B. The highest pH in post harvest soil (6.222) was recorded from B_2 (1 kg B ha^{-1}) which was statistically similar

(6.056) with B_1 (0 kg B ha^{-1}), whereas the lowest pH (5.959) from B_3 (2 kg B ha^{-1}). The highest organic matter in post harvest soil (1.709%) was found from B_3 (2kg B ha^{-1}), whereas the lowest organic matter in post harvest soil (1.377%) was recorded from B_1 (0 kg B ha^{-1}). Statistically non significant variation was observed in total N, P, K content of the post harvest soil. The highest total N content (0.071%) was observed in B_3 (2kg B ha^{-1}) and the minimum value (0.063%) was found in the control treatment. The highest P content (22.85%) was observed in B_2 (1kg B ha^{-1}) and the minimum value (22.52%) was found in the B_3 (2kg B ha^{-1}). The highest K content (0.13%) was observed in B_3 (2kg B ha^{-1}) and the minimum value (0.118%) was found in the control treatment. The highest S content in (11.78%) was observed in B_3 (2kg B ha^{-1}) and the minimum value (10.46%) was found in the control treatment. The highest available zinc in post harvest soil (0.438 ppm) was recorded from B_3 (2kg B ha^{-1}), whereas the lowest available zinc (0.342 ppm) from B_1 (0 kg B ha^{-1}). The highest available boron in post harvest soil (0.573 ppm) was obtained from B_3 (2kg B ha^{-1}), while the lowest available boron (0.143 ppm) was recorded from B_1 (0 kg B ha^{-1}).

The treatment combinations of Zinc and Boron had significant effect on plant height. The tallest plant (30.81 cm) was found in Zn_3B_1 treatment statistically similar with Zn_3B_2, Zn_3B_3 and Zn_2B_3. The shortest plant (22.13 cm) was observed in the control treatment. The second highest plant (29.79 cm) was observed in the treatment of Zn_3B_2. Interaction effects of different levels of zinc and boron influenced non significantly the pod length of BARI Jhar Sheem-1. The longest pod (14.60 cm) was recorded from Zn_3B_3 (3 kg Zn ha^{-1} and 2 kg B ha^{-1}), whereas the shortest pod (12.33 cm) was observed from Zn_1B_1 (0kg Zn ha^{-1} and 0kg B ha^{-1}). The highest diameter of green pod (3.47 cm) was obtained from the treatment combination of 3 kg Zn ha^{-1} and 1 kg B ha^{-1}, which was statistically similar with that of Zn_2B_3. The lowest diameter of green pod (3.13 cm) was obtained from Zn_2B_2 which was similar with Zn_3B_1 and the control treatment which was statistically similar with that of Zn_2B_1. The maximum number of pods $plant^{-1}$ (74.45) was found from Zn_3B_3 (3 kg Zn ha^{-1} and 2 kg B ha^{-1}) which closely similar with (66.89) Zn_3B_2 and (66.22) Zn_3B_1

while the minimum number (40.22) was found from Zn_1B_1 (0 kg Zn ha^{-1} and 0 kg B ha^{-1}). The highest weight of 100 pods (529.6 g) was observed from Zn_3B_3 (3 kg Zn ha^{-1} and 2 kg B ha^{-1}) and the lowest weight (326.6 g) from Zn_1B_2 (0 kg Zn ha^{-1} and 1 kg B ha^{-1}) treatment combination which was similar with Zn_1B_1 (0kg Zn ha^{-1} and 0kg B ha^{-1}). The highest pod yield (12.57 t/ha) was recorded from the treatment combination of 3kg Zn ha^{-1} and 1kg B ha^{-1}, which was significantly similar with Zn_3B_3 and Zn_2B_3 treatments. The lowest pod yield (7.63 t/ha) was in the 0kg Zn ha^{-1} and 1kg B ha^{-1} which was similar with the control treatment. The highest stover yield (7.427 t/ha) was obtained from the treatment combination of 3 kg Zn ha^{-1} and 2 kg B ha^{-1}. The lowest stover yield (3.373 t/ha) was obtained from the control treatment which was similar with Zn_1B_2 and closely similar with Zn_1B_3. Interaction effect of different levels of zinc and boron showed non significant variation on pH and organic matter in post harvest soil. The highest pH in post harvest soil (6.367) was observed from Zn_2B_2 (1.5 kg Zn ha^{-1} and 1 kg B ha^{-1}) and the lowest pH in post harvest soil (5.9) was found from Zn_1B_1 (0 kg Zn ha^{-1} and 0 kg B ha^{-1}). The highest organic matter in post harvest soil (1.883%) was obtained from Zn_3B_3 (3 kg Zn ha^{-1} and 2 kg B ha^{-1}), while the lowest organic matter in post harvest soil (1.263%) was found from Zn_3B_1 (3 kg Zn ha^{-1} and 0 kg B ha^{-1}). The effect of combined applications of different doses of Zn and B resulted non significant variations in N, P, K content in the post harvest soil. The higher total N content of the post harvest contents (0.076 %) were recorded in the treatment combination of Zn_3B_3 (3kg Zn ha^{-1} and 2kg B ha^{-1}) and the lowest value of 0.060% in Zn_1B_2, Zn_1B_3, Zn_2B_1, Zn_3B_1. The highest P content (23.41%) was observed in Zn_2B_1 (1.5kg Zn ha^{-1} and 0k B ha^{-1}) and the minimum value (20.90%) was found in the control treatment. The highest K content (0.14%) was observed in Zn_2B_3 (1.5kg Zn ha^{-1} and 2kg B ha^{-1}) which was similar with Zn_3B_2 (3kg Zn ha^{-1} and 1kg B ha^{-1}) and the minimum value (0.11%) was found in the control treatment. The highest S content (13.38%) was observed in Zn_3B_3 (3kg Zn ha^{-1} and 2kg B ha^{-1}) and the minimum value (8.50%) was found in the control treatment. The highest available zinc in post harvest soil (0.6833 ppm) was observed from Zn_3B_3 (3kg Zn ha^{-1} and 2kg B ha^{-1}) and the lowest available zinc in post harvest soil (0.1767 ppm) was found from Zn_1B_1 (0 kg Zn

ha^{-1} and 0 kg B ha^{-1}). The highest available boron in post harvest soil (0.5867 ppm) was found from Zn_2B_3 (1.5 kg Zn ha^{-1} and 2kg B ha^{-1}) which was similar with (0.560 ppm) was found in Zn_1B_3 (0kg Zn ha^{-1} and 2kg B ha^{-1}) and (0.5733ppm) was found in Zn_3B_3 (3kg Zn ha^{-1} and 2kg B ha^{-1}). On the other hand, the lowest available boron in post harvest soil (0.120 ppm) was recorded from Zn_3B_1 (3kg Zn ha^{-1} and 0 kg B ha^{-1}) treatment combination which was similar with (0.130 ppm) Zn_1B_1 (0kg Zn ha^{-1} and 0kg B ha^{-1}) and (0.180 ppm) Zn_2B_1 (1.5kg Zn ha^{-1} and 0kg B ha^{-1}).

Conclusion

From the findings it was found that application of 3 kg Zn ha^{-1} & 2 kg B ha^{-1} and 3 kg Zn ha^{-1} & 1 kg B ha^{-1} showed statistically same pod yield. So, it can be concluded that combination of 3 kg Zn ha^{-1} & 1 kg B ha^{-1}can be more beneficial for the farmers to get better yield for the cultivation of BARI Jhar Sheem-1.

Considering the above results of this 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 compliance and other performances.

2. More experiments may be carried out with organic and also macro nutrients.

REFERENCES

Ahlawal, I. P. S. and S. P. Sharma, 1989. Response of French bean genotypes to soil moisture regimes and phosphate fertilization. Ind. J. *Agron*., 34: 70-74.

Awad, F., M. A. Aziz and M. S. Omar, 1982. Interaction of phosphorous fertilization and soil moisture depletion on kidney bean (*Phaseolus vulgaris* L.). Egypt. J. Soil Sci., 22: 135-142.

Abhijit S.; Bijan, K.; Mandal and Probir, Mukhopadhyay, K. (1999). Boron and molybdenum uptake by yellow sarson as influenced by their fertilization in different levels and modes. *Indian J. Plant Physiol.***4**(2): 114-116.

Alloway, B.J. (2004). Zinc in Soils and Crop Nutrition. Publ. of International Zinc Association.http:/www.iza.com/Documents/Communications/Publications/ALLOWAY_PRINT.pdf.

Ahlawat, I.P.S., Gangaiah, B. and Zadid, M.A. (2007). Nutrient management in chickpea. In: Chickpea breeding and management (Yadav, S.S., Redden, R., Chen, W., Sharma, B. Eds). CAB International, Wallingford, Oxon, United Kingdom. pp. 213–232.

Ashraf. M. (2009). Biotechnological approach of improving plant salt tolerance using antioxidents as markers. *Biotechnol. Adv*., **27:**84-93.

Alam, M.K., Uddin, M.M., Ahmed, M.,. Latif, M.A. and Rahman M.M. (2010). Growth and green pod yield of garden pea varieties under different nutrient levels. *J. Agrofor. Environ*., **4**(1): 105-107

Ahmad, A., Tahir, M., Ullah, U., Naeem, M., Rehman, H. and Talha, M. (2012). Effect of silicon and boron foliar application on yield and quality of rice. *Pakistan J. Life Soc. Sci*., **10**: 161-165.

Bouyoucos, G. J. (1927). The hydrometer as a new method for the mechanical analysis of soils. Soil Sci. 23: 343-353.

Black, C. A. (1965). Methods of soil analysis. Part 1and 11. Amer. Soc. Of Agron. Inc. Publiser, Madison, Wisconsin, USA. Pp. 545- 567.

Barcelo, J. and Poschenrieder, C. (1990). Plant water relations as affected by heavy metal stress: a review. *J. Plant Nutr*., **13**: 1-37.

Buzetti, S., Bansal, K. N. (1990).Effect of applied B fractions and critical limit of boron in soybean plant.*J. Indian Soc. Sol. Sci*.**42**: 96-101.

Brown, P.H., Cakmak, I. and Zhang, Q. (1993). Form and function of zinc in plants. Chap. 7, In A.D. Robson (Ed). pp 90-106. Zinc in Soils and Plants, Kluwer Academic Publishers, Dordrecht.

BARI (Bangladesh Agricultural Research Institute). (1998). Mungbean cultivation in Bangladesh Pulse Research Station.Bangladesh Agric. Res. Inst., Gazipur- 1701.

Broughton, W. J., Hemandez, G., Blair, M. and Beebe, S. 2003. Bean (*Phaseolus vulgaris*) model food legume. Plant and Soil. 252: 55-128.

Banu, M.A. (2003). Effects of sulphur and boron on some physiological and biochemical parameters of chickpea at different growth stages. M.S. Thesis, Dept. of April. Chem. Bangladesh Agricultural University, Mymensingh.

Bassil. E. Hu. H. and Brown. P. H. (2004). Use of phenyl boronic acids to investigate boron function in plants: possible role of boron in trnsvacuolar cytoplasmic strands and cell wall adhesion. *Plant Physiol*., **136:** 3383-3395.

Brennan, R.F. (2005). Zinc Application and Its Availability to Plants. Ph. D. dissertation, School of Environmental Science, Division of Science and Engineering, Murdoch University.

Coleman. J. E. (1991). Zinc proteins: Enzymes, storage proteins, transcription factors and replication protein. Ann. Rev. Biochem. 61: 897-946.

Cakmak, I., Torun, B., Erenoglu, B., Kalayci, M., Yilmaz, A., Ekiz, H. and Brun, H.J. (1996). Zinc deficiency in soils and plants in Turkey and plant mechanism involved in Zinc deficiency. *Turk. J Agric*. (Special issue): 13–23.

Chaoui A., Mazhoudi, S., Ghorbal, M.H. and Elferjani, E. (1997). Cadmium and zinc induction of lipid peroxidation and effects on antioxidant enzyme activities in bean (*Phaseolus vulgaris* L.). *Plant Sci*., **127**: 139-147.

Chandel**,** R. S.; Raghavendra Singh; R. S. Singh; and O. N. Singh. (2002). Influence of nitrogen levels and Rhizobium inoculation on yield, quality and nitrogen uptake of French bean (Phaseolus vulgaris L.). Department of Agronomy, Institute of Agricultural Sciences, BHU, Varanasi - 221 005 (U. P.), India. Research-on-Crops. 3(3): 524-528.

Dutta, R.K. Uddin, M. and Rahman, L. (1984). Production of mungbean, rice and mustard in relation to boron in Brahmaputra Floodplain soils. *Bangladesh J. Soil Sci*., **20**: 77-78.

Dwivedi, M.; Upadhaya, R. M. and Dwivedi, G. K. (1990). Effect of inorganic organic and biofertilizer on yield, protein and amino acid content of black gram on wheat grown in sequence. *Ann. Agril. Res.***11**(2): 991-998.

De Vos, C.H.R., Schat, H, De Waal, M.A.M., Voorja, R. and Ernst, W.H.O. (1991) Increased resistance to copper-induced damage of root cell plasmalemma in copper tolerant *Silene cucubalus*. *Physiol. Plant*. **82**: 523-528.Doncheva *et al*., 2001.

Dell. B. and Huang. L. (1997). Physiological responses of plants to boron. *Plant Soil*. **193**: 103-120.

Duffy. B., L. E. Datnoff., W. H. Elmer. And D. M. Huber. (2007). Zinc and plant disease. In mineral nutrition and plant disease. Eds. 155-175.

Disante, K.B., Fuentes, D. and Cortina, J. (2010). Response to drought of Zn-stressed *Quercus suber* L. Seedlings. *Env. Exp. Bot*., **70**: 96-103

Eguchi, S. (2000).Comparision on B extractable bio-available maethods and its critical level in soil and plant.*Sarhad J. Agric.***16**(30): 292-297.

El Sayed Hameda, E.A., Amen El-Sh. A., EI-Morsy, A.H. and Tolba, M.H. (2012). Effects of foliar spraying with microelements and different fertilizer sources on quality and yield of *Pisum sativum*, L. plant. *Int. Res. J. Agric. Sci. Soil Sci*., **21**(1): 17-24.

Frances, C. A., C. A. Flof and M. Prager (1986) Fitotecnia Latinoamericana (Cited from Adoms, m. w., D. P. Coyne, J. H. C. Davis, 1985).

FAO. (2000). Production year book. Food and Agriculture Organization of the United Nations Rome, Italy. 54: P.108.

Fageria. N. K. and Baligar. V. C. (2005). Growth components and zinc recovery efficiency of upland rice genotypes. Pesq. Agropec. Bras. **10:** 1211-1215.

Fageria. N. K. and Boca Raton. F. L. (2006). The use of nutrients in crop plants. CRC Press.

Gomez, K. A. and Gomez, A. A. (1984).Statistical Procedures for Agricultural Research (2nd edition). International Rice Research Institute, John Willey and Sons, Inc. Singapore, pp. 139-240.

George, R. A. T. 1985. Vegetable seed production. Longman, London and New York. pp. 193-207.

Howeler, R. H.; Flor, C. A. and Gonzalez, C. A. (1987).Diagnosis and correlation of B deficiency in beans and mungbean in a mollisol from Cauca Valley of Colombig.*Agron. J*.**70**:493-497.

Hermantarajan, R., Singh, A. K. and Ram, H. (2000).Effect of boron and zinc fertilization on growth and quality of Soybean.Dept, of Agril.Chem. And Soil Sci. Nagaland University, SASRD, Medziphema, Nagaland, *India J. Interacademicia*.**5**(2): 305-309.

Hamsa Aparna and Puttaiah, E.T. (2012). Residual Effect of Zinc and Boron on Growth and Yield of French bean (*Phaseolus vulgaris* L.) - Rice (*Oryza sativa* L.) Cropping system. *Intl. J. Env. Sci*., **3**(1): 167-172.

Islam, M. A.; Saha, U. K.; Islam, M. S. and Saha, R. R. (1995).Fertilizing chickpea for high yield with special emphasis on boron and molybdenum in grey flood plain soils of Bangladesh.*Ann. Bangladesh Agric.***5**(1): 43-49.

Jackson, M. L. 1973. Soil Chemical analysis. Prentice Hall. Inc. N. J., USA. P. 46.

Kastori, R. and Petrovic, N. (1989). Effect of boron on nitrate reductase activity in young sunflower plants. *J. Plant Nutr.,* **12**(5): 621-632.

Kulkami, J. H.; Sojitra, V. K.; and Bhatt, D. M. 1989.Effect of micronutrient application on nodulation and pod yield of groundnut.*Legume Res.***12**(1): 49-51.

Kalyani, R.R., Sree Devi, V., Satyanarayana, N.R. and Rao, M.K. (1993). Effect of foliar application of boron on crop growth and yield of Pigonpea (*Cajanus Cajan* L.) (Mill sp). *Indian J. Plant. Phyto*. **4**: 223 – 226.

Kumar, H.; Singh, S. and Singh, R. N. (2002).Response of mungbean to boron in an acid soil.*J. Res.***12**(4): 258-262.

Kasim, W.A. (2007). Physiological consequences of structural and ultra-structural changes induced by Zn stress in *Phaseolus vulgaris*. I. Growth and Photosynthetic apparatus. *Int. J. Bot.*, **3**(1): 15-22.

Kumar, R., Deka, B.C., Kumawat, N. and Ngachan S.V. (2014). Effect of integrated nutrition, biofertilizers and zinc application on production potential and profitability of garden pea (*Pisum sativum* L.) in Eastern Himalaya, India. *Legume Res.*, **37**(6): 614-620.

Lucas, R. E. and Knezek, B. C. (1972). Climate and Soil conditions promoting micronutrient deficiencies in plants. In “Micronutrients in agriculture” (J. J.

Mortvedt, P. M. Giordano, and W. L. Lindsay, Eds.), Soil Science Society of America, Madison. pp. 265-268.

Luo, X.Y., Peng, Y.C. and Wang, B.Y. (1990). Effect of boron fertilizer on yield and quality of groundnut. *Zheijiang Agric. Sci.*, **1**: 30-32.

Lin, K.H., and Deng, J.N. (1992). Effects of Mg. Zn and B fertilizers on some physiological biochemical indices, yield and quality of flue cured tobacco. Ed. S. Portch, Sulphur Institute. Symposium on the role of S, Mg and micronutrients in balanced plant nutrition Chengdu. 352-356.

Liu, P., Yang, Y., Liu, P. and Yang, Y.A. (2000). The effect of boron and molybdenum stress on nitrate reductase activity and contents of nitrate-N in leaves of soybean. *J. Zheijiang Univ. Agric. Life Sci*., **26**(2): 151-154.

Lalit Bhatt, Srivastava, B.K. and Singh, M.P.M. (2004). Studies on the effect of foliar application of micronutrients on growth, yield and economics of tomato (*Lycopersicon esculantum* Mill). *Prog. Hort*., **2**: 331 – 334.

Marschner, H. (1986). Mineral Nutrition of Higher Plants. Academic Press, New York.

Marschner, H. (1995). Mineral Nutrition of Higher Plants, 2nd edn. Academic Press, London, UK.

Mengel, K., Kirkby, E.A., Kosegarten, H., Appel, T. (2001). Principles of Plant Nutrition. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Moghazy A.M., Saed, S.M. El. and Awad, El. S.M. (2014). The Influence of Boron Foliar Spraying with Compost and Mineral Fertilizers on Growth, Green pods and Seed Yield of Pea. *Nat Sci*., **12**(7): 50-57. [http://www.sciencepub.net /nature].

Olsen, S.R., Cole, C.V.; Watanabe, F. S. and L. A. Dean . 1954. Estimation of available phosphorus in soil by extracion with sodium bicarbonate. U.S. Dept. Agr. Cire.p.939**.**

Page, A. L.; Miller, R. H. and D. R. Keeney. 1982. Methods of soil analysis, Part 2. Amer. Soc. Agron. Madi. USA. Pp. 539- 622.

Purseglove, J. W. (1987). Tropical crops : Dicotyledons. Longman. New York, P. 52.

Pahlsson, A.M.B. (1989) Toxicity of heavy metals (Zn, Cu, Cd, Pb) to vascular plants. *Water Air Soil Pollution*. **47**: 287-319.

Posypanov, S., Saxena, S. C. and Chandel, A. S. (1994).Effect of Zn fertilization on different varieties of soybean *(Glycine max).Indian J. Agron.***39**(4): 586-590.

Panwar. B. S.; Gupta, S. P. and Kala. P. (1998).Response to boron in pearl millet and chickpea in a pot experiment with a non calcareous soil in India.*ActaAgronomicaHungarica*.**46**(4): 335-340.

Peck, A.W. and McDonald, G. K. (2010). Adequate zinc nutrition alleviates the adverse effects of heat stress in bread wheat. *Plant Soil*. **337**: 355-374.

Pandey, N., Gupta, B. and Pathak, G.C. (2012). Antioxidant responses of pea genotypes to zinc deficiency. *Russian J. Plant Physiol*., **59**(2): 198-205.

Romheld. V., Marschner. H. (1991). Function of micronutrients in plants.Micronutrients in Agriculture. In J. J. Mortvedt. F. R. Cox. L. M. Shumma. R. M. Welch. Ed2. Soil Science Society of America. Madison. W1. Pp. 297-328.

Roy, S. N., Singh, B.G. and Rao, I. V. S. (1992).Response of lentil to boron application in calcareous soils.*Int. Chickpea Newsletter*.**21**: 23-26.

Rashid, M. M. (1993) Sabji Biggan (in Bengali), 1st ed. Bangla Academy, Bangladesh. Pp. 387-390.

Rizk, W.M. and Abdo, F.A. (2001). The response of two mungbean cultivars to zinc, manganese and boron II. Yield and chemical composition of seeds. *Bulletin Fac. Agril. Cairo Univ.*, **52**(3): 467-477.

Rerkasem, B. and Jamjod, S. (2004). Boron deficiency in wheat.Agron.Dept., Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand.*Field Crops Res.***89**(2/3): 173-186.

Rehman, H., Aziz, T., Farooq, M., Wakeel, A., Rengel, Z. (2012). Zinc nutrition in rice production systems. *Plant Soil*. **88**: 465-468.

Singh, V. and Singh, S.P. (1984). Effect of applied boron on nutrient uptake by barley crop. *Curr. Agric.* **8**: 89-90.

Salukhe, D. K., Desai, B. B. and N. R. Bhat . 1987. Leguminous Vegetables (Peas and Beans) . In. Vegetabl and Flower Seed Production, Agricole Publishing Academy, NewDelhi. pp. 265-302.

Sakal, R., Singh, R.B. and Singh, A.P. (1988). Effect of boron application on blackgram and chickpea production in calcareous soil. *Fert. News.* **33**(2): 27-30.

Singh, J.P., Dahiya, D.J. and Narwal, R.P. (1990). Boron uptake and toxicity in wheat in relation to zinc supply. *Fertilizer Res.*, **24**(2): 105-110.

Sakai. R .: Sinha. R. B. and Singh, A. P. (1990). Response of chickpea to boron application in calcareous soils.*Int. Chickpea Newsletter*.**22**: 28-29.

Swiader, J. M., Ware, G. W. and J. P. Mccollum. 1992. Producing vegetable crops. 4th ed. Interstate publishers. Inc. Danville. Illions. USA, pp. 223-249.

Sinha, A.C., Mandal, B.B. and Jana, P.K. (1994). Yield and water use efficiency of rainfed lentil (*Lens culinaris*) as influenced by boron zinc and molybdenum. *J. Agric. Sci.*, **64**(12): 863-866.

Singh, A. C.; Mandah, B. B. and Jana, P. K. (1994).Yield and water use efficiency of rainfed lentil *(Lens culinaris)* as influenced by boron, zinc and molybdenum. *Indian J. Agric. Sci.***54**(12): 833-839.

Srivastava, S.P. (1994). Effect of soil Multiple a (Micronutrient mixture) and foliar Multiplex (boron) with or without nitrogen. Presented at the GLRP-NARC/CLAN-ICRISAT Review and Planning Meeting, Nepal.

Saha, A., Mandal, B. K. and Mukhopadhyay, P. (1996). Residual effect of boron and molybdenum on the yield of succeeding mungbean in summer. *Indian Agriculturist*. **40**(1): 11-16.

Saini,J.P and S. C.Negi. 1996. Effect of cultivation and date of sowing on growth and yield of French bean (*Phaseolus vulgaris* L.). Under dry temperature condition. Indian J. Agron. ,43(1) : 110-113.

Srivastava, S.P., Yadav, C.R., Rego, T.J. Johansen, C. and Saxena, N.P. (1997). Diagnosis and alleviation of boron deficiency causing flower and pod abortion in chickpea (*Cicer arietinum L.*) in Nepal. In: Proc. Boron in soils and plants. R.W. Bell and B, Rerkaseni ed. Kluwer Acad. Pub. p. 95-99.

Srivastava, S. P.; Johansen, C. and Rego, J. J. (1999).Boron deficiency of lentil in Nepal *J. Indian Soil. Sci.***47**(2): 22-24.

Sakai. R., Verroa, R. J. and Mxshra, P. H. (1999).Effect of doses and methods of boron application on growth and yield of lentil-maize intercrpopping.Dept, of Crop Physiol. C. S. Azad Univ. of Agri. and Technol. Kanpur India.*Indian J. Pul. Res.***12**(1): 102-108.

Singh, R.; Yadav, D. S. and Maurya, M. L. (2002).Effect of B application on yield of pea *(Pisumsativum*) and Black gram *(Vignamungo*Heper) in calcareous soil.*Fertilizer news.* **47**(2): 67-68.

Stoyanova, Z. and Doncheva, S. (2002). The effect of zinc supply and succinate treatment on plant growth and mineral uptake in pea plant. *Braz. J. Plant Physiol*., **14**(2): 111-116.

Singh, N. B; and K. K.Verma. (2002). Nitrogen and phosphorus nutrition of French bean (Phaseolus vulgaris L.) grown in eastern Uttar Pradesh under late-sown condition.Zonal Agricultural Research Sub-Station, Narendra Dev University of Agriculture and Technology, Bari-Bagh, Ghazipur, Uttar Pradesh 233 001, India. Indian-Journal-of-Agronomy. 47(1): 89-93 .

Sathya, S., Pitchai, G.J, Indirani, R. (2009). Boron nutrition of crops in relation to yield and quality review. *Agric. Rev*., **2**: 139-144.

Tindall, H. D. 1988. vegetable in the tropics. Mcmillan Education Ltd., 527 p.

Talashilkar, S. C. and Chavan, A. S. (1996).Response of groundnut to calcium, sulphur and boron with and without F YM on Inceptisol.*J. Indian Soc. Soil Sci*..**44**(2): 343-344.

Tisdale, S.L., Nelson, W.L., Beatson, J.D. and Havlin, J.L. (1999). Soil Fertility and Fertilizers. 6th Ed.Perntice Hall of India. p. 220-346.

Tewari, J. K. and Singh, S. S. (2000). Effect of nitrogen and phosphorus on growth and seed yield of French bean (*phaseolus vulgaris* L.). Vegeta. Sci., 27(2) : 172-175.

Tanaka, M., Fujiwar, T. (2008). Physiological roles and transport mechanisms of boron: perspectives from plants. *Pflügers Arch. European J. Physiol*. **456**: 671-677.

Tavallali, V., Rahemi, M., Eshghi, S., Kholdebarin, B. and Ramezanian, A. (2010). Zinc alleviates salt stress and increases antioxidant enzyme activity in the leaves of pistachio (*Pistacia vera* L. 'Badami') seedlings. *Turk. J. Agr. Forest*: **34**(4): 349-359.

USDA. (1951). Soil survey manual by soil survey stuff. Bureau of plant industry, soil and agricultural engineering. Hand book no. 18, 205. US Govt. printing Office, Washington D.C.

Verma, R.J. and Mishra, P.H. (1999). Effect of doses and methods of boron application on growth and yield of mungbean. *Indian J. Pulses Res*., **12**(1): 115-118.

Valenciano. J. B., Boio. J. A. and Marcelo. V. (2010). Response of chickpea (*Cicer arietinum* L.) yield to zinc, boron and molybdenum application under pot conditions. *Spanish J. Agril. Res*. **8**(3):797-807.

Yang, Y.A., Xu., H.K., Jie, Z.Q. and Wang, B.Y. (1989). Influence of B, N and K nutrient level on B uptake, quality and yield of rape seed. *Scientia Agricultura Sinica.* **22**(1): 44-51.

Yaseen. M., Nadeem. M. and Hussain. S. (2004). Investigating the effectiveness of micropower foliar spray on growth and yield of different crops. *Pakistan J. Life Sci. Sci*., **2:** 156-158.

APPENDICES

Appendix I. Analysis of variance of the data on yield contributing characters and yield of BARI Jhar Sheem-1 as influenced by different levels of Zinc and Boron

Source of variation	Degrees of freedom	Mean Square						
		Plant height (cm)	Pod length (cm)	Pod diameter (cm)	Wt. of 100 pods(gm)	No. of pod/plant	Total pod yield (ton/ha)	Stover yield (ton/ha)
Replication	2	54.428	9.787	0.380	5687.455	76.881	2.060	0.239
Level of zinc(A)	2	104.062⋆	6.503⋆	0.007^NS	32763.922⋆	1637.597⋆	23.912⋆	21.477⋆
Level of boron(B)	2	5.743^NS	0.796 NS	0.019 NS	16148.456⋆	69.661 NS	11.078⋆	1.958⋆
Interaction (A×B)	4	5.627⋆	0.760 NS	0.051 NS	2962.889⋆	14.599⋆	1.727⋆	0.326⋆
Error	16	3.333	2.605	0.048	2480.132	42.910	0.506	0.247

* Significant at 0.05 level of probability

Appendix II. Analysis of variance of the data on pH, organic matter, N, P, K, S, available Zn and B of post harvest soil of BARI Jhar Sheem-1 as influenced by different levels of Zinc and Boron

Source of variation	Degrees of freedom	Mean Square							
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me/100gm)	Available S (ppm)	Available Zn (ppm)	Available B (ppm)
Replication	2	0.343	0.325	0.001	19.977	0.001	1.134	0.001	0.001
Level of zinc(A)	2	0.084 NS	0.038 NS	0.001 NS	1.063 NS	0.001 NS	36.396⋆	0.375⋆	0.004 NS
Level of boron(B)	2	0.163 NS	0.295 NS	0.001 NS	0.314 NS	0.001 NS	4.393⋆	0.021⋆	0.416⋆
Interaction (A×B)	4	0.021 NS	0.077 NS	0.001 NS	4.229 NS	0.001 NS	1.490⋆	0.002⋆	0.003⋆
Error	16	0.156	0.030	0.001	5.884	0.001	1.179	0.001	0.003

* Significant at 0.05 level of probability

Appendix III. Effect of Zinc on yield contributing characters and yield of BARI Jhar Sheem-1

Treatment	Plant height (cm)	Pod length (cm)	Pod diameter (cm)	No. of pod/plant	Wt. of 100 pods (gm)	Total pod yield (ton/ha)	Stover yield (ton/ha)
Levels of Zinc							
Zn_1	23.38c	12.56b	3.267	42.30c	372.1c	8.556c	3.501c
Zn_2	27.64b	13.40ab	3.233	53.85b	436.2b	10.63b	5.539b
Zn_3	30.11a	14.26a	3.289	69.19a	492.7a	11.77a	6.531a
$LSD_{(0.05)}$	1.824	1.613	NS	6.55	49.77	0.71	0.497
CV(%)	11.75	12.04	-	11.89	11.48	2.89	10.57

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Zn_1=0 kg Zn ha^{-1} , Zn_2=1.5 kg Zn ha^{-1} , Zn_3=3 kg Zn ha^{-1}

Appendix IV. Effect of Boron on yield contributing characters and yield of BARI Jhar Sheem-1

Treatment	Plant height (cm)	Pod length (cm)	Pod diameter (cm)	No. of pod/plant	Wt. of 100 pods(gm)	Total pod yield (ton/ha)	Stover yield (ton/ha)
Levels of Boron							
B_1	26.12	13.13	3.21	52.56	398.5b	9.289c	4.952b
B_2	27.43	13.36	3.30	54.70	421.8b	10.17b	4.891b
B_3	27.58	13.72	3.27	58.08	480.7a	11.49a	5.728a
$LSD_{(0.05)}$	NS	NS	NS	NS	49.77	0.71	0.497
CV(%)	-	-	-	-	11.48	2.89	10.57

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

B_1=0 kg B ha^{-1}, B_2=1 kg B ha^{-1} , B_3=2 kg B ha^{-1}

Appendix V. Interaction effect of Zinc and Boron on yield contributing characters and yield of BARI Jhar Sheem-1

Treatment	Plant height(cm)	Pod length(cm)	Pod diameter (cm)	No. of pod/plant	Wt. of 100 pods (gm)	Total pod yield (ton/ha)	Stover yield (ton/ha)
Zn_1B_1	22.13 d	12.33	3.27	40.22e	345.7de	7.83c	3.373d
Zn_1B_2	24.34cd	13	3.3	43.89de	326.6e	7.63c	3.373d
Zn_1B_3	23.68cd	12.33	3.23	42.78de	444.1abc	10.20b	3.757d
Zn_2B_1	25.43bc	12.90	3.2	51.22cde	415.1cd	9.767b	5.187c
Zn_2B_2	28.16ab	13.07	3.13	53.33cd	425.2cd	10.32b	5.430c
Zn_2B_3	29.33a	14.23	3.37	57.00bc	468.5abc	11.80a	6.00bc
Zn_3B_1	30.81a	14.17	3.17	66.22ab	434.8bc	10.27b	6.297b
Zn_3B_2	29.79a	14	3.47	66.89ab	513.8ab	12.57a	5.870bc
Zn_3B_3	29.72a	14.60	3.23	74.45a	529.6a	12.48a	7.427a
$LSD_{(0.05)}$	3.16	NS	NS	11.34	86.20	1.231	0.86
CV(%)	11.75	-	-	11.89	11.48	6.89	10.57

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Zn_1=0 kg Zn ha^{-1} B_1=0 kg B ha^{-1}

Zn_2=1.5 kg Zn ha^{-1} B_2=1 kg B ha^{-1}

Zn_3=3 kg Zn ha^{-1} B_3=2 kg B ha^{-1}