EFFECTS OF POTASSIUM AND BORON ON THE GROWTH AND YIELD OF CHILI (*Capsicum annuum L.*)

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EFFECTS OF POTASSIUM AND BORON ON THE GROWTH AND YIELD OF CHILI (*Capsicum annuum L.*)

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CERTIFICATE

This is to certify that the thesis entitled "EFFECTS OF POTASSIUM AND BORON ON THE GROWTH AND YIELD OF CHILI (*Capsicum annuum L.*) **submitted to the DEPARTMENT OF SOIL SCIENCE,, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment 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 Mahabuba Khnom Munni, Registration No. 19-10045, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institute.**

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

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DEDICATED TO

MY

BELOVED PARENTS

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ABSTRACT

A field experiment was conducted at the Sher-e-Bangla Agricultural University farm, (Tejgoan soil series under AEZ 28) during Rabi season of October 2019-March 2020 to evaluate the effect of potassium (K) and boron (B) on the growth and yield of chili (*Capsicum annuum* L.). Two factor experiment with three rates of K (0, 75 and 100 kg K ha^{-1}) and three rates of B (0, 1.5 and 3 kg B ha^{-1}) was laid out in the Randomized Complete Block Design (RCBD) with three replication. Application of K and B significantly influenced the number of leaves $plant^{-1}$, number of fruits $plant^{-1}$, yield and other yield parameters of chili. The maximum number of leaves $plant^{-1}$ (50.9) and number of branches $plant^{-1}$ (9.2) were observed in K_2B_2 treatment combinations. The maximum number of flowers $plant^{-1}$ (119) and maximum number of fruits $plant^{-1}$ (107.9) were recorded in K_2B_0 treatment combination. The maximum height of plant (33 cm) and fruit length (6.7 cm) were recorded in $K_1B_{1.}$ Highest weight of fruits as well as highest yield (10.74 t/ha) was obtained in treatment combination K_1B_2. The results of this research work indicated that the plants performed better in all parameters over the control treatment (K_0B_0). Yield of chili was found maximum in K_1B_2 treatment which was said to be the optimum dose of K and B among the treatment combinations and that was cost effective as well than K_2B_2 which produced the similar yield as $K_2B_{1.}$ So, It can be therefore, concluded from the above study that the treatment combination K_1B_2 was found to a promising practice for the higher yield of chili in AEZ 28 (Madhupur Tract).

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SOME COMMONLY USED ABBREVIATIONS AND SYMBOLS

Abbreviation	Full word
%	Percentage
@	At the rate
ABA	Abscisic Acid
AEZ	Agro Ecological Zone
Agric.	Agriculture
ASTA	American Spice Trade Association
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BD	Bangladesh
BINA	Bangladesh Institute of Nuclear Agriculture
CEC	Cation Exchange Capacity
cm	Centimeter
CRD	Completely Randomized Design
CV%	Percentage of Coefficient of Variance
DAT	Days after transplanting
df	Degrees of Freedom
dm3	Cubic decimeter
EC	Emulsifiable concentration
Et al.	and others
etc	Etcetera

Abbreviation	Full word
g	gram
GA	Gibberellic Acid
Hort.	Horticulture
IAA	Indole -3 Acetic Acid
J.	Journal
mM	Mili mole
NUE	Nutrient Use Efficiency
PGR	Plant Growth Regulator
pH	Potential of hydrogen ion
ppm	Parts per million
q /ha	Quintals per hector
RDF	Recommended Dose of fertilizer
RDK	Recommended Dose of potassium
Res.	Research
Sci.	Science
SOP	Sulphate of Potash
t/ha	Tons/ hectare
WAT	Weeks after transplanting
WP	Wettable Powder

CHAPTER 1

INTRODUCTION

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INTRODUCTION

Chili (*Capsicum spp.* L.) is an important spice crop which belongs to the family, Solanaceae which is also called Nightshade family. In this family, after tomato and potato, chili is the 3rd most significant crop. In Bangladesh, chilies are cultivated on commercial scale, covering the largest area after onion and potato. Economically, chilies are grown as cash crop. The genus Capsicum contains almost 20 species and among them only 5 species are cultivated, out of that *Capsicum frutescence* and *Capsicum ann uum* is regularly cultivated all over the world (Khan *et al.*, 2003). *Capsicum frutescence*, also called hot peppers, has an extra amount of alkaloid capsaicin ($C_{18}H_{27}0_3$) which is responsible for the pungency (Udoh *et al.*, 2005). Chili is the universal spice and that is widely cultivated throughout temperate, tropical and subtropical countries. It is an essential spice due to its pungency, spice, taste, appealing odor and flavor. The dried fruit are widely used as spices. The ground powder and oleoresin are practiced in pharmaceutical preparations (Warrier, 1989). Total annual production of Rabi chili in Bangladesh is about 79747 metric tons from 426157 acres of land Chilies are grown in all the districts of the country but plenty of chilies are produced in the district of Bogura, Rangpur, Kurigram, Natore, Jamalpur and Jashore (BBS, 2019). Usually the chili farmers of Bangladesh selected local cultivars for the production of chili which produce very low yields. The main reasons of low yield are lack of adopting new cultivation techniques and improper fertilization To enhance the production of the chili, it is necessary to pay attention on balanced use of nutrient through fertilizer application. Growers and farmers need to manage the fertilizer for better quality of fruit production. Potassium is considered to be one of the most crucial elements for the growth and development of plants (Ortas *et al.*, 1999).

Among the plant mineral nutrients, the elements P and K play an important role in the growth and yield of chilies (Olaniyi *et al.*, 2010). Potassium plays an essential role in plant growth and metabolism which includes photosynthesis, enzymatic activities, and translocation of nutrients and water in the plant. The Solanaceous group of vegetables (tomato, eggplant and chili) generally takes up large amounts of nutrients that have specialized functions and should be supplied to plant at the right time with suitable quantity (Mengel *et al.,* 1980; Shukla *et al.*, 1993). When chilies are adequately supplied with the essential nutrients through fertilization it improves their yield, quality and enhance maturity. Although K is not a constituent of any organic molecule or plant structure, it is involved in numerous biochemical and physiological processes vital to plant growth, yield, quality, and stress tolerance. In addition to stomatal regulation of transpiration and photosynthesis, potassium is also involved in photophosphorylation, enhance enzyme activation, turgor maintenance, and stress tolerance. Adequate K nutrition has also been associated with increased yields, fruit size, increased soluble solids and ascorbic acid concentrations, improved fruit color, increased shelf life, and shipping quality of many horticultural crops (Lester *et al.*, 2010).

The productivity of crop is being adversely affected in many areas due to deficiencies of micronutrients (Bose and Tripathi, 1996). Intensive cropping, loss of top soil by erosion, loss of micronutrients by leaching, liming of soil and lower availability and use of farm yard manure is markedly increased the micronutrients deficiency (Fageria *et al.*, 2002). Micronutrients are usually required in minute quantities, nevertheless are vital to the growth of plant (Benepal, 1967). Improvement in growth characters as a result of application of micronutrients might be due to the enhanced photosynthetic and other metabolic activity that leads to an increase in various plant metabolites responsible for cell division and elongation (Hatwar *et al.*, 2003). The photosynthesis is improved in presence of boron (Rawat and Mathpal, 1984). The deficiency of B retards apical growth and development because it has role in cell development, sugar formation and translocation. Boron also plays a significant role in flowering and fruiting processes, N metabolism, hormonal action and cell division. The nutrient removal and uptake capacity by *capsicum* cultivar is high, which denotes that they need greater nutrient requirements (Hegde, 1997; Sharma *et al*., 1996).

The effect of B concentration in the nutrient solution to other nutrients may be exerted via antagonism or by modifying the endogenous hormone levels such as indole 3-acetic acid (IAA), gibberellic acid (GA) and abscisic acid (ABA) (Ayvaz *et al*., 2012). The ABA regulates stomatal closure in peppers resulting in bring down of transpiration and decreased nutrient absorption and total nutrient content. Furthermore, high B concentration affects the response of crops in acid or limed soils (Paparnakis *et al*., 2013) and also the solubility and availability of other nutrients in soil (Tariq and Mott, 2007). The chemistry of B in soil and its roles in plants differs from the other elements. Marschner (1995) noticed that maintenance of optimal concentrations of mineral elements in the nutrient substrates and their absorption by plants results in increased productivity and better fruit quality. Another important aspect is how B concentration in nutrient solution affects the nutrient use efficiency (NUE) of the various nutrients (Ali *et al*., 2015). It is crucial in nitrogen and phosphorus metabolism and pollen tube growth which plays an essential role in flowering and fertilization thus boron supply is necessary for improving fruits yield and quality of vegetable crops (Esringü *et al.*, 2011 and Uchida, 2000)

The present research was conducted to find out the optimum levels of potassium and boron for growth, yield and quality of chili crop. Although, many experiment have been carried out on nutrient requirement of chili but few reports are found on the Potassium and Boron fertilizer requirement and the combined effects of these element on chili. From this point of view, the experiment was conducted at Sher-e-Bangla Agricultural University farm under the agro-ecological zone of Madhupur Tract (AEZ-28) with the following objectives:

1. To determine the effect of potassium and boron application on the growth and yield of chili;
2. To find out the optimum dose in combination of potassium and boron for yield maximizing on chili production

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

The Solanaceous group of vegetables (tomato, eggplant, chili and bell peppers) generally takes up large amounts of nutrients depending upon the quantity of fruit and dry matter they produce, which is mostly influenced by a number of genetic and environmental variables. Nutrient deficiency in soil is the key factor for poor productivity of chili. To improve the yield of crop, it is necessary to pay attention to optimum balance use of nutrients through fertilizer application. Currently Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have started extensive research work on varietal development and improvement of this crop. A very few studies related to yield and development of chili have been carried out in this country as well as many other countries of the world, which is not adequate and conclusive. In this chapter, an attempt has been made to review the available information at home and abroad regarding the effect of K and B on the yield of chili and other solanaceae.

2.1 Effect of K on growth and yield attributing characters of chili

Idan *et al.* (2017) reported that K combination with N played a significant role in affecting number of fruits per plant where superior Combined (Urea 60 kg + potassium sulfate 20 Kg) on other Combineds which was recorded (22.10), followed by @ Urea 30 kg + potassium sulfate 20 Kg (21.53). The minimum number of fruits per plant was noticed with control (14.67). and also found that N combination with K application significant role in affecting Total yield where superior Combined (Urea 60 kg +

potassium sulfate 20 Kg on other Combineds which was recorded (3.26 tons), followed by @ Urea 30 kg + potassium sulfate 20 Kg. The minimum Total yield was noticed with control (1.53 tons).

Kar *et al.* (2016) conducted an experiment and found the maximum fruit yield of (2719.82 kg) was obtained in treatment K_3 (120 kg/ha) which is 24 % higher than K_1 (90 kg/ha).The effect of application of different PGRs on fruit yield per hectare was found to be highly significant. Maximum fruit yield of (2888.70 kg) was obtained with application of NAA 40 ppm which is 25% higher than control followed by application of GA3 50 ppm (2655.38 kg). Minimum dry fruit yield of (1910.98 kg) was recorded from 2, 4-D 5 ppm. Combined effect of different levels of potassium and PGRs on fruit yield per hectare was found to be highly significant. The values of fruit yield per hectare ranged from 1599.89 kg/ha to 3199.79 kg/ha

Khan *et al*. (2014) conducted an experiment and found that Potassium levels influenced the number of fruit per plant with the (47.7) recorded from plots that received 50 kg K ha^{-1} which was statistically at par with 40 kg K ha^{-1} (47.5), while the minimum number of fruits $plant^{-1}$ (44.7) was recorded from the control plots. And reported that in case of potassium highest yield (7.10 tons ha^{-1}) was obtained from 50 kg K ha^{-1} which was statistically at par with 40 kg K ha^{-1} (7.09 tons ha^{-1}), while the minimum was obtained from control plot (6.89 tons ha^{-1}). Also, the results are in harmony with those obtained by Padem and Ocal (1999) who demonstrated that increasing K-humate application dose led to a significant increase in fruit weight and total yield.

Golcz *et al*. (2012) observed that height of red pepper plants at successive dates of measurements conducted at monthly intervals during the two years of the experiments no significant effect was observed for potassium chloride, potassium sulfate or potassium nitrate at the two levels of nitrogen and potassium fertilization. In turn, it was found that an increase in the level of nitrogen from 250 to 350 mg N·dm-3 substrate and potassium from 300 to 400 mg K·dm-3 substrate had a significant effect on plant height. On average for the two years of the analyses in the combination with higher fertilization plants were by 2.7 cm higher in June, by 3.55 cm in July and by 3.7 cm in August.

As stated by Oseni *et al.* (2010) reported that increased K application increased plant length for all measurements. K has a significant effect on photosynthesis which is related with number of leaf and leaf size, which plays an important role in chili seedling growth and development.

Prabhavathi *et al.* (2008) studied the influence of sources and levels of potassium on quality attributes and nutrient composition of red chilies. Application of potassium @ 150 percent RDF (Recommended Dose of Fertilizer) through sulphate of potash in 2 split doses recorded highest ascorbic acid content (175.16 mg 100 g^{-1}), colour value (225.28 ASTA units) and oleoresin content (16.79%). It was observed that the concentration of K is highest in the fruit followed by N.

Hari *et al*. (2007) noticed that the chili fruit yield was significantly influenced by the levels and sources of potassium. The highest yield (10.71 q ha^{-1}) was observed at application of 150 per cent RDK through SOP in 2 split doses (T_6) and it was 11.33 and

25.00 per cent higher than the yields obtained at 150 per cent RDK applied through MOP and 100 per cent RDK through SOP both in 2 split doses (T_5 and T_4). The increased yield was due to the presence of both K and S in SOP in readily available forms (K_2O and SO_4^{2-}) for the plant to get it absorbed easily. Progressive yield increase observed due to incremental doses of potassium as SOP and MOP might be attributed to the cumulative favorable effects of potassium on nutrient uptake, dry matter production and efficient translocation of photosynthates from source to sink.

Shankar and Sumangala (2005) conducted a field experiment to assess the impact of SoP and MoP (50, 75 and 100 kg K_2O ha^{-1}) on growth and yield of chilli in Alfisols. They reported that, application of potassium as SoP @ 50 kg ha^{-1} resulted in significantly higher growth (101.1 cm plant height), yield parameters (8.35 cm fruit length, 50.7 fruits per plant and 51.6 g 100 fruit weight) and highest dry chill yield (11.19 q/ha).

Aldana (2005) carried out an experiment. The main growth experiment was conducted in spring/summer growing period of 2003. This experiment consisted of 8 treatments; 4 levels of P (P_1 0.25, P_2 1.25, P_3 2.5, and P_4 3.75 mM) and 4 levels of K (K_1 0.25, K_2 1.25, K_3 2.5, and K_4 3.75 mM). The average fruit weight of fresh pepper fruits was influenced by K rates. Treatment K_4 produced the highest fruit weight (0.71 g) of the experiment followed closely by K_3 (0.67 g) and K_2 (0.68 g), with no significant statistical differences between the treatments. Harvest periods significantly affected fruit weights, but the Combined between K treatment and harvest period was not significant. An overall decrease in fruit weight as harvest time progressed was noticed for all the K treatments. Increasing P and K rates also affected plant yield and some fruit quality variables. Results were consistent for most of the variables, suggesting that the 0.25 mM concentration for both P and K was insufficient for pepper production. Concentrations higher than 1.25 mM and close to 2.5 mM are the most appropriate for hydroponic tabasco pepper production.

Ananthi *et al*. (2004) noticed that, among different levels and sources of potassium (30, 45, 60 and 75 kg ha^{-1} as MoP and SoP), highest color value (199.63 ASTA units) and oleoresin content (15.50%) were obtained at 60 kg K_2O ha^{-1} as SoP. Application of 75 kg K_2O ha^{-1} has resulted the highest ascorbic acid content (117.96 mg/100 g), which was significantly superior over 45 kg K_2O ha^{-1} as SoP (111.54 mg/100 g). And found out the best level as well as source of potassium for irrigated chili in sandy clay loam soil at Coimbatore. They observed maximum number of fruits (135.00 per plant) and highest dry fruit yield (5.77 t ha^{-1}) with the application of 60 kg K_2O ha^{-1} as MoP, which was on par with 75 kg K_2O ha^{-1} as SoP, but significantly superior over 75 kg K_2-O ha^{-1} as muriate of potash (115.00 fruits per plant and 5.65 t ha^{-1} yield).

Bidari *et al.* (2004) concluded that the effect of different soil types in influencing the quality of red chilies in an agro-climatic zone to identify the nutrients responsible for the synthesis of quality attributes in chilies. In deep black soils, due to high K availability coupled with adequate K uptake synchronizing with colour development in fruits enhanced carbohydrates synthesis in leaves. These were further translocation to developing fruits to balance the acids. Low colour value in fruits of red soil locations was due to inadequate K supply and imbalance in sugar: acid ratio in fruits. There was sudden increase in the uptake of K by plants after 75 days after transplanting which closely correlated with red colour development. Partitioning of nutrients into pericarp and seed components revealed that, except K, all other nutrients got partitioned significantly more in seed, while K got partitioned more in pericarp. This differential partitioning of nutrients between seeds and pericarp components is attributed to their probable role in influencing quality attributes and also due to genetic factors. Potassium concentration of whole red fruit/ pericarp component bear significant positive relationship with quality attributes particularly colour value (r = 0.86* and 0.96*). Pungency and red colour of chilies are influenced by nitrogen and potassium supply, respectively. Hence, plants should have adequate supply of these nutrients particularly at the time of synthesis of capsaicin (after 75 DAT) and colour development (90 DAT).

Ananthi *et al.* (2004) studied that the highest number of fruits per picking (36.74 plant^{-1}) was recorded in treatment (T_6) that received 150 percent RDK through SoP in 2 split doses which was at par with potassium application at the rate of 100 per cent RDK and 200 per cent RDK through SoP in 2 split doses (T_4 and T_8), but it (T_6) was significantly superior over treatment (T_5) receiving 150 per cent RDK through MoP in 2 split doses (29.94 plant^{-1}). Application of potassium through SoP produced significantly higher number of fruits per plant per picking than MoP. The reason might be the hormonal balance brought about in plant system by sulphur available through SoP resulting in less flower drop and more fruit set. The weight of 100 dry chili fruits was not much influenced by the two sources of potassium (MoP and SoP) but, increased fruit weight was observed with incremental doses of potassium. The highest 100 fruit weight (131.74 g) was recorded in the treatment (T_6) that received 150 per cent RDK through SoP in 2 split doses and it was higher by 10.37 per cent than treatment receiving 100 per cent

RDK through SoP in 2 split doses (T_4). The reason might be the accelerated mobility of photosynthates from source to sink as influenced by potassium and its accumulation in fruits.

Suresh (2000) found that, the total extractable colour in chili was significantly influenced by increased levels of potassium. The highest colour value (110.64 ASTA units) was obtained at 75 kg K_2O ha^{-1}, which was significantly superior over 50 and 25 kg ha^{-1} of potash (104.96 and 101.77 ASTA units, respectively). The effect of nitrogen and potassium on yield and quality of Byadgi chilies grown on medium black soil at Dharwad. He reported highest dry fruit yield (13.37 q ha^{-1}) at 75 kg K_2O ha^{-1} which was on par with 25 and 50 kg K_2O ha^{-1} (13.02 and 13.20 q ha^{-1}), respectively.

Thakur *et al.* (2000) concluded that foliar spray of potassium (0.5% and 1.0%) was very effective in maintaining higher production of bell pepper under varying levels of water deficit. They reported that, bell pepper (Cv. California Wonder) gave significantly higher fruit yield (18.13 t ha^{-1} and 14.51 t ha^{-1}) with 0.5 and 1 per cent potassium single spray under water stress condition of 50 per cent over control (no spray) (11.80 t ha^{-1}).

Shrivastava (1996) observed maximum percent fruit set (29.5%) with higher dose of nutrients (300:250:250 kg N, P_2O_5 and K_2O ha^{-1}) in sweet pepper (*Capsicum annuum* var. Grossum L.). This might be due to more carbohydrate production and assimilation in fruit.

Kaminwar and Rajagopal (1993) noticed significant increase in ascorbic acid content of red ripe chilli fruits (cv. Sindhur) with potassium application and highest ascorbic acid content (40.1 mg/100 g) was registered with 100 kg K_2O per ha, whereas in control the value was 36.9 mg per 100 g.

Medhi *et al*. (1990) carried out a field experiment on sandy loam acid Alfisol at Barapani (West Bengal) to know the effect of varying levels of NPK on chili. They applied four levels of potassium (20, 40, 60 and 80 kg ha^{-1}) and observed significant increase in yield up to 60 kg K_2O ha^{-1}. However, highest yield (77.19 q/ha) was obtained at 80 kg K_2O ha^{-1}).

Subhani *et al.* (1990) carry out a field experiment on sandy loam soil at Bapatla (A.P.) and reported significant increase in dry fruit yield of chili (cv. G-4) with application of potassium. The highest yield (90.8 g $plant^{-1}$) was obtained through 120 kg K_2O ha^{-1} and 180 kg N ha^{-1}.

Shibila Mary and Balakrishnan (1990) observed significant increase in vitamin C content of chilli fruits (cv. K2) with increased levels of potassium application. Highest vitamin C content was obtained with 52.5 kg K_2O per ha both in green (100.06 mg/100 g) and red ripe fruits (115.56 mg/100 g).

Balasubramanian *et al.* (1991) tried different levels of potassium (0, 35, 70 and 105 kg ha^{-1}) in chili on sandy clay soil at Madurai. Results indicated that, application of 105 kg ha^{-1} K_2O resulted in highest yield (16.26 q ha^{-1}), which was significantly superior over control (15.27 q ha^{-1}), but on par with 70 kg K_2O per ha (16.16 q ha^{-1}).

Everett and Subramanya (1983), who studied increasing N -K_2O rates on bell peppers along with plant spacing, they found that increasing N-K_2O rates had no effect on average fruit weight, yield or the number of fruit per plant.

Sundstrom *et al.* (1987) reported increased tabasco pepper red fruit yields as a result of seed treatment methods. The researchers found that plug planted pregerminated seed increased red fruit yields. Plots established by transplanting or by use of pregerminated seed produced higher total fruit yields. The study concluded that of all the seed treatment, and planting methods that were tested, crop performance of pregerminated seeds was superior.

2.2 Effect of B on growth and yield attributing characters of chili

Nawrin *et al*. (2020) carried out and experiment with treatment combination of B and VC (Vermicompost) where eight treatments with three replications were as follows: control (B and VC), VC_5 ton/ha, $B_{0.5}$ kg/ha, $B_{1.0}$ kg/ha, $B_{1.5}$ kg/ha, $B_{0.5}$ kg/ha+VC_5 ton/ha, $B_{1.0}$ kg/ha+VC_5 ton/ha, and $B_{1.5}$ kg/ha + VC_5 ton/ha. Pots were arranged in a completely randomized design (CRD). The highest leaf number was recorded 73 in $B_{0.5}$ kg/ha+VC_5 ton/ha treatment at harvest. It was found that the number of leaf significantly increased with the combined application of organic and inorganic fertilizer. Leaf area was maximum (502.53 cm^2/plant) in $B_{0.5}$ kg/ha +VC_5 ton/ha treatment. The application of vermicompost in combination with chemical fertilizer resulted in higher leaf area index.

Ashraf *et al*. (2020) Plant height (cm) represents the growth rate of hot pepper as it is one of the main growth contributing factors. The characteristic affiliated with this trait (plant height) are which denoted significant difference among plant height of all treatments. It was observed that treatment T_9 ($ZnSO_4$ + B_2O_3 @1.0 + 0.8g/L of water respectively) increased plant height up to 76.183cm which was maximum while control treatment T_0 produced plants with plant height of 57.847cm. Therefore, it was observed that there was a great variation among most of the treatments in term of plant height (cm) which would be very beneficial for vegetable growers. Hot pepper plants with more plant height (cm) produces more flowers; thus ultimately producing more yield per plant. Therefore, peasants growing pepper crop would apply dose of Zinc and Boron (T_9) which would increase plant height (cm) up to maximum.

Shil *et al*. (2013) applied Zinc and Boron on chili crop in addition to NPK application and observed increase in fruit length which interestingly supported to my results fruit length (cm) expresses marketability rate of hot pepper fruit as it is a main yield contributing factor. The consequences related to this trait (fruit length) which described significant difference among fruit length of all treatments. It was observed that treatment T_8 produced pepper fruits with maximum fruit length of 12.49 cm while treatment T_0 produced fruits with minimum fruit length of 7.82 cm. Generally, it was found that three treatments produced fruits having length less than 10 cm fruit length while remaining treatments produced fruits with fruit length greater than 10 cm and less than 12.50 cm.

Naga-Sivaiah *et al*. (2013); Manna (2013) and Ali *et al*. (2015) observed increase in fruit yield per plant with the application of Zinc and Boron on different crop. Hence, their findings added a support in my results obtained for this trait Average fruit yield (g) data were significantly analyzed. Significant variability was observed for this trait (fruit yield) among all the treatments. Results showed that maximum fruit yield obtained was 1113 g while minimum fruit yield obtained was 826.25 g. However, treatment T_8 gave maximum fruit yield of 1113 g while treatment T_0 gave minimum fruit yield of 826.25 g under these climatic conditions. Therefore, peasants growing pepper crop would apply dose of Zinc and Boron (T_8) which would increase fruit yield (g) up to maximum.

Jeyakumar and Balamohan (2007) applied Zinc in Zinc deficient soil and observed that Zinc deficiency in soil is responsible for plant stunted growth with less stem thickness and less number of leaves per plant.

El-Mohsen *et al*. (2007) applied Zinc and Boron @ 1g/L on chilli crop in foliar form and found the increase in plant height and number of leaves per plant. Moreover, research findings of Baloch *et al*., (2008) in case of plant height supported to my results. This denoted significant difference among number of branches per plant of all treatments. It was observed that treatment T_8 ($ZnSO_4$ + B_2O_3 @ 0.75 + 0.6 g/L of water respectively) increased number of branches up to 36 branches per plant which was maximum while control treatment T_0 produced 19 branches per plant which was less than all treatments. Hence, it was observed that there was a great variation among most of the treatments in term of number of branches per plant which would be very beneficial for vegetable growers. Hot pepper plants with more branches produces more flowers; thus ultimately producing more yield per plant.

Natesh *et al*. (2005) applied 0.1% dose of Zinc and Boron on chili crop and observed a tremendous increase in seeds per fruit. Average number of seeds per fruit data was significantly analyzed. Significant variability was observed for this trait (number of seeds) among all the treatments Results showed that maximum number of seeds per fruit obtained were 158.25 while minimum number of seeds per fruit obtained was 103.25. On general basis it was estimated that number of seeds of seven treatments was found more than 120 seeds per fruit while remaining treatments produced fruits with number of seeds less than 120 seeds per fruit. However, treatment T_9 gave highest number of seeds 158.25 per fruit while treatment T_0 gave minimum number of seeds 103.25 seeds per fruit under given climatic conditions. Hence their findings are according to findings of my trial. Sultana *et al.* (2016) results related to this trial also resembles to my findings.

Harris *et al*. (2018) carried out an experiment where the treatments were laid out in a Completely Randomized Design (CRD) and replicated four times. All the agronomic practices were carried out in accordance with Department of Agriculture, Sri Lanka. Maximum plant height (98 cm), number of branches (18 plant^{-1}), number of leaves (25 plant^{-1}), number of flowers (29 plant^{-1}), total dry weight (66 plant^{-1}), number of fruits (24 plant^{-1}), and unripe fruit yield (333 plant^{-1}) were observed with the foliar application of Boron (H_3BO_3) +Magnesium ($MgSO_4.7H_2O$) at 100 ppm and minimum was found in the control treatment. Foliar application of Boron (H_3BO_3) + Magnesium ($MgSO_4.7H_2O$) at 100 ppm increased yield by three-fold than that of control treatment. Plant height was significantly different at different stages of growth. At 2 weeks after transplanting (WAT) the highest plant height was obtained at T_8 and T_9 followed by T_6 and then by T_2 and T_3, respectively and the lowest plant height was obtained at T_0. At 5 WAT, maximum plant height was recorded in T_8 followed by T_9 and T_6, respectively. At 7 WAT, highest plant height was attained in T_8 followed by T_9 and the T_6. In all stages, plant height was the highest at T_8 and lowest was with the control treatment (T_0). The chilli crop that was supplied with combined application of B and Mg at the rate of 100 (24 fruits) and 150 ppm (22 fruits) produced maximum number of fruits plant^{-1} followed by combined application of B and Mg at the rate of 50 ppm (19 fruits) and Mg at the rate of 50 ppm 100 ppm (18 fruits). However, a minimum number of fruits plant^{-1} was recorded in the control plants

Venkatramana (2012) noticed that foliar application of 1% $MgSO_4$ and 0.5% Borax increased the yield in pepper. This was due to the fact that boron was needed for vegetative growth and it had a great contribution in increasing the flower production and retention, elongation of pollen tube and germination and seed and fruit setting and development

Kavvadias *et al*. (2012) reported that the foliar application of Boron concentration in fruits of that treatment was increased in both cultivation years compared to most of the applied treatments. Foliar application of B at flowering, fruit set, and fruit growth, primarily in 11 combinations with foliar calcium (Ca) application, showed fruits to be less affected by cracking over all treatments.

Saleem *et al*. (2011) studied Boron is unique, not only in its chemical properties, but also in its roles in biology. Normal healthy plant growth requires a continuous supply of B, once it is taken up and used in the plant; it is not translocated from old to new tissue. That is why, deficiency symptoms starts with the youngest growing tissues. Therefore, adequate B supply is necessary for obtaining high yields and good quality yield of agricultural crops.

Khayyat *et al*. (2007) conducted an experiment on chili and found that the highest yield was obtained with the foliar spray of H_3BO_3 (1500 ppm) which is fifteen times (15) greater than the concentration used in this experiment.

Govindan (1952) conducted an experiment and found that the highest dry yield (917, 933 and 933 kg/ha for the first, second and third year, respectively) was obtained with 2.0 kg B/ha, which was significantly higher over control and the highest dose (3.0 kg B/ha) but at par with immediate lower dose (1.0 kg B/ha). Three years' mean yield varied from 759.0 to 927.7 kg/ha where the highest result was estimated with 2.0 kg B/ha and the lowest in boron control. As a result, boron contributed yield benefit over control by 20.9, 22.2 and 13.0 % for 1.0, 2.0 and 3.0 kg B/ha, respectively. These findings revealed that 1.0-2.0 kg B/ha are sufficient enough for maximizing the yield of chili.

The literature stated above indicates that numerous work in the K and B in chili has been done across the world. Nevertheless research is limited in Bangladesh content as far as chili is concerned. Thus, the prevailing situation justifies a study of examining the effect of K and B application on chili in dddition to N, P, S and Zn supplement in soil.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

This chapter describes the materials and methods of this research work. It includes the experimental site, experimental period, climatic condition, land preparation, experimental design and layout, treatments, intercultural operations, data collection, preparation and chemical analysis of soil along with statistical analysis.

3.1 Experimental site

The experiment was done at Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during Rabi season in 2019-2020. The experimental location situated at $23^{0}77$ N and $90^{0}33$ E longitudes with an elevation of 1 meter from sea level. The map (Appendix I) shows specific location of experimental site.

3.2 Description of soil

Soil of the experimented field belongs to the Tejgaon series under the agro-ecological zone, AEZ-28 (Madhupur Tract). General soil type is deep red brown terrace Soils. The morphological characteristics of the experimental field and initial physical and chemical characteristics of the soil are presented in Tables 1, 2 and 3, respectively.

Table 1 Morphological characteristics of experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University
AEZ No. and name	AEZ-28, Madhupur Tract
General soil type	Shallow Red Brown Terrace Soil
Soil series	Tejgaon
Topography	Fairly leveled
Depth of inundation	Above flood level
Drainage condition	Well drained
Land type	Medium high land

Table 2 Physical properties of the initial soil of the experimental field

Physical properties	Values
%Sand (2-0.02 mm)	42%
%Silt (0.02-0.002 mm)	45%
%Clay (<0.002 mm)	13%
Textural Class	Silty clay loam
Particle density	2.60 g cc^{-1}

Table 3 Chemical characteristics of the initial soil of the experimental field

Chemical properties	Values
pH	5.8
Organic carbon (%)	0.649
Organic Matter (%)	1.124
Total N (%)	0.091
Available P (ppm)	10.4
Available S (ppm)	14.7

3.3 Description of chili variety

Chili (cv. BARI Morich -1) was used as experimental material developed by Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh. Plant type is dwarf and spreading (55-60), plant height 30-35cm, number of fruits/plant 400-500, length of fruit 5.5-6.5 cm, width of fruit 2.5-3.5cm, fruit weight 1.5-2.0g, fresh yield/plant 700-750g, number of seeds/fruit 70-75, hotness: hot.

3.4 Climate

The experiment was carried out in the month of October 2019 to April 2020. The monthly average minimum to maximum temperature and relative humidity during the crop period was 16.8°C to 22.5°C and 57% to 76%, respectively. The monthly average rainfall was 1-37 mm. Details of the metrological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment were noted from the Bangladesh Meteorological Department, Sher-e-Bangla Nagar, Dhaka and are presented in Appendix II.

3.5 Seedbed preparation

Seedbed was prepared by repeated ploughing on 1st October 2019 for raising seedlings of green chili ploughed. Seeds were soaked in water for 24 hours to break dormancy. Weeds, stubbles and dead roots were removed from the seedbed. Cowdung was applied to the prepared seedbed @ 10 t/ha. The soil was treated by Sevin 50WP @ 5 kg ha^{-1} to protect the young plants from the attack of ants and cutworms. Seeds were treated by Vitavex-200 @ 5 g kg^{-1} seeds to protect some seed borne diseases such as leaf spot, blight, anthracnose, etc. Seeds were sown in lines and after sowing, the whole seedbed was covered with straw. Watering was done at alternate days.

3.6 Preparation of the land

The selected plot was opened for conducting the experiment in the first week of November 2019, with a power tiller and left exposed to the sun for a week to kill soil borne pathogens and soil inhabitant insects. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. Weeds, crop residues and stubbles were removed from the field. The basal dose of manure and fertilizers were applied at the final ploughing. The plots were prepared according to design and layout of the experiment. The soil of the plot was treated by Sevin 50WP @ 5 kg ha^{-1} to protect the young plants from the attack of ants and cutworm.

3.7 Treatment combinations

The experiment consists of 2 factors K and B. They were used at the following rates.

Rate of Potassium (K):	Rate of Boron (B):
K_0: 0 kg K ha^{-1}	**B_0:** 0 kg B ha^{-1}
K_1: 75 kg K ha^{-1}	**B_1:** 1.5 kg B ha^{-1}
K_2: 100 kg K ha^{-1}	**B_2:** 3 kg B ha^{-1}

Combination of treatments

Three doses of potassium fertilizer with three doses of boron fertilizer made 9 treatment combinations. Treatment combinations are as follows-

K_0B_0= Control(No K and B);
K_0B_1= 0 kg K ha^{-1} + 1.5 kg B ha^{-1};
K_0B_2= 0 kg K ha^{-1} + 3 kg B ha^{-1};
K_1B_0= 75 kg K ha^{-1} + 0 kg B ha^{-1};
K_1B_1= 75 kg K ha^{-1} + 1.5 kg B ha^{-1};
K_1B_2= 75 kg K ha^{-1} + 3 kg B ha^{-1};
K_2B_0= 100 kg K ha^{-1} + 0 kg B ha^{-1};
K_2B_1= 100 kg K ha^{-1} + 1.5 kg B ha^{-1};
K_2B_2= 100 kg K ha^{-1} + 3 kg B ha^{-1}

3.8 Experimental design and layout

Field preparation was done after final land preparation. The entire experimental plot was divided into 3 blocks and each block contained 9 plots of 3m x 1.5m size, giving 27 unit plots.

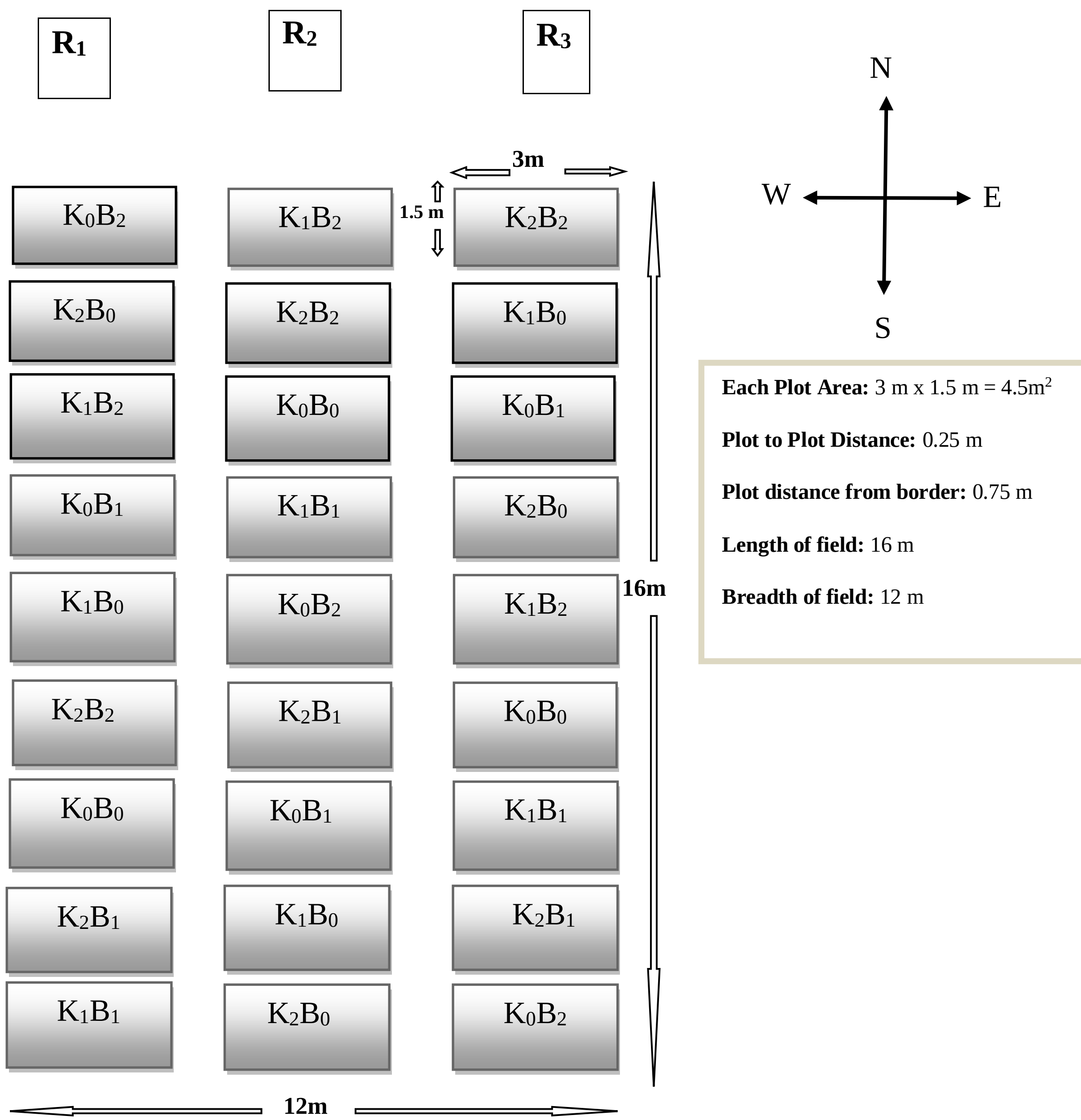

Figure 3.1 Layout of experimental plot

3.9. Application of fertilizers

Recommended doses of N, P, S and Zn (120 kg N, 50 kg P, 20 kg S and 3 kg Zn ha^{-1}, respectively) were applied to all plots. The MoP (as per treatment), TSP, Gypsum, Zinc Sulphate mono hydrate, Boric acid (as per treatment) and half of the recommended dose of urea fertilizer were applied as basal dose during final land preparation for the application of K, P, S, Zn, B and N, respectively. The remaining half of urea was top dressed after 22 days of transplanting.

3.10 Raising of seedlings

Light watering and weeding were done several times as per needed. No chemical fertilizers were applied for rising of seedlings. Seedlings were not attacked by any kind of insect or disease.

3.11 Transplanting

Healthy 30 days old chili seedlings were transplanted in the experimental plots on the 1st November, 2019. The seedlings were uprooted carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the seed beds were watered one hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were transplanted in the plot with maintaining distance the row to row and plant to plant spacing were 35 cm and 50 cm, respectively and total 12 plants were accommodated in each plot. A number of seedlings were also planted in the border of the experimental plots for gap filling.

3.12 Intercultural operation

After raising seedlings, various intercultural operations, such as gap filling, weeding, stacking, earthing up, irrigation, pest and disease control etc. were practiced for better growth and development of the chili seedlings.

3.13 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. Few seedlings were damaged after transplanting due to the bad weather condition during transplanting period and such seedlings were replaced by new seedlings from the same stock. Seedling planted earlier on the border of the experimental plots same as planting time. The seedlings were transplanted with a big mass of soil with roots in order to minimize transplanting shock. Replacement was done with healthy seedlings. The transplants were given shading and watering for 7 days for their proper establishment.

3.14 Weeding and thinning

Weeds of different types were controlled manually and removed from the field. The weeding and thinning were done after 25 days after sowing, on December 23, 2019. Care was taken to maintain constant plant population (12 plants) per plot.

3.15 Irrigation

Light watering was given by a watering cane at every morning and afternoon for 7 days. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings. Flood irrigation was done during the fruiting stage and drainage was done when required.

3.16 Pest Management

To protect the plant from the infested cutworm at the seedling stage application of Dursban-25EC @ 2.5ml Litre^{-1} was done twice on December 30, 2019 and January 15, 2020. Intensive care was taken to protect the crop from birds especially after sowing and germination stages by covering the field with a net.

3.17 Harvesting

The harvesting of crop was done several times but 1st harvesting was done on 15 March, 2020. The harvested crop of each individual plot was collected separately. Fruit yields were recorded plot wise and the yields were expressed in ton ha^{-1}.

3.18 Collection of sample

Samples were collected from different places of each plot. 5 plants from each plot were selected as samples.

3.19 Collection of data

Five (5) plants were randomly selected for data collection from the middle rows of each unit plot for avoiding border effect, except yields of fruits, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth, yield attributes and yields.

Data were collected on the following parameters:

1. Plant height (cm)
2. Number of leaves plant^{-1}
3. Number of primary branches plant^{-1}
4. Number of flowers plant^{-1}
5. Number of fruits plant^{-1}
6. Fruit length (cm)
7. Weight of fruits plant^{-1} (g)
8. Yield (g plot^{-1})
9. Yield (t ha^{-1})

3.19.1 Plant height

The plant height was measured from the ground level to the top of the plant. Five plants were selected randomly from each plot at harvesting stage. Plant height was measured and averaged.

3.19.2 Number of leaves plant^{-1}

Numbers of leaves were counted at harvesting stage. Five plants were selected randomly from each plot and number of leaves were counted and averaged.

3.19.3 Number of primary branches plant^{-1}

Five plants were selected randomly from each plot at harvesting stage. Number of primary branches were counted and averaged for each plot.

3.19.4 Number of flowers plant^{-1}

Flowers were counted at the flowering stage. Five plants were selected randomly from each plot. Number of flowers were counted and averaged for each plot.

3.19.5 Number of fruits plant^{-1}

Five plants were selected randomly from each plot. At first, number of fruits plant^{-1} were counted and averaged for each plot. Then it was multiplied with number of fruits plant^{-1} and averaged.

3.19.6 Fruit length

The length of fruit was measured with a measuring scale from the neck of the fruit to the bottom of 5 randomly selected marketable fruits from each plot and their average was taken and expressed in cm.

3.19.7 Weight of fruits plant^{-1} (g)

Five plants are selected randomly weight of fruit was measured and averaged for per plant.

3.19.8 Yield (g/plot)

Five plants are selected randomly and average yield per plant was measured in gram unit.

3.19.9 Yield (t ha^{-1})

The yield per hectare was calculated from per plot yield data and their average was taken. It was measured by the following formula,

$$\text{Yield per hectare (ton)} = \frac{\text{Yield plot}^{-1} \times 10000}{\text{Area of plot in m}^2 \times 1000}$$

3.20 Chemical analysis of the post harvest soil samples

3.20.1 Nitrogen

Soil samples were digested with 30% H_2O_2, cone. H_2SO_4 and a catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Selenium powder in the ratio 100: 10: 1, respectively) for the determination of total nitrogen by Micro-Kjeldal method. Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate absorbed in H_3BO_3 with 0.01N H_2SO_4 until the color change from green to pink (Jackson, 1965).

The total nitrogen was calculated with following formula

$$\% N = (T-B) \times N \times 0.014 \times 100/S$$

Where,

T = Sample titration value (ml) of standard H_2SO_4

B = Blank titration value (ml) of standard H_2SO_4

N = Normality of H_2SO_4

S = Sample weight in gram

3.20.2 Available Phosphorous

Phosphorous extracted by 0.5M $NaHCO_3$ solutions (Olsen *et al.*, 1954) and determined by spectrophotometer.

3.20.3 Available Sulphur

Sulphur content was extracted from soil by 0.15% Cacl2 solution and then it was determined by turbid metric method using a Spectrophotometer (LKB Novaspec, 4049)

3.20.4 Soil pH

Soil pH was determined by pH meter in a soil-water mixture of 2.5:1 ration.

3.20.5 Organic Carbon

Organic carbon in soil was determined by wet oxidation method of Walkley and Black (1934). The underlying principle is to oxidize the organic matter with an excess of N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1N $FeSO_4$ solution. To obtain the organic matter content, the amount of organic carbon was multiplied by the Van Bemmelen factor, 1.73. The result was expressed in percentage.

3.21 Statistical analysis

The data found from the experiment were analyzed statistically by MSTAT-C to find out the significance of the difference among the treatments. The significance of the differences among pairs of treatments was estimated by the DMRT (Duncan's Multiple Range Test) test at 5% and 1% level of probability.

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

This chapter presents results and discussion of the experiment which aimed at evaluating the effect of different rates of K and B application of Chili (cv. BARI Morich 1). The results were presented under different sub headings such as different plant growth, yield contributing characters and yield and chemical characteristics of the post harvest soil.

4.1 Effects of K and B on the growth parameter of chili

4.1.1 Plant Height

Effect of K on plant height of chili

Different K levels show insignificant variation on plant height of chili (Table 4.1a). This insignificant variation was observed on the plant height of chili when the field was fertilized with 3 levels of K dose (e.g. 0, 75 and 100 kg K ha^{-1}). Among the different K doses, K_2 (100 kg K ha^{-1}) showed the highest plant height (31.0 cm) at harvesting period. On the other hand, the lowest plant height (27.8 cm) was observed in the K_0 (Control) treatment where no K was applied. Golcz *et al*. (2012) found similar experimental findings in chili by application of potassium nitrate as a source of K in soil.

Effect of B on plant height of chili

Plant height shows insignificant variation among the different levels of B treatments (0, 1.5, and 3 kg B ha^{-1}) were applied (Table 4.1b). Among the B doses, B_2 (3 kg B ha^{-1}) showed the highest plant height (30.5 cm). The lowest plant height (27.8 cm) was observed in the treatment B_0 (Control) where no B fertilizer was applied. Similar findings of increase in plant height due to the application of boron were also reported. Shnain *et al.* (2014) found increased plant height in pepper due to the foliar application of boron @ 75 ppm on chili plants.

Combined effects of K and B on plant height of chili

Combined application of different doses of K and B fertilizers had no significant effect on the plant height of chili (Figure 4.1.1). The lowest plant height (24.17 cm) was observed in the treatment combination of K_0B_1 (0 kg K ha^{-1} + 1.5 kg B ha^{-1}). On the other hand, the highest plant height (33.03 cm) was recorded with K_1B_1 (75 kg K ha^{-1} + 1.5 kg B ha^{-1}) treatment. On the contrary Ashraf *et al.* (2020) observed significant difference in plant height of chili due to B fertilizer in combination with Zn fertilizer.

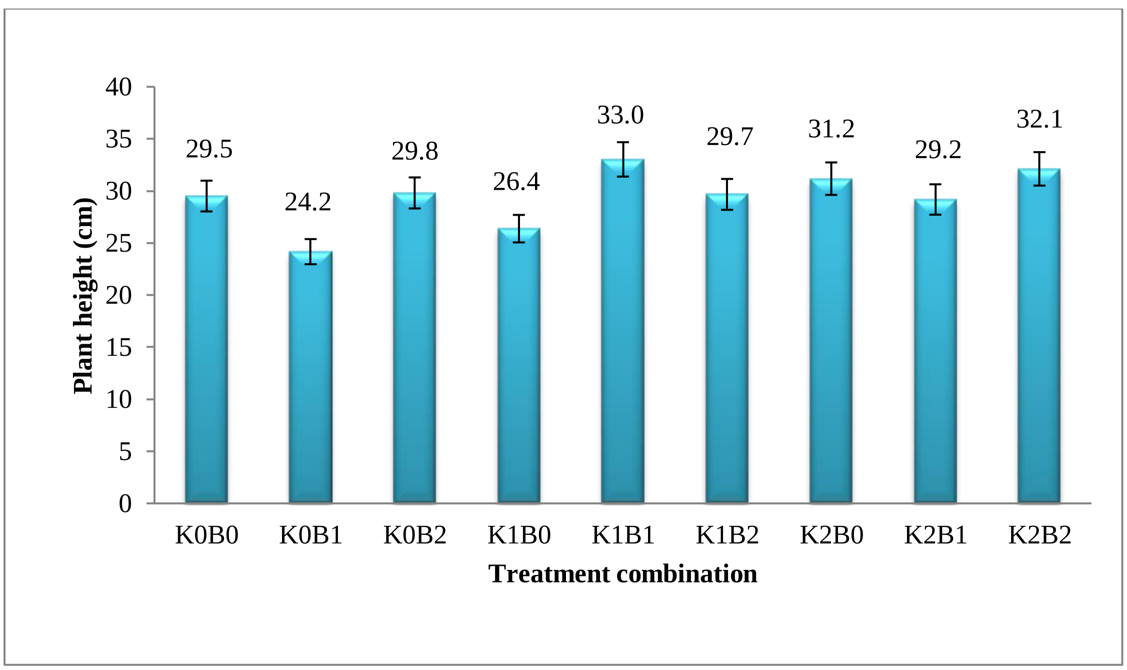

Figure 4.1.1 Combined effects of K and B on the plant height of chili

K_0B_0= Control (No K and B); **K_0B_1**= 0 kg K ha^{-1} + 1.5 kg B ha^{-1}; **K_0B_2**= 0 kg K ha^{-1} + 3 kg B ha^{-1} **;** **K_1B_0**= 75 kg K ha^{-1} + 0 kg B ha^{-1} ; **K_1B_1**= 75 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_1B_2**= 75 kg K ha^{-1}+ 3 kg B ha^{-1}; **K_2B_0**= 100 kg K ha^{-1}+ 0 kg B ha^{-1} ; **K_2B_1**= 100 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_2B_2**= 100 kg K ha^{-1}+ 3 kg B ha^{-1}

4.1.2 Number of leaves plant^{-1}

Effect of K on the number of leaves plant $^{-1}$ of chili

The maximum number of leaves plant^{-1} (44.1) was observed in K_2 (100 kg K ha^{-1}) treatment which shows significant variation (40.0) from K_1 (75 kg K ha^{-1}) treatment (Table 4.1a). The lowest number of leaves plant^{-1} (37.3) was noted in the K_0 (control) treatment. El-Bassiony et al. (2010) observed the maximum number of leaves plant^{-1} treated with potassium of 200 kg/fed.

Table 4.1a Effects of K on plant height, number of leaves and number of branches plant^{-1} of chili

Treatment (K dose)	Plant height (cm)	Number of leaves/ Plant	Number of branches/ Plant
K_0	27.8	37.322a	6.211a
K_1	29.7	40.044a	6.344a
K_2	31.0	44.144a	7.489a
SE (±)	1.66	1.87	0.30
CV (%)	16.91	13.84	13.57
Level of Significance	NS	*	*

SE (±) = Standard Error; CV (%) = Co–efficient of variation and * & **= Significant at 5% and 1% level of probability, respectively.

K_0: 0 kg K ha^{-1}; **K_1:** 75 kg K ha^{-1}; **K_2:** 100 kg K ha^{-1}

Effect of B on number of leaves plant $^{-1}$ of chili

The application of different levels of B produced significant variation among the treatments (Table 4.1b). The maximum number of leaves per plant (46.1) was recorded in B_2 (3 kg B ha^{-1}) which was statistically significant (39.29) with B_1 (3 kg B ha^{-1}) treatments. It was also observed that the minimum number of leaves per plant (36.1) was recorded (B_0) where no B was applied. Harris *et al.*, (2018) observed a significant effect of foliar application of boron on the number of leaves $plant^{-1}$.

Combined effects of K and B on the number of leaves $plant^{-1}$ of chili

The number of leaves plant $^{-1}$ of chili varied significantly with the combined effects of K and B fertilizer (Figure 4.1.2). The highest number of leaves plant $^{-1}$ (50.9) was recorded with the treatment combination of K_2B_2 (100 kg K ha^{-1}+ 3 kg B ha^{-1}) which was statistically similar with the other treatment combination except K_1B_0 (75 kg K ha^{-1} + 0 kg B ha^{-1}), K_0B_1 (0 kg K ha^{-1} + 1.5 kg B ha^{-1}) and K_0B_0 (control). The lowest number of leaves $plant^{-1}$ (30.53) was observed in K_0B_0 (Control). It was also observed that the increasing dose of K and B combination treatment results increasing the number of leaves $plant^{-1}$ of chili.

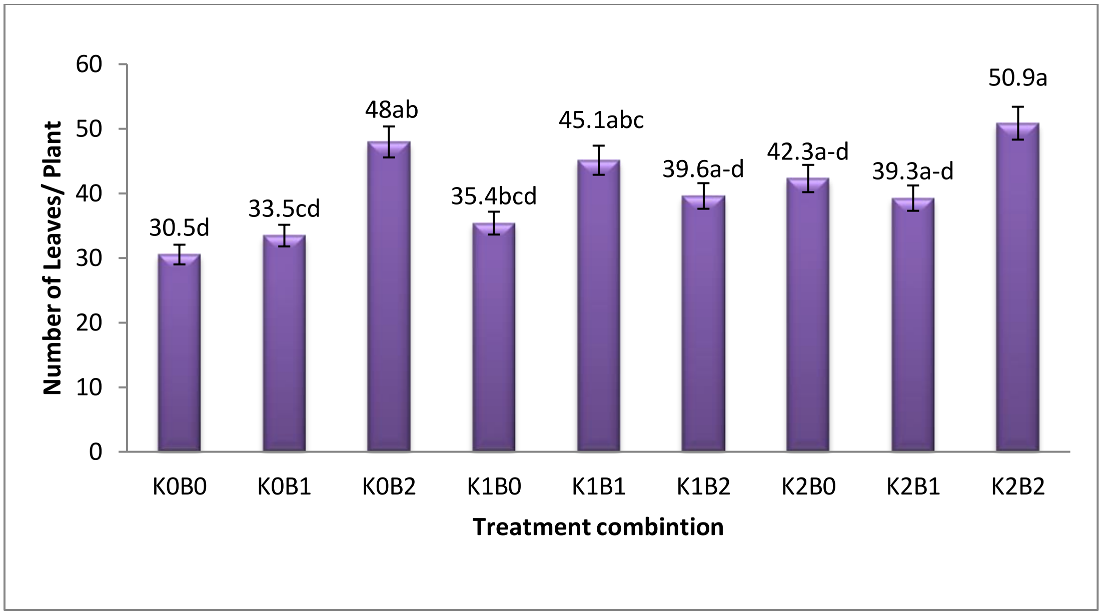

Figure 4.1.2 Combined effects of K and B on the number of leaves plant $^{-1}$ of chili

K_0B_0= Control (No K and B); **K_0B_1**= 0 kg K ha^{-1} + 1.5 kg B ha^{-1}; **K_0B_2**= 0 kg K ha^{-1} + 3 kg B ha^{-1} **;** **K_1B_0**= 75 kg K ha^{-1} + 0 kg B ha^{-1} ; **K_1B_1**= 75 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_1B_2**= 75 kg K ha^{-1}+ 3 kg B ha^{-1}; **K_2B_0**= 100 kg K ha^{-1}+ 0 kg B ha^{-1} ; **K_2B_1**= 100 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_2B_2**= 100 kg K ha^{-1}+ 3 kg B ha^{-1}

4.1.3 Number of Branches Plant^{-1}

Effect of K on the number of branches plant^{-1} of chili

Significant variation was observed on number of branches on plant^{-1} when different dose of K fertilizer was applied (Table 4.1a). Among the different doses of K, K_2 (100 kg K ha^{-1}) showed the highest number of branches plant^{-1} (7.5) which was statistically similar with other treatments.

Effect of B on the number of branches plant^{-1} of chili

In the number of branches plant^{-1} of chili significant variation was observed when three levels of B were applied (Table 4.1b). The highest number of branches plant^{-1} (7.71) was recorded in B_2 (3 kg B ha^{-1}) treatment which was statistically different with both B_1 (1.5 kg B ha^{-1}) and K_0B_0 (Control) treatments. In B_0 treatment lower number of branches plant^{-1} (6.1) was observed. Baloch *et al.* (2008) in case of branches per plant supported to my results.

Table 4.1b Effect of B on plant height, number of leaves and number of branches plant^{-1} of chili

Treatment (B dose)	**Plant height (cm)**	**Number of leaves/ Plant**	**Number of branches/ Plant**
B_0	29.24	36.08a	6.10a
B_1	28.80	39.29a	6.23a
B_2	30.54	46.14b	7.71b
SE (±)	1.66	1.87	0.30
CV (%)	16.91	13.84	13.57
Level of Significance	NS	**	**

SE (±) = Standard Error; CV (%) = Co–efficient of variation and * & **= Significant at 5% and 1% level of probability, respectively.

B_0: 0 kg B ha^{-1}; **B_1:** 1.5 kg B ha^{-1}; **B_2**: 3 kg B ha^{-1}

Combined effects of K and B on the number of branches plant^{-1} of chili

No significant variation was observed in the combined application of different doses of K and B fertilizers on the number of branches plant^{-1} of chili which was recorded in figure 4.1.3. The maximum number of branches plant^{-1} (9.2) was recorded with the treatment combination of K_2B_2 (100 kg K ha^{-1}+ 3 kg B ha^{-1}). On the other hand, the lowest number of branches plant^{-1} (5.33) was found in K_0B_0 treatment (control treatment).

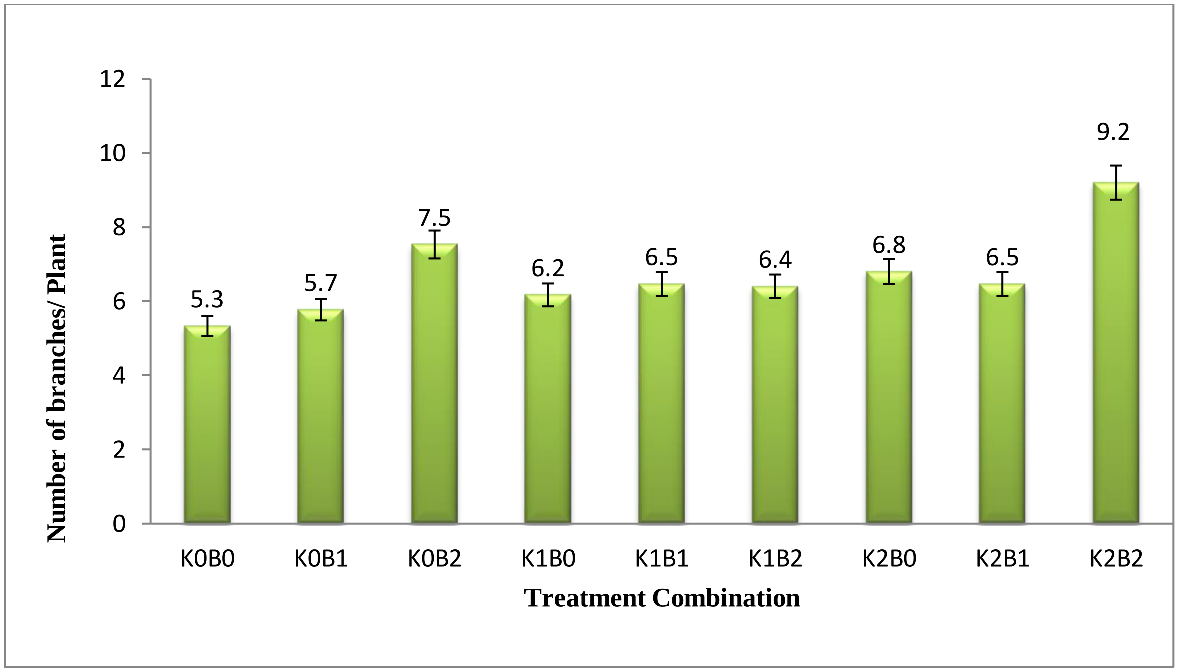

Figure 4.1.3 Combined effects of K and B on the number of branches plant^{-1} of chili

K_0B_0= Control (No K and B); **K_0B_1**= 0 kg K ha^{-1} + 1.5 kg B ha^{-1}; **K_0B_2**= 0 kg K ha^{-1} + 3 kg B ha^{-1} **;** **K_1B_0**= 75 kg K ha^{-1} + 0 kg B ha^{-1} ; **K_1B_1**= 75 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_1B_2**= 75 kg K ha^{-1}+ 3 kg B ha^{-1}; **K_2B_0**= 100 kg K ha^{-1}+ 0 kg B ha^{-1} ; **K_2B_1**= 100 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_2B_2**= 100 kg K ha^{-1}+ 3 kg B ha^{-1}

4.2 Effects of K and B on yield contributing character of chili

4.2.1 Number of Flowers Plant^{-1}

Effect of K on the number of flowers plant^{-1} of chili

A significant variation was observed in respect of the number of flowers plant^{-1} by the application of different levels of K (Table 4.2a). Among the different doses of K fertilizers, K_2 (100 kg K ha^{-1}) showed the highest number of flowers (108.9) which was significantly different (98.9) from K_1 (75 kg K ha^{-1}) treatment. The lowest number of flowers (89.6) was observed with K_0 (control) where no K fertilizer was applied.

Effect of B on the number of flowers plant^{-1} of chili

Significant variations were found in respect of the number of flowers plant^{-1} due to the application of different doses of B (Table 4.2b). The highest number of flowers plant^{-1} (104.69) was recorded in B_0 (control) treatment. On the other hand, the lowest number of flowers plant^{-1} (91.8) was recorded in the B_1 (1.5 kg B ha^{-1}) treatment. Venkatramana (2012) observed that the foliar application of 1% $MgSO_4$ and 0.5% Borax increased the yield in pepper.

Combined effects of K and B on the number of flowers plant^{-1} of chili

The number of flowers plant^{-1} of chili showed no significant variation when different doses of K and B were applied (Figure 4.2.1). The highest number of flowers plant^{-1} (119.1) was recorded in K_2B_0 (100 kg K ha^{-1}+ 0 kg B ha^{-1}). The lowest flower number plant^{-1} (89.3) was recorded in the K_0B_0 treatment where no K and B were applied. Kavvadias *et al.*, (2012) reported that the foliar application of boron increased flowering in combinations with calcium (Ca) application.

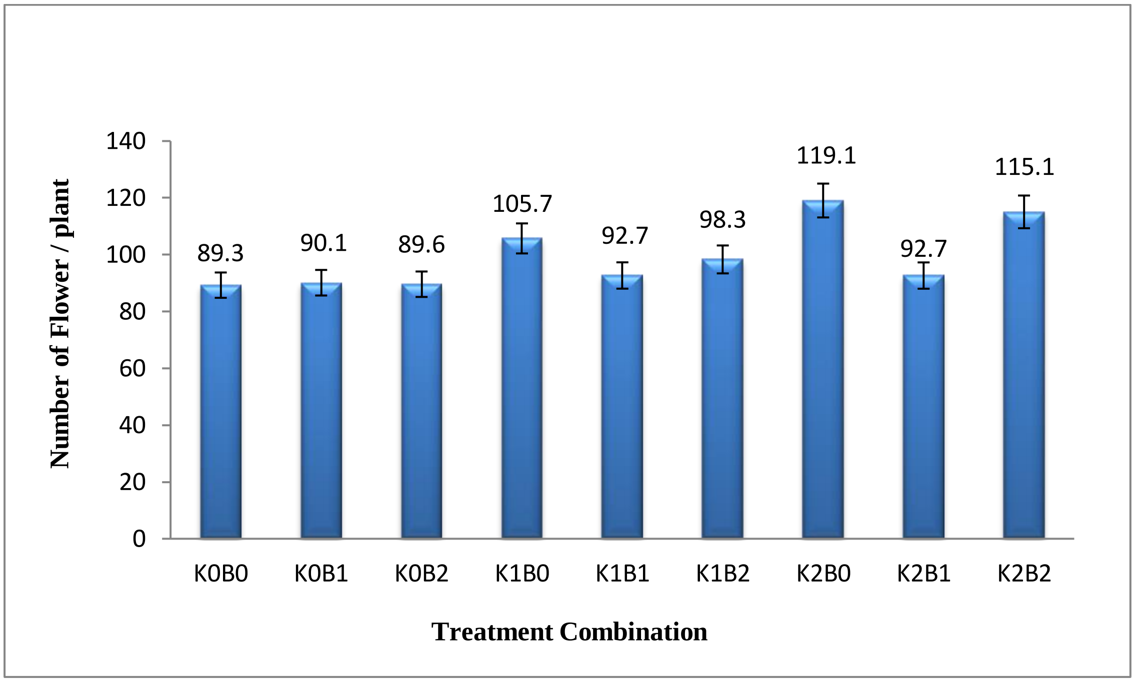

Figure 4.2.1 Combined effects of K and B on the number of flowers plant^{-1} of chili

K_0B_0= Control (No K and B); **K_0B_1**= 0 kg K ha^{-1} + 1.5 kg B ha^{-1}; **K_0B_2**= 0 kg K ha^{-1} + 3 kg B ha^{-1} **;** **K_1B_0**= 75 kg K ha^{-1} + 0 kg B ha^{-1} ; **K_1B_1**= 75 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_1B_2**= 75 kg K ha^{-1}+ 3 kg B ha^{-1}; **K_2B_0**= 100 kg K ha^{-1}+ 0 kg B ha^{-1} ; **K_2B_1**= 100 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_2B_2**= 100 kg K ha^{-1}+ 3 kg B ha^{-1}

4.2.2 Number of Fruits Plant^{-1}

Effect of K on the number of Fruits plant $^{-1}$ of chili

Application of K fertilizers at different doses showed significant variation on the number of fruits plant $^{-1}$ of chili (Table 4.2a). Among the different K fertilizer doses, K_2 (100 kg K ha^{-1}) showed the maximum fruit number plant^{-1} (100.5) which was statistically different with K_0 (70.7) treatment but statistically similar (95.5) with K_1 (75 kg K ha^{-1}) treatment. The lowest fruit number plant $^{-1}$ was recorded in the K_0 (control) treatment where no K was applied. Ananthi et al. (2004) found better performance of potassium in irrigated chili.

Effect of B on the number of fruits plant^{-1} of chili

Significant variation was not found in respect of the number of fruits plant $^{-1}$ of chili as affected by different doses of B (Table 4.2b). Among the different doses of B the maximum fruit number plant^{-1} (91.2) was observed in B_2 (3 kg B ha^{-1}) treatment which was statistically similar (90.3) with B_1 (1.5 kg B ha^{-1}) treatment. The lowest fruit number plant^{-1} (85.2) was recorded in the B_0 (control) treatment which was also statistically similar with both two treatments.

Table 4.2a Effect of K on number of flowers, number of fruits, weight of fruit and fruit length plant^{-1} of chili

Treatment (K Dose)	**Number of flowers / Plant**	**Number of fruits/ Plant**	**Weight of fruit/ Plant**	**Fruit length(cm)**
K_0	89.67b	70.67b	168.27b	6.05
K_1	98.91ab	95.52a	211.04a	6.30
K_2	108.93a	100.47a	201.53a	6.29
SE (±)	2.745	1.744	5.400	0.113
CV (%)	8.30	5.86	8.37	5.45
Level of Significance	**	**	**	NS

SE (±) = Standard Error; CV (%) = Co–efficient of variation and * & **= Significant at 5% and 1% level of probability, respectively.

K_0: 0 kg K ha^{-1}; **K_1**: 75 kg K ha^{-1}; **K_2**: 100 kg K ha^{-1}

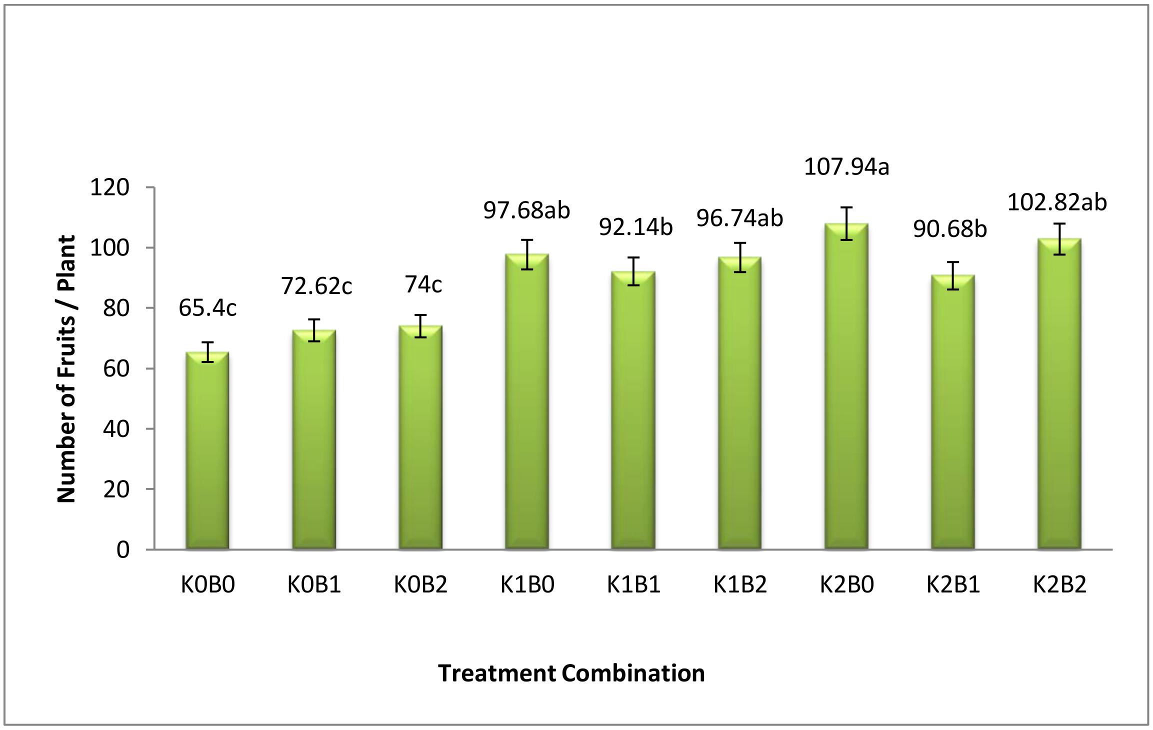

Figure 4.2.2 Combined effect of K and B on the number of fruits plant $^{-1}$ of chili

K_0B_0= Control (No K and B); **K_0B_1**= 0 kg K ha^{-1} + 1.5 kg B ha^{-1}; **K_0B_2**= 0 kg K ha^{-1} + 3 kg B ha^{-1} **;** **K_1B_0**= 75 kg K ha^{-1} + 0 kg B ha^{-1} ; **K_1B_1**= 75 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_1B_2**= 75 kg K ha^{-1}+ 3 kg B ha^{-1}; **K_2B_0**= 100 kg K ha^{-1}+ 0 kg B ha^{-1}; **K_2B_1**= 100 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_2B_2**= 100 kg K ha^{-1}+ 3 kg B ha^{-}

Combined effect of K and B on the number of fruits plant $^{-1}$ of chili

Combined effect of different doses of K and B fertilizers on number of fruits plant^{-1} showed a statistically significant variation (Figure 4.2.2). The highest fruit number plant^{-1} (107.9) was recorded in the treatment combination K_2B_0 (100 kg K ha^{-1}+ 0 kg B ha^{-1}). K_2B_2 (100 kg K ha^{-1} + 3 kg B ha^{-1}) combination gave second highest fruit number (102.8) which was statistically similar (97.7) and (96.7) with treatment combination K_1B_0 (75 kg

K ha^{-1} + 0 kg B ha^{-1}) and K_1B_2 (75 kg K ha^{-1}+ 3 kg B ha^{-1}) respectively. On the other hand, the lowest fruit number (65.4) was found in K_0B_0 treatment (control).

4.2.3 Weight of fruit Plant^{-1}

Effect of K on the weight of fruit of chili

Different doses of K fertilizers showed significant variations in respect of weight of fruit of chili (Table 4.2a). Among the different doses of K fertilizers, K_1 showed the highest fruit weight plant^{-1} (211g) which was statistically similar with K_2 (201.5g) but statistically different with K_0 (168.3g) where no K was applied. Ananthi *et al.*, (2004) also observed increased fruit weight with incremental doses of potassium. The highest fruit weight was recorded that received 150 per cent RDK through SOP.

Table 4.2b Effect of B on number of flowers, number of fruits, weight of fruit and fruit length plant^{-1} of chili

Treatment (B dose)	Number of flowers / Plant	Number of fruits/ Plant	Weight of fruit/ Plant (g)	Fruit length(cm)
B_0	104.7a	90.3a	185.3b	5.6b
B_1	91.8c	85.2b	186.9b	6.6a
B_2	101.0b	91.2a	208.8a	6.5a
SE (±)	2.45	1.74	5.40	0.11
CV (%)	8.30	5.86	8.37	5.45
Level of Significance	*	*	*	**

SE (±) = Standard Error; CV (%) = Co–efficient of variation and * & **= Significant at 5% and 1% level of probability, respectively.

B_0: 0 kg B ha^{-1}; **B_1**: 1.5 kg B ha^{-1}; **B_2:** 3 kg B ha^{-1}

Effect of B on weight of fruit of chili

Significant variation was noticed on weight of fruit of chili when different doses of B were applied (Table 4.2b). The highest fruit weight (208.76 g) was recorded in B_2 (3 kg B ha^{-1}) treatment. On the other hand, the lowest fruit weight (185.28 g) was recorded in the B_0 treatment where no B was applied. And all the treatments were statistically similar to each other. Harris *et al.,* (2018) found increased dry matter production of chili with the application of boron along with magnesium.

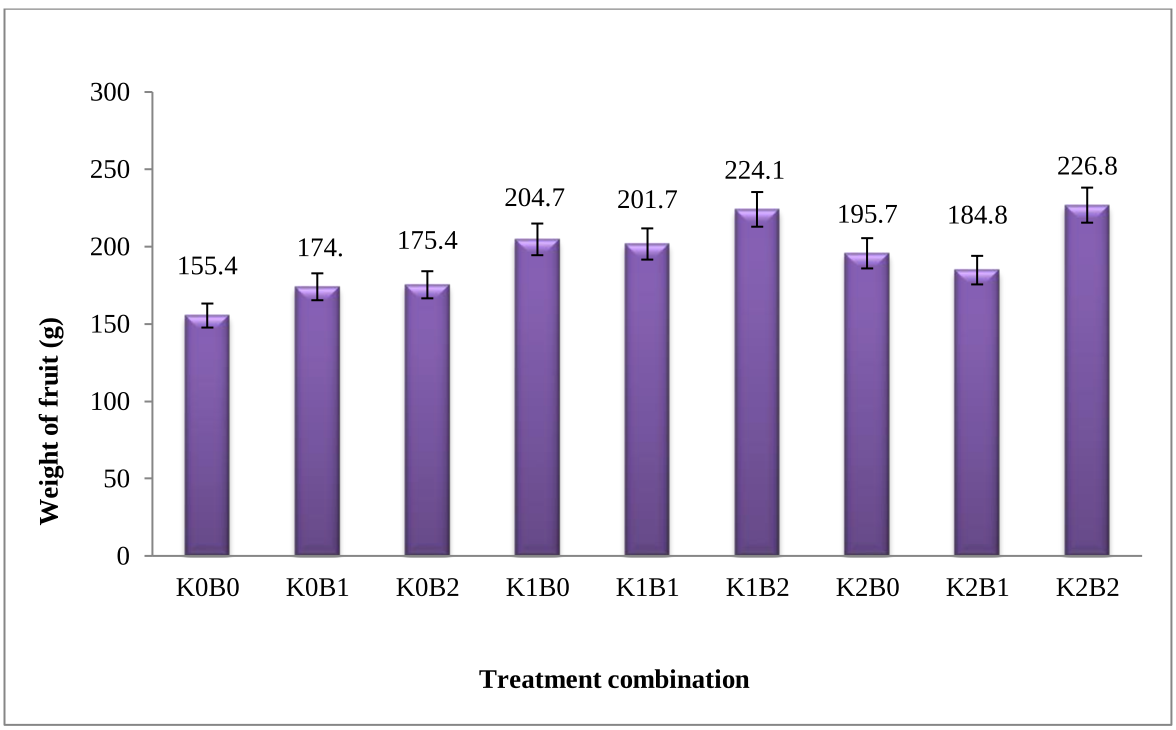

Figure 4.2.3 Combined effect of K and B on the weight of fruits of chili

K_0B_0= Control (No K and B); **K_0B_1**= 0 kg K ha^{-1} + 1.5 kg B ha^{-1}; **K_0B_2**= 0 kg K ha^{-1} + 3 kg B ha^{-1} **;** **K_1B_0**= 75 kg K ha^{-1} + 0 kg B ha^{-1} ; **K_1B_1**= 75 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_1B_2**= 75 kg K ha^{-1}+ 3 kg B ha^{-1}; **K_2B_0**= 100 kg K ha^{-1}+ 0 kg B ha^{-1} ; **K_2B_1**= 100 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_2B_2**= 100 kg K ha^{-1}+ 3 kg B ha^{-1}

Combined effects of K and B on the weight of fruit plant^{-1} of chili

The combined effect of different doses of K and B fertilizers on weight of fruit showed insignificant variation among the individual (Table 4.2b). The highest fruit weight (226.833 g) was recorded in the treatment combination K_1B_2 (75 kg K ha^{-1}+ 3 kg B ha^{-1}). On the other hand, the lowest fruit weight (155.433 g) was found in K_0B_0 (control) treatment.

4.2.4 Fruit length of chili

Effect of K on the fruit length of chili

There is no significant variation was found on the fruit length of chili due to application of different doses of K (Table 4.2). Among the different K fertilizer doses, K_1 showed the highest fruit length (6.3 cm). The lowest fruit length (6.1 cm) was recorded in the K_0 (control) treatment where no K was applied. Shankar and Sumangala (2005) found higher yield of chili where K was applied @50 kg ha^{-1}.

Effect of B on the fruit length plant^{-1} of chili

The fruit length as affected by different doses of B showed significant variation (Table 4.2b). Among the different doses of B the highest fruit length (6.5 cm) was observed in B_2 (3 kg B ha^{-1}) treatment which was statistically similar (6.6 cm) with B_1 (1.5 kg B ha^{-1}) treatment. The lowest length of fruit (5.6 cm) was observed B_0 (Control) treatment. Shil *et al*., (2013) observed increase in fruit length due to the application of zinc and boron which supported to my results.

Combined effect of K and B on the fruit length plant^{-1} of chili

Combined effect of different doses of K and B fertilizers on fruit length showed no significant variation compare with control (Figure 4.2.4). The highest fruit length (6.7 cm) was recorded in the treatment combination of K_1B_1 (75 kg K ha^{-1}+ 1.5 kg B ha^{-1}) which were statistically similar (6.6) to treatment combination K_2B_1 (100 kg K ha^{-1}+ 1.5 kg B ha^{-1}). The lowest fruit length (5.2 cm) was found in K_0B_0 treatment (control).

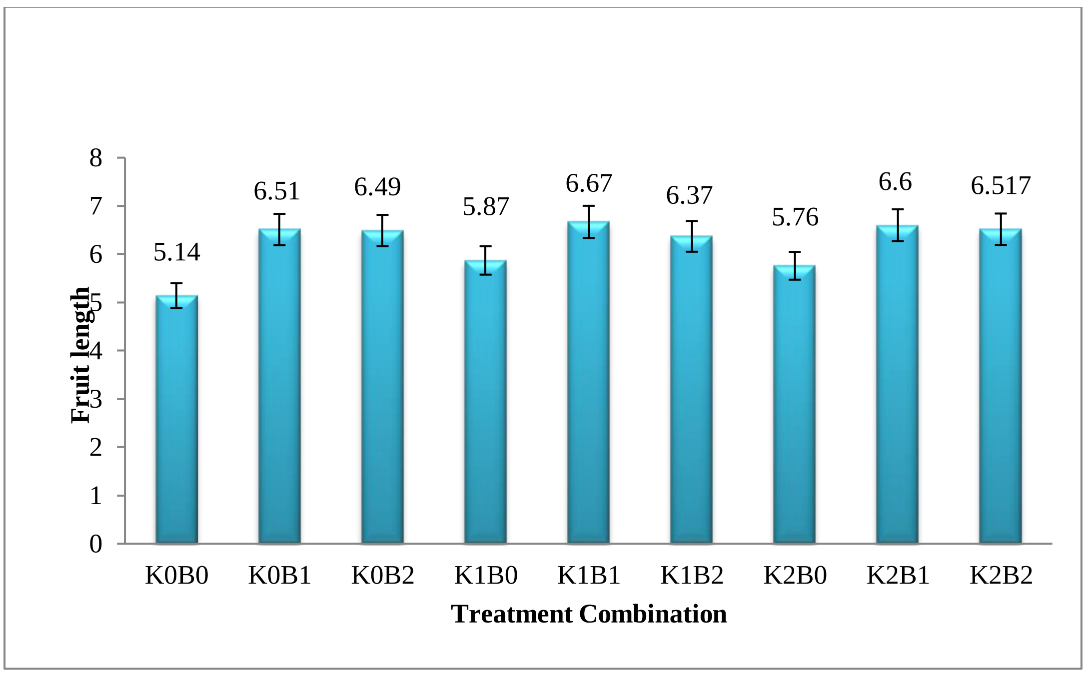

Figure 4.2.4 Combined effect of K and B on the fruit length plant^{-1} of chili

K_0B_0= Control (No K and B); **K_0B_1**= 0 kg K ha^{-1} + 1.5 kg B ha^{-1}; **K_0B_2**= 0 kg K ha^{-1} + 3 kg B ha^{-1} **; K_1B_0**= 75 kg K ha^{-1} + 0 kg B ha^{-1} ; **K_1B_1**= 75 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_1B_2**= 75 kg K ha^{-1}+ 3 kg B ha^{-1}; **K_2B_0**= 100 kg K ha^{-1}+ 0 kg B ha^{-1} ; **K_2B_1**= 100 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_2B_2**= 100 kg K ha^{-1}+ 3 kg B ha^{-1}

4.3 Effect of K and B on yield of chili

4.3.1 Effect of K on the yield(t ha^{-1}) of chili

. Application of K fertilizers at different doses showed significant variation on the yield of chili (Table 4.3a). Among the different K fertilizer doses, K_2 (100 kg K ha^{-1}) showed the highest yield (9.6 t ha^{-1}). The lowest yield (6.6 t ha^{-1}) was recorded in the K_0 (Control) treatment where no K was applied. Khan *et al.* (2014) reported that highest yield was obtained from the application of potassium @ 50 kg K ha^{-1}

Table 4.3a Effect of K on the yield of chili

Treatments	**Yield (t ha^{-1})**
K_0	6.6b
K_1	9a
K_2	9.6a
SE (±)	0.1
CV (%)	9.1
Level of Significance	**

SE (±) = Standard Error; CV (%) = Co–efficient of variation and * & **= Significant at 5% and 1% level of probability, respectively.

K_0: 0 kg K ha^{-1}; **K_1:** 75 kg K ha^{-1}; **K_2:** 100 kg K ha^{-1}

Effect of B on the yield (t ha^{-1}) of chili

The yield affected by different doses of B showed no significant variation (Table 4.3b). Among the different doses of B, the highest yield (9.2 t ha^{-1}) was observed in B_2 (3 kg B ha^{-1}) treatment and the lowest yield (8 t ha^{-1}) was observed B_1 (1.5 kg B ha^{-1}) treatment. All the treatments were statistically similar to each other. Saleem *et al.*, (2011) studied Boron is unique, not only in its chemical properties, but also in its roles in biology. Normal healthy plant growth requires a continuous supply of B, once it is taken up and used in the plant; it is not translocated from old to new tissue. That is why, deficiency symptoms starts with the youngest growing tissues. Therefore, adequate B supply is necessary for obtaining high yields and good quality yield of agriculture crops.

Table 4.3b Effect of B on the yield of chili

Treatments	**Yield (t ha^{-1})**
B_0	8
B_1	7.8
B_2	9.2
SE (±)	0.1
CV (%)	9.1
Level of Significance	NS

SE (±) = Standard Error; CV (%) = Co–efficient of variation and * & **= Significant at 5% and 1% level of probability, respectively.

B_0: 0 kg B ha^{-1}; **B_1**: 1.5 kg B ha^{-1}; **B_2:** 3 kg B ha^{-1}

Combined effect of K and B on the yield (t ha^{-1}) of chili

Combined effect of different doses of K and B fertilizers a statistically significant variation was observed in yield compare with control (Table 4.3c). The highest yield (10.74 t ha^{-1}) was recorded in the treatment combination of K_1B_2 (75 kg K ha^{-1}+ 3 kg B ha^{-1}) which was statistically similar (10.72 t ha^{-1}) in K_2B_2 (100 kg K ha^{-1}+ 3 kg B ha^{-1}) treatment combinations. The lowest yield (6.16 t ha^{-1}) was found in K_0B_0 treatment (control).

Table 4.3.c Combined effect of K and B on the yield of chili

Treatment Combinations	Yield (t ha^{-1})
K_0B_0	6.16d
K_0B_1	7.24cd
K_0B_2	6.12d
K_1B_0	7.88cd
K_1B_1	8.18bc
K_1B_2	10.74a
K_2B_0	9.9ab
K_2B_1	8.1c
K_2B_2	10.72a
SE (±)	0.219
CV (%)	9.10
Level of Significance	*

SE (±) = Standard Error; CV (%) = Co–efficient of variation and * & **= Significant at 5% and 1% level of probability, respectively.

K_0B_0= Control (No K and B); **K_0B_1**= 0 kg K ha^{-1} + 1.5 kg B ha^{-1}; **K_0B_2**= 0 kg K ha^{-1} + 3 kg B ha^{-1} **;** **K_1B_0**= 75 kg K ha^{-1} + 0 kg B ha^{-1} ; **K_1B_1**= 75 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_1B_2**= 75 kg K ha^{-1}+ 3 kg B ha^{-1}; **K_2B_0**= 100 kg K ha^{-1}+ 0 kg B ha^{-1} ; **K_2B_1**= 100 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_2B_2**= 100 kg K ha^{-1}+ 3 kg B ha^{-1}

4.4 Effect of K and B on chemical properties and nutrient content on the post harvest soil of chili field

4.4.1. Soil Organic Matter (SOM) of post harvest soil

Effect of K on soil organic matter content of post harvest soil

There was significant variation of SOM on post harvest soil of chili field among the treatments (Table 4.4a). There was highest organic matter in post harvest soil (1.7 %) was recorded from K_2 (100 kg K ha^{-1}), on the contrary the lowest organic matter (1.4%) was observed in K_0 (Control) treatment.

Effect of B on soil organic matter content of post harvest soil

Significant variation was observed in organic matter of post harvest soil of chili field due to the different dose of B (Table 4.4b). The highest organic matter (1.6%) was recorded in treatment B_2 (3 kg B ha^{-1}) and whereas the lowest organic matter (1.4%) was obtained from the treatment B_0 (Control).

Combined effect of K and B on soil organic matter content of post harvest soil

Combined effect of different doses of K and B fertilizers organic matter of soil showed a statistically significant variation compare with control (Table 4.4c). The highest organic matter (1.8 %) was obtained in the treatment combination of K_2B_1 (100 kg K ha^{-1} + 1.5 kg

B ha^{-1}) which was statistically dissimilar other treatment combinations. The lowest organic matter (1.1%) was found in K_0B_0 treatment combination (control).

4.4.2. Total N content of post harvest soil

Effect of K on total N content of post harvest soil

There was significant variation of N on post harvest soil of chili field among the treatments (Table 4.4a). There was highest total N content in post harvest soil (0.12%) was recorded from K_2 (100 kg K ha^{-1}), whereas lowest N content (0.09%) was observed in K_0 (Control) treatment.

Effect of B on total N content of post harvest soil

Significant variation was observed in total N of post harvest soil of chili field due to the different dose of B (Table 4.4b). The highest total N (0.13%) was recorded in treatment B_2 (3 kg B ha^{-1}) and on the contrary the lowest total N (0.09%) was obtained from the treatment B_0 (Control).

Combined effect of K and B on total N content of post harvest soil

Combined effect of different doses of K and B fertilizers in the field showed a statistically significant variation in total N compare with control (Table 4.4c). The highest total N (0.15%) was obtained in the treatment combination of K_2B_2 (100 kg K ha^{-1} + 3 kg B ha^{-1}) which was statistically dissimilar other treatment combinations. The lowest total N (0.08%) was found in K_0B_0 treatment combination (control).

Table 4.4a Effect of K on the chemical components of post harvest soil

Treatments	SOM (%)	Total N (%)	Available S (ppm)	Available P
K_0	1.36c	0.09c	12.37c	10.69a
K_1	1.50b	0.11b	17.02a	10.29b
K_2	1.61a	0.13a	14.88b	10.02b
CV (%)	0.27	1.01	0.82	1.49
SE (±)	0.0013	0.0004	0.0404	0.0514
Level of Significance	**	**	**	**

SE (±) = Standard Error; CV (%) = Co–efficient of variation and * & **= Significant at 5% and 1% level of probability, respectively.

K_0: 0 kg K ha^{-1}; **K_1:** 75 kg K ha^{-1}; **K_2:** 100 kg K ha^{-1}

4.4.3 Available S of post harvest soil

Effect of K on available S of post harvest soil

Significant variation was observed in available S on post harvest soil of chili field due to the application of different levels of K (Table 4.4a). There was highest available S in post harvest soil (17.02 ppm) was recorded from K_1 (75 kg K ha^{-1}) which was statically dissimilar (14.88 ppm) with K_2 (100 kg K ha^{-1}), on the contrary the lowest available S (12.35 ppm) was observed in K_0 (Control) treatment.

Effect of B on available S of post harvest soil

Significant variation was observed in available S of post harvest soil of chili field due to the different dose of B (Table 4.4b). The highest available S (19.94 ppm) was recorded in treatment B_1 (1.5 B ha^{-1}) and whereas the lowest available S (11.74 ppm) was obtained from the treatment B_0 (Control).

Table 4.4b Effect of B on the chemical components of post harvest soil

Treatments	SOM	Total N (%)	Available S (ppm)	Available P
B_0	1.361c	0.090c	11.737c	9.602c
B_1	1.542b	0.111b	19.942a	10.869a
B2	1.565a	0.128a	12.589b	10.519b
CV (%)	0.27	1.01	0.82	1.49
SE (±)	0.0013	0.0004	0.0404	0.0514
Level of Significance	**	**	**	**

SE (±) = Standard Error; CV (%) = Co–efficient of variation and * & **= Significant at 5% and 1% level of probability, respectively.

B_0: 0 kg B ha^{-1}; **B_1**: 1.5 kg B ha^{-1}; **B_2:** 3 kg B ha^{-1}

Combined effect of K and B on available S of post harvest soil

Combined effect of different doses of K and B fertilizers of soil showed a statistically significant variation in available S compared with control (Table 4.4c). The highest available S (23.72 ppm) was obtained in the treatment combination of K_2B_1 (100 kg K ha^{-1} + 1.5 kg B ha^{-1}) which was statistically dissimilar other treatment combinations. The lowest available S (10.25 ppm) was found in K_0B_2 (0 kg K ha^{-1} + 3 kg B ha^{-1}) treatment combination

4.4.4. Available P of post harvest soil

Effect of K on Available P of post harvest soil

There was significant variation of available P of post harvest soil among the treatments of K (Table 4.4a). There was highest available P in post harvest soil (10.69 ppm) was recorded from K_0 where no K fertilizer was applied and the lowest available P (10.02 ppm) was observed in K_2 (100 kg K ha^{-1}) treatment which is statistically similar (10.28 ppm) with K_1 (75 kg K ha^{-1}) treatment.

Effect of B on available P of post harvest soil

Significant variation was observed in available S of post harvest soil of chili field due to the different dose of B (Table 4.4b). The highest available P (10.87 ppm) was recorded in treatment B_1 (1.5 kg B ha^{-1}) which was statistically dissimilar (10.52 ppm) with the treatment B_2 (3 kg B ha^{-1}). The lowest available P (9.60 ppm) was obtained from the treatment B_0 where no B fertilizer was applied.

Combined effect of K and B on available P of post harvest soil

Combined effect of different doses of K and B fertilizers showed a statistically significant variation on available P compared with control (Table 4.4c). The highest available P (11.787 ppm) was obtained in the treatment combination of K_1B_1 (75 kg K ha^{-1} + 1.5 kg B ha^{-1}) which was statistically dissimilar other treatment combinations. The lowest available P (8.46 ppm) was found in K_1B_0 (75 kg K ha^{-1} + 0 kg B ha^{-1}) treatment combination.

Table 4.4c Combined effect of K and B on the chemical components of post harvest soil

Treatment Combinations	SOM	Total N (%)	Available S (ppm)	Available P (ppm)
K_0B_0	1.120g	0.082f	15.087d	11.160b
K_0B_1	1.440e	0.091e	11.753f	9.610d
K_0B_2	1.520d	0.097de	10.253h	11.297b
K_1B_0	1.424f	0.104cd	21.020b	8.460e
K_1B_1	1.427f	0.124b	13.107e	11.787a
K_1B_2	1.649b	0.105c	16.920c	10.6c
K_2B_0	1.537c	0.111c	10.350gh	9.66d
K_2B_1	1.760a	0.118b	23.720a	10.737c
K_2B_2	1.526d	0.154a	10.593g	9.66d
CV (%)	0.27	1.01	0.82	1.49%
SE (±)	0.0023	0.0006	0.0699	0.0890
Level of Significance	**	**	**	**

SE (±) = Standard Error; CV (%) = Co–efficient of variation and * & **= Significant at 5% and 1% level of probability, respectively.

K_0B_0= Control (No K and B); **K_0B_1**= 0 kg K ha^{-1} + 1.5 kg B ha^{-1}; **K_0B_2**= 0 kg K ha^{-1} + 3 kg B ha^{-1} **; K_1B_0**= 75 kg K ha^{-1} + 0 kg B ha^{-1} ; **K_1B_1**= 75 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_1B_2**= 75 kg K ha^{-1}+ 3 kg B ha^{-1}; **K_2B_0**= 100 kg K ha^{-1}+ 0 kg B ha^{-1} ; **K_2B_1**= 100 kg K ha^{-1} + 1.5 kg B ha^{-1} ; **K_2B_2**= 100 kg K ha^{-1}+ 3 kg B ha^{-1}

CHAPTER 5

SUMMARY AND CONCLUSION

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A field experiment was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka (Tejgoan series under AEZ No. 28) during Rabi season in 2019 to study the Effects of potassium and boron on the growth and yield of chili (*Capsicum annuum*). The soil was loam in texture having pH 5.8. Organic matter and Organic carbon content were 1.1% and 0.6% respectively.

There were three levels of Potassium (0, 75, 100 kg ha^{-1}) and the levels of Boron (0, 1.5, 3 kg ha^{1}) in the study and these two factors (K and B) made 9 treatment combinations The experiment was carried out in Randomized Complete Block Design (RCBD) with three replications.

Recommended doses of N, P, S, Zn at the rate of 120 kg N, 50 kg P, 20 kg S, and 3 kg Zn ha^{-1} respectively were used for all plots. The K (as per treatment) and half recommended dose of urea were applied as per treatment combination after the preparation of field layout of the experimental plot and mixed properly by hand spading. For raising chili seedling a seedbed was prepared on 1st October 2019. Healthy 30 days old seedlings were transplanted in the main field on 1st November, 2019. The data was collected on the following parameters named, plant height (cm), number of leaves plant^{-1}, number of primary branches plant^{-1}, number of flowers plant^{-1}, number of fruits plant^{-1}, fruit length (cm), weight of fruits plant^{-1}(g), weight of fruits plot^{-1}, yield (g plot^{-1} or t ha^{-1}).

Soil samples before start of the experiment and after crop harvest were collected from 0-15 cm depth. Soil pH, organic matter, N, P and S were analyzed form those collected soil samples. All the data were statistically **a**nalyzed by using MSTAT-C software to find out the significant variation among the treatment combinations. The results of the experiment are stated below.

Different levels of K application had significant variation on number of leaves plant^{-1}, number of branches plant^{-1}, number of flowers plant^{-1}, number of fruits plant^{-1}, weight of fruit plant^{-1}, yield of chili. Results showed that in terms of effect, number of leaves plant^{-1} (44.1), number of branch plant^{-1} (7.5), number of flowers plant^{-1} (108.9), number of fruits plant^{-1} (100.5), weight of fruit plant^{-1} (211g) and yield (8.16 t ha^{-1}) were recorded from K_2 (100 kg K ha^{-1}). On the contrary, Plant height and fruit length remained unaffected.

Application of boron also exerted significant positive effect on the growth and yield contributing parameters of chili except plant height. It appears that in terms of B effect, number of leaves plant^{-1} (39.3), number of branch plant^{-1} (7.7), Number of fruits plant^{-1} (91.2), weight of fruit plant^{-1} (208.8 g), and yield (8.12 t ha^{-1}) were recorded from B_2 (3 kg B ha^{-1}). On the contrary, Plant height was found insignificant variation among the different level of B where the highest plant height (30.5 cm) was observed from B_2 (3 kg B ha^{-1}). On the other hand highest fruit length (6.6) was found in treatment B_1 (1.5 kg B ha^{-1}). But maximum Number of flowers (104.7) plant^{-1} was observed in B_0 (Control) treatment. That result may be found as because Boron has not such role in flowering of chili plant.

Combined effect of K and B, significant variation was also remarkable in respect of yield and yield contributing character in chili. The maximum number of leaves plant^{-1} (50.87) and branches plant^{-1} (9.2) were observed in K_2B_2 (100 kg K ha^{-1} + 3 kg B ha^{-1}) treatment combinations. Whereas, the highest number of flowers plant^{-1} (119.0) and fruits plant^{-1} (107.9) was obtained in K_2B_0 (100 kg K ha^{-1} + 0 kg B ha^{-1}) treatment combination. The maximum height of plant (33.03 cm) and fruit length (6.67 cm) were recorded in K_1B_1 (75 kg K ha^{-1} + 1.5 kg B ha^{-1}). And the highest yield (10.74 t ha^{-1}) was obtained in treatment combination K_1B_2 (75 kg K ha^{-1} + 3 kg B ha^{-1}).

Significant variation was also noticed in soil properties after crop harvest due to the application of K and B fertilizer at different level. Highest SOM (1.61% and 1.57%) total N (0.12% and 0.13%) was obtained from both K_2 (100 kg K ha^{-1}) and B_2 (3 kg B ha^{-1}) treatments respectively. Available S (17.0 ppm) and (19.94 ppm) were recorded in K_1 (75 kg K ha^{-1}) and B_1 (1.5 kg B ha^{-1}) treatments respectively. In case of available P, the highest values (10.7 ppm) and (10.9 ppm) were observed in K_0 (Control) and B_1 (1.5 kg B ha^{-1}) respectively.

Considering combined effect of K and B the maximum SOM (0.8 %) and available S (23.7 ppm) were found in K_2B_1 (100 kg K ha^{-1} + 1.5 kg B ha^{-1}) treatment combination. The highest total nitrogen (0.15%) and available P (11.8 ppm) were observed in K_2B_2 (100 kg K ha^{-1} + 3 kg B ha^{-1}) and K_1B_1 (75 kg K ha^{-1} + 1.5 kg B ha^{-1}) treatment combinations, respectively.

The results of this research work indicated that the crop performed better in respect of all field parameters due to application of K and B over the control treatment (K_0B_0). It was also observed that some of the parameters showed statistically similar results and many of the parameters showed insignificant and closest results among the treatment but yield of chili was found maximum in K_1B_2 (75 kg K ha^{-1} + 3 kg B ha^{-1}) treatment which was optimum doses of K and B treatment and that was cost effective as well than K_2B_2 (100 kg K ha^{-1} + 3 kg B ha^{-1}). So, It can be therefore, concluded from the above study that the treatment of K_1B_2 (75 kg K ha^{-1} + 3 kg B ha^{-1}) was found to a promising practice for the higher yield of chili in shallow Red Brown Terrace Soils of Bangladesh.

REFERENCES

REFERENCES

Aldana, M. E. (2005). Effect of phosphorus and potassium fertility on fruit quality and growth of Tabasco pepper (*Capsicum frutescens*) in hydroponic culture. *LSU Master's Theses*. 3356. https://digitalcommons.lsu.edu/gradschool_theses/3356.

Ali, F., Ali, A., Gul, H., Sharif, M., Sadiq, A., Ahmed, A., Ullah, A., Mahar, A., Kalhoro, S.A. (2015). Effect of boron soil application on nutrients efficiency in tobacco leaf. *American J. Plant. Sci*. **6**: 1391-1400.

Ananthi, S., Veeraragavathatham, D., Srinivasan, K. (2004). Influence of sources and levels of potassium on quality attributes of chilli (*Capsicum annuum* L.). *South Indian Hort.,* **52** : 152-157.

Ashraf, M.I., Liaqat, B., Anam ,L., Kiran, S., Asghar ,R., Shaukat , M.B., Nazar Hussain, N. (2020). Effect of foliar application of zinc and boron on growth and yield of Chilli (*Capsicum frutescens* L.) *Int. J. of Agro. and Agric. Res. (IJAAR).* 2223-7054.

Ayvaz, M., Koyuncu, M., Guven, A., Fagerstedt, K. (2012). Does boron affect hormone levels of barley cultivars? *Eurasia J. Biosci*. **6**: 113-120.

Balasubramanian, R., Balakrishnan, K. and Manoharan, S., (1991). Effect of potassium on chilli. Spice India, **4** (5): 5-6.

Baloch, Q.B., Chachar, Q.I., Tareenn, M.N., (2008). Effect of foliar application of macro and micro nutrients on production of green chilies (*Capsicum annuum* L.). J. of Agric. Sci. and Tech. **4**(2): 177-184.

BBS, (2019). Statistically Year of Bangladesh, Bangladesh Bureau of Statistics, Ministry of Planning. Government of the Peoples Republic of Bangladesh.

Benepal, P. S. 1967. Influence of micronutrients on growth and yield of potatoes. *American Pot. J*. **44**: 363-369.

Bidari, B.I., Martur, M.D. and Math, K.K., (2004), Influence of soil properties on yield and quality of chillies (*Capsicum annuum* L.) and partitioning of nutrients in fruit components. Paper presented in "Nation. Symp. on Input Use Efficiency in Agric. Issues and Strategies", *Kerala Agric. Univ., Thrissur, Kerala.*

Bose, U. .S. and Tripathi S. K. (1996). Effect of micronutrients on growth, yield and quality of tomato cv. Pusa Ruby. *Crop. Res. Hisar*. **12**(1): 61-64.

Chude, V.O., Oyinlola, E.Y., Horst, W.J., Schenk, M.K., Burkert, A. (2001). Yield and nutritional qualities of two tomato (*Lycopersicon lycopersicum* Karst) varieties as influenced by boron fertilisation in a tropical environment. Plant-nutrition. *Hannover, Germany*. **11**: 358-359. DOI: https://doi.org/10.3329/jbcbm.

Efkar, A., Jan, N., Khattak, S. G., Khattak, M.J. Ahmad, E. (1995). Potato yield as affected by boron fertilizer mixing with and without farm yard manure. *Sarhad J. Agril.* **11**(6): 725-728.

El-Bassiony A..M., Fawzy, Z. F., Abd El-Samad E.H., Riad, G.S., (2010). Growth, yield and fruit quality of sweet pepper plant (*Capsicum annuum* L.) as affected by potassium fertilization. *J Amemican Sci.* **6**: 722-729.

El-Mohsen, M.A., El-Bassiony, M., Fawzy, F., ElNemr, M.A., Shehata, S.M., (2007). Response of pepper plants (*Capsicum annuum* L.) to foliar spray with Fe, Mn and Zn. Egyptian Society for Environ. Sci. **2**(1): 1-5.

Esringü, A. , Turan, M., Gunes, A. , Eşitken, A., and Sambo, P. (2011). Boron application improves on yield and chemical composition of strawberry', Acta Agriculturae Scandinavica, *Section B - Plant Soil Sci.*, **61**: 245 – 252.

Everet, P. H., and R. Subramanya. (1983). Pepper production as influenced by plant spacing and nitrogen-potassium rates. *Proc. Fla. State Hort. Soc*., **96**: 79-82.

Fageria, n. k., baligar, v. c., clark, r. b. (2002) Micronutrients in crop production. *advances in agronomy, new york*, **77**: 189-272,.

Golcz, A., Kujawski, P., Markiewicz, B. (2012). Yielding of red pepper (*Capsicum annuum* L.) under the influence of varied potassium fertilization. *Acta Scientiarum Polonorum-Hortorum Cultus* **11**(4) : 3-15.

Govindan, P. R. 1952. Influence of boron on yield and content of carbohydrates in tomato fruits. *Curr. Sci*. **21**: 14-15

Hari, G.S.,Rao, P.V., Reddy,Y.N., Reddy, M.S. (2007). Effect of nitrogen and potassium levels on yield and nutrient uptake in Paprika (*Capsicum annuum* L.) under irrigated conditions of northern Telangana zone of Andhra Pradesh. *Asian J. Hort*., **2** (1): 193-196.

Harris, K.D., Vanajah, T., Puvanitha, S., (2018). Effect of foliar application of Boron and Magnesium on growth and yield of green chilli (*Capsicu annum* L.). AGRIEAST: *J. of Agric. Sci.*, **12**(1): 26–33. DOI: http://doi.org/10.4038/agrieast.v12i1.49.

Hatwar, G. P., Gondane, S. U., Urkude, S. M., Gahukar., O. V. (2003). Effect of micronutrients on growth and yield of chilli. *J. Soil Crops*. **13**: 123-125.

Hedge, D. M. (1997). Nutrient requirements of solanceous vegetable crops. *Extension Bulletin ASPAC, Food and Fertilizer Technology Center*, **441**, 9.

Idan, R.O., Hasaen, S. A., Sakr, M. A. (2017). effect of potassium and nitrogen on yield of pepper (*capsicum annuum* l.) cv charisma under protected cultivation. *Int. J. of Sci. & Eng. Res.* 2229-5518.

Jackson, M. L. (1965). Soil Chemical Analysis. Prentice-HallInc., New York, USA. 498 .

Jeyakumar, P., Balamohan, T.N., (2007). Micronutrients for horticultural crops. Training manual on role of balanced fertilization for horticultural crops, TNAU, Coimbatore-03.

Kaminwar, S.P. and Rajagopal, V. (1993). Fertilizer response and nutrient requirement of rainfed chillies in Andhra Pradesh. Fert. News, **36**(7): 21-26.

Kar, B., Chakradhar, P., Aditya, K. P., and Mohanty, S. K., (2016) . Effect of different levels of potassium and plant growth regulators on different yield attributes of chilli (*Capsicum annuum* L.) *Int. J. of Sci., Environment and Tech.* **5**: 3147 – 3159

Kavvadias, V., Paschalidis, C., Akrivos, Petropoulos, D., (2012). Nitrogen and potassium fertilization responses of potato *(Solanum tuberosum)* cv. *Spunta. Com. Soil Sci. Plant Anal.* **43**(1-2): 176-189. Doi: 10.1080/00103624.2012.634711.

Khan, A., , Noor, S., Shah, M., Rab, A., , Sajid, M., Ali, K., Ahmed, A., Faisal, A. (2014). Influence of nitrogen and potassium levels on growth and yield of chillies (*Capsicum annuum* L.). *Int. J. of Farming and Allied Sci.* 2322-4134.

Khan, M. S., Raj, S. K. (2003). First report of molecular detection of an Aster yellows phytoplasma (*Candidatus phytoplasma* Magdatena Vc. Salinity and nitrogen rate effects of the growth and yield of chilli pepper plants. *J. of Soil Sci.* ;**67**: 1781–1789.2.

Khayyat, M., Tafazoli, E., Eshghi, S., Rajaee, S. (2007). Effect of nitrogen, boron, potassium and zinc sprays on yield and fruit quality of date palm. *American Eurasian J. Agric. & Environ. Sciences*. **2**(3):289-96.

Lester, G.E., John, L.J., Donald, J.M. (2010). Impact of potassium nutrition on food quality of fruits and vegetables. *Better Crops* **94**: 18-21.

Majumdar, S.P., Meena, R.L., Baghel, G.D.S. (2000). Effect of levels of compaction and potassium on yield and quality of tomato and chilli crops grown on highly permeable soils. *J. Indian Soc. Soil Sci*., **48** (2): 215-220.

Manna ,D. (2013). Growth, yield and bulb quality of onion (*Allium cepa* L.) in response to foliar application of Boron and Zinc. *SAARC J. of Agric*. **11**(1): 149-153.

Marschner, H. (1995) Mineral nutrition of higher plants. 2nd Edition, *Academic Press, London*, 889 .

Medhi, R.P., Singh, B., Parthasarathy, V.A., (1990). Effect of N, P and K on chillies. *Prog. Hort.*, **22** (1-4): 173-175.

Mengel, K., Kirkby, E. A. (1980). Potassium in crop production. *Adv. Agron.* **33**:59-110.

Naga, S.K., Swain, S.K., Sandeep, V.V., Raju, B.(2013). Effect of foliar application of micronutrients on growth parameters in tomato (*Solanum lycopersicum* Mill.) *J. of Agric. and Food Sci.* ***1**(10): 146-151.*

Natesh, N., Vyakaranahal, B.S., Shekhargouda, M., Deshpande, V.K., (2010). Effect of micronutrients and organics on growth, seed yield and quality of chilli. Karnat. *J. of Agric.Sci.* **18**(2), 334-337

Nawrin, K. S., M. J. Uddin, A. H. M. Z. Ali and M. K. Rahman., (2020). Effects of boron and vermicompost on growth, yield and nutrient content of chilli (*Capsicum annum* L.). *J. biodivers. conserv. bioresour. manag.* **6**(1)

Olaniyi, J.O., Ojetayo, A.E. (2010). The effect of organmineral and inorganic fertilizers on the growth, fruit yield and quality of pepper (*Capsicum frutescence* L.). *J Anim Plant Sci* **3**: 1070-1076.

Olsen, S. R., C. V. Cole., F. S. Watanabe and L. A. Dean. (1954). Estimation of available phosphorus in soils by extraction with NaHCO3, *USDA Cir.939. Washington, United States of America.*

Ortas, I., Guzel, N., Ibrikci, H. (1999). Determination of potassium and magnesium status of soils using different soil extraction procedures in the upper part of Mesopotamia (in the Harran Plain). *Comm. Soil Sci. Plant Anal.* **30**(19-20):2607-2625.

Oseni ,T.O., Shongwe, N.S., Masarirambi, M.T. (2010). Effect of Arbuscular Mycorrhiza (AM) Inoculation on the Performance of Tomato Nursery Seedlings in Vermiculite. *Int. J. Agric. Biol.* **12**(5):789-792

Padem, H., Ocal, A. (1999). Effects of humic acid applications on yield and some characteristics of processing tomato. *Acta Hort* **487**: 159-164

Palkovics, M., Gyori, D. (1984). Trials of boron fertilization on rusty brown forest soil 50 in potatoes. Novenytermeles. **33** (3): 265-273.

Papadakis, I.E., Dimassi, K.N., Bosabalidis, A.M., Therios, I.N., Giannakoula, A. (2004). Boron toxicity in Clementine mandarin plants grafted on two rootstocks. *Plant Sci.* **166**: 539-547.

Paparnakis, A., Chatzissavvdid, C., Antoniadis, V. (2013). How apple responds to boron excess in acidic and limed soil. *J. Soil Sci. Pl. Nutr*. **7**: 787- 796

Prabhavathi, K., Bidari, B.I., Shashidhara, G.B., Mathad, J.C. (2008). Influence of sources and levels of potassium on quality attributes and nutrient composition of red chillies. *Karnataka J. Agric. Sci.*, **21** (3): 379-381.

Prince, C.A., Sanders, D.C. and Campbell, C.R., (1988), Respone of pepper to N fertilizer and N/K ratios. Proc. *4th Int. Micro. Irrig. Cong. Inst., Australia*, **2**: 478-480.

Quaggio, J. A., Ramos, V. J. (1986). Potato response to lime and boron application. *Revista Brasilerea de Ciencea do Solo*, **10** (3): 247-251.

Rawat, P. S. and K. N. Mathpal. (1984). Effect of micronutrients on yield and sugar metabolism of some of the vegetables under Kumaon hill conditions. *Sci. Cult*. **50**: 243-244.

Roychaudhury, A., Chatterjee, R., Mitra, S.K. (1995). Effect of different doses of nitrogen, phosphorus, potassium, magnesium, calcium and iron on growth and development in chilli. *Dept. of Hort. Kalyani West Bengal India*. **13**: 96-99.

Saleem, M., Khanif, Y. M., Fauziah, I., Samsuri, A. W., Hafeez, B. (2011). Importance of 51 boron for agriculture productivity: a review. *Int. Res. J. of Agric. Sci. and Soil Sci*., **1**(8): 293-300.

Shankar, M.A. and Sumangala, B.J., (2005), Response of chilli to sources and levels of potassium under rainfed conditions. Dryland. *Agri. Proj.¸Univ. Agric. Sci., GKVK, Bangalore.*

Sharma, B. R., Chadha, A. P. S., Bajpai H. K. (1996). Response of Chilli (Capsicum annum Linn.) to nitrogen and phosphorus levels under irrigated condition. *Advances in Plant Sciences*. **2**: 213-214.

Shibila Mary, S. and Balakrishnan, R., (1990), Effect of irrigation, nitrogen and potassium on pod characters and quality in chilli cv. K2. *South Indian Hor.* **38** (2): 86-89.

Shil, K. N. C., Naser, H. M., Brahma, S., Yousuf, M. N., Rashid, M. H. (2013). Response of chili (*Capsium annuum L.*) to Zinc and Boron application. *Bangladesh Agric. Res. Unit.* **38**(1): 49-59.

Shnain, R. S., Prasad, V.M. and Saravanan, S. (2014). Effect of zinc and boron on growth, yield and quality of tomato (*Lycopersicon esculentum*. Mill) cv. Heem Sohna, under protected cultivation. *European Aca. Res*., **2** (3): 45724597.

Shrivastava, A. K. (1996). Effect of fertilizer levels and spacing on flowering, fruit set and yield of sweet pepper (*Capsicum annuum* var. Grossum L.) cv. Hybrid Bharat. *Adv. Pl. Sci*., **9**: 171-175.

Shukla, V., Naik, L.B. (1993). Agro-techniques for solanaceous vegetables. In: Advances in Horticulture. *Malhotra Publishing House, New Delhi, India* **5**: 364-399.

Subhani, P.M., Ravisankar, C., Narayana, N. (1992). Effect of graded levels and time of application of N and K_2O on flowering, fruiting and yield of irrigated chilli. *India Cocoa, Arecanut and Species J* **14**(2): 70-73.

Sultana, S., Naseer, H. M., Akhter, S., Begum, R. A. (2016). Effectiveness of soil and foliar application of Zinc and Boron on thye yield of tomato. Bangla. *J. of Agric. Res.* **41**(3) : 411-418.

Sundstrom, F. J., Thomas,C.H., Edwards, R. L., Baskin, G. R. (1984). Influence of N and plant spacing on mechanically harvester tabasco pepper. *J. Amer. Soc. Hort. Sci.* **109**(5): 642645.

Suresh, V.V. (2000). Effect of nitrogen and potassium on yield and quality parameters of Byadagi chilli (*Capsicum annuum* L.). *M.Sc. (Agri.) Thesis, Univ. Agric., Sci., Dharwad (India*).

Tariq, M, Mott, C.J.B. (2006). Effect of boron supply on the uptake of micronutrients by radish (*Raphanus sativus* L.). *J. Agr. Biol. Sci.* **1**: 1-8.

Thakur, P.S., Thakur, A. and Kanaujla, S.P. (2000). Influence of bioregulators, bio-extracts and potassium on the performance of bell pepper (*Capsicum annuum*) varieties under water stress. *Indian J. Agric. Sci.* **70**: 543-545.

Uchida, R. (2000). Essential Nutrients for Plant Growth: Nutrient Functions and Deficiency Symptoms, Chapter 3, from Plant Nutrient Management in Hawaii's Soils, Approaches for Tropical and Subtropical Agriculture J. A. Silva and R. Uchida, eds. *College of Tropic. Agric. and Human Resources*, 31- 55.

Udoh, J. D., Ndoh, A. B., Asuquo, E. P. (2005). Crop production techniques for the tropics. *Concept publications.* 261–265.

Venkataramana, P. (2012). Magnesium and boron nutrition of black pepper (*Piper nigrum* L.). In laterite soils. M. Sc. Thesis. Faculty of Agriculture, Kerala Agriculture University, India.

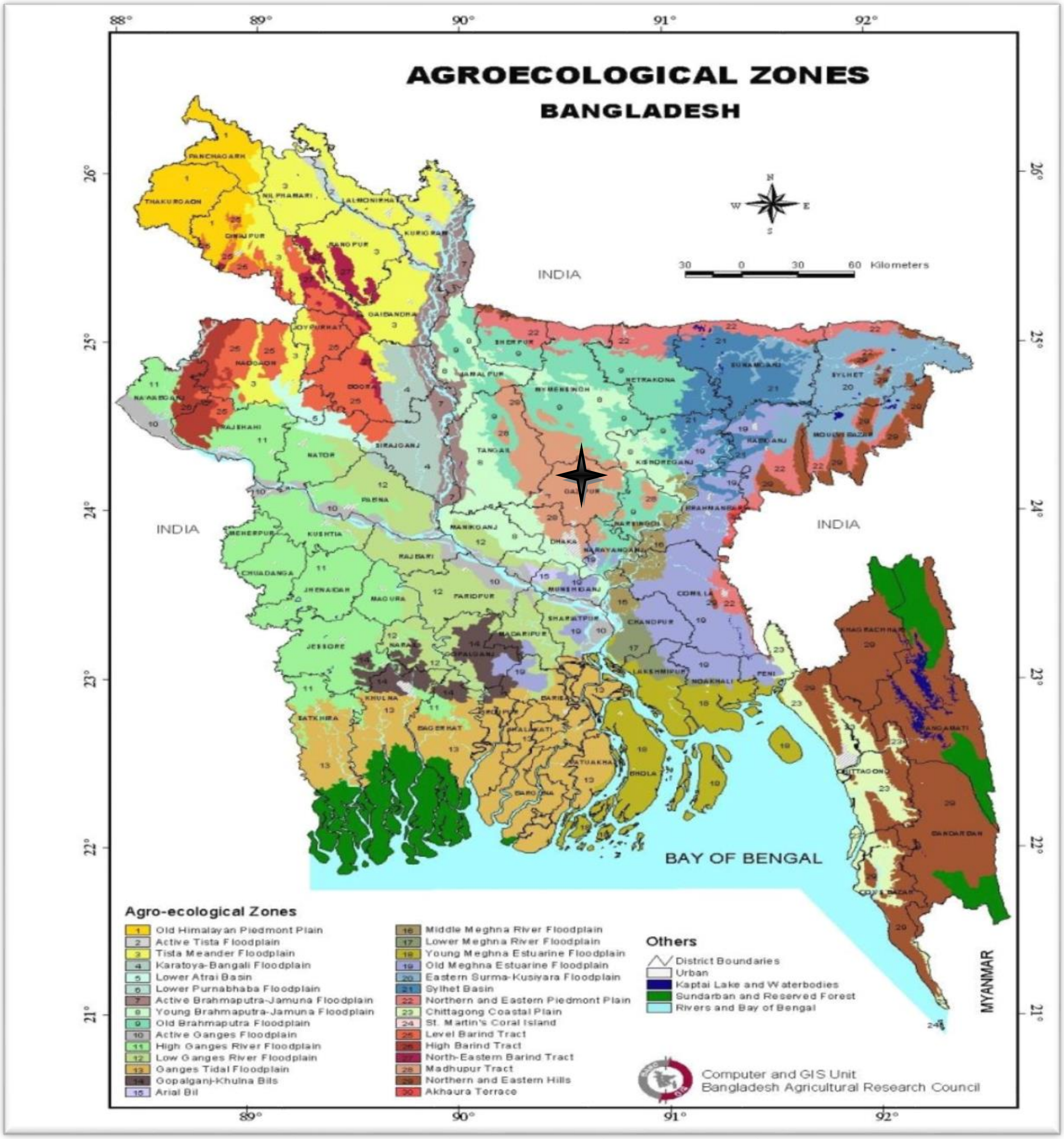
Walkley, A. and Black, I. A. (1934). An examination of the degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Sci.* **37**: 29-38.

Warrier, P.K. (1989). Spice in Ayurveda. *Indian Spices,* **26**(2): 21-23.

APPENDICES

APPENDICES

Appendix I. Experimental site at Sher-e-Bangla Agricultural University, Dhaka.



Appendix II. Record of meteorological information (Monthly) during experimental period from November 2019 to March 2020

Month	Year	Monthly average air temperature (^oC)			Average relative humidity (%)	Total rainfall (mm)	Total sunshine / hours
		Maximum	Minimum	Mean			
Nov	2019	24.9	18.5	21.7	74	37	216.4
Dec	2019	19.3	15.5	17.4	74	5	212.50
Jan	2020	18.5	15	16.8	76	21	212.50
Feb	2020	21.6	18	19.8	59	1	195.00
Mar	2020	26.4	18.5	22.45	57	30	225.50

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Combined effects of K and B on growth parameters plant height, number of branches, number of leaves, number of flowers, number of fruits/ plant, weight of fruit/ plant, fruit length and yield

Treatment Combination	Plant height (cm)	Number of leaves / plant	Number of branches / plant	Number of flowers / plant	Number of fruits / plant	Weight of fruit/ plant	Fruit length (cm)	Yield (t/ha)
K_0B_0	29.51	30.53d	5.33	89.27	65.40c	155.43	5.15	6.16c
K_0B_1	24.17	33.47cd	5.77	90.13	72.62c	174.04	6.51	7.24cd
K_0B_2	29.81	47.97ab	7.53	89.60	74.00c	175.34	6.49	6.12c
K_1B_0	26.38	35.40bcd	6.17	105.73	97.68ab	204.70	5.87	7.88bc
K_1B_1	33.03	45.13abc	6.47	92.67	92.14b	201.71	6.67	8.18b
K_1B_2	29.67	39.60abcd	6.40	98.33	96.74ab	226.83	6.37	10.74a
K_2B_0	31.81	42.30abcd	6.80	119.07	107.94a	195.70	5.76	9.9a
K_2B_1	29.18	39.27abcd	6.47	92.65	90.68b	184.80	6.60	8.1b
K_2B_2	32.13	50.87a	9.20	115.07	102.82ab	224.10	6.52	10.72a
SE (±)	2.442	3.237	0.523	4.754	3.007	9.354	0.196	0.219
CV (%)	16.91	13.84	3.57	8.30	5.86	8.37	5.45	9.10
Level of significance	NS	*	NS	NS	*	NS	NS	*

SE (±) = Standard Error; CV = Co–efficient of variation, * & **= Significant at 5% and 1% level of probability, respectively

K_0B_0= Control (No K and B)
K_0B_1= 0 kg K ha^{-1} + 1.5 kg B ha^{-1}
K_0B_2= 0 kg K ha^{-1} + 3 kg B ha^{-1}
K_1B_0= 75 kg K ha^{-1} + 0 kg B ha^{-1}
K_1B_1= 75 kg K ha^{-1} + 1.5 kg B ha^{-1}
K_1B_2= 75 kg K ha^{-1}+ 3 kg B ha^{-1}
K_2B_0= 100 kg K ha^{-1}+ 0 kg B ha^{-1}
K_2B_1= 100 kg K ha^{-1} + 1.5 kg B ha^{-1}
K_2B_2= 100 kg K ha^{-1}+ 3 kg B ha^{-1}

Appendix IV. Pictorial view of experimental plot

Experimental site of chili field

Plant during vegetative growth

Reproductive stage of chili plant

Harvested green chili

Appendix IV. Pictorial view of lab work