EFFECT OF ZINC AND BORON ON THE GROWTH AND YIELD OF POTATO

A Thesis

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CERTIFICATE

*This is to certify that the thesis entitled **" EFFECT OF ZINC AND BORON ON THE GROWTH AND YIELD OF POTATO"** submitted to the **DEPARTMENT OF SOIL SCIENCE,** Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in SOIL SCIENCE,** embodies the results of a piece of bona fide research work carried out by **ALAMIN SOHAG,** Registration No. **18-09082**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.*

I further certify that any help or sources of information received during the course of this investigation have been duly acknowledged.

Dated: December,2020

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Dedicated To

My Beloved Parents

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The Author

EFFECT OF ZINC AND BORON ON THE GROWTH AND YIELD OF POTATO (*Solanum tuberosum*)

ABSTRACT

The experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during November 2019 to February 2020 to study the effect of Zinc and Boron fertilizer on growth and yield of potato (*Solanum tuberosum*). Three Zinc levels; Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1} and Zn_2 = 6 kg Zn ha^{-1} and Three Boron levels; B_0 = 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1} and B_2= 2 kg B ha^{-1} were considered for the present study. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield of potato were recorded. Most of parameters were significantly affected by different levels of Zn application. The highest tuber yield ha^{-1} (25.42 t) and marketable yield ha^{-1} (23.05 t) were found from the treatment Zn_2 (6 kg Zn ha^{-1}) compared to control treatment Zn_0 (0 kg Zn ha^{-1}). Boron treatment also significantly affected all the studied parameters and the highest tuber yield ha^{-1} (23.15 t) and marketable yield ha^{-1} (20.78 t) were achieved from the treatment B_2 (2 kg B ha^{-1}) compared to control treatment B_0 (0 kg B ha^{-1}). Considering combined effect of Zn and B, the highest plant height (70.93 cm) was recorded from the treatment combination of Zn_2B_0 (6 kg Zn ha^{-1} + 0 kg B ha^{-1}), Again the highest number of leaves $hill^{-1}$ (58.19) , number of stem $hill^{-1}$ (5.56) , number of tuber $hill^{-1}$ (8.58), weight of tuber $hill^{-1}$ (244.2 g), weight of tuber $plot^{-1}$ (6.89 kg), tuber yield ha^{-1} (27.82 t) and marketable yield ha^{-1} (25.05 t) were recorded from the treatment combination of Zn_2B_2 (6 kg Zn ha^{-1} + 2 kg B ha^{-1}) whereas lowest plant height (45.55 cm), number of stem $hill^{-1}$ (4.50), number of leaves $hill^{-1}$ (40.28), number of tuber $hill^{-1}$ (6.34), weight of tuber $hill^{-1}$ (90.03 g), weight of tuber $plot^{-1}$ (4.12 kg), tuber yield ha^{-1} (11.32 t) and marketable yield ha^{-1} (9.03 t) were found from the treatment combination of Zn_0B_0 (0 kg Zn ha^{-1} + 0 kg B ha^{-1}). So, it may be recommended that Zn_2 (6 kg Zn ha^{-1}) with B_2 (2kg B ha^{-1}) was better for growth and yield of potato.

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LIST OF ACCRONYMS AND ABBREVIATIONS

AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Anon.	Anonymous
As	Arsenic
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BCF	Bio Concentration Factors
cm	Centi-meter
cm^2	Square centi-meter
CV	Coefficient of Variance
DAP	Days After Planting
Dev.	Devlopment
DMRT	Duncan's Multiple Range Test
Environ.	Environmental
et al.	And others
Expt.	Experimental
FAO	Food and Agriculture Organization
g	Gram (s)
$hill^{-1}$	Per hill
i.e.	*id est* (L), that is
j.	Journal
kg	Kilogram (s)
mg	Milligram
m^2	Meter squares
M.S	Master of Science
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
SE	Standard Error
$t\ ha^{-1}$	Ton per hectare
TSS	Total Soluble Solids
UNDP	United Nations Development Programme
viz	Namely
WHO	World Health Organization

CHAPTER I

INTRODUCTION

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a tuber crop belongs to the family Solanaceae. Potato originated in the central Andean area of South America (Keeps, 1979). It is the 4th world crop after wheat, rice and maize. Bangladesh is the 7th potato producing country in the world (FAOSTAT, 2018). It contributes not only energy but also substantial amount of high quality protein and essential vitamins, minerals and trace elements to the diet (Horton, 1987).

In Bangladesh, it ranks second after rice in terms of production. The total area under potato crop, national average yield and total production in Bangladesh are 4,30,446 hectares, 19.071 t ha^{-1} and 82,05,470 metric tons, respectively. The total production is increasing over the time as such consumption also rapidly increasing in Bangladesh (MOA, 2015). It is considered as a vegetable crop and contributes as much 55% of the total vegetable production in Bangladesh (BBS, 2013).The yield is very low in comparison to that of the other leading potato growing countries of the world, 40.16 t ha^{-1} in USA, 42.1t ha^{-1} in Denmark and 40.0 t ha^{-1} in UK (FAO, 2013).

In Bangladesh, potato is grown during the winter season. Nutritionally, the tuber is rich in carbohydrates or starch and is a good source of protein, vitamin C and B, potassium, phosphorus and iron. Potato is one of the most important vegetable crops and having a balanced food containing about 75 to 80% water, 16 to 20 % carbohydrates, 2.5 to 3.2% crude protein, 1.2 to 2.2% true protein, 0.8 to 1.2% mineral water, 0.1 to 0.2% crude fats, 0.6% crude fibre and some vitamins (Schoenemann, 1977). It is a staple diet in European countries and its utilization both in processed and fresh food form increasing considerably in Asian countries (Brown, 2005). Being a carbohydrate rich crop, potato can partially substitute rice, which is our main food item. It is grown in almost all countries of the world. In main countries including those Europe, America and Canada, potato is a staple food. In the last 2-3 decades, production of potato in Bangladesh has increased with the cultivation of high yielding varieties. In Bangladesh, potato is mainly used as vegetable and available in the market throughout the year with reasonable price as compared to other vegetables. According to Kadly (1972), among crops, the potato ranks first in protein production per gram per day. Biological value, which is an index of the protein of absorbed nitrogen retained in body for growth or maintenance or both, is 73 for potato compared to 54 for maize and 53 for wheat flour. Potato has acquired great importance in rural economy in Bangladesh. It is not only a cash crop but also an alternative of food crop against rice and wheat. Bangladesh has a great agro-ecological potential of growing potato. The area and production of potato in Bangladesh has been increasing during the last decades but the yield per unit area remains more or less static. The reasons for such a low yield of potato in Bangladesh are imbalanced fertilizer application, use of low quality seed and use of sub-optimal production practices. Available reports indicated that potato production in Bangladesh can be increased by improving cultural practices among which optimization of manure and fertilizer, planting time, spacing and use of optimal sized seed are important which influences the yield of potato (Divis and Barta, 2001).

It is reported that among micronutrients Zn and B have occupied unique position in enhancing the yield of potato (Trehan and Grewal, 1989). Zn help to increase the rate of photosynthesis and the translocation of photosynthates leading to increased size and number of tubers. Hence, application of micronutrients becomes essential to increase the productivity of potato. Availability of Zn to plant is hampered by its immobile nature and adverse soil conditions. Thus, Zn deficiency is observed eventhough high amount is available in soil. Its deficiency results in severe yield losses and in acute cases, plant death. The critical limits of Zn in soils vary according to different extractants used and nature of soil properties and plant species. The critical values of DTPA- Zn in soils ranged very widely from 0.45 to 2.0 mg/kg. Zinc is required in several plant metabolic processes (Palmer and Guerinot 2009). In plants, Zn deficiency reduces growth, tolerance to stress and chlorophyll synthesis (Kawachi *et al.*, 2009; Lee *et al*., 2010).

Boron is essential for sugar transport, cell-wall synthesis lignifications and phenol metabolism. Boron is involved in carbohydrate metabolism and protein synthesis. On molar basis, the requirement of boron for dicotyledons is higher than any other micronutrient (Sathya *et al*., 2009). Boron Requirement of boron for potato crop is higher than monocotyledons. Reisenauer *et al.* (1973) re-ported that < 1 mg/kg water-soluble boron in soil may not supply sufficient boron to support normal plant growth. Boron application in potato increases the percentage of large and medium tubers and decreases the proportion of small tubers (Das and Jena, 1973). Omission of boron application in potato reduces the tuber yield and quality of potato significantly compared to balanced use of fertilizers (Prasad *et al.*, 2014).

Hence, the experiment was conducted with different levels of zinc and boron application for potato cultivation with the following objectives

i) To study the effect of boron and zinc on growth and yield of potato

ii) To determine the suitable doses of boron and zinc fertilizer on growth and yield of potato

iii) To find the proper combinations of boron and zinc for higher yield of potato.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Potato is the most important tuber crop in the world as well as in Bangladesh. Numerous experiments have been conducted throughout the world on potato crop but information regarding Zinc and Boron in potato and their effects on growth and yield parameters are still inadequate. Brief reviews of available literature pertinent to the present study have been presented in this chapter.

2.1 Effect of Zinc on growth and yield of potato

Farajnia and Ardalan (1998) stated that potato is relatively sensitive to Zn deficiency, therefore it has shown a good reaction to zinc application. They carried out an experiment near Tabriz , Iran in 1997 and statistical analysis indicated that $ZnSO_4$ was most effective in improving yield and quality of potato compared to other treatment and in this study , they found that the application of 7 kg Zn/ha as $ZnSO_4$ was highly effective and increased yield and production of potato to 23.5 t/ha whereas application of 9 kg Zn/ha as $ZnSO_4$ improved the quality of potato.

Mahmood et al (1995) studied the effects of micronutrients on the growth and yield of potato on a zinc deficient soil in Pakistan .The potato cv.Desiree was sprayed with 5 ppm zinc sulphate or given a soil application of 9.5 kg/ha zinc sulphate per hectare.They observed that soil application of zinc sulphate gave the highest mean tuber yield of 33.30 t/ha whereas the control yield was 26.4 t/ha .

Chowdhury et al. (1995) examine the distribution of zinc fractions in the soil of Bangladesh Agricultural University Farm, Mymensingh. It was noticed that phosphorus reduced soil zinc concentration showing an interaction between two elements.

Zaved et al. (1995) carried out an experiment at 3 sites in Punjab, Pakistan in 1992-95 .They observed that potato received 0 or 12.5 kg $ZnSO_4$/ha .It was concluded that Zn application increased tuber yield by 8.4-11.7%.

Karim et al.(1992) observed that at present about two millions hectares of net cultivable area of Bangladesh in different agro-ecological regions are deficient in zinc. In the zinc deficient area,they noticed a decreasing yield of seeding tubers.

Tiwari and Dweivedi (1991) conducted an experiment to find out the effect of manure and fertilizers on the growth and yield of potato in uttar pradesh,india using four levels of zinc (0, 1.25, 2.5 and 5.0 kg/ha) . They noted that the application of 5 kg zinc/ha increased tuber yield by 21.9, 7.5 and 0.7% in soil having low, medium and high content.

Sanderson and Gupta (1990) conducted an experiment to determine the effects of Zn and Cu Russet Burbank potatoes grown on fine sandy loam soil in Prince Edward Island using 15 kg Zn and 2 kg Cu/ha. It was concluded that soil application of zinc gave the highest yield over control.

Rasid et al. (1989) conducted a field experiment in peshwar on soil with 2.28 ppm cu had no significant effects on sprouting, growth and tuber yield of potato cv. Cardinal.

A field trial was conducted by Dornescu and Tatarsanu (1988) on the Moldavian plain, a zinc deficient area with seeding tubers from TPS using 86 ppm Zn or without Zn. They stated that seedling tubers gave yield of 26 and 24 t/ha with and without Zn application , respectively.

Sharma and Grewal (1988) carried out and experiment to find out the effects of micronutrients on potato cv.Kufrisundari using various methods of Zn and Cu application.They noted that Zn at 10 kg/ha ,applied in soil,foliar spraying (0.2% $ZnSO_4$ solution) and soaking of seed tuber(0.05% $ZnSO_4$ solution) all increase the yield of potato tuber significantly over control. Application of Zn increased the weight of medium sized tubers over control.

Talukder et al.(1987) carried an experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh to find the effect of Zn on the yield,yield contributing character and quality of two potato cultivars (Elvira and Pakhrilolity).They noted that application of Zn decreased the yield of the variety Elvira and increased the yield of pakhrilolita variety and improved the quality of increased the dry matters, protein and starch content of tuber in both the variations.

Aasen (1987) studied the effect of application of $ZnSO_4$ to potato in a heavily limed Zn deficient soil in Norway. He found that foliar application of 1% zinc sulphate solution at 250L/ha increased potato yield by 200%.

Agaev (1986) conducated an experiment on a leached hilly Chernozen soil with potato applying 1-3 kg Zn/ha. He reported that the application of Zn increased tuber yield by 2.27-3.0 t/ha. He recommended that the optimum does of Zn for potato production was 2 kg/ha.

Abdel el al. (1986) conducted a field trial with potato in the Nile Delta and North-West Egypt. It was reported that foliar spraying with Zn chealate increased tuber yield significantly.

An experiment was carried out by Sahota (1985) to investigate the response of potato cv. Kufriojyoti to phosphorus and zinc interaction at Shillong , India applying factorial combination of 0,26,52 or 78 kg p, and 0,15 or 30 kg Zn/ha. Thay reported that tuber yield was highest in the treatment 78 kg P+ 30kg Zn/ha .Yield of tuber did not differ significantly between Zn rates. Large sized tuber was obtained from 15 kg/ha and lower size from 30 kg Zn/ha application.

Trehan and Grewal (1984) conducted an experiment on acidic hill soils of Simla to determine the economic response of potato to zinc application. They observed that Zn application would be economic if the available Zn (NH_4OAC extractable) was less than 1.5 and 2.1 ppm in summer and winter potato respectively.

Zinc is a micronutrient, which is required for plant growth and development relatively in small amount. Zinc is involved in a diverse range of enzyme system. The functional role of Zn includes:auxin metabolism, influence on the activity of dehydrogenase and carbonic anhydrase enzymes, synthesis of cytochrome C and stabilization of ribosomal fractions(Tisdale et al.1984)

Trehan and Grewal (1983) investigated the interaction effect of zinc and phosphate on potato plant grown in acidic brown hill soils at Simal in India.They found that phosphorus at 600 ppm in absence of Zn or at 100 ppm Zn with optimum phosphorus level significantly decreased the tuber yield. Higher phosphorus level decreased Zn uptake. Zn at 100 ppm decreased phosphorus uptake. Higher level of zinc or phosphorus created imbalance between phosphorus and zinc contents in leaves which decreased the tuber yield.

Das and Barooah (1982) studied the response of micronutrient on the growth,yield and quality of potato in acidic soil (pH 5.2).They concluded that applicantion of zinc increased yield,starch and protein contents of potato tubers.

Tiwari et al. (1982) conducted an experiment to determine the effect of potassium and zinc application and dry matter production, yield and nutrient uptakes by potato variety "Kufri Chandramukhi on alluvial soils of Uttar Pradesh, lndia applying 3 levels of potassium (0,2.5 and 5 kg/ha).They noticed that potassium and zinc application significantly increased dry matter percentage and yield of tubers.

The TSP Technology is a newly strengthened concept, which can meet up the need of quality table potato in the country (Mondy and Chandra,1981).They found that 100 lb $ZnSO_4$ per acre significantly reduced the total N content of potato cv.Katahdin,whereas 40 lb $ZnSO_4$ per acre did not affect yield.Zinc fertilizer reduced phenol content, discolouration, nonprotein N and amino acids in tubers.

Christensen and Jackson (1981) carried out an experiment with potato using three levels of zinc (0,0.14 and 0.41 ppm) in factorial combination with 4 levels of phosphorus (0.02,0.10,1.0 and 3.0 ppm) . It was found that potato plant responded to zinc only when the phosphorus supply was adequate.

The response of potato to zinc applicantion was investigated by Trehan and Grewal (1981) on the acidic hill soils of Simla, India .They reported that size application in soil increased the tuber yield of potato by 40.0,35.5 and 79.1% respectively. They also found that zinc application increased the size and did not adversely affect plant emergence.

An experiment was carried out by Chaveri and Bornemisza (1977) in pacajas area in costa rica to find out the effect of phosphorus and zinc interaction on growth and yield of potato cv.Atzimba applying 4 doses of phosphorus (0,480,720 and 960 kg P_2O_5/ha).They observed that total tuber yield increased significantly with the application of 480 kg P_2O_5/ha and a futher increased in zinc. But at the higher rates of phosphorus and zinc application decreased yield slightly.

Holm et al. (1974) conducted a fertilizer trial on potato cv. Bintje grown on sandy soils using different levels of nitrogen (80,120 and 160 kg N/ha), potassium(64,48 and 32 kg/ha) and zinc (0,10,15 and 21 kg Zn/ha).They have reported that increasing rate of zinc resulted in increased tuber yield, but K and Zn had no significant effect on yield.

2.2 Effect of Boron on growth and yield of potato

Sarkar et al. (1996) carried out an experiment at Gangachara series of Mithapukur, Rangpur indicated that the highest tuber yield of 28.72 t/ha was produced by the combined effect of 150 kg N + 60 kg P +120 Kg K+ 20 kg S + 10 kg Zn + 2 kg B + 15 kg Mg +5t cowdung/ha.

Peixoto et al. (1996) conducted an experiment to study the response of potato cv. Desire to the application of boron fertilizer in Pakistan using 4 levels of boron (0,1,1.5 and 2 kg/ha).The crop also received a basal dressing of NPK fertilizers and FYM (5 t/ha).Application of 2 kg B/ha gave the highest tuber yield of 10.9 t/ha compared with the control yield of 7.9 t/ha.

Kabir et al. (1994) reported that application of boron with different levels showed positive response to the yield of potato.

Lozer and Fecenko (1993) studied in a small plot trial on loamy brown soil in 1992-93 and reported that potatoes were grown given foliar application of 2 kg Sodium humate and/or 0.5 kg Mn,0.2 kg B or both .Without yield was increased by 4.2% with Sodium humate alone,11.7-15.7% with Mn or B and 17.8-23.6% with Sodium Humate +Mn and/or B.Tuber nitrate content was 45.5 mg/kg in the control and increased to 50.5 mg/ha with Mn alone and 47.2 mg with B alone. It was decreased with the other treatments and was lowest (30.1 mg/kg) with sodium humate+B.

In a field study conducted by Gupta and Sanderson (1993) in 1988-1990 at two locations at prince Eduard land with potatoes cv. Ellite III. They noted that Ca and B application had no effect on the tuber yield, while Ca application were ineffective in increasing the Ca concentration in leaf tissue. B application significantly increased the leaf tissue B concentration in both samplings.

Dwivedi and Dwivedi (1992) carried out an experiment to find out the efficiency of different methods of application of copper, zinc and boron to potato cv. Kufrijyoti on an acid inceptisol during 1986-1987 at Uttar Pradesh, india. It was concluded that the highest yield was obtained when boron was applied with a basal dressing.

Pregno and Arour (1992) carried a field experiment to find out boron deficiency and toxicity in potato cv. Sebago on an Oxisol of the Atherton Tablelands at North Queensland, Australia. It was found that tuber yield was the highest when 2 kg B/ha was applied followed by 4 kg/ha.

Quaggio and Ramos (1986) studied the influence of boron on the production of potato. Boron was applied at the rates of 0, 3, 6, 9 and 12 kg/ha as boric acid. They concluded that the effect of boron was more pronounced on yield of large sized tubers than on the small ones.

A field experiment was carried out by porter et al. (1986) to study the response of potatoes cv. Katahdin to B application. They reported that application of boron in a complete fertilizer was the most efficient technique but the tuber yield was not affected by application of <2.2 kg B/ha, whereas plants were stunted and yield reduced at application of 74.5 kg B/ha.

The effect of added trace element by Rasp (1985) in a years crop rotation in which potatoes and cereals were grown on alternate years. It was noted that only boron tended to increase potato yield.

Palkovies and Gyori (1984) were conducted a field experiment to determine the effect of growth and yield of potato cv. Sonogy on rusty brown forest soil. It was found that the application of boron contributed to yield increments and to the improvement of tuber quality.

The requirement of micronutrient for growth and development of plant relatively to a smaller amount. Boron requirements for plant growth process like development of new meristematic tissue, translocation of sugers, starch nitrogen and phosphorus and synthesis of amino acids and proteins(Tisdale et al,1984).

The effect of micronutrient through commercial mixture on the growth and yield of potato was conducted by Upadhayay and Grewal (1983) with cv. Chandramukhi . It was found that trace elements having Zn, Cu, Mn, Mo and B increased tuber yield by increasing the tuber size and number. The application of Zn and B significantly increased the yield of tubers with N,P,K fertilizers on acidic brown hill soils at Sillong,India (Sahota et al.1982).

A similar work was carried out by Medevedev et al.(1981) and found that when Zn, Mn , B, Cu and Mo were used in the field with N,P,K compost and lime not only increased the tuber yield of potato but also the dry matter, starch, ash, protein and carbohydrate content of tubers.

Grewal and Trehan(1981) conducted an experiment to find out the effect of micronutrients on potato at different places of India and reported that potatoes gave yield response to the application of Zn and B at Gujrat and in the other places, tuber yield did not respond to the application of boron.

The response of potatoes to application of Zn and B with NPK fertilizers was studied by Kirynkhin and Bezzubtseva (1980) on Derhopodzolic soil in Moscow region. It was reported that zinc and boron increased 9-12.9% and 5-13% average tuber yield respectively over control. It was also found Zn and B increased dry matter, starch, protein and ascorbic acid content of tubers.

Grewal and Trehan (1980) studied the effect of trace elements on potato.It was found that some cultivars showed a marked response to Zn and B application ,while others showed little response.

Awasthi and Grewal (1977) studied with potatoes on slightly acidic soils at Shilling, India using soil application of 25 kg $ZnSO_4$/ha or foliar application of o.1% boron solution .They observed that both Zn and B increased yield by 100-150 kg/ha.

The effect of mineral nutrients and growth regulators on growth and yield of potato cv. Kufrisundari was studied by Das and Padly (1976) AND reported that spraying of 0.5% boron had a great influence on the yield and quality of potato.

Mica (1975) studied the influence of boron, manganese and zinc on the yield and quality of potato cv.Karasara. It was found that the application of B and Mn incre ased the weight of both haulm and tubers.

Sapatyi and Shkvaruk (1973) reported that the application of Zn, B, Co and Ba was less effective in the growth , yield and quality of potato.

The effect of NPK and several micronutrients in various combinations at basal dressing on potato cv. Gunda and Feldsloha examined by gargantini et al.(1970).It was concluded that boron application increased potato yield by 54% in Gunda and 28% in Feldsohn as compared to NPK only. But application of Fe, Zn, Cu and Mn had no significant effect on yield.

Going through the above reviews, it is concluded that the use of micronutrients in potato production is important considering plant growth and yield. The literature revealed that the effects of zinc and boron have not been studied well for the production of potato under Bangladesh condition.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

In this chapter the details of different materials used and methodologies followed during the experimental period are presented under the following heads

3.1 Experimental site

The experiment was carried out at the research field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November 2019 to February 2020. Geographically the experimental area is located at $23^0$41' N latitude and $90^0$22' E longitudes at the elevation of 8.6 m above the sea level. The experimental field was medium high land belonging to the Madhupur Tract, AEZ-28. Fertility status of soil in experimental site has been showen in the **Appendix I.**

3.2 Climate and weather

The experimental field was under subtropical climates characterized by heavy rainfall during the month of April to September and scanty rainfall during October to March. The monthly means of daily maximum, minimum and average temperature, relative humidity, total rainfall of the experimental site during the period between November 2019 to February 2020 have been presented in **Appendix II.**

3.3 Soil characteristic

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive–gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and had organic matter 1.1%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0–15 cm depths were collected from experimental field. The morphological, physical and chemical characteristics of initial soil are presented in **Appendix VIII.**

3.4 Plating material

The variety Cardinal (BARI Alu-8) was used for the present study and were collected from the Tuber Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Land preparation

The land of the experimental site was first opened in the first week of November 2019 with power tiller. Later on, the land was ploughed and cross-ploughed four times followed by laddering to obtain the desirable tilth. The corners of the land were spaded and weeds and stubbles were removed from the field. The land was finally prepared on 10 November 2019 three days before planting the seed. In order to avoid water logging due to rainfall during the study period, drainage channels were made around the land. The soil was treated with Furadan 5G @10 kg ha^{-1} when the plot was finally ploughed to protect the young seedlings from the attack of cut worm.

3.6 Experimental design and layout

The two factor experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The size of the unit plot was 1.55 m × 1.55 m. Plot to plot and block to block distances were 0.50 and 0.50 m, respectively. Treatments were randomly distributed within the blocks. The plots were raised up to 10 cm.

3.7. Treatments of the experiment

Two factor experiment was conducted as follows

Factor A: Zinc - 3 levels

1. Zn_0 = 0 kg Zn ha^{-1}
2. Zn_1 = 3 kg Zn ha^{-1}
3. Zn_2 = 6 kg Zn ha^{-1}

Factor B: Boron -3 levels

1. B_0 = 0 kg B ha^{-1}
2. B_1= 1 kg B ha^{-1}
3. B_2= 2 kg B ha^{-1}

Combined effect of Zinc and Boron

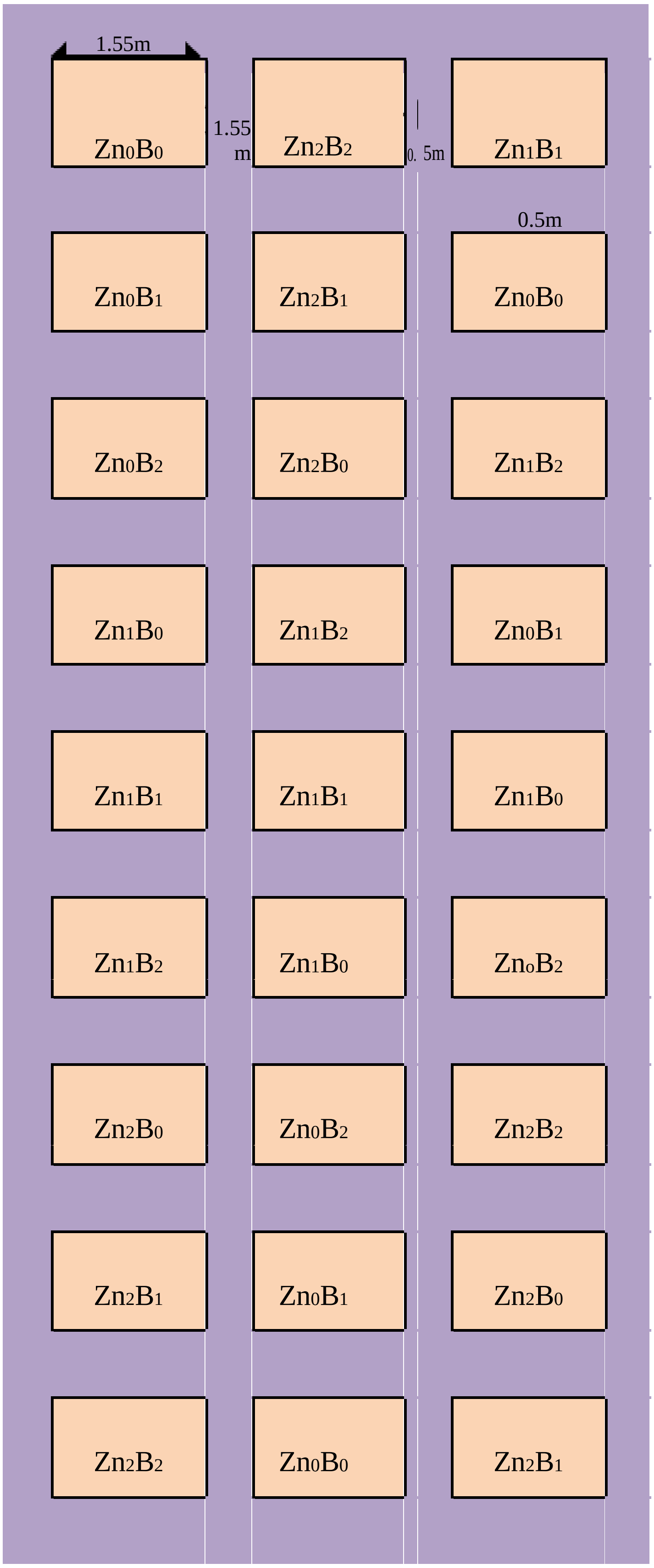
Zn_0B_0, Zn_0B_1, Zn_0B_2, Zn_1B_0, Zn_1B_1, Zn_1B_2, Zn_2B_0, Zn_2B_1, Zn_2B_2

3.8 Manure and fertilizer application

The crop was fertilized as per recommendation of TCRC (2004). Urea, triple superphosphate (TSP), zinc sulphate and boric acid were used as sources of nitrogen, phosphorus, zinc and boron, respectively. The recommended doses of fertilizers were 320, 150, 250, 120 and 10000 kg ha^{-1} for urea, TSP, MoP, gypsum, and cowdung respectively. Under the present study, zinc sulphate and boric acid were applied as per treatment. Cowdung was applied 10 days before of final land preparation. Total amount of TSP, MoP, gypsum and half of urea was applied at basal doses during final land preparation. The remaining 50% urea was side dressed in two equal splits at 25 and 45 days after planting (DAP) during first and second earthing up.

3.9 Seed preparation and sowing

The seedling tubers were taken out of the cold store about three weeks before planting. The tubers were kept under diffuse light conditions to have healthy and good sprouts. Planting was done on 13 November 2019. The well sprouted seed tubers were planted at a depth of 5-7 cm in furrow made 45 cm apart. Hill to hill distance was 15. After planting, the seed tubers were covered with soil.



Plot size: 1.55m x 1.55m
Plot to Plot distant: 0.5m
Block to Block distant: 0.5m

Treatments
Factor A: Zinc-3 levels
1. Zn_0=0 kg Zn ha^{-1}
2. Zn_1=3 kg Zn ha^{-1}
3. Zn_2=6 kg Zn ha^{-1}

Factor B: Boron-3 levels
1. B_0=0 kg B ha^{-1}
2. B_1=1 kg B ha^{-1}
3. B_2=2 kg B ha^{-1}

Fig. 1. Layout of the experimental plot

3.10. Intercultural operations

3.10.1Weeding

First weeding was done 28 November 2019. Another weeding was done after urea super granule application.

3.10.2Earthing up

Earthing up was done twice during growing period. The first earthing up was done at 25 days after planting and second earthing up was done after 20 days of first earthing up.

3.10.3 Irrigation

Frequency of watering was done upon moisture status of soil retained as requirement of plants. Excess water was not given, because it is always harmful for potato seedlings.

3.10.4 Plant protection

Furadan 5G @ 10 kg $ha^{-1}$was applied in soil at the time of final land preparation to control cut worm. Dithane M-45 was sprayed in 2 installment at an interval of 15 days from 50 DAP as preventive measure against late blight disease.

3.10.5 General observation

The field was frequently observed to notice any changes in plants, pest and disease attack and necessary action was taken for normal plant growth.

3.10.6 Haulm Cutting

Haulm cutting was done at 1 February 2020 when 40-50% plants showed senescence and the tops started drying.After haulm cutting the tubers were kept under the soil for 7 days for skin hardening.

3.10.7 Harvesting

Harvesting of potato was done at 8 February 2020 at 7 days after haulm cutting .The potatoes of each treatment were separately harvested, bagged, tagged and brought to the laboratory. Harvesting was done manually by hand.

3.11 Collection of Data

Data were recorded on the following parameters from the sample plants during the course of experiment.

Growth parameters

3.11.1 Plant height

Plant height was determined by measuring the height of the plant from the base of the main shoot to the apex at 30DAP, 45DAP, 60DAP and 75DAP.

3.11.2 Number of stems hill^{-1}

Number of stems hill^{-1} was recorded as an average count of five hills plot^{-1} at flowering. Only stems arising from the mother tuber were considered as main stems (Zelalem *et al*., 2009)

3.11.3 Number of leaves plant^{-1}

Number of leaves plant^{-1} was counted at different days after sowing of crop duration. Leaves number plant^{-1} was recorded from pre-selected 10 plants by counting all leaves from each plot and mean was calculated. Data was taken at 30, 45, 60 and 75 days after planting (DAP).

Yield parameter

3.11.4 Number of tuber hill^{-1}

The number of tubers from 10 selected plants was counted at harvest from each replication and average number of tubers was calculated.

3.11.5 Weight of tuber hill^{-1}

The weight of tubers from 10 selected hills was recorded and average weight of tubers per hill was calculated.

3.11.6 Weight of tuber plot^{-1}

The weight of tubers plot^{-1} was recorded at the time of harvest of all tubers from all plants of a unit plot.

3.11.7 Yield of tuber hectare^{-1}

The yield of tuber per hectare was calculated from that of per plot yield and expressed in ton per hectare (t ha^{-1}).

3.11.8 Marketable yield ha^{-1}

Collect tuber from each plot was separated to different grades and those tubers were deducted from each unit plot which is unsuitable to sell and remain tubers were counted and selected as marketable yield and expressed as ton per hectare (t ha^{-1}).

3.12 Collection and analysis of soil sample

Soil samples were collected at 0- 15 cm soil depths 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**.**

3.12.1 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).

3.12.2 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)

3.12.3 Organic matter (%)

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

3.12.4 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).

3.12.5 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).

3.12.6 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.

3.12.7 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.

3.12.8 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.

3.12.9 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).

3.13 Statistical analysis

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the means were separated by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT- C (Gomez and Gomez,1984) at 5% and 1% level of significant

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The current inquiry was supervised in the research field to estimate the growth and yield of potato as influenced by Zn and B levels. To present, analyses and compare the data obtained from the present study; different figures, tables, and appendices have been used in this section. The acknowledgement and all possible explanations were given under the following heading:

4.1 Growth parameters

4.1.1 Plant height

Effect of Zinc

At 30 DAP variation was prominent among different Zn levels to plant height (Fig.2 and Appendix III).The upper limit of plant height (19.43 cm) was retained by Zn_2 and lower limit of plant height (18.24 cm) was retained by Zn_0 (Fig.2). Notable difference was noticed to plant height among distinct Zn levels at 45 DAP (Fig.2).The maximum plant height (57.05 cm) was found by Zn_2 treatment and the minimum (37.84 cm) was observed by Zn_0 treatment (Fig.2). Application of different Zn levels of the plant height at 60 DAP was observed outstanding distinction (Fig. 2).The taller plant (65.93 cm) was observed from Zn_2 treatment and the shorter (45.53 cm) was in treatment Zn_0 (Fig.2). In respect of plant height at 75 DAP due to different Zn levels was observed statistically significant (Fig.2).The maximum plant height (70.43 cm) was retained in the plant produced from treatment Zn_2 and the minimum (47.06 cm) was in treatment Zn_0 (Fig.2). Similar result was also observed by the findings of Gabr and Sarg (1998), Kumar and Singh (1979) and Kushwah (1989) which supported the present study.

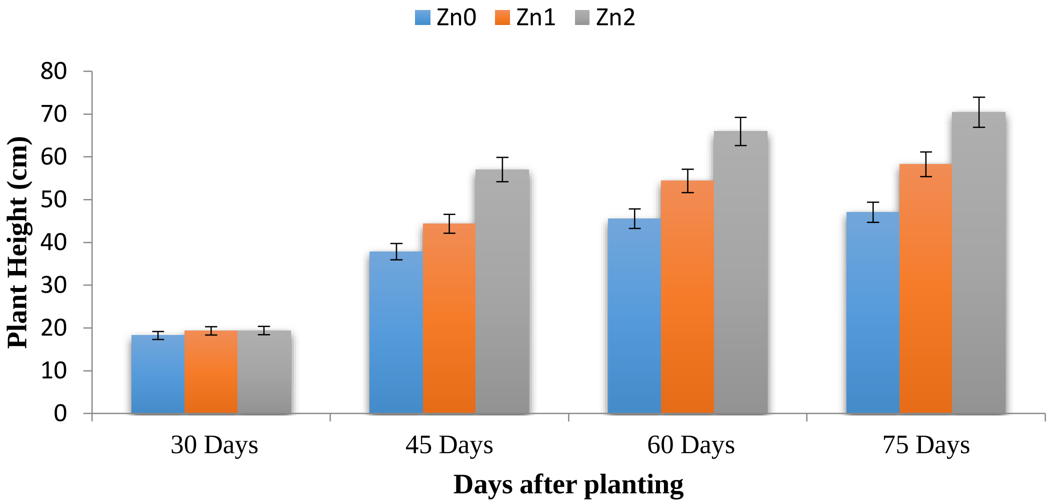


Fig. 2. Plant height of potato influenced by Zinc

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}.

Effect of Boron

In aspect of plant height at 30 DAP because of different B doses was perceived statistically significant (Fig. 3 and Appendix III). The upper limit of plant height (19.07 cm) was revealed by B_1, while lower limit (18.93 cm) was revealed by B_0 treatment. Plant height was statistically similar for B_0 and B_1 treatments. Maximum plant height (47.9 cm) was noticed in treatment B_2 and the minimum (45.67 cm) was noticed in B_1 treatment which was statistically similar to B_1 and B_2 treatment (Fig. 3) by 45 DAP. By different B levels of potato tubers the plant height at 60 DAP different variation was observed (Fig. 3).The maximum plant height (56.27cm) was measured for the treatment B_2 and the minimum (54.44 cm) was recorded for the control plot B_0 which was not significantly different from the treatments B_0 and B_2 (Fig. 3). Variation was noticed to plant height among distinct B rates at 75 DAP (Fig.3). Application of B at the rate of 2 kg ha^{-1} (B_2) gave the highest plant height (60.62 cm) while the lowest (57.53 cm) was recorded for control (B_0) (Fig.3).

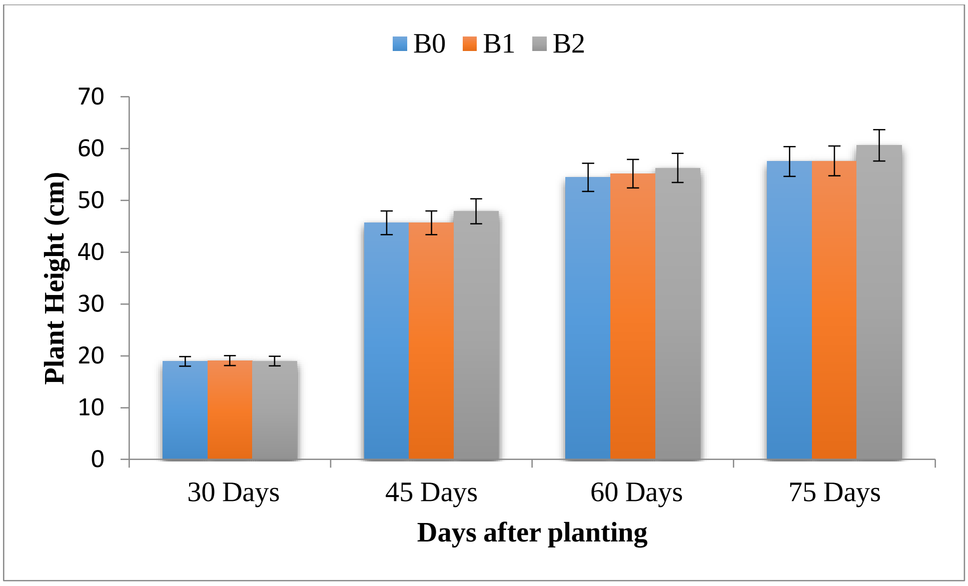


Fig. 3. Plant height of potato influenced by Boron

B_0 = 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}

Effect of Zn and B combination

In case of plant height at 30 DAP the interaction effect of Zn and B levels was appeared statistically significant (Table 1 and Appendix III). The maximum plant height (19.84cm) was recorded at combination of 3 kg Zn ha^{-1} and 0 kg B ha^{-1} (Zn_1B_0) treatment combination and minimum plant height (17.42 cm) was measured for the combination of 0 kg Zn ha^{-1} and 0 kg B ha^{-1} (Zn_0B_0) treatment combination. Plant height at 45 DAP was significantly influenced by combination of Zn and B levels (Table 1). The highest plant height (58.13 cm) was recorded from the combination of 6 kg Zn ha^{-1} and 0 kg B ha^{-1} (Zn_2B_0) while the lowest (36.22 cm) value was obtained from the control treatment combination of (Zn_0B_0). Among different combination of Zinc and Boron levels, the plant height at 60 DAP was significant (Table 1). Numerically, the taller plant (66.38 cm) was seen from Zn_2B_0 treatment and smaller plant (43.89 cm) was exhibited by Zn_0B_0 treatment (Table 1). Remarkable difference was observed among different Zinc and Boron levels on plant height at 75 DAP (Table 1). The maximum plant height (70.93 cm) was retained by Zn_2B_0 treatment, while the minimum plant height (45.55 cm) was recorded for control plot (Zn_0B_0). Similar trend was also observed for $Zn_0B_1$and Zn_0B_2 treatment combination. A good supply of Zinc stimulates root growth and development as well as the uptake of other nutrients. The highest plant height of potato, as it was obtained in the current experiment that application of the maximum Zinc and Boron rate gave the highest plant height (70.93 cm). The result obtained from the present study was similar with the findings of Zelalem *et al*. (2009)

Table 1. Combined effects of zinc and boron on Plant height of potato

Zinc × Boron	Plant Height (cm)			
	30 DAP	45 DAP	60 DAP	75 DAP
Zn_0B_0	17.42h	36.i22	43.89i	45.55i
Zn_0B_1	18.77f	37.43h	45.21h	46.11h
Zn_0B_2	18.54g	39.88g	47.50g	49.53g
$Zn_1 B_0$	19.84a	42.68f	53.05f	56.13f
$Zn_1 B_1$	19.38d	43.29e	54.73e	56.67e
$Zn_1 B_2$	18.79f	47.13d	55.41d	62.06d
$Zn_2 B_0$	19.55c	58.13a	66.38a	70.93a
$Zn_2 B_1$	19.08e	56.31c	65.51c	70.09c
$Zn_2 B_2$	19.68b	56.71b	65.91b	70.29b
Level of Significance	*	*	*	*
CV (%)	2.02	3.32	7.05	5.20
LSD at 5%	0.05474	0.05474	0.05474	0.09744

* Significant at 5% level of probability, CV= Coefficient of variation,

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}.

B_0 = 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2= 2 kg B ha^{-1}

4.1.2 Number of stem hill^{-1}

Effect of Zinc

Profound variation was found among different levels of zinc on numbers of stem hill^{-1}. Increasing application zinc from 0 to 6 kg ha^{-1} increased main stem number hill^{-1} from 1.7 to 5.34. The maximum stem number (5.34) hill^{-1} was recorded at 6 kg Zn ha^{-1} and the minimum stem number (1.7) hill^{-1} was obtained from the control (Fig.4). Individual treatment was statistically different from each other. An increase in zinc level up to 6 kg Zn ha^{-1} brought about an increase in stem number hill^{-1}. This might be related to the fact that main stem number is mostly dependent on the number of sprout per tuber. In agreement with the present finding, Nizamudin *et al.* (2003), Hassanpanah *et al.* (2009) and Alam *et al.* (2007) have reported that the lowest stem number of potato was obtained from unfertilized control. Shakh *et al.* (2001) have also reported that increased in stem number with an increased in zinc application (7 kg Zn ha^{-1}). Similarly, Jamaati-e-Somarin *et al.* (2009) reported that increasing Zn level up to 5 kg Zn ha^{-1} increased the stem number; but further increases in Zinc fertilizer level did not affect it any more.

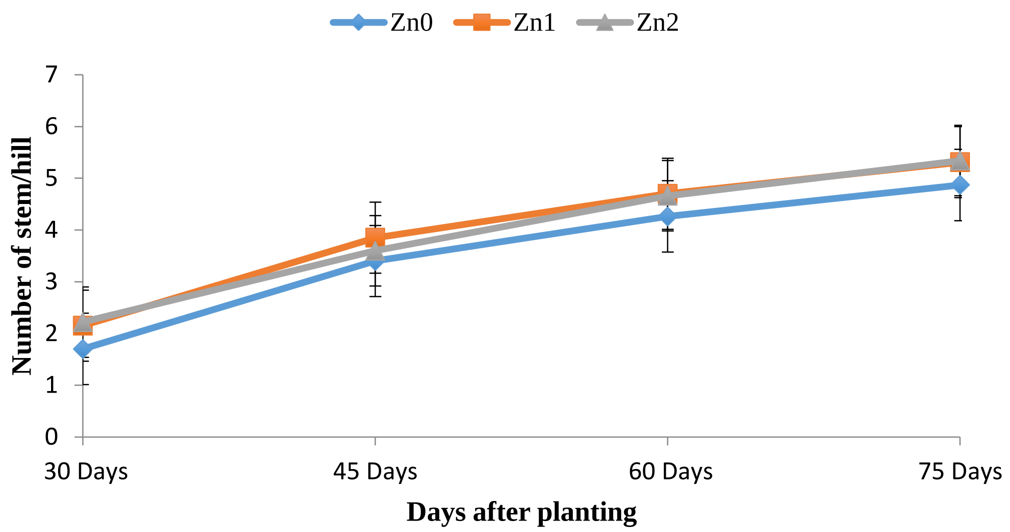


Fig. 4. Number of stem $hill^{-1}$ of potato influenced by zinc

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}

Effect of Boron

Similar to zinc, increasing the level of Boron significantly increased main stem number $hill^{-1}$ of potato (Fig.5). Increasing application of boron from 0 to 2 kg ha^{-1} increased main stem number $hill^{-1}$ from 1.71 to 5.36 .The maximum stem number (5.36) $hill^{-1}$ was recorded at 2 kg B ha^{-1} and the minimum stem number (1.71) $hill^{-1}$ was obtained from the control (Fig.5). Stem number $hill^{-1}$ at 1 kg B ha^{-1}(5.14) was not statistically different from that at 2 kg ha^{-1} (5.36). Similar result have been reported by Rosen and Bierman (2008), who showed that Boron applications increased the number of stems $hill^{-1}$ compared with the zero boron levels (control). Maier *et al.* (2002) have also reported a significant increase in stem number $plant^{-1}$ with boron fertilization in a greenhouse study which might be related to the fact that adequate amount of boron forms good root system, strong stem and good growth.

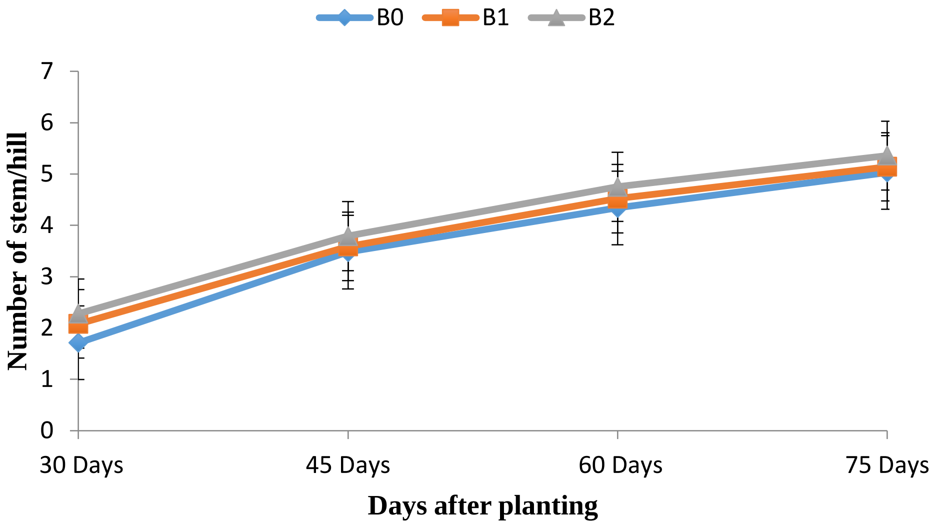


Fig. 5. Number of stem hill^{-1} of potato influenced by boron

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

Combined effect of Zinc and Boron

Profound contrast was found among different levels of combinations of stem hill^{-1}. Increasing application zinc and boron combination rates from 0 kg Zn ha^{-1} and 0 kg B ha^{-1} (Zn_0B_0) to 6 kg Zn ha^{-1} and 0 kg B ha^{-1} (Zn_2B_0) combination increased main stem number hill^{-1} from 1.34 to 5.53. The maximum stem number (5.53) hill^{-1} was recorded at Zn_2B_0 treatment. The minimum stem number (1.34) hill^{-1} was obtained from the control (Table 2)

Table 2. Combined effects of zinc and boron on Number of stem hill^{-1} of potato

Zinc × Boron	Number of stem hill^{-1}			
	30 DAP	45 DAP	60 DAP	75 DAP
Zn_0B_0	1.34f	3.04h	3.89h	4.50h
Zn_0B_1	1.55e	3.25f	4.11f	4.72f
Zn_0B_2	2.23c	3.93b	4.78c	5.39c
Zn_1 B_0	1.89d	3.24g	3.90h	4.56g
Zn_1 B_1	2.33b	3.56e	4.23e	4.88e
Zn_1 B_2	2.23c	3.72c	4.88b	5.44b
Zn_2 B_0	1.92d	3.25f	4.01g	4.52h
Zn_2 B_1	2.37ab	3.62d	4.36d	4.98d
Zn_2 B_2	2.39a	4.01a	4.98a	5.56a
Level of Significance	*	*	*	*
CV (%)	3.31	4.56	6.12	3.68
LSD at 5%	0.2896	0.2896	0.2896	0.5767

* Significant at 5% level of probability, CV= Coefficient of variation.

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B h

4.1.3 Number of leaves hill^{-1}

Effect of Zinc

Different zinc (Zn) levels had significant influence on number of leaves hill^{-1}at different growth stages of potato (Fig. 6 and Appendix V). Results showed that the highest number of leaves hill^{-1}(24.26, 35.47, 51.52 and 54.17 at 30, 45,60 and 75 DAP, respectively) was found the treatment Zn_2 (6 kg Zn ha^{-1}) which was significantly different from all other treatments followed by Zn_1 (3 kg Zn ha^{-1}). The lowest number of leaves hill^{-1}(18.05, 25.38 ,35.05 and 42.64 at 30, 45,60 and 75 DAP, respectively) was observed from the control treatment Zn_0 (0 kg Zn ha^{-1})which was also significantly different from all other treatments followed by Zn_1 (3 kg Zn ha^{-1}).

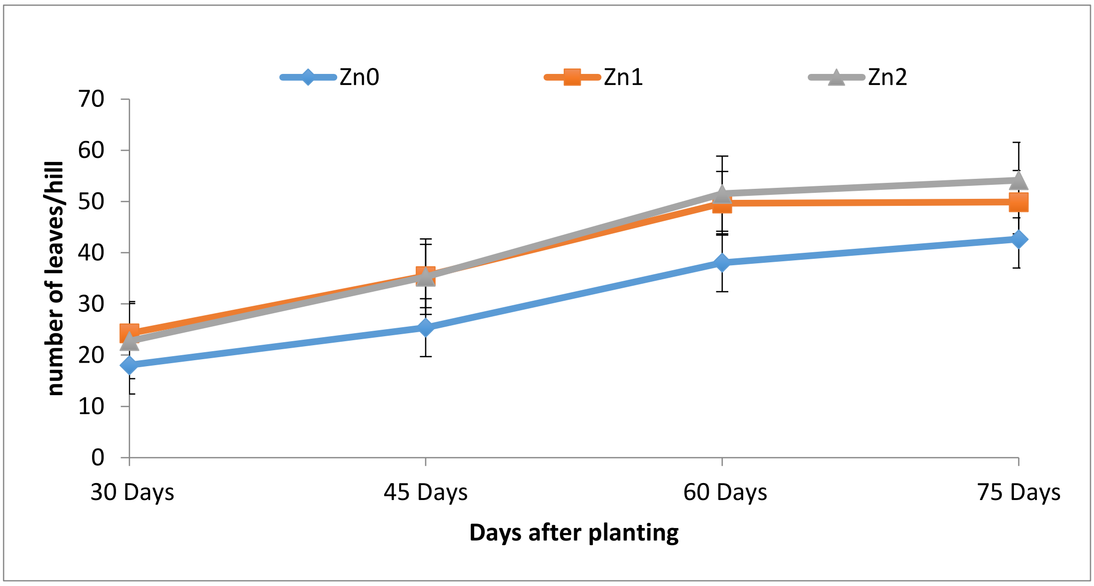


Fig. 6. Number of leaves hill^{-1} of potato influenced by zinc

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}.

Effect of Boron

There was a significant variation on number of leaves hill^{-1}influenced by different Boron (B) levels at different growth stages (Fig.7 and Appendix V).The highest number of leaves hill^{-1}(23.15, 33.25 , 47.54 and 52.9 at 30, 45,60 and 75 DAP, respectively) was achieved from the treatment B_2 (2 kg B ha^{-1})which was significantly different from all other treatments at all growth stages. The lowest number of leaves hill^{-1}(19.6, 29.98, 44.33 and 43.56 at 30, 45,60 and 75 DAP, respectively) was obtained from the control treatment B_0 (0 kg B ha^{-1})which was also significantly different from all other treatments at all growth stages.

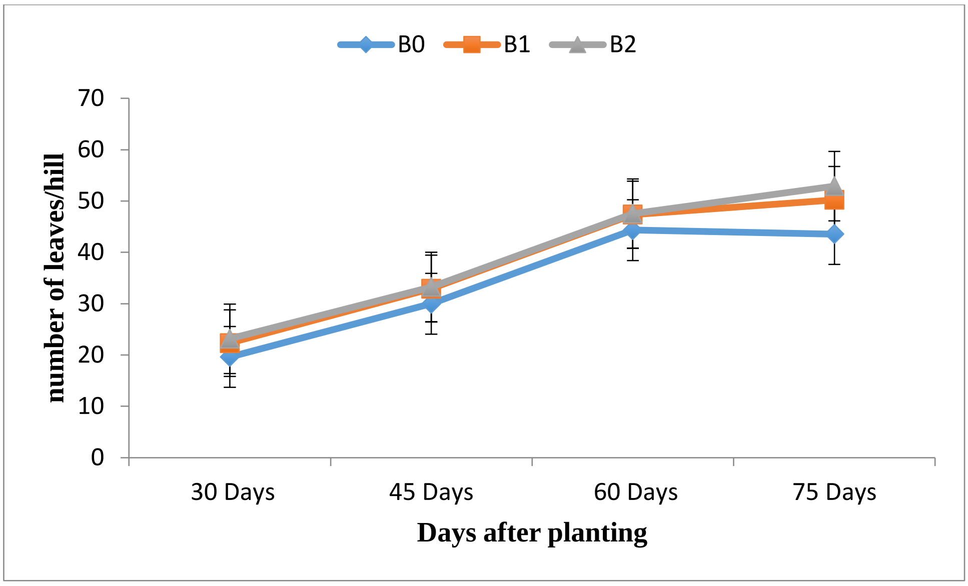


Fig. 7. Number of leaves hill^{-1} of potato influenced by boron

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

Combined effect of Zinc and Boron

Number of leaves hill^{-1} was significantly influenced by combined effect of different Zn and B levels at different growth stages (Table 3 and Appendix V). The highest number of leaves hill^{-1} (24.93, 37.62, 53.14 and 58.19 at 30, 45,60 and 75 DAP, respectively) was recorded from the treatment combination of Zn_2B_2. At all growth stages, Zn_2B_2 was significantly different from all other treatment combinations followed by the treatment combination of Zn_2B_1. The lowest number of leaves hill^{-1} (16.13, 23.13, 35.13 and 40.28 at 30, 45,60 and 75 DAP, respectively) was found from the treatment combination of Zn_0B_0.The result obtained from the present study was similar with the findings of Zelalem*et al*. (2009).

Table 3. Combined effects of zinc and boron on Number of leaves hill^{-1} of potato

Zinc × Boron	Number of leaves hill^{-1}			
	30 DAP	45 DAP	60 DAP	75 DAP
Zn_0B_0	16.13i	23.13i	35.13i	40.28h
Zn_0B_1	19.68g	27.68g	40.68g	44.30e
Zn_0B_2	18.35h	25.35h	38.35h	43.35g
$Zn_1 B_0$	22.68e	34.68e	48.68f	44.23f
$Zn_1 B_1$	23.93c	34.93d	49.13e	48.22c
$Zn_1 B_2$	26.18a	36.80b	51.15c	57.20b
$Zn_2 B_0$	20.00f	32.14f	49.18d	46.18d
$Zn_2 B_1$	23.33d	36.20c	52.24b	58.17ab
$Zn_2 B_2$	24.93b	37.62a	53.14a	58.19a
Level of Significance	*	*	*	*
CV (%)	4.82	2.65	5.06	7.44
LSD at 5%	0.05474	0.05474	0.05474	0.09744

* Significant at 5% level of probability, CV= Coefficient of variation

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}.

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

4.2 Yield parameters

4.2.1 Number of tuber hill^{-1}

Effect of Zinc

The recorded data on number of tuber hill^{-1} showed significant differences with the application of different zinc (Zn) levels (Fig 8 and Appendix VI). Results revealed that the highest number of tuber hill^{-1} (8.3) was found from the treatment Zn_2 (6 kg Zn ha^{-1}) which was statistically identical with Zn_1 (3 kg Zn ha^{-1}). The lowest number of tuber hill^{-1} (6.95) was observed from the control treatment Zn_0 (0 kg Zn ha^{-1}) which was significantly different from all other treatments. Jenkins and Ali (2000) also observed that the number of tubers varied considerably as a result of Zn fertilization, and doubled when Zn level was increased to higher levels.

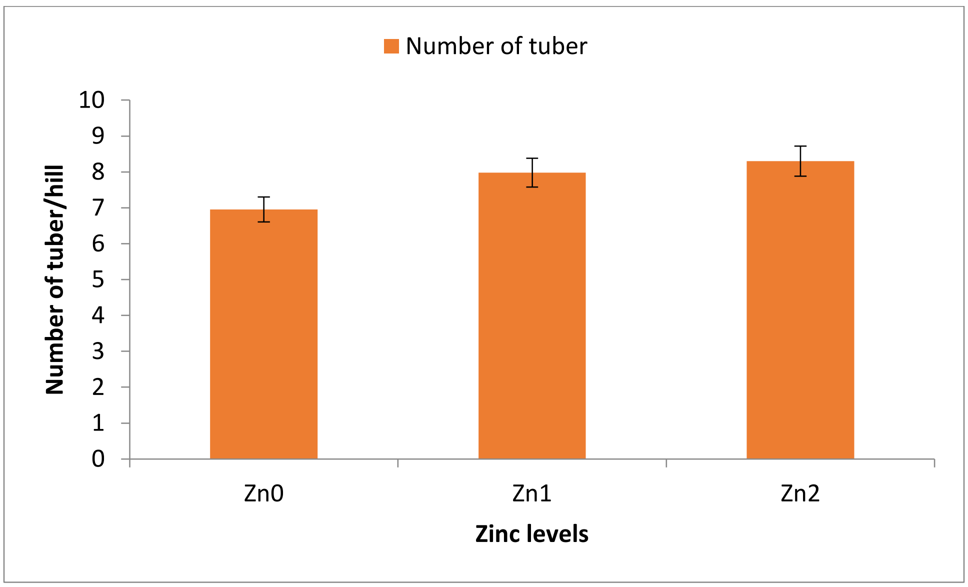


Fig.8.Number of tuber hill^{-1} of potato influenced by zinc

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}

Effect of Boron

Considerable influence was observed on number of tuber hill^{-1} influenced by different Boron (B) levels (Fig 9 and Appendix VI).The highest number of tuber hill^{-1} (8.22) was achieved from the treatment B_2 (2 kg B ha^{-1}) which was statistically identical with B_1 (1 kg B ha^{-1}) where the lowest number of tuber hill^{-1} (7.14) was obtained from the control treatment B_0 (0 kg B ha^{-1}).

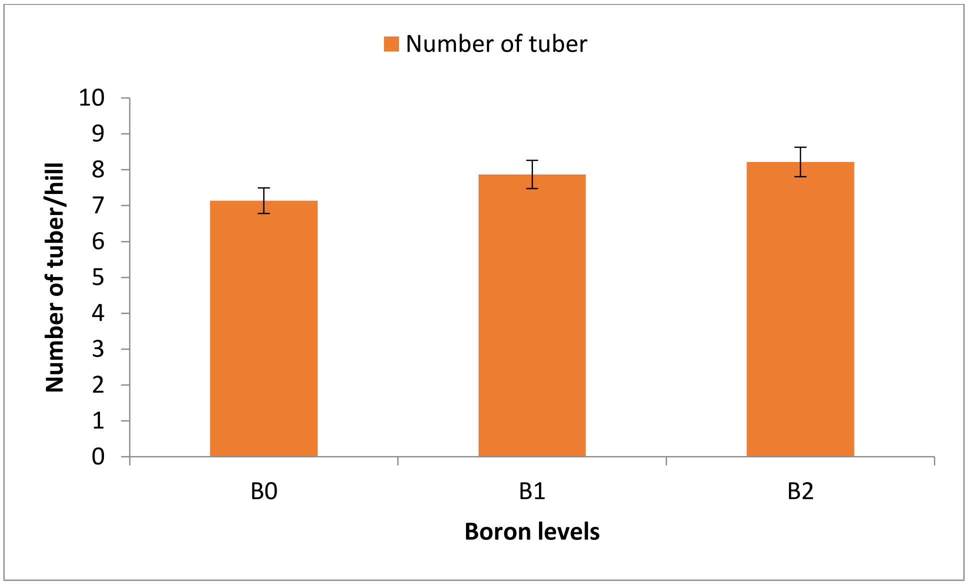


Fig.9.Number of tuber hill^{-1} of potato influenced by boron

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

Combined effect of Zn and B

Remarkable variation was identified on number of tuber hill^{-1} due to the combined effect of different Zn and B levels (Table 4 and Appendix VI). The highest number of tuber hill^{-1} (8.57) was recorded from the treatment combination of Zn_2B_2 which was statistically identical with the treatment combination of Zn_2B_1.The lowest number of tuber hill^{-1} (6.34) was found from the treatment combination of Zn_0B_0.

Table 4. Combined effects of zinc and boron on Number of tuber hill^{-1} of potato

Zinc × Boron	Number of tuber hill^{-1}
Zn_0B_0	6.34h
Zn_0B_1	6.93g
Zn_0B_2	7.58e
$Zn_1 B_0$	7.30f
$Zn_1 B_1$	8.10c
$Zn_1 B_2$	8.54ab
$Zn_2 B_0$	7.78d
$Zn_2 B_1$	8.55b
$Zn_2 B_2$	8.58a
Level of Significance	*
CV (%)	2.98
LSD at 5%	0.05307

* Significant at 5% level of probability, CV= Coefficient of variation

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}.

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

4.2.2 Weight of tuber hill^{-1}

Effect of Zinc

Significant influence was noted on weight of tuber hill^{-1} affected by different zinc (Zn) levels (Fig 10 and Appendix VI). The highest weight of tuber hill^{-1} (193.26g) was found from the treatment Zn_2 (6 kg Zn ha^{-1}) which was significantly different from all other treatments. The lowest weight of tuber hill^{-1} (117.75g) was observed from the control treatment Zn_0 (0 kg Zn ha^{-1}) which was significantly different from all other treatments. Guler (2009) and Zamil*et al*. (2009) also found similar result which supported the present study.

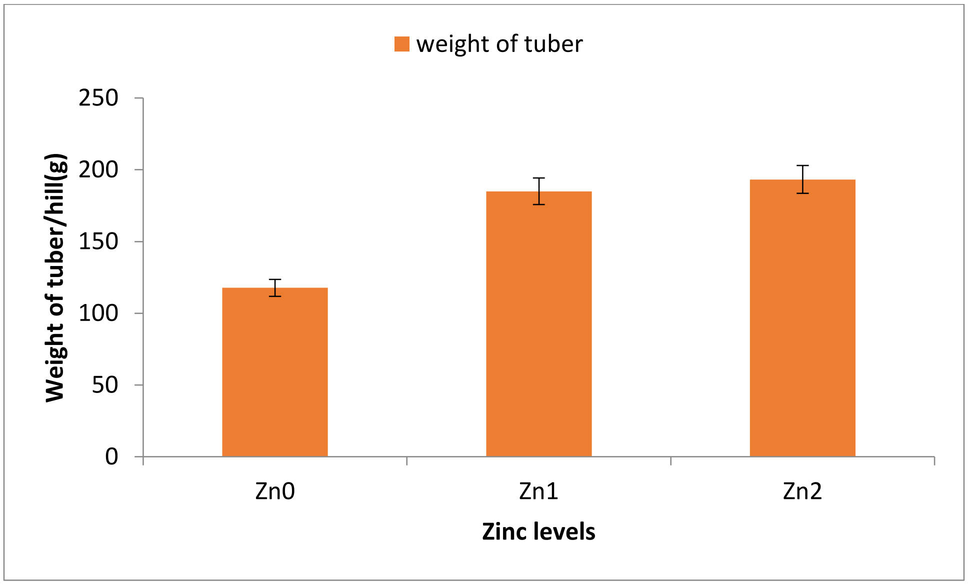


Fig.10.Weight of tuber $hill^{-1}$ of potato influenced by zinc

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}

Effect of Boron

Weight of tuber $hill^{-1}$ varied significantly due to different boron (B) levels (Fig 11 and Appendix VI). The highest weight of tuber $hill^{-1}$ (181.2g) was achieved from the treatment B_2 (2 kg B ha^{-1}) which was statistically identical with B_1 (1 kg B ha^{-1}). The lowest weight of tuber $hill^{-1}$ (119.05g) was obtained from the control treatment B_0 (0 kg B ha^{-1}).

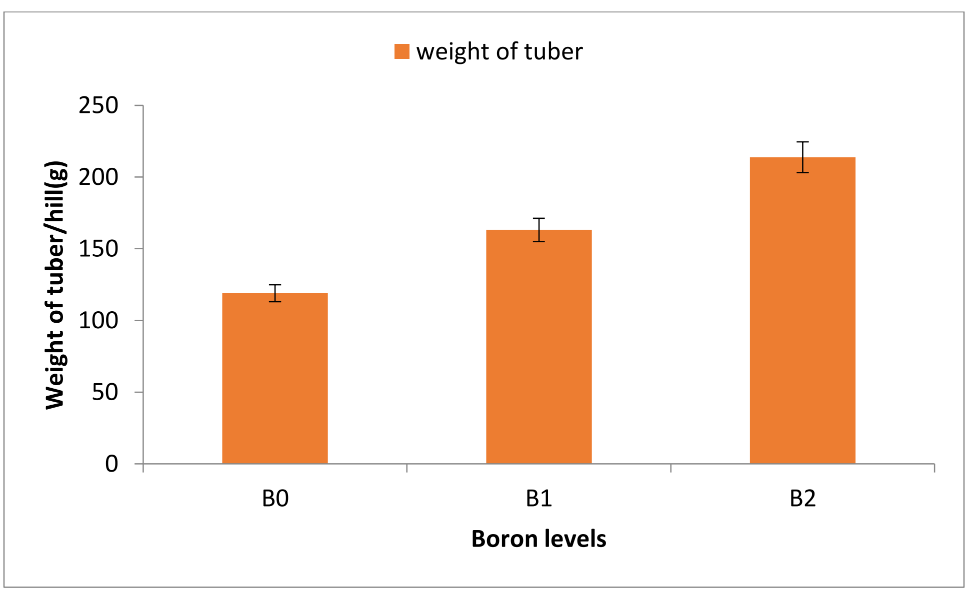


Fig.11.Weight of tuber $hill^{-1}$ of potato influenced by boron.

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

Combined effect of Zn and B

Significant variation was remarked on weight of tuber hill^{-1} as influenced by combined effect of different Zn and B levels (Table 5 and Appendix VI). The highest weight of tuber hill^{-1} (244.2g) was recorded from the treatment combination of Zn_2B_2 which was statistically similar with the treatment combination of Zn_1B_2.The lowest weight of tuber hill^{-1} (90.03g) was found from the treatment combination of Zn_0B_0 which was significantly different from all other treatment combinations.

Table 5. Combined effects of zinc and boron on Weight of tuber hill^{-1} of potato

Zinc × Boron	Weight of tuber hill^{-1}(g)
Zn_0B_0	90.03i
Zn_0B_1	106.3h
Zn_0B_2	156.9e
Zn_1 B_0	128.3g
Zn_1 B_1	186.4d
Zn_1 B_2	240.2b
Zn_2 B_0	138.8f
Zn_2 B_1	196.8c
Zn_2 B_2	244.2a
Level of Significance	*
CV (%)	6.00
LSD at 5%	0.05307

* Significant at 5% level of probability, CV= Coefficient of variation

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}.

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

4.2.3 Weight of tuber plot^{-1}

Effect of Zinc

Application of different zinc (Zn) levels showed significant influence on weight of tuber plot^{-1}(Fig12 and Appendix VI). The highest weight of tuber plot^{-1} (6.17 kg) was found from the treatment Zn_2 (6 kg Zn ha^{-1}) which was statistically identical with Zn_1 (3 kg Zn ha^{-1}) where the lowest weight of tuber plot^{-1}(4.7 kg) was observed from the control treatment Zn_0 (0 kg Zn ha^{-1}).

Fig.12.Weight of tuber plot^{-1} of potato influenced by zinc.

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}

Effect of Boron

Variation on weight of tuber plot^{-1}was noted as significant influenced by different boron (B) levels (Fig.13 and Appendix VI). The highest weight of tuber plot^{-1}(6.09 kg) was achieved from the treatment B_2 (2 kg B ha^{-1}) which was statistically identical with B_1 (1 kg B ha^{-1}). The lowest weight of tuber plot^{-1}(4.71 kg) was obtained from the control treatment B_0 (0 kg B ha^{-1}).

Fig.13.Weight of tuber plot^{-1} of potato influenced by boron.

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

Combined effect of Zn and B

Weight of tuber plot^{-1}of potato was significantly varied due to the combined effect of different Zn and B levels (Table 6 and Appendix VI).The highest weight of tuber plot^{-1}(6.89 kg) was recorded from the treatment combination of Zn_2B_2 which was statistically identical with the treatment combination of Zn_2B_1 and Zn_1B_2.The lowest weight of tuber plot^{-1}(4.12 kg) was found from the treatment combination of Zn_0B_0 which was significantly different from all other treatment combinations.

Table 6. Combined effects of zinc and boron on Weight of tuber plot^{-1} of potato

Zinc × Boron	Weight of tuber per plot(kg)
Zn_0B_0	4.12h
Zn_0B_1	4.83g
Zn_0B_2	5.16f
$Zn_1 B_0$	4.78g
$Zn_1 B_1$	5.38d
$Zn_1 B_2$	6.24c
$Zn_2 B_0$	5.23e
$Zn_2 B_1$	6.40b
$Zn_2 B_2$	6.89a
Level of Significance	*
CV (%)	0.17
LSD at 5%	0.05307

* Significant at 5% level of probability, CV= Coefficient of variation

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}.

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

4.2.4 Tuber yield ha^{-1}

Effect of Zinc

The recorded data on tuber yield ha^{-1} was significant with the application of different Zinc (Zn) levels (Fig.14 and Appendix VI). The highest tuber yield ha^{-1} (25.42 t) was found from the treatment Zn_2 (6 kg Zn ha^{-1}) which was statistically identical with Zn_1 (3 kg Zn ha^{-1}) where the lowest tuber yield ha^{-1} (13.84 t) was observed from the control treatment Zn_0 (0 kg Zn ha^{-1}). Guler (2009) reported that the maximum tuber yield was obtained when the crop received 5 and 9 kg zinc per ha, respectively. They also noted a reduction in tuber yield when Zn was applied above the aforementioned rates. The yield reduction due to excess rates of Zn may be explained by the fact that excessive Zn application stimulates shoot growth more than tuber growth which may result in deterioration of canopy structure and physiological conditions.

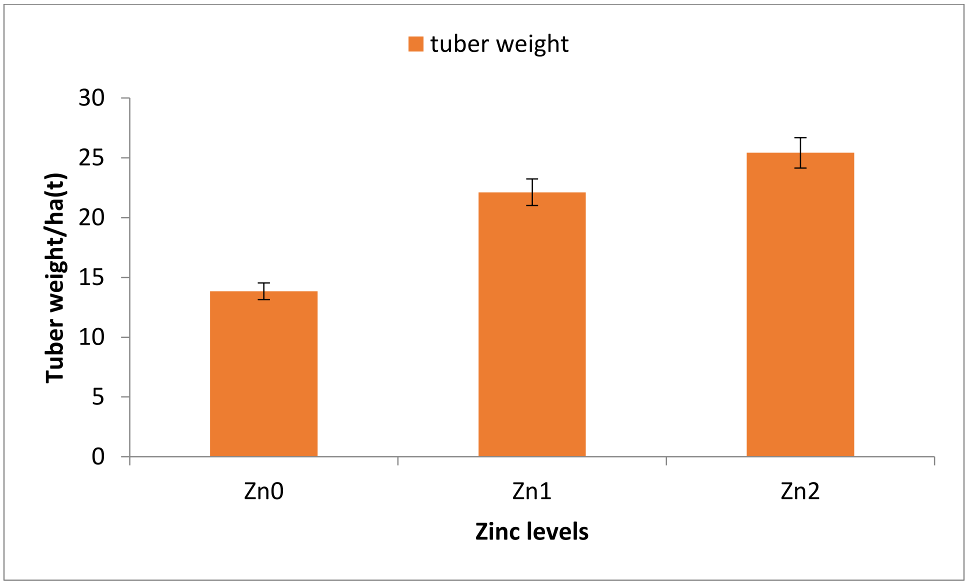


Fig.14.Tuber weight ha^{-1} of potato influenced by zinc.

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}

Effect of Boron

Considerable influence was observed on tuber yield ha^{-1} persuaded by different boron (B) levels (Fig. 15 and Appendix VI).The highest tuber yield ha^{-1} (23.15 t) was achieved from the treatment B_2 (2 kg B ha^{-1})which was statistically identical with B_1 (1 kg B ha^{-1}). The lowest tuber yield ha^{-1} (17.62 t) was obtained from the control treatment B_0 (0 kg B ha^{-1}). Sharma and Arora, (1987) reported that yield response to increasing levels of B fertilizer was generally positive up to a particular level, above which the response became negative.

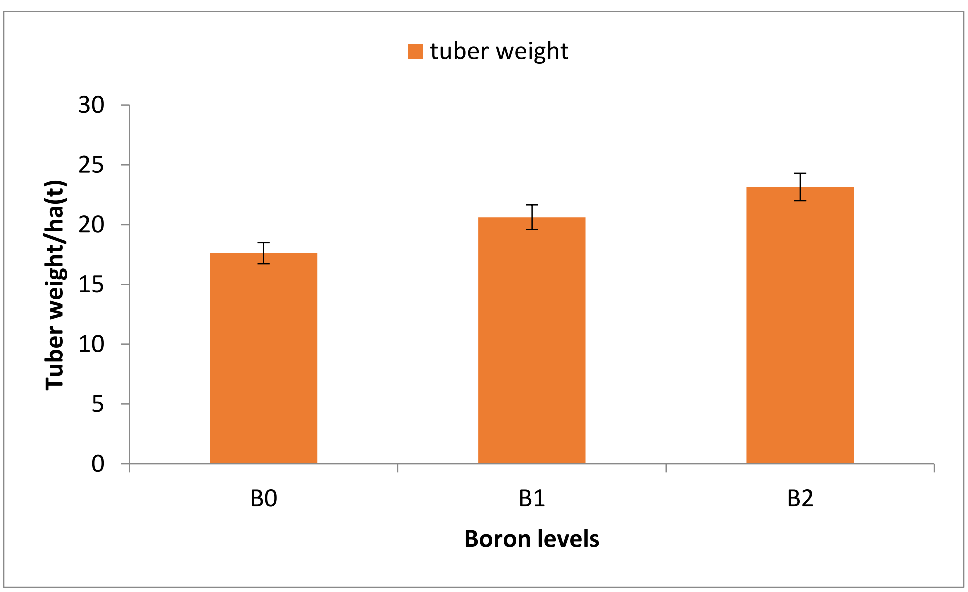


Fig.15.Tuber weight ha^{-1} of potato influenced by boron.

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

Combined effect of Zn and B

Remarkable variation was identified on tuber yield ha^{-1} due to the combined effect of different Zn and B levels (Table 7 and Appendix VI). The highest tuber yield ha^{-1} (27.82 t) was recorded from the treatment combination of Zn_2B_2 which was statistically similar with the treatment combination of Zn_2B_1 and Zn_1B_2. The lowest tuber yield ha^{-1} (11.32 t) was found from the treatment combination of Zn_0B_0 which was significantly different from all other treatment combinations.

Table 7. Combined effects of zinc and boron on Tuber yield per ha of potato

Zinc × Boron	Tuber yield per ha(t)
Zn_0B_0	11.32i
Zn_0B_1	13.99h
Zn_0B_2	16.22g
$Zn_1 B_0$	18.32f
$Zn_1 B_1$	22.62e
$Zn_1 B_2$	25.43b
$Zn_2 B_0$	23.22d
$Zn_2 B_1$	25.22c
$Zn_2 B_2$	27.82a
Level of Significance	*
CV (%)	5.01
LSD at 5%	0.05307

* Significant at 5% level of probability, CV= Coefficient of variation

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}.

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

4.2.5 Marketable yield ha^{-1}

Effect of Zinc

Variation on marketable yield ha^{-1} of potato was found significant as influenced by different zinc (Zn) levels (Fig.16 and Appendix VII). The highest marketable yield ha^{-1} (23.05 t) was found from the treatment Zn_2 (6 kg Zn ha^{-1}) which was statistically identical with Zn_1 (3 kg Zn ha^{-1}). The lowest marketable yield ha^{-1} (11.66 t) was observed from the control treatment Zn_0 (0 kg Zn ha^{-1})

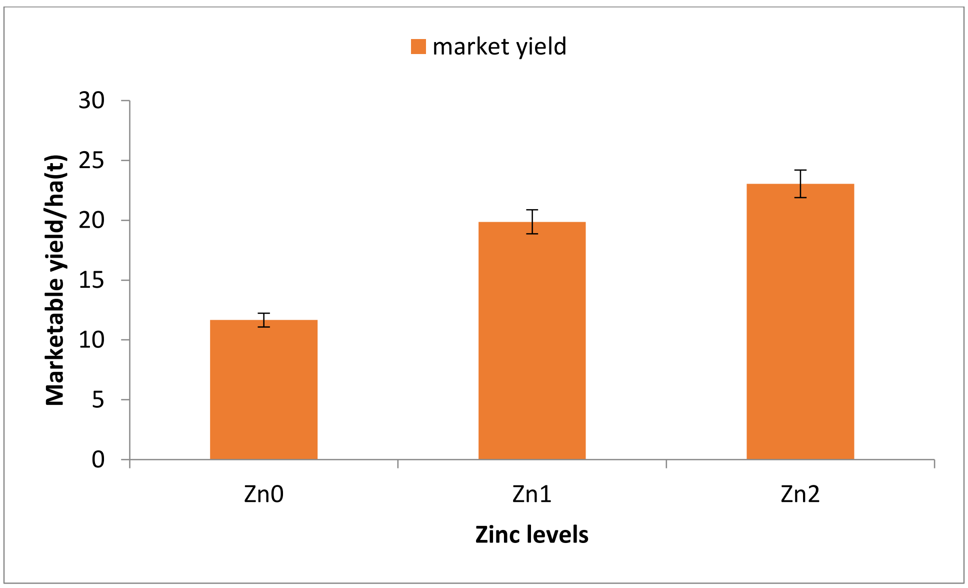


Fig.16.Marketable yield ha^{-1} of potato influenced by zinc.

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}

Effect of Boron

Considerable influence was observed on marketable yield ha^{-1} of potato affected by different Boron (B) levels (Fig.17 and Appendix VII). It was found that the highest marketable yield ha^{-1} (20.78 t) was achieved from the treatment B_2 (2 kg B ha^{-1}) which was statistically same with B_1 (1 kg B ha^{-1}). The lowest marketable yield ha^{-1} (15.24 t) was obtained from the control treatment B_0 (0 kg B ha^{-1}) which was significantly different from all other treatments. Zelalem *et al*. (2009) reported that application of 3 kg B ha^{-1} increased marketable tuber number by 33.5% over the control.

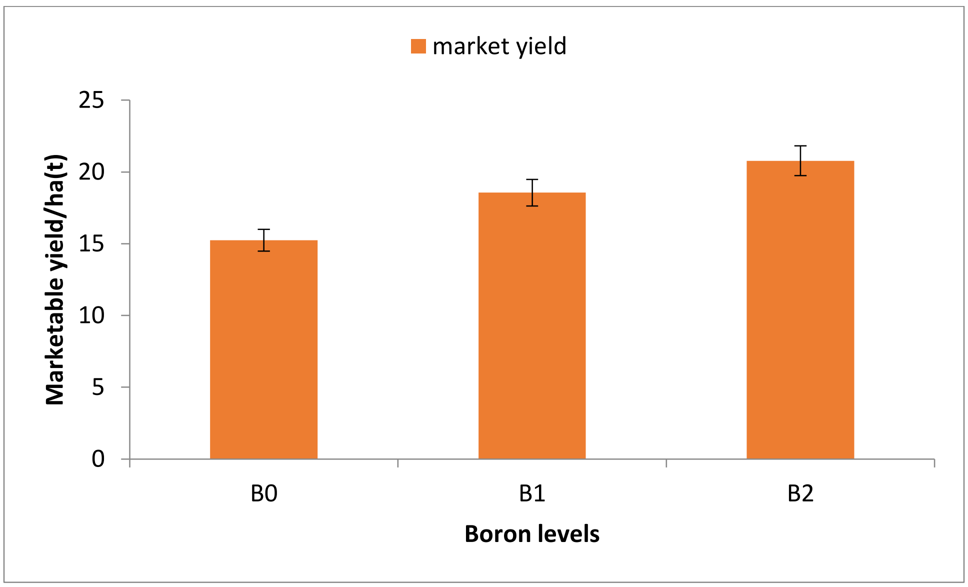


Fig.17. Marketable yield ha^{-1} of potato influenced by boron.

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

Combined effect of Zn and B

The recorded data on marketable yield ha^{-1} was influenced significantly by combined effect of different Zn and B levels (Table 8 and Appendix VII). Results indicated that the highest marketable yield ha^{-1} (25.05 t) was recorded from the treatment combination of Zn_2B_2 which was statistically similar with the treatment combination of Zn_2B_1 and Zn_1B_2. The lowest marketable yield ha^{-1} (9.03 t) was found from the treatment combination of Zn_0B_0 which was significantly different from all other treatment combinations followed by the treatment combination of Zn_0B_1 and Zn_0B_2.

Table 8. Combined effects of zinc and boron on Market yield per ha of potato

Zinc × Boron concentration	Market yield ha^{-1}(t)
Zn_0B_0	9.03i
Zn_0B_1	11.83h
Zn_0B_2	14.14g
$Zn_1 B_0$	15.83f
$Zn_1 B_1$	20.63e
$Zn_1 B_2$	23.15c
$Zn_2 B_0$	20.88d
$Zn_2 B_1$	23.23b
$Zn_2 B_2$	25.05a
Level of Significance	*
CV (%)	4.20
LSD at 5%	0.05307

* Significant at 5% level of probability, CV= Coefficient of variation

Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}.

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The experiment was conducted at the Research Field, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 during the period from November, 2019 to February 2020.The site was located at $23^0$77'N latitude and $90^0$33'E longitude at an altitude of 8.6 meter above the sea level. The experimental site go with the agro-ecological zone of "Modhupur Track",[AEZ-28]. The soil type of the experimental site was to the general soil type of shallow red brown terrace soils under Tejgaon series. The soil was also labeled by pH 5.60 and 0.76% organic carbon.

The experiment considered of two factors *viz*. Factor A: Zinc – 3 levels; Zn_0 = 0 kg Zn ha^{-1}, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1} and Factor B: Boron – 3 levels; B_0 = 0 kg B ha^{-1}, B_1 =1kg B ha^{-1}, B_2 = 2 kg B ha^{-1} . The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield of potato were recorded.

Most of parameters were significantly affected by different levels of Zn application. It was found that the highest plant height (19.43, 57.05, 65.93 and 70.43 cm at 30, 45, 60 and 75 DAP, respectively), highest number of leaves $hill^{-1}$ (22.75, 35.32, 51.52 and 54.17 at 30, 45, 60 and 75, DAP respectively) , highest number of tuber $hill^{-1}$ (8.3), highest weight of tuber $hill^{-1}$ (193.26), highest weight of tuber $plot^{-1}$ (6.17 kg), highest tuber yield ha^{-1} (25.42 t) and highest marketable yield ha^{-1} (23.05 t) were obtained from the treatment Zn_2 (6 kg Zn ha^{-1}) where the lowest plant height (18.24, 37.84, 45.53 and 47.06 cm at 30, 45, 60 and 75 DAP, respectively), lowest number of stem $hill^{-1}$ (1.7, 3.4, 4.26 and 4.87 at 30, 45,60 and 75 DAP, respectively), lowest number of leaves $hill^{-1}$ (18.05, 25.38, 38.05 and 42.64 at 30, 45, 60and 75 DAP, respectively), lowest number of tuber $hill^{-1}$ (6.95), lowest weight of tuber $hill^{-1}$ (117.75), lowest weight of tuber $plot^{-1}$ (4.7 kg), lowest tuber yield ha^{-1} (13.84t) and lowest marketable yield ha^{-1} (11.66t) were also observed from the control treatment Zn_0 (0 kg Zn ha^{-1}),but the highest number of stem $hill^{-1}$ (2.15, 3.85, 4.7 and 5.31 at 30, 45, 60 and 75 DAP, respectively) was from the treatment Zn_1 (3 kg Zn ha^{-1}).

Regarding B treatment, all the studied parameters were significantly affected by different levels of B. Results revealed that the highest plant height (19, 47.9, 56.27 and 60.62 cm at 30, 45, 60 and 75 DAP, respectively), number of leaves hill^{-1} (23.15, 33.25, 47.54 and 52.9 at 30, 45, 60 and 75 DAP, respectively) , highest number of stem hill^{-1} (2.28, 3.79, 4.75 and 5.36 at 30, 45, 60 and 75 DAP, respectively), number of tuber hill^{-1} (8.22), weight of tuber hill^{-1} (181.2), weight of tuber plot^{-1} (6.09 kg), tuber yield ha^{-1} (23.15 t) and marketable yield ha^{-1} (20.78 t) were achieved from the treatment B_2 (2 kg B ha^{-1})Again, the lowest plant height (18.93, 45.67, 54.44 and 57.53 cm at 30, 45, 60 and 75 DAP, respectively), number of stem hill^{-1} (1.71, 3.48, 4.34 and 5.03 at 30, 45, 60 and 75 DAP, respectively), number of leaves hill^{-1} (19.6, 29.98, 44.33 and 43.56 at 30, 45,60 and 75 DAP, respectively), the lowest number of tuber hill^{-1} (7.14), weight of tuber hill^{-1} (119.05), weight of tuber plot^{-1} (4.71 kg), tuber yield ha^{-1} (17.62 t) and marketable yield ha^{-1} (15.24) were also obtained from the control treatment B_0 (0 kg B ha^{-1}).

Considering combined effect of Zn and B, the highest plant height (19.55, 58.13, 66.38 and 70.93 cm at 30, 45,60 and 75 DAP, respectively), number of stem hill^{-1} (1.91, 3.81, 4.71and 5.53 at 30, 45, 60 and 75 DAP, respectively) were recorded from the treatment combination of Zn_2B_0. But the highest number of leaves hill^{-1} (24.93, 37.62, 53.14 and 58.19 at 30, 45, 60 and 75 DAP, respectively) , the highest number of tuber hill^{-1} (8.58), weight of tuber hill^{-1} (244.2 g), weight of tuber plot^{-1} (6.89 kg), tuber yield ha^{-1} (27.82 t) and marketable yield ha^{-1} (25.05 t) were recorded from the treatment combination of Zn_2B_2.The lowest plant height (17.42, 36.22, 43.49 and 45.55 cm at 30, 45, 60 and 75 DAP, respectively), number of stem hill^{-1} (1.34, 3.04, 3.89 and 4.50 at 30, 45, 60 and 75 DAP, respectively), number of leaves hill^{-1} (16.13, 23.13, 35.13 and 40.28 at 30, 45, 60 and 75 DAP, respectively), the lowest number of tuber hill^{-1} (6.34), weight of tuber hill^{-1} (90.03 g), weight of tuber plot^{-1} (4.12 kg), tuber yield ha^{-1} (11.32 t) and marketable yield ha^{-1} (9.03 t) were also found from the treatment combination of Zn_0B_0.

Considering the above results, it may conclude that Zn and B positively influenced the entire physiology, growth and yield of potato. At all stage of growth and yield, Zn_2 (6 kg Zn ha^{-1}) and B_2 (2 kg B ha^{-1}) gave better result which produced higher height growth and yield. So, it may be recommended that Zn_2 (6 kg Zn ha^{-1}) with B_2 (2kg B ha^{-1}) was better for growth and yield of potato.

The experiment was done only one growing season, for more confirmation of the result such type of experiment is required before recommendation. Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.

2. Another level of Zinc and boron fertilizer may be used for identifying more accurate doses.

3. Different fertilizers may be included for attaining better results.

CHAPTER VI

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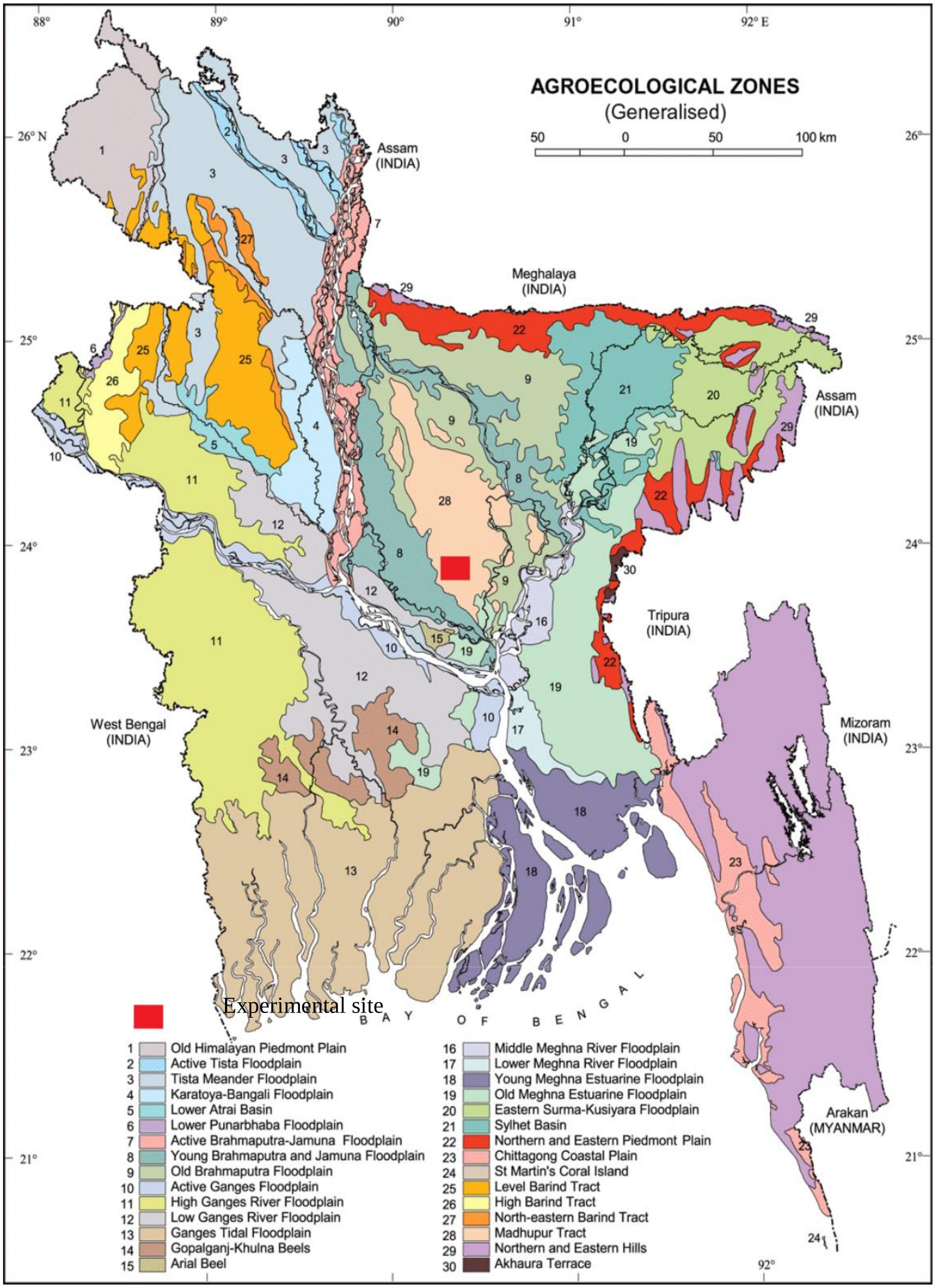
CHAPTER VII

APPENDICES

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location (AEZ-28)



Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from November, 2019 to February, 2020.

Months	**Air temperature (0C)**		**Relative humidity (%)**	**Total rainfall (mm)**
	Maximum	**Minimum**		
November	29.74	19.15	67.21	66
December	23.92	14.50	75.58	5
January	24.55	12.20	64.39	12
February	28.60	17.5	48.16	30

Source: Bangladesh Meteorological Dept. (Climate & weather division) Agargoan, Dhaka – 1207

Appendix III: Analysis of variance (mean square) of the data on plant height influenced by Zinc and Boron

Sources of Variation	Degrees of freedom	Mean square value of plant height at different DAP			
		30 days	45days	60 days	75 days
Replication	2	0.001	0.001	0.004	0.004
Factor A (Zinc)	2	3.944*	858.475*	941.720*	1229.848*
Factor B (Boron)	2	0.044*	14.919*	7.691*	27.863NS
AB	4	1.325*	7.858*	3.657*	9.447*
Error	12	0.001	0.001	0.001	0.234

* Significant at 5% level, NS= non significance

Appendix IV: Analysis of variance (mean square) of the data on number of stem per plant influenced by Zinc and Boron

Sources of Variation	Degrees of freedom	Mean square value of number of stem at different DAP			
		30 days	45days	60 days	75 days
Replication	2	0.001	0.001	0.004	0.004
Factor A (Zinc)	2	0.707*	0.449*	0.533*	0.641NS
Factor B (Boron)	2	0.741*	0.229*	0.368*	0.260 *
AB	4	0.138*	0.340*	0.226*	0.314 *
Error	12	0.028	0.001	0.003	0.011

* Significant at 5% level , NS= non significance

Appendix V: Analysis of variance (mean square) of the data on number of leaves per hill influenced by Zinc and Boron

Sources of Variation	Degrees of freedom	Mean square value of number of leaves hill^{-1} at different DAP			
		30 days	45days	60 days	75 days
Replication	2	0.007	0.003	0.003	0.003
Factor A (Zinc)	3	94.401*	300.649 *	479.247*	305.802 *
Factor B (Boron)	2	30.978 *	29.309 *	29.259*	208.360 *
AB	6	3.543*	7.257 *	6.080*	40.517 *
Error	16	0.001	0.001	0.001	0.001

* Significant at 5% level, , NS= non significance

Appendix VI: Analysis of variance (mean square) of the data on yield and yield contributing characters influenced by Zinc and Boron

Sources of Variation	Mean square value			
	Degrees of freedom			Number of tuber hill^{-1}
Replication	2			0.004
Factor A (Zinc)	2			4.495*
Factor B (Boron)	2			2.747*
AB	4			0.105*
Error	12			0.001

* Significant at 5% level, NS= non significance

Appendix VI: Analysis of variance (mean square) of the data on yield and yield contributing characters influenced by Zinc and Boron

Sources of Variation	Mean square value			
	Degrees of freedom	Weight of tuber hill^{-1}	Weight of tuber plot^{-1}	Tuber yield ha^{-1}
Replication	2	0.004	0.003	0.001
Factor A (Zinc)	2	15432.930*	4.879 *	320.102 *
Factor B (Boron)	2	20216.959 *	4.382*	69.092*
AB	4	591.427*	0.134*	1.684*
Error	12	0.001	0.003	0.001

* Significant at 5% level, , NS= non significance

Appendix VII: Analysis of variance (mean square) of the data on market yield influenced by Zinc and Boron

Sources of Variation	Mean square value	
	Degrees of freedom	Market yield ha^{-1}
Replication	2	0.004
Factor A (Zinc)	2	310.627 *
Factor B (Boron)	2	69.797 *
AB	4	2.222*
Error	12	0.001

* Significant at 5% level, , NS= non significance

Appendix VIII: Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Table A: Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Experimental Filed, SAU, Dhaka
AEZ	Modhupur tract (28)
General Soil type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Source: Soil Resource Development Institute (SRDI)

Table B: Physical and chemical characteristics of the initial soil (0-15 cm depth)

Characteristics	Value
Mechanical fractions: % Sand (2.0-0.02 mm) % Silt (0.02-0.002 mm) % Clay (<0.002 mm)	 27 43 30
Textural class	Clay loam
pH	5.6
Organic carbon	0.76
Organic matter (%)	1.31
Total N (%)	0.06
Available P (ppm)	18.49
Exchangeable K (me/100g soil)	0.10
Available S (ppm)	15.6
Available Zinc(ppm)	0.94
Available Boron(ppm)	0.64

Source: Soil Resource Development Institute (SRDI)