RESPONSE OF POTASSIUM AND BORON ON THE GROWTH AND YIELD OF ONION (BARI Peyaj-4)

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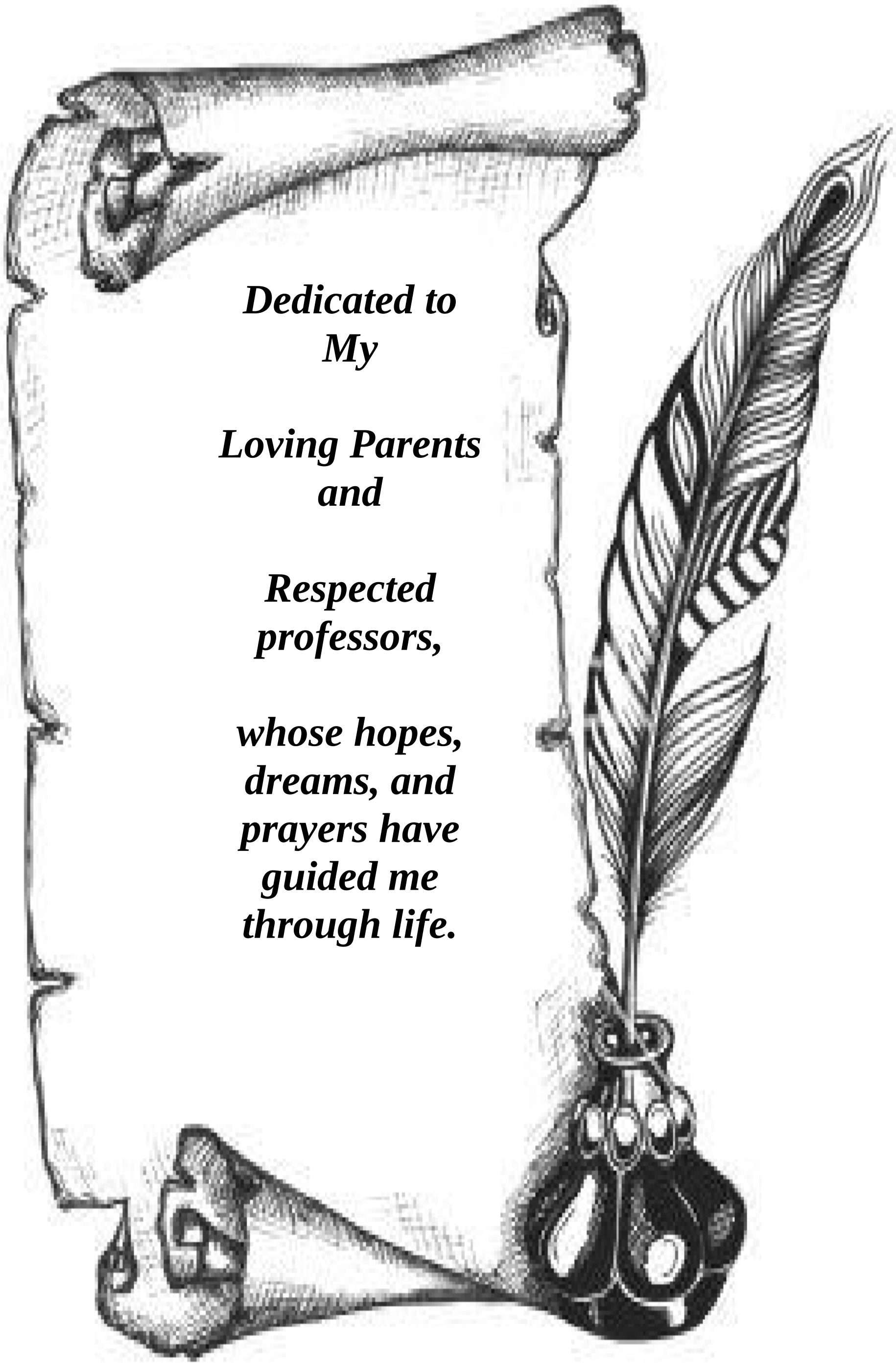

Dedicated to
My

Loving Parents
and

Respected
professors,

whose hopes,
dreams, and
prayers have
guided me
through life.

DEPARTMENT OF SOIL SCIENCE

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

*This is to certify that the thesis entitled **"RESPONSE OF POTASSIUM AND BORON ON THE GROWTH AND YIELD OF ONION(BARI Peyaj-4)"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **SOIL SCIENCE**, embodies the result of a piece of bona fide research work carried out by **SURAVY YEASMIN SETU**, Registration number: **19-10219** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:
Dhaka, Bangladesh

(Dr. Mst. Sharmin Sultana)
Associate Professor
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ABSTRACT

The experiment was conducted at the Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh from January to April 2022 to determine the effects of potassium (K) and boron (B) on the growth and yield of onion (BARI Peyaj-4). In this experiment, onion (BARI Peyaj-4) was selected as the test crop. The experiment consisted of two variables. Factor A: Potassium doses (4 levels); 0 kg potassium ha^{-1}, 60 kg potassium ha^{-1}, 90 kg potassium $ha^{-1}$and 120 kg potassium ha^{-1} and factor B (3 levels): 0 kg boron ha^{-1}, 1.0 kg boron ha^{-1}, and 2 kg boron ha^{-1}.The experiment consisted of three replications with an RCBD design. K & B combination, $B_2 \times K_3$ (2 kg boron ha^{-1} and 120 kg potassium ha^{-1}) showed the highest plant height (61.09 cm) whereas $B_0 \times K_0$ (0 kg boron ha^{-1} and 0 kg potassium ha^{-1}) showed the lowest plant height (30.30 cm), The taller plants at the highest doses received more nutrients which might have encouraged more vegetative growth. $B_2 \times K_3$ (2 kg boron $ha^{-1}$and 120 kg potassium ha^{-1}) showed the highest number of leaves of Onion (7.67) whereas $B_0 \times K_0$ (0 kg boron ha^{-1} and 0 kg potassium ha^{-1}) showed the lowest no. of leaves (4.49), $B_2 \times K_3$ (2 kg boron $ha^{-1}$and 120 kg potassium ha^{-1}) showed the highest plant height (57.82 cm) and $B_2 \times K_0$ (2 kg boron $ha^{-1}$and 0 kg potassium ha^{-1}) showed the lowest leaf length (25.52 cm). $B_2 \times K_3$ (2 kg $ha^{-1}$and 120 kg ha^{-1}) showed the highest fresh weight of leaves (55.42 cm) whereas $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1}) showed the lowest fresh weight of leaves (36.69 cm). $B_2 \times K_3$ (2 kg $ha^{-1}$and 120 kg ha^{-1}) showed the highest Diameter of the bulb (5.25 cm) whereas $B_0 \times K_1$ (0 kg ha^{-1} and 60 kg ha^{-1}) showed the lowest Diameter of the bulb (3.75 cm), The most oversized diameter of a bulb of the plant at the highest doses received more nutrients which might have encouraged more vegetative growth. $B_2 \times K_3$ (2 kg $ha^{-1}$and 120 kg ha^{-1}) showed the highest length of the bulb (5.75 cm) whereas $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1}) showed the lowest length of the bulb (3.74 cm). The interaction effect of different doses of potassium and boron showed $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}) showed the highest yield (22.41 t ha^{-1}) whereas $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1}) showed the lowest yield (13.19 t ha^{-1}) which is statistically similar to the treatment combination of $B_1 \times K_0$ (1.0kg ha^{-1} and 0 kg ha^{-1}) . The maximum yield gained at the highest doses received more nutrients which might have encouraged more vegetative growth and yield. The $B_2 \times K_2$ (2 kg B ha^{-1} and 120 kg K ha^{-1}) treatment combination showed a better response in most studied parameters.

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ABBREVIATIONS

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-banglaAgricultural University
BBS	Bangladesh Bureau of Statistics
Co	Cobalt
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAE	Department of Agricultural Extension
DAS	Days after sowing
^0C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
Max	Maximum
mg	Milligram
Min	Minimum
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
UPOV	Union for the Protection of Plant Varieties
Wt.	Weight

CHAPTER I

INTRODUCTION

The onion (*Allium cepa* L.) is one essential spice and a widely cultivated vegetable crop, particularly during the Rabi season. It is a member of the genus Allium and the family Alliaceae. Iran, Afghanistan, and mainly their northern areas are the origins of onions. China produced the most onions worldwide in 2019, followed by India and the United States (FAO, 2019). In 2019, China and India had more than 50 billion pounds of onions (FAO, 2019). The top onion-producing nations include China, India, the United States, Egypt, Turkey, Pakistan, Sudan, Bangladesh, and Iran (FAO, 2019).

To supply domestic demand, onions are farmed in all regions of Bangladesh. However, for commercial purposes, they are grown in the larger districts of Faridpur, Pabna, Rajshahi, Kushtia, Jessore, Dhaka, and Rangpur (BBS, 2011). They are producing 17.04 lakh metric tons (MT) of onions on 4.19 lakh acres of land; onions rank first in Bangladesh in terms of production and consumption among spice crops (BBS, 2015). In terms of land use and yield, onions rank second among the spices planted in Bangladesh (BBS, 2008).

From 2007-2008, Bangladesh produced 769000 metric tons of onions from 114400 hectares of land, with an average yield of 2.09 metric tons ha^{-1} (BBS, 2008). This is very small compared to onion-growing nations such as Spain, Pakistan, Australia, Korea, Japan, the United States, and Germany (FAO, 2005). Bangladesh's overall demand for onions is approximately 450 thousand metric tons, but the country only produces 153 thousand metric tons (BBS, 2008). As a result, enormous quantities of onion bulbs are imported from neighboring nations like India, Myanmar, Pakistan, and China at the expense of the nation's hard-earned foreign exchange. Due to a lack of available land, increasing the crop's horizontal production area is impossible. However, the yields can be boosted by applying the correct management measures, such as fertilizer and irrigation.

The farmers of Bangladesh employ only three primary nutrients nitrogen, phosphorus, and potassium and one secondary component, sulfur, for the cultivation of onions. The significance of micronutrient utilization is primarily disregarded, although it can be the primary limiting factor for crop output. There has been significant growth in fertilizer usage in recent years, but the production of the various nutrients used in the country is not well-balanced. Approximately 78% of the total nutrients used (Bhuiyan, 1999) are nitrogen, which may not boost crop output unless additional vital nutrients are included. To increase crop yield, the other limiting nutrient(s) must be identified, and soils should be enhanced by adding these nutrients as part of a balanced fertilization program.

Numerous physiological and biochemical functions in plants, including photosynthesis, improving the translocation of assimilates, protein synthesis, maintaining water balance, and stimulating enzyme activities, depending on the presence of potassium (K) (Marschner, 2012). It has been stated that K is crucial to onion yield and quality in a practical sense (Yadav *et al.,* 2002; Masalkar*et al.,* 2000). The crop's storage quality also depends on the bulb's K content. In onions, a K deficit manifests as brown leaf tips on older leaves and poor bulb production. Applying a sufficient amount and source of potassium to onions at critical growth phases is, therefore, essential for growth and quality maintenance (Subba and Brar, 2002).

Boron application can increase onion and garlic bulb size, the number of cloves per bulb, and crop output (Smriti *et al.,* 2002). The response of onions to zinc therapy is also observable (Lal and Maurya, 1981). Mishra *et al.* (1990) found that the application of zinc sulfate ($ZnSO_4$) (0.5%) and iron sulfate ($FeSO_4$) (1.0%) as foliar spray resulted in significantly larger plant height and other growth metrics than other treatments. In a different experiment, Matthew *et al.* (2000) found that copper (Cu), manganese (Mn), zinc (Zn), and molybdenum (Mo) reacted well to onion, whereas B responded poorly. According to Havlin*et al.* (2007), Zn, boron (B), manganese, and molybdenum displayed high sensitivity in onion production. Iron (Fe), zinc, and boron effectively boost onion CV's growth, yield, and quality. Dake*et al.* (2011) reported Balwant 780.

To collect data on the topic, a field experiment will be conducted to determine the effects of potassium and boron on onion growth and yield.

Taking into account the things that have happened, the following goals were in mind when this study was done:

i. To observe the effect of K and B on the growth and yield of onion
ii. To investigate the interaction effect of K and B on the growth and yield of onion
iii. To find out the suitable doses of K and B for maximum yield of onion

CHAPTER II

REVIEW OF LITERATURE

Several lessons on the split application of potassium and boron and a restricted investigation with varying Potash and boron levels on the performance of diverse crops in numerous global regions were conducted. Compared to the outcomes of interactive potassium and boron treatments, the results of split potassium and boron application were forequarter. This may be owing to the loss of various Potash types when the entire dose is administered simultaneously. In crops with shallow roots, such as onions, separate applications of nitrogen and Potash may be more beneficial for the plant's uptake. In Bangladesh, some research has been conducted on the effect of split application of Potash on certain vegetable crops, but most research has focused on muriate of Potash (KCl). Very little is known about the application method and different potassium and boron levels for onion cultivation in Bangladesh's diverse soil and climate conditions. However, this chapter examines some of the associated research findings on onion from domestic and international sources that may be essential and beneficial for the current study.

Katyal considered the effects of FYM, ammonium sulphate, superphosphate, and potassium sulphate (1977). He suggested using 15 to 20 tons. Rashid (1983) advised 10 tons of cow manure, 175 kilograms of urea, 125 kilograms of trisodium phosphate, and 150 kilograms of mono ammonium phosphate per hectare for the cultivation of onions in Bangladesh.

Green *et al.* (1980) determined that the ideal levels of N, P, and K fertilizer were 206, 105, and 119 kg ha^{-1} for spring-sown bulb crops on a nutrient-depleted sandy loam soil 209 and 138 kg ha^{-1} for autumn-sown bulb crops.

Gupta and Gaffar (1981) investigated the influence of row spacing on the growth and yield of onion under various combinations of nitrogen, phosphorus, and potassium. Onion yield and yield-contributing characteristics were significantly influenced by NPK application. The NPK treatment yielded an economic yield of 46,36,36 kg ha", respectively.

Agarwal *et al.* (1981) found that plots receiving either 160:40:40 or 80:40:80 kg ha^{-1} of N, P_20_5, and K_20 produced the maximum yield.

Patil *et al.* (1983) tested NPK on the onion cultivar White local. In their investigation. N, P_20_5, and K_2O were added at individual rates of 75, 150, 75, or 150, and 50 or 100kg ha^{-1}. The abdicate for 75 kg N was 222.9 q ha^{-1}. With the addition of phosphorus, the abandonment grew excessively, whereas the application of potassium did not affect the abandonment.

Satanarayana and Arora (1984) noted that onion bulb abandonment increased with direct application of nitrogen up to 60 kg ha^{-1} and Potash at 40 kg as K_20 ha^{-1}, but onion bulb yields were unaffected. Deshmukh *et al.* also highlighted the positive influence of K on onion bulb yield up to 40 kg K_2O ha^{-1}.

Madan and Sandhu (1985) noted that optimal plant growth, maximum bulb production, and dry matter abdication were obtained by applying N: P_2O_5: K_2O at 120: 60: 60 kg ha^{-1}.

Amin (1985) reported that nitrogen at 60 kg ha^{-1}combined with Potash at 1,000 kg ha^{-1} resulted in the best bulb diameter (5.86 cm), bulb weight (64.70 g), and onion yield (27.47 t ha^{-1}).

In an onion fertilization experiment conducted by Beresniewiez and Nowosiecski (1986). it was said that 200 kg K_20 together with 200 kg N. The maximum yield was achieved with 200 kilogram P_20_5, 20 kg Mg, 5 kg Mn, 5 kg Zn, 10 kg Cu, and 1.5 kg Mo per hectare. The yield was also enhanced when 100 N43/ha of organic fertilizer (lignite or peat).

Rudolph (1986) recommended that for a single crop of onion, a base dressing containing 30-40 kg of phosphorus and 80-100 kg of potassium be applied per hectare; if crops are to be grown on a site for up to three successive years, the recommended rates are 48-56 kg and 180-222 kg of phosphorus and potassium per hectare, respectively.

Saimbhi*et al.* (1987) reported that administering NPK at the highest rate produced the largest bulb size. The highest yield (33.89 t ha^{-1}) and finest quality of dried unions. The most excellent NPK combination per hectare was 100 kg N, 60 kg P_20_5, and 60 kg K_20.

Soto (1988) conducted a field trial with basic level for P. K and S and response to N. The rate was 100 kg $ha^{-1}$for P_20_5, 50 kg $ha^{-1}$for K_2O, and 50 kg ha^{-1} for S. The nitrogen ® 0, 55, 100, and 150 kg ha^{-1} were applied, and it was observed that 50 kg N ha^{-1} was optimal for abdication response.

Hedge (1988) experimented with cv. Pusa Red onion found that N fertilizer boosted bulb yield but not quality. Additionally, he demonstrated that nutrient intake of N, P, K, Ca, and Mg primarily increased due to increased dry matter synthesis.

Bruckner (1988) stated that onion yield was similarly lowest when soil K_2O levels were low. The site with the highest yield had the most significant nutrient absorption from the soil. There was a positive link between the potassium content of onions and the potassium level of soil, but not with phosphorus. Onion nitrogen concentration was lower than potassium, resulting in a greater demand for Potash.

Singh and Dhankhar (1988) reported that a higher nitrogen level boosted plant growth, ascorbic acid content, and yield while decreasing anchoring. Potassium also decreased bulb anchoring and neck thickness and increased plant growth, yield, ascorbic acid, dry matter, sugar, and sulfur content.

Duque *et al.* (1989) evaluated onion's growth and nitrogen, phosphate, and potassium consumption. The results demonstrated that the plant's demand for N and K was greatest during the early growth phases, whereas the demand for P remained constant throughout the development. For the production of 2.5 t ha^{-1}, the uptake levels were 38.8, 38.6, and 71.3 kg N. P_20_5 and K_20, respectively.

Singh *et al.* (1989) observed the effect of green manure on onion abdication. They established two types of land, one without green manure and the other with Sesbania aculeate green manure. The combination of 120 kg N and 50 kg K_20 resulted in taller plants and a more significant number of shoots per plant, the most significant bulb weight and diameter per plant, and a higher bulb abdication rate in the initial investigation of green manuring.

Goohkin (1989) demonstrated an experiment on improving vegetable seed germination and stated that seed priming in a solution of mixed potassium salts was as efficient as polyethylene glycol (PEG-6000) treatment. Using aerated solutions of 0.4-0.5% KNO_3 + K_3PO_4, seedlings' germination vitality and sustained emergence were boosted by 17-22 percent. The yield was improved by 2% to 28%.

According to Jayabharathi (1989), the highest yield of onion may be obtained by using the highest NPK concentration (75 kg of each nutrient). It was between 55 and 75 percent superior to the control. With a larger dose of fertilizer, the yield of large bulbs compared to medium and small bulbs was considerably more significant than that of bulbs with a lower dose.

To estimate the yield and quality of Kharif onion, Pandey *et al.* (1990) examined four levels of nitrogen (0, 50, 100, and 150 kg ha^{-1}), three levels of phosphorus (0, 40, and 80 kg ha^{-1}), and two levels of Potash (0 and 50 kg ha^{-1}). They initiate optimum yield and net return with 150:40:50 kg of nitrogen, phosphorus, and potassium ha^{-1}.

Baloch *et al.* (1991) obtained the highest bulb production (22.66 t ha^{-1}) by applying 125 kg N and 75 kg K_20 per hectare. The tallest plant growth (38.5 cm). With 125 kg N + 100 kg K_2O ha^{-1}, the number of leaves $plant^{-1}$ (17), the weight of a single bulb (82 g), the vertical bulb diameter (4.80 cm), and the horizontal bulb diameter (5.78 mm) were increased.

Amado and Teixeira (1991) conducted research in an uncultivated area with or without N; all treatments received 120 kg P_20_5 ha^{-1} and 66 kg K_2O ha^{-1}. Onion yielded the driest matter and bulbs after receiving combined treatment of NPK. In addition, they claimed that the increase in bulb yield was proportional to the amount of dry weight in the Cover crop leftovers.

In their experiment with onion CVs, Jitendra *et al.* (1991) administered N at 80, 120, and 160 kg ha^{-1}, K_20 at 100, and $ZnSO_4$ at 2.5 kg ha^{-1}. Increased nitrogen levels enhanced plant growth and yield. K alone and in combination with Zn enhanced plant growth, yield, and dry matter content. The maximum yield (27.48-32.20 t ha^{-1})was achieved with a greater concentration of N, K, and Zn.

Mukhopadhyay *et al.* (1992) conducted a field experiment to determine the influence of potassium doses (25, 50, 75, and 100 kg K_20 ha^{-1} administered as basal and in two equal splits along with control) on the growth and production of IB440 sweet potato. It was discovered that the response to potassium fertilizer applied in splits was more distinct. CGR, tuber bulking rate, and quantity of tubers per plant with the greatest LAI. Overall tuber yield (18.16 t ha^{-1}) and total vine production (22.12 t ha^{-1}) were observed at two equal splits of 75 kg K_20 ha^{-1}.

Rahim *et al.* (1992) conducted an onion production fertilizer experiment. On November 6, onion sets were planted at 25 x 15 cm spacing and given 0-160 kg N and 0-100 kg potassium per hectare. Half of the fertilizers were applied before planting and the other half 30 days after planting. The combined application of higher rates of N and K resulted in a maximum yield of 11,11 t ha^{-1} as opposed to the control yield of 4.5 t ha^{-1}.

According to Sharma (1992), the application of K as K_20 at a rate of 40 kg ha^{-1} produced substantially larger bulbs than the control. A further rise in K level had no beneficial effect. In addition, he discovered that the optimal economic doses were 81 kg nitrogen and 59 kg K_20 ha^{-1}. The optimal level of N and K produced a response of up to 43,3 t ha^{-1}.

Nasiruddin *et al.* (1993) reported that the influence of potassium and sulfur on onion growth and yield improved plant height, leaf production capacity, bulb width, weight, and bulb output. They proposed two kilograms of Potash and thirty kilograms of sulfur per hectare for onion cultivation.

Sangakkara and Piyadasa (1993) studied the effect of eight levels of potassium given as KCI, whether administered either basal or split (basal and top dressing), on the growth and yields of multiplier (onion) in the presence of a constant amount of nitrogen and phosphorus. These treatments were developed in both rainfed and irrigated environments. Potassium enhanced multiplier (onion) bulb size, bulb number, and yields per plant, as well as dry weights. When potassium was administered as base fertilizer, 100 kg K_20 per hectare produced the highest yield. 75 kg K_20 per hectare of potassium was required for optimal yields with split applications. Irrigation did not alter the necessary potassium concentration for optimal production, even though the response was much larger than in tinder-wet circumstances.

Vachltani and Patel (1993) analyze the impact of varying quantities of nitrogen (50, 100, and 150 kg N kg ha^{-1}), phosphorus (25, 50, and 75kg P_20_5 ha^{-1}), and potash (50, 100, and 150 kg K_20 ha^{-1}) on the growth and production of onion. They found that 150 kg N ha^{-1} produced the highest plant height, number of leaves $plant^{-1}$, bulb weight, and yield. In comparison, bulb weight and production were not significantly different with 100 kg N ha^{-1}. Applying more phosphorus enhanced the number of leaves $plant^{-1}$, their weight, and their yield. Tender of K merely raised the leaf count $plant^{-1}$.

According to Katwale and Saraf (1994), the optimal bulb production was obtained by applying NPK at the rates of 125:60:100 kg ha^{-1}individually. Additionally, the rate provided the maximum economic return.

Rizk (1997) accepted an experiment to examine the influence of plant density and NPK fertilizers on onion yield. Lower planting density increased leaf number per plant, fresh and dry weight, leaf area, average bulb weight, and nitrogen absorption. The total and marketable bulb yield were most significant when planting was concentrated. Increasing the NPK concentration boosted all vegetative growth indices and bulb production. The optimal NPK application consisted of two equal dosages administered 30 and 60 days after planting.

Anwar *et al.* (1998) observed that the application of nitrogen, phosphorus, potassium, sulphur, and zinc increased the number of onion leaves along with the bulb production in the Jessore zone, at rates as high as 150 kg N ha^{-1}, 120 kg P_20_5 ha^{-1}, 120 kg K_20 ha^{-1}, 20 kilogram S ha^{-1}, and 5 kg Zn ha^{-1}.

Nagaich*et al.* (1998) observed in a field experiment at Gwalior where S was treated at 0, 20, 40, and 60 kilogram S ha^{-1} and K was applied at 0,40, 80, and 120 kg K_20 ha^{-1} to Nasik Red onions that bulb yields increased with increasing rate and were greatest at a moderate K rate (80 kg K_2O ha^{-1}).

Janardan and Singh (1998) conducted a field study to determine the effect of stockosorb and potassium concentrations on potato and onion. According to the authors, the authors, the biomass, bulb weight, width, and bulb yield were determined to be greatest with 300 kg K_20 + 150 kg stockosorbthinkg-1 plus a suitable number of irrigations. At 150 kg stockosorbthinha-l, the maximal response of 11.1 kg bulbthinkg-1 stockosorb was recorded. N, P, and K values were comparatively elevated in soils treated with stockosorb.

In 1995-96 and 1996-97, Sing and Mohanty (1998) discuss the growth and yield of onion in Orissa, India. Nitrogen (80. 120, and 160 kg ha^{-1}). In a randomized block, K_20 (80, 100, and 120 kg ha^{-1}) and P205 (60 kg ha^{-1}) were applied to yield eight treatments. During the testing period, plant height grew due to the total N concentration. Nitrogen and potassium at 160 and 80 kg ha^{-1}, respectively (160:80 NK) produced the most significant plant height, while 120:80 NK produced the smallest plant height. Bulb diameter and leaf count were greatest with 160:80 NK and lowest with 80:80 NK. The bulb weight was most significant with 160:80 NK, followed by 120:120 NK and 160:100 NK; the bulb weight was much lower with 80:80 NK. With 160:80 NK, the maximum yield (295.8 q ha^{-1}) was achieved. Based on these findings, the recommended nitrogen rates for onion production in and near bulb answer are 160 kg N. 80 kg K_20 and 60 kg P_2O ha^{-1}.

Harun-or-Rashid (1998) conducted a field experiment at the Bangladesh Agricultural University in Mymensingh to determine the effect of NPKS on the growth and yield of onion at various plant spacings. He reported that the highest bulb weight (40.50 g) and bulb yield (20.75 t ha^{-1}) were obtained from the combination of 125-150-150-30 kg N. P_20_5, K_20. S ha^{-1}, whereas the lowest bulb yield (16.75 t ha^{-1}) was observed in the control treatment. Application of NPKS increased plant height, leaf count, bulb length, bulb diameter, bulb weight, and bulb production. He recommended 100-150-200-30 kg N. P_20. K_20. S ha^{-1} for the cultivation of BARI piaj-4 under BAU Farm conditions.

In onion plot trials, Jiang *et al.* (1998) used 0, 375, 450, or 525 kg potassium sulfate per hectare. Bulb weight grew from 231 g with no fertilizer to 331 g with the maximum fertilizer rate as bulb size increased with the fertilizer application rate. The lowest bulb production of 69.4 t ha^{-1} was observed with no fertilizer, while the highest bulb yield of 85.3 t ha^{-1} was marked with a greater potassium sulphate rate. The net benefit rose as the potassium fertilizer application rate increased.

During the winter of 1994-1995, Islam (1999) experimented at the Bangladesh Agricultural Research Institute, Gazipur, to determine the effects of various potassium sources and application methods on onion yield, onion yield quality, and potassium uptake by plants. The study employed three potassium sources (muriate of Potash, potassium nitrate, and potassium sulfate) and three delivery strategies: basal, 1/2 basal+1/2 at 20 days after transplantation (DAT) 1/3 basal +1/3 at 20 DAT +1/3 at 40 DAT. Two split treatments and a single basal application produced maximum (35 kg ha^{-1}) and minimum (26 kg ha^{-1}) K accumulations, respectively.

In 1993-1994 and 1994-1995, Rodriguez *et al.* (1999) funded onion research to determine the effect of nitrogen, phosphorus, and potassium rates, sources, and forms on onion (*Allium cepa*) bulb yield and quality. In treatments with various rates, sources, and forms of N, P, and K, product, plant height, leaf number, and polar and equatorial diameters were assessed. It was not possible to discover any substantial link between P and K rates (up to 98.2 and 200 kg ha^{-1}, respectively) nor between N and P.

In 1995-96 and 1996-97, Nagaich*et al.* (1999) studied the effects of four potassium rates (0, 40, 80, and 120 kg K_20 ha^{-1}) on the growth characteristics, yield qualities, yield, and quality of onion on a sandy loam soil in Madhya Pradesh, India. The application of 80 kg K_20 ha^{-1} significantly boosted the bulb's weight per plant and its horizontal diameter.

Singh *et al.* (2000) experimented Rajasthan during the rabi season of 1993-1995. Onion cv. N-53 was grown in mixtures containing three amounts of nitrogen (50, 75, and 100 kg N), phosphate (3, 2, 22.0, and 30.8 kg P), and Potash (3, 2, 22.0, and 30.8 kg K) (41.5, 62.2 and 83.0 kg K). The application of 100 kg nitrogen, 30.8 kg phosphorus, and 810 kg potassium per hectare was determined to increase the onion yield significantly.

Mohanty and Das (2001) discovered that the application of 90 kg N and 60 kg K_20 $ha^{-1}$was optimal for achieving a higher yield with larger bulbs, whereas 30 kg ha^{-1} of each N and K_20 was suggested for appreciating medium bulbs with moderate output and improved maintaining quality in long-term storage.

Yadav *et al.* (2002) presented a trial of puna Red, White Marglobe, Nasik Red, and Rasidpura Local onion cultivars supplied 50, 100, and 150 kg N and K ha^{-1}in Jaipur, Rajasthan, India during the rabi seasons of 1998-2000. With the rise in N and K rates, yield, fresh weight of bulb, total soluble solids, and allyl propyl disulfide content increased, whereas ascorbic acid concentration fell. Except for allyl propyl disulfide concentration, which was highest in Nasik Red, Rasidpura Local had the highest values for all examined metrics.

Mandira and Khan (2003) accepted an experiment with varying levels of nitrogen (0, 100, 150, and 200 kg ha^{-1}) and potassium (0, 75, and 150 kg ha^{-1}) assumed as soil application in order to determine their effect on the growth, yield, and yield quality of onion cv. N-53 in a 2001 study conducted in Tripura, India. In terms of yield and growth, nitrogen at 150 kg ha^{-1}, potassium at 75 kg ha^{-1}, and their combination produced the best results. All additional treatments and their combinations outperformed the control.

During the rabi seasons of 1998 and 1999, Sharma *et al.* (2003) conducted a field experiment in Leo, Himachal Pradesh, India, to examine the effect of mutual usage of NPK and farmyard manure (FYM) on onion (Allium cepa) production characteristics, yield, nutrient uptake, and NPK accumulation. There were three levels of FYM (0, 10, and 20 ha^{-1}) and four levels of NPK in the treatments (0, 50, 100, and 150 percent of the recommended dose, 125 kg N, 33 kg P and 50 kg K ha^{-1}). One hundred percent (325 kg N, 33 kg P, and 50 kg K ha^{-1}) and 150 percent (187 kg N, 49kg P, and 75 kg K ha^{-1}) of the recommended dose increased onion bulb yield by 42 and 56 percent, respectively, compared to a 50 percent NPK level. Applying FYM at 10 and 201 ha^{-1} increased bulb yield by 9 and 19 percent compared to 100 percent NPK alone. In the case of 100 percent NPK plus 20 t FYM ha^{-1}, the bulb yield (19.87 t ha^{-1}) was identical to that of 150 percent NPK alone (18.82 1 ha^{-1}), indicating a savings of 52 kg N, 16 kg P, and 25 kg K ha^{-1} in chemical fertilizers. Applying NPK fertilizers in conjunction with FYM led to a considerable improvement in the soil's available N, P, and K.

Yadav *et al.* (2003) demonstrated an experiment to determine the optimal potassium concentration for maximizing onion bulb yield and quality. Three potassium concentrations were administered to Puna Red, White Macglobe, Nasik Red, and Rasidpura native cultivars (50, 100, and 150 kg ha^{-1}). The highest K value was associated with the most significant plant height, leaf count per plant, fresh leaf weight, and dry weight. Neck thickness, bulb equatorial diameter, polar bulb diameter, bulb new weight, and bulb yield are correlated with one another. The lowest K score indicated the thinnest neck.

Singh *et al.* (2003) evaluated the effects of K fertilizer (30, 60, 90, and 120 kg ha^{-1}) applied as split dressings (1/2 as basal + 1/2 as top dressing at 45 days after transplanting or DAT or 1/3 as basal + 1/3 top dressing at 45 DAT + 1/3 top dressing at 90 DAT) on the seed yield of onion cv. N-53 at Dhaulakuan, Himachal Pradesh, India, during the rabi seasons of 1994/1995 and 1995/19 The treatment of 60, 90, and 120 kg ha^{-1} of potassium in three splits (one-third as a basal, one-third as a top dressing at 45 DAT, and one-third as a top dressing at 90 DAT) promoted early bolting. It resulted in the most significant flower stalk height, 1000-seed weight, and seed production. Therefore, the most cost-effective rate for onion was 60 kg K ha^{-1} applied in three splits.

According to these analyses, both potassium and its fertilizing method significantly impacted the growth and output of a successful onion crop. In most instances. As a potash source, muriate of Potash (KCI) was employed. Consequently, the optimal potassium concentration and administration strategy may play a vital role in enhancing onion output. Therefore, it was hypothesized that the purpose of this study would be to compare the efficacy of various potash concentrations and fertilization methods.

CHAPTER III

MATERIALS AND METHODS

The present investigation entitled "**RESPONSE OF POTASSIUM AND BORON ON THE GROWTH AND YIELD OF ONION(BARI Peyaj-4).**" was carried out during the ***rabi*** season of January 2022 under AEZ- 28 (Madhupur tract), Sher-e-Bangla Nagar, Dhaka-1207. The details of materials used, experimental procedures followed, and techniques adopted during the investigation are described in this chapter. Climatic and edaphic conditions prevailing during crop season, selection of site, cropping history of the field, and other experimental details are also being presented.

3.1. Site description

3.1.1 Geographical location

The experimental area was situated at $23^0 77'$ latitude and $90^0 33'$E longitude at an altitude of 8.6 meters above sea level (Anon., 2004).

The experimental field was attached to the main irrigation channel connecting to the farm water source for quick, regular, and timely irrigation. A proper drainage facility was also provided to remove excess water during the experimental period.

3.1.2 Agro-ecological region

The experimental field belongs to the Agroecological zone of "The Madhupur Tract," AEZ-28 (Anon., 1988). This region of complex relief represents the red lateritic soil of the Madhupur area. The soil of this region has a clayey texture and contains a large quantity of iron and aluminum. The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3. Climate and weather conditions

The climate is sub-tropical, with high temperatures, high relative humidity, and heavy rainfall. It falls in the southwest monsoon region; generally, the monsoon starts from mid-June and continues up to October. The mean average annual rainfall is 2730 mm, of which nearly 80-90 % is received between June and October.

The meteorological data related to the weather conditions of the experimental site prevailing during the ***rabi*** season, 2022, concerning rainfall, relative humidity, and temperature obtained from the Bangladesh meteorological department, is presented in Appendix III & IV.

3.1.3.1. Rainfall

The monsoon shower was cumbersome during the year of experimentation. The total rainfall of 1535 mm was recorded during the cropping period. Out of which 383 mm of rainfall was recorded during the seedling stage, 947 mm of precipitation occurred between active tillering and the maximum tillering stage of rice. However, 175 mm of rain was recorded between panicle initiation to panicle emergence stage of the crop. A little rainfall occurred between the milk to maturity stages, and heavy rain occurred during the Maturity Stage.

3.1.3.2. Temperature

Temperature is one of the significant meteorological variables influencing plants' germination, growth, and development in each agro-climatic condition. The mean maximum temperature ranged from 26.5 ºC to 31.5 ºC, and the mean minimum temperature went from 14.5 ºC to 26.5 ºC during the experimental period of 2021.

3.1.3.3. Relative humidity

The relative humidity varied between 75% to 85% during the experimental period in 2021. It attained the maximum level during the vegetative phase. Minimum relative humidity was recorded during the maturity period of the crop.

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils, under Tejgaon Series. Topsoil is silty clay in texture, olive-gray with standard fine to medium distinct dark yellowish-brown mottles. Soil pH 6. The flat experimental area had available irrigation and drainage system and was above flood level.

3.2. Details of the experiments

3.2.1 Treatments

Two sets of treatments included in the experiment were as follows:

Factor A: Potassium level (K)

K_0= 0 kg Potassium ha^{-1}
K_1= 60 kg Potassium ha^{-1}
K_2= 90 kg Potassium ha^{-1}
K_3= 120 kg Potassium ha^{-1}

Factor B: Boron level (B)

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

3.3 Crop/Planting Material

One Onion variety, BARI Peyaj-4, was used as planting material. This chapter organizes the materials and methods used in the experiment, including a brief overview of the experimental location, onion variety, soil, climate, land preparation, experimental design, treatments, soil and plant sample collection cultural operations, and analytical methods. Here are the specifics of the study technique.

3.2 Collection and preparation of initial soil sample

Before initiation of the experiment, initial soil samples at 0-15 cm depth were collected from different plots of the experimental field. The composite soil sample was air dried, ground to pass through a 2 mm sieve, and used for the analysis of the physical and chemical properties of soil.

3.4 Layout of the experimental plots

Total number of plots	: 36
Individual plot size (2m×1m)	: 2 m^2
Space between block to block	: 0.5 m
Block to border (row)	: 0.50 m
Block to border (column)	: 0.50 m
Replication	: 3
Drainage size	: 0.38 m

11m

18m

B_0K_2	B_2K_1	B_1K_3
B_0K_0	B_2K_3	B_1K_0
B_0K_1	B_2K_0	B_1K_2
B_0K_3	B_2K_2	B_0K_3
B_1K_2	B_1K_1	B_0K_1
B_1K_0	B_0K_2	B_2K_1
B_1K_3	B_0K_1	B_2K_3
B_1K_1	B_0K_3	B_2K_0
B_2K_2	B_1K_2	B_2K_2
B_2K_0	B_0K_0	B_1K_1
B_2K_3	B_1K_3	B_0K_2
B_2K_1	B_0K_2	B_0K_0

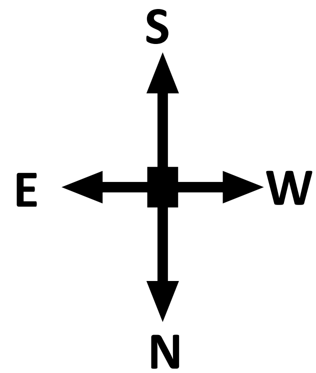

Fig. 1. Field layout of the experimental plot

3.2.2 Experimental Design

The experiment was laid in a Randomized Complete Block Design (RCBD) with 3 replications. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of the unit plot was 2 m × 1 m. The distances between plot to plot and replication to replication were 0.5 m. The layout of the experiment is shown in Appendix II.

3.5 Cultivation of Onion

3.5.3 Land Preparation

The trial plot was opened in the month in January 2022 with the help of a tractor. Subsequently, the land was prepared by numerous ploughings and cross ploughings with a power tiller followed by laddering. Weeds and stubbles were removed, and the large clods were broken into smaller pieces to acquire a desirable tilth of friable soils for transplanting the seedlings.

3.5.4 Rate of fertilizers

Fertilizers were used in the experiment according to the recommendation of fertilizer recommended guide as follows:

Fertilizers	Dose ha^{-1}
N	140 kg ha^{-1}
P	45 kg ha^{-1}
K	100 kg ha^{-1}
S	30 kg ha^{-1}

3.5.5 Fertilizer application

During final field preparation, the whole amount of thoroughly decomposed cow dung, as well as all fertilizers except nitrogen, potassium, and Boron, were put into the soil. Urea was used in this experiment. There are three equal divides. The first divide was applied during final land preparation, while the second split was applied after that. After 20 days of transplanting, the second split was applied, followed by a third split after 40 days. The fertilizer had been extensively incorporated into the soil.

3.5.6 Seedling transplantation

28-days-old seedlings were collected from healthy and disease-free seedbeds from Spice Research Centre, Shivganj, Bograand placed in the main field with a line-to-line spacing of 10 cm. On 06th January 2022 and plant to plant spacing of 10 cm. In the afternoon. the seedbed had previously been irrigated. Uprooting the seedlings to avoid root damage. The seedlings had been Immediately after transplantation the plants were watered. A few seedlings were also put next to one other. Gap fills will be done in the experimental area.

3.5.7 Intercultural operation

After transplanting the seedlings, intercultural operations were done whenever required to get better growth and development of the plants. So, the crop was always kept under careful observation.

3.5.7.1 Gap fillings

Within one week, damaged seedlings were replaced with healthy plants from surplus plants.

3.5.7.2 Weeding and mulching

To keep the crop free of weeds and pests, weeding was done three times after transplantation. Mulching was accomplished by fracturing the soil crust for easier aeration and soil conservation. When moisture is required, especially after irrigation, it should be provided.

3.5.7.3 Plant protection

Preventive measure was taken against soil-borne insects. For the prevention of Cutworm Furadan, 5G@20 kg ha^{-1} was applied. No insect pest infestation was found in the field after pesticide application. A few days after transplanting some plants were attacked by purple blotch disease caused by *Alternaria puri.* It was controlled by spraying Rovral 50WP four times 10 days after transplanting.

3.6 Harvesting

The crop was when harvested according to their maturity; they reached adulthood on 13th April 2022 majority of the leaves have dried out and are collapsing at the neck of the plant bulbs.

3.7 Data collection

Data on different parameters were collected from the sample plants. Five plants were chosen at random from each plot to capture data to prevent the border effect and achieve the best level of accuracy. The outside rows, as well as the outer plants in the middle rows, were avoided for this.

3.8 Data were collected on the different parameters:

1. Plant height (cm)

2. Number of leaves

3. Length of leaves (cm)

4. Fresh weight of leaves (g)

5. Fresh weight of bulb (g)

6. Diameter of bulb (cm)

7. Dry weight of bulb (g)

8. Length of the bulb (cm)

9. Yield (t ha^{-1})

3.8.1 Plant height (cm)

At harvesting time after transplanting, the height of the chosen five plants in each plot was measured (DAT). The height measured centimeters (cm) from the floor to the ceiling. The length of the bulb's neck to the tip of the longest leaf, as well as the average heights of the chosen five. The plants were taken to see how quickly they grew.

3.8.2 Number of leaves

At harvesting time, the number of leaves per plant on chosen plants was counted, and the average of five plants was used to determine the number of leaves per plant. The number of leaves at harvesting, plants were also detected.

3.8.3 Length of leaves (cm)

From the pseudo stem to the tip of the leaf, the length of the leaf was measured in centimeters. The average of five chosen plants at harvesting time was recorded.

3.8.4 Fresh weight of leaves (g)

The leaves are cut from the onion, the fresh leaves from the field are collected, and the weight is taken and adequately measured.

3.8.5 Fresh weight of bulb (g)

Five plants from each unit plot were plucked at random. By cutting the pseudo stem and leaving just 2.5 cm with the bulb, the top was removed. In an electric balance, five bulbs were weighed, and the average was used to determine the individual bulb weight.

3.8.6 Diameter of the bulb (cm)

The bulb's diameter was measured at the center section of the bulb during harvest from five different angles. A sliding caliper was used to choose plants randomly, and the average was taken.

3.8.7 Dry weight of bulb (g)

Each unit plot's complete onion bulbs were collected. For each unit plot after drying the onion dry weight of the bulbs was recorded separately.

3.8.8 Length of Bulb (cm)

The length of the bulb was measured with a slide caliper from the neck to the bottom of t he bulb from five randomly selected plants during harvest, and the average was calculate d.

3.8.9 Yield (t ha^{-1})

The weight of the bulbs was then measured in kilograms (kg) from each unit plot using a simple balance. The bulb yield per plot was calculated to provide a yield in t ha^{-1}.

3.9 Soil sample analysis

In the laboratory of the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, the initially acquired soil samples were tested for both physical and chemical properties like texture,bulk density,particle density & porosity, pH, organic matter, total N, available P, exchangeable K, and available Swere among the parameters investigated. (Table 5)
shows the physical and chemical characteristics of the original soil. Standard procedures were used to examine the soil.

3.10 Post-harvest soil sampling

The post harvest soil samples were taken at a depth of 0 to 5 cm at harvest. The samples were taken from each plot using an auger to create a plot-wise individual composite sample. Plant roots, leaves, and other plant parts were picked up and discarded after soil samples. The samples were then air dried and analyzed for physical and chemical analyses and stored in a clean plastic container.

3.11 Physio-chemical properties of soil

3.11.1 Soil Physical Properties

3.11.1.1 Particle size analysis

The hydrometer method was used to determine the particle size of the soil sample, and the USDA textural triangle was used to determine the textural class.

3.11.1.2 Bulk density

The bulk density was calculated using a core sampler to get a known volume of undisturbed soil cores. It was calculated by dividing the oven dried (at 105°C) mass of the soil core by the inner volume of the sampler.

3.11.1.3 Density of particles

The density of soil particles was measured using the Pycnometer technique, as described by black (1965)

3.11.1.4 Porosity

The relationship between bulk density and particle density was used to calculate the porosity of the soil, as shown below:

% Soil Porosity = (1 - (Bulk Density ÷ Particle Density)) x 100

3.11.2 Soil Chemical Properties

3.11.2.1 Soil pH

In soil water suspension, pHwas measured using a glass electrode pH meter.Jackson recommended a 1:2.5 soil-to-water ratio (1958).

3.11.2.2 Organic Carbon (%)

The wet oxidation method developed by Walklev and Black was used to measure organic carbon in soil (1935). Following concentrated sulphuric acid digestion and distillation with 40% NaOH, total nitrogen was measured using the micro Kjeldahl method. The resulting ammonia was collected in a boric acid indicator and titrated against 0.02 NH_2 SO_4 (Black. 1965).

3.11.2.3 Available phosphorus

phosphorus was extracted from soil by shaking with 0.5 M $NaHCO_3$ solution of, pH 8.5 (Olsen *et al.* 1954). The phosphorus in the extract was then determined by developing blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660 nm wavelength by spectrophotometer, and available P was calculated with the help of a standard curve.

3.11.2.4 Exchangeable potassium

Exchangeable potassium was determined by 1 N NH_4 OAC (pH 7.0) extract from the soil by using a flame photometer (Black, 1965).

3.11.2.5 Available Sulphur

By extracting soil samples using a 0.15 percent CaCl2 solution, the amount of available Sulphur in the soil was measured (Page *et al.*, 1982). The concentration extraction was calculated turhidinietrically, and the turbidity intensity was quantified with a spectrophotometer at 420 nm wavelength.

3.13 Statistical analysis

All the data were statistically analyzed by using statistix 10 computer package programs for different characters to find out the significance of the difference between the different doses of potassium on yield and yield contributing characteristics of onion. The mean values of all the treatments were calculated, and analyses of variance were performed by the F-test (variance ratio). The significance of the difference among the treatment combinations of means were estimated by least significance difference (LSD) at a 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the investigation. The results of the effects of potassium (K) and boron and their effects on the yield of onion have been presented and discussed in this following chapter. The analysis of variance of data on Plant height (cm) Number of leaves, Length of leaves (cm), Fresh weight of leaves (g),Fresh weight of bulb (g),Diameter of the bulb (cm),Dry weight of bulb(g), Length of the bulb (cm), Yield (t ha^{-1}) obtained from the present experiment discussed in this chapter. The results and possible interpretations of the results have been given under the following headlines for easy discussion, comprehension, and understanding.

4.1. Effect of K and Boron on Plant Height of onion

4.1.1 Effect of K on plant height (cm) of onion

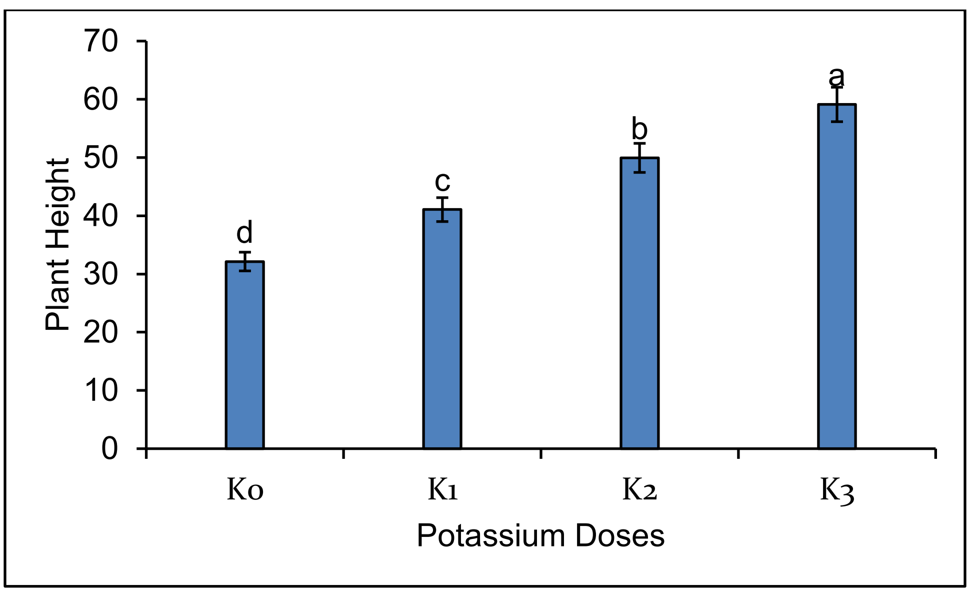

Figure 01. Effect of K on plant height (cm) of onion

Different doses of Potassium showed statistically significant variation in respect of the plant height when fertilizers in different doses were applied (Figure 1) However among the different doses of fertilizer, K_3 (120 kg ha^{-1}) showed the highest plant height (59.114 cm) and K_1 (0 kg ha^{-1}) showed the lowest plant height (53.13 cm). The taller plants at the highest doses received more nutrients which might have encouraged more vegetative growth. Rai (1981) and Pandey and Mundra (1971) reported that the height of plants increased with the increasing levels of nitrogen. A similar result was also found by Vachhani and Patel (1993). These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

4.1.2 Effect of B on plant height (cm) of onion

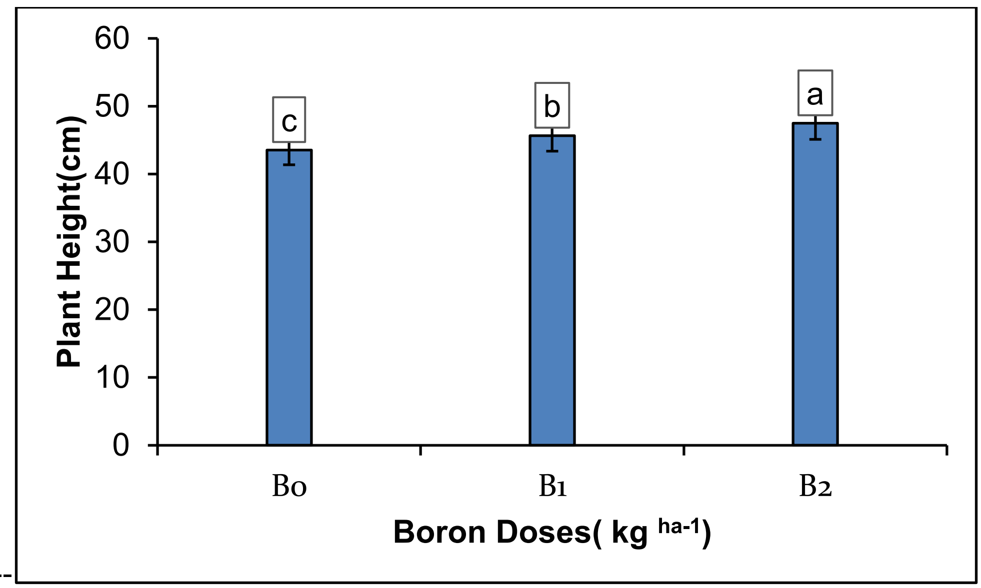

Figure 02. Effect of B on plant height (cm) of onion

Different doses of Boron showed statistically significant variation in respect of the plant height when fertilizers in different doses were applied (Figure 2) However among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest plant height (47.49 cm) whereas B_0(0 kg $ha^{-1)}$ showed the lowest plant height (43.54 cm). The taller plants at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the height of plant increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

4.1.3 Interaction Effects of K and B on plant height (cm) of onion

Interaction effect of different doses of potassium and boron showed statistically significant variation in respect of the plant height when fertilizers in different doses were applied (Table 2) However among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kgboron $ha^{-1}$and 120 kgpotassium ha^{-1}) showed the highest plant height (61.09 cm) whereas $B_0 \times K_0$ (0 kgboron ha^{-1} and 0 kgpotassium ha^{-1}) showed the lowest plant height (30.30 cm), The taller plants at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the height of plant increased with the increasing levels of boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

Table 01. Interaction Effects of K and B on plant height (cm) of onion

Treatment combinations	**Plant Height**
$B_0 \times K_0$	30.30 l
$B_0 \times K_1$	39.18 i
$B_0 \times K_2$	47.72 f
$B_0 \times K_3$	56.95 c
$B_1 \times K_0$	31.98 k
$B_1 \times K_1$	41.33 h
$B_1 \times K_2$	50.01 e
$B_1 \times K_3$	59.30 b
$B_2 \times K_0$	34.13 j
$B_2 \times K_1$	42.66 g
$B_2 \times K_2$	52.07 d
$B_2 \times K_3$	61.08 a
$LSD_{(0.5)}$	**0.88**
CV	**1.14**

Here,

K_0 = 0 $kgha^{-1}$
K_1 = 60 $kgha^{-1}$
K_2 = 90 $kgha^{-1}$
K_3 = 120 kg ha^{-1}

B_0 = 0 $kgha^{-1}$
B1 = 1 kg ha^{-1}
B_2 = 2 kg ha^{-1}

4.2 Effect of potassium and boron on the number of leaves of onion

4.2.1 Effect of k on the number of leaves of onion

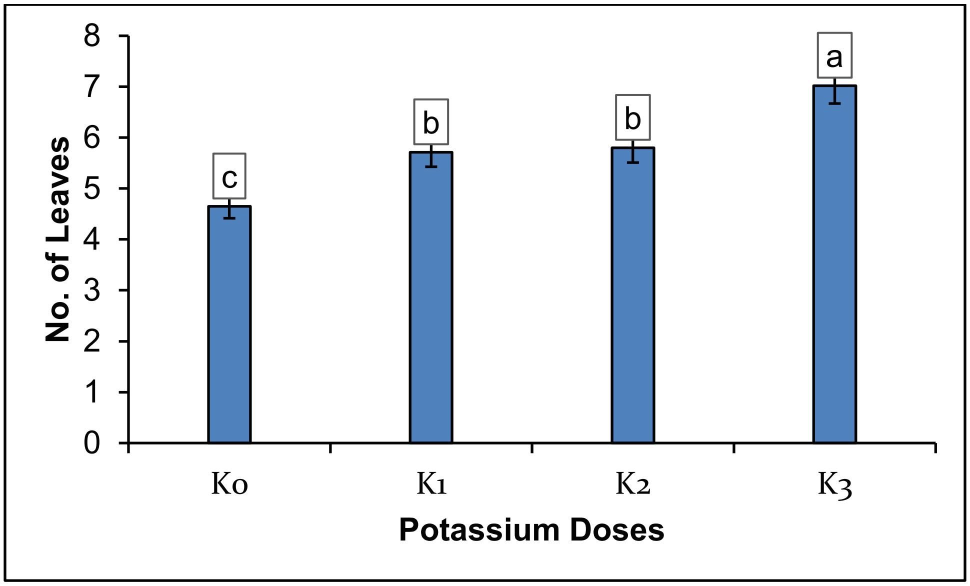

Figure 03. Effect of K on No. of Leaves of onion

There was a significant variation observed in the number of leavesof onion per plant when different doses of potassium were applied (Figure 3). Among the different doses of fertilizers K_3(120 kg ha^{-1}) treatment, showed the highest number of leaves(7.02) $plant^{-1}$. On the contrary, the lowest number of leaves(4.65) was observed with K_0 (0 kgpotassium ha^{-1}), where no fertilizer was applied. The finding of Vachhani and Patel (1993) was in support with these results. The increased number of leavesmight be due to favorable effects of nitrogen on the vegetative growth and accumulation of materials that helped proper growth and development of the onion bulb.

4.2.2 Effect of B on Number of Leaves of onion

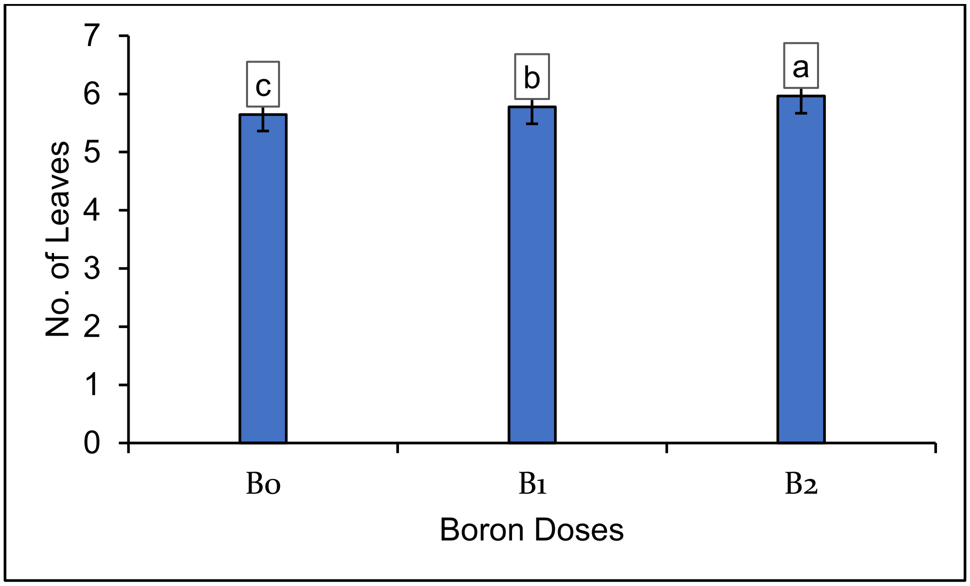

Figure 04. Effect of B on No. of Leaves of onion

Different doses of Boron showed statistically significant variation in respect of No.of leaves of onion the plant (Fig.04).However among the different doses of fertilizer, B_2 (2 kg $ha^{-1)}$ showed the highest number of leaves of onion (5.9658) whereas B_0(0 kg Boron ha^{-1}) showed the lowest no of leaves (5.64). The more leaves of the plant at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that onion the leaves increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

4.2.3 Interaction Effect of K and B on Number of Leaves of Onion

Interaction effect of different doses of potassium and boron showed statistically significant variation in respect of the plant height when fertilizers in different doses were applied (Table 2) However among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kgboron ha^{-1} and 120 kgpotassium ha^{-1}) showed the highest number of leaves of Onion

(7.6740) whereas $B_0 \times K_0$ (0 kgboron ha^{-1} and 0 kgpotassium ha^{-1}) treatment combinations showed the lowest plant height (4.49), followed by $B_1 \times K_0$ (1.0kgboron ha^{-1} and 0 kgpotassium ha^{-1}) treatment combinations showed no. of leaves of the plant is 4.72. The more leafy plants at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the height of plant increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

Table 02. Interaction Effect of K and B on Number of Leaves of Onion

Treatment combinations	**No. of Leaf**
$B_0 \times K_0$	4.4943 e
$B_0 \times K_1$	5.6720 c
$B_0 \times K_2$	5.7983 c
$B_0 \times K_3$	6.6143 b
$B_1 \times K_0$	4.7170 d
$B_1 \times K_1$	5.7913 c
$B_1 \times K_2$	5.8207 c
$B_1 \times K_3$	6.7733 b
$B_2 \times K_0$	4.7329 d
$B_2 \times K_1$	5.6757 c
$B_2 \times K_2$	5.7807 c
$B_2 \times K_3$	7.6740 a
$LSD_{(0.5)}$	**0.1633**
CV	**1.66**

Here,

K_0 = 0 $kgha^{-1}$
K_1 = 60 $kgha^{-1}$
K_2 = 90 $kgha^{-1}$
K_3 = 120 kg ha^{-1}

B_0 = 0 $kgha^{-1}$
B1 = 1 kg ha^{-1}
B_2 = 2 kg ha^{-1}

4.3 Effect of K and B on the length of leaves of onion

4.3.1 Effect of K on the length of leaves of onion

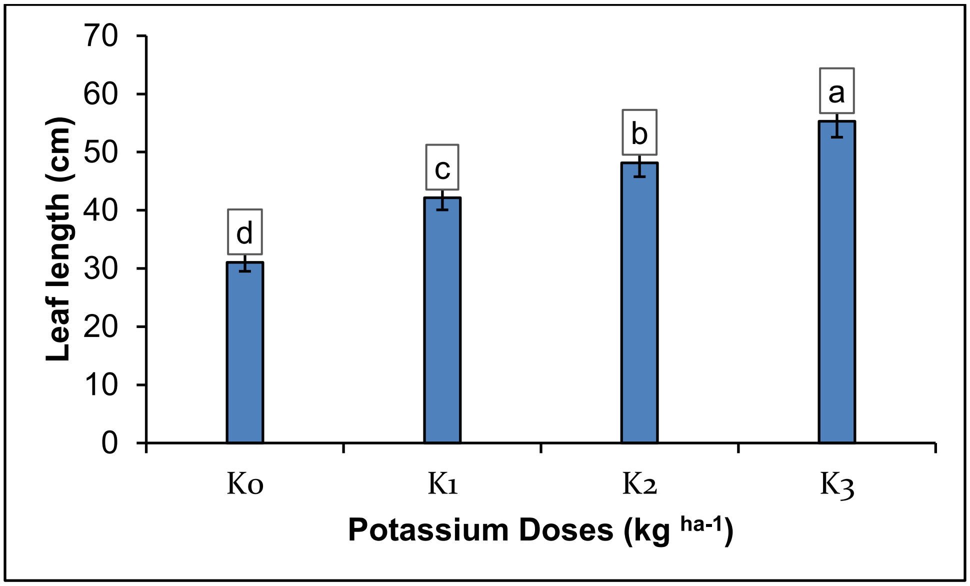

Figure 05. Effect of K on the length of leaves of onion

The application of potassium fertilizer at different doses showed a significant variation in the length of the onion leaves (Figure 05). Among the different fertilizer doses K_3(120 kg Potassium ha^{-1}) showed the highest leaf length (55.33 cm), and the second highest was (48.18 cm) statistically dis-similar to the fertilizer dose of K_2 (90 kg Potassium ha^{-1}). On the other hand, the lowest leaf length (31.07 cm) was recorded with K_0 (0 kg Potassium ha^{-1}) treatment where no potash was applied. Optimum fertilizer doses might be increased the vegetative growth of onion which lead to the highest leaf length. Bulb weight, abdicate of the bulb, Yadav *et al* (2003) reported that the length of leaves of onion increased with increased levels of potassium.

4.3.2 Effect of B on the length of leaves of onion

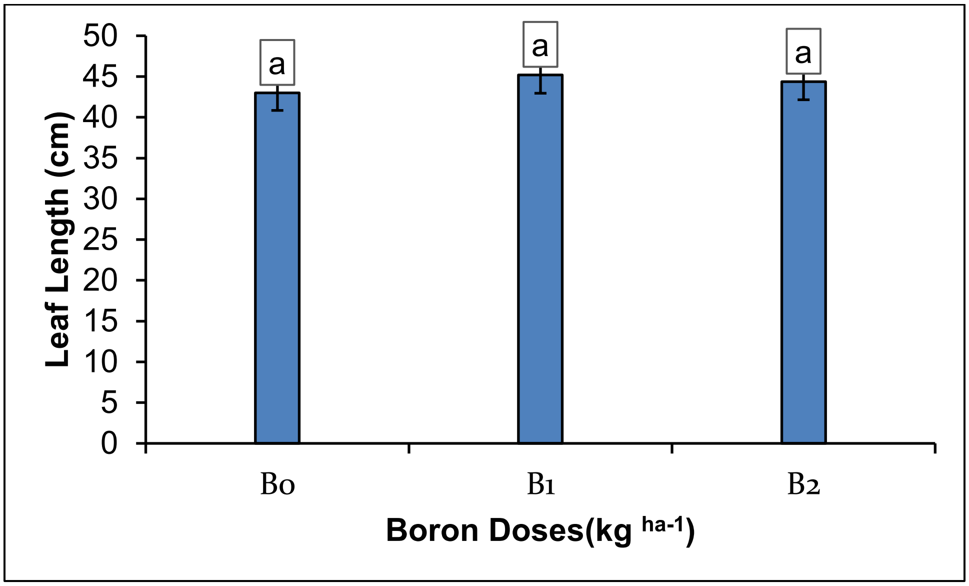

Figure 06. Effect of B on the length of leaves of onion

Different doses of boron showed statistically significant variation in respect of the length of leaves when fertilizers in different doses were applied (Table 6) However among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest length of leaves of onion (44.37 cm) whereas B_0(0 kg Boron ha^{-1}) and B_1 (1.0kg Boron ha^{-1}) showed the statistically similar length of leaves (42.99 cm) and (45.21 cm) respectively. The more length of leaves at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the length of leaves increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

4.3.3. Interaction Effect of K and B on Length of Leaves of Onion

Interaction effect of different doses of potassium and boron showed statistically significant variation in respect of the plant height when fertilizers in different doses were applied (Table 3) However among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kgboron ha^{-1} and 120 kgpotassium ha^{-1}) showed the highest plant height (57.82 cm) which is statistically similar with the treatment combination of $B_0 \times K_3$ (0 kgboron ha^{-1} and

120 kgpotassium ha^{-1}), $B_1 \times K_3$ (1.9 kgboron ha^{-1} and 120 kgpotassium ha^{-1}), and $B_2 \times K_2$(2 kgboron ha^{-1} and 90 kgpotassium ha^{-1}), showed the length of leaves is (32.96 cm), (55.65 cm) and (50.74 cm) respectively. On the other hand, $B_2 \times K_0$ (2 kgboron ha^{-1} and 0 kgpotassium ha^{-1}) showed the lowest length of leaf (25.52 cm) which is statistically similar to the treatment combination of ($B_1 \times K_0$) and ($B_0 \times K_0$) showed the length of the leaf is (34.73 cm) and (32.96 cm) respectively. The longest length of the leaf of plants at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the length of leaves increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

Table 03. Interaction Effect of K and B on Length of Leaves of Onion

Treatment combinations	Leaf Length
$B_0 \times K_0$	32.96 gh
$B_0 \times K_1$	40.61 efg
$B_0 \times K_2$	45.89 cde
$B_0 \times K_3$	52.52abc
$B_1 \times K_0$	34.73 fgh
$B_1 \times K_1$	42.54 def
$B_1 \times K_2$	47.92bcde
$B_1 \times K_3$	55.66 ab
$B_2 \times K_0$	25.52 h
$B_2 \times K_1$	43.40 cdef
$B_2 \times K_2$	50.74abcd
$B_2 \times K_3$	57.82 a
$LSD_{(0.5)}$	**9.3047**
CV	**12.43**

Here,

K_0 = 0 $kgha^{-1}$ | B_0 = 0 $kgha^{-1}$
K_1 = 60 $kgha^{-1}$ | B1 = 1 kg ha^{-1}
K_2 = 90 $kgha^{-1}$ | B_2 = 2 kg ha^{-1}
K_3 = 120 kg ha^{-1}

4.4 Effect of K and B on the fresh weight of leaves (g) of onion

4.4.1 Effect of K on the fresh weight of leaves (g) of onion

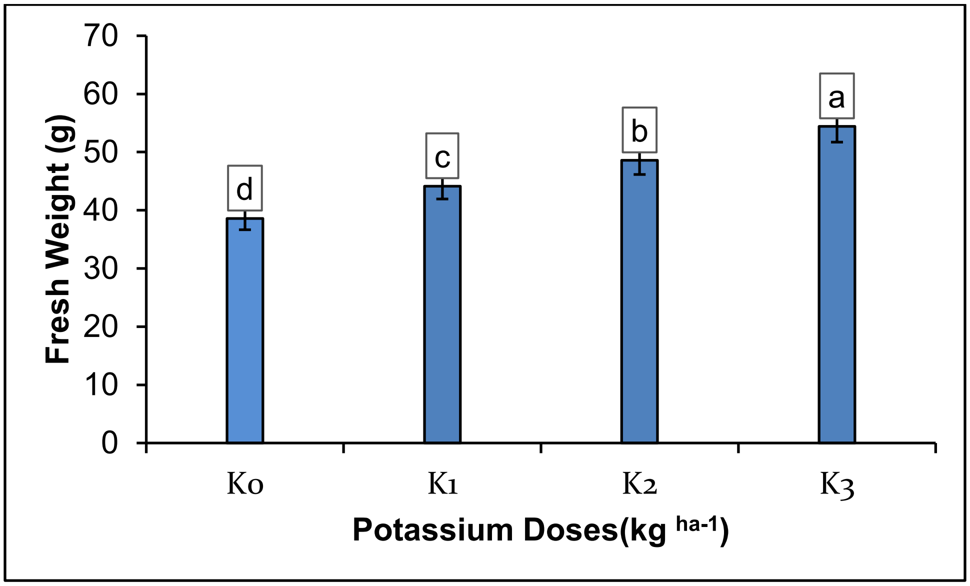

Figure 07. Effect of K on the fresh weight of leaves (g) of onion

The fresh weight of leaves as influenced by diverse measurements ofK application appeared (Figure 7). The maximum fresh weight of leaves was (54.44 g) with K_3(120 kg ha^{-1}), and the lowest fresh weight of leaves was found from (38.59 g) with K_0 (0 kg ha^{-1}) treatments. The discoveries of these tests are near similar to Kumar *et al.* (2006), and they showed that the fresh weight of leaves was essentially higher with the application of an Ideal level of potassium might have expanded the accessibility of leaves growth and development.

4.4.2 Effect of B on the fresh weight of leaves (g) of onion

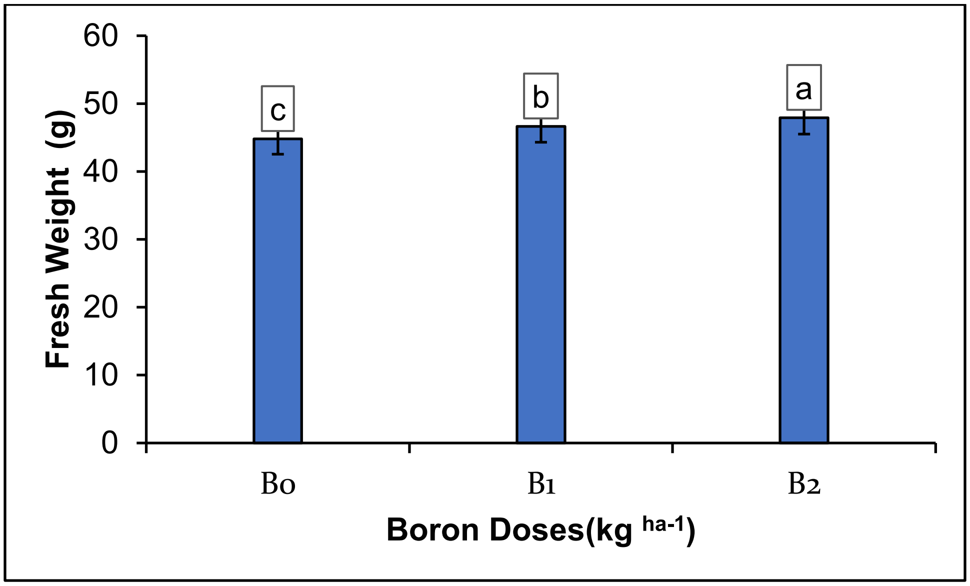

Figure 08. Effect of B on the fresh weight of leaves (g) of onion

Different doses of Boron showed statistically significant variation in respect of the fresh weight of leaves when fertilizers in different doses were applied (Figure 8) However among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest fresh weight of leaves of onion (47.90 cm) whereas B_0(0 kg ha^{-1}) showed the lowest fresh weight of leaves (44.79 cm). The more fresh weight of leaves at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the fresh weight of leaves increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

4.4.3 Interaction Effect of K and B on the fresh weight of leaves (g) of onion

The interaction effect of different doses of Potassium and Boron showed statistically significant variation in the fresh weight of leaves when fertilizers in different doses were applied (Table 4). However, among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}) showed the highest fresh weight of leaves (55.42 cm) whereas $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1}) showed the lowest fresh weight of leaves (36.69 cm), The heaviest plants in respect of fresh weight at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the fresh weight of leaves increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

Table 04. Interaction Effect of K and B on the fresh weight of leaves (g) of onion

Treatment combinations	Fresh Weight
$B_0 \times K_0$	36.69 l
$B_0 \times K_1$	42.58i
$B_0 \times K_2$	46.54 f
$B_0 \times K_3$	53.33 c
$B_1 \times K_0$	38.71 k
$B_1 \times K_1$	44.62 h
$B_1 \times K_2$	48.67 e
$B_1 \times K_3$	54.57 b
$B_2 \times K_0$	40.38 j
$B_2 \times K_1$	45.26 g
$B_2 \times K_2$	50.55 d
$B_2 \times K_3$	55.42 a
$LSD_{(0.5)}$	**0.41**
CV	**0.52**

Here,
K_0 = 0 $kgha^{-1}$ — B_0 = 0 $kgha^{-1}$
K_1 = 60 $kgha^{-1}$ — B1 = 1 kg ha^{-1}
K_2 = 90 $kgha^{-1}$ — B_2 = 2 kg ha^{-1}
K_3 = 120 kg ha^{-1}

4.5 Effect of K and B on the fresh weight of bulb (g) of onion

4.5.1 Effect of K on the fresh weight of bulb (g) of onion

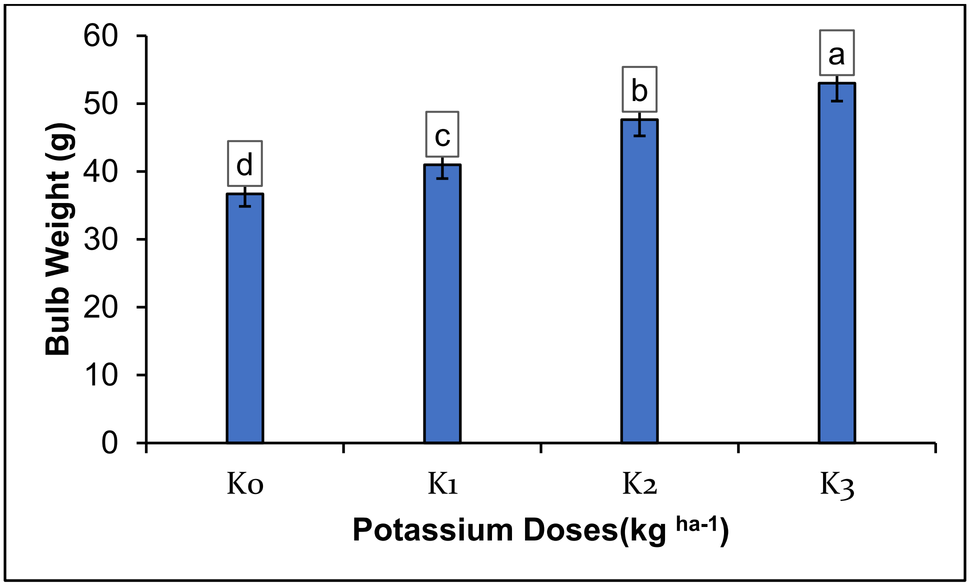

Figure 09. Effect of K on the fresh weight of bulb (g) of onion

The fresh weight of bulb (g) of onion was influenced by diverse doses of K application (Figure 09). The highest fresh weight of bulb plant^{-1} was (53.02 g) gotten with K_3 (120 kg ha^{-1}) treatment, and the lowest fresh weight of bulb plant^{-1} was (36.69 g) gotten with K_0(0 kg ha^{-1}) treatment. Significant improvement in bulb weight of onion in response to split application of potassium was also reported by several investigators at home and abroad (Islam,l999; Nagaich*et al*, 1999; Sangakkara and I'iyadas, 1993; Bhuyan, 1979: Salter and Haque. 1975).

4.5.2 Effect of B on the fresh weight of bulb (g) of onion

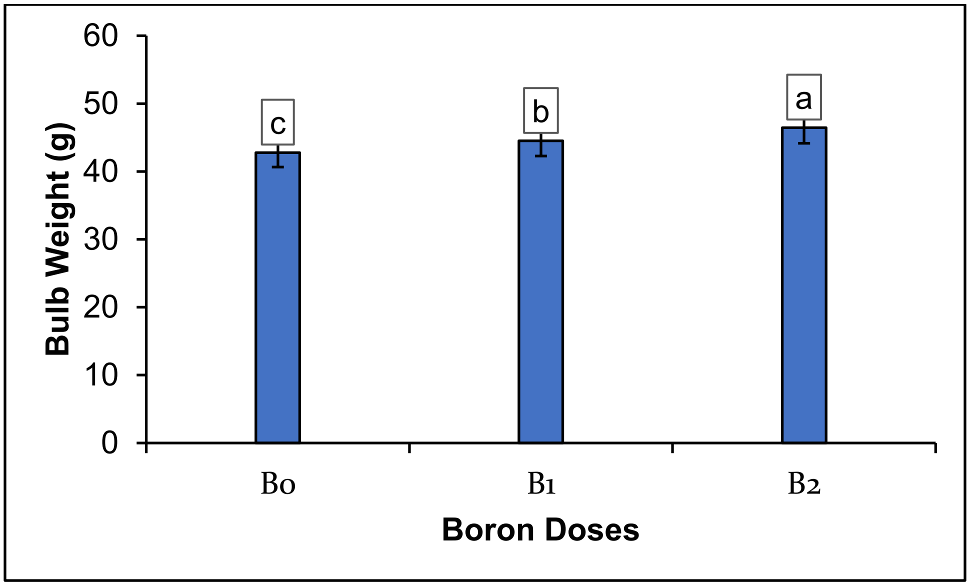

Figure 10. Effect of B on the fresh weight of bulb (g) of onion

Different doses of Boron showed statistically significant variation in respect of the fresh weight of the bulb when fertilizers in different doses were applied (Figure 10) However among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest fresh weight of bulb of onion (46.47 g) whereas B_0(0 kg ha^{-1}) showed the lowest fresh weight of bulb (42.79 cm). The more fresh weight of the bulb at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the weight of bulb increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

4.5.3 Interaction Effect of K and B on the fresh weight of bulb (g) of onion

The fresh weight of the bulb per plant showed a significant variation because of different potassium and boron levels (Figure 4). The highest bulb fresh weight (55.61 g) was obtained from the grown with the dose of $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}), and the lowest fresh weight of bulb (35.81 g) was found when the plants were raised from the grown with the dose of $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1}). A similar result was reported by

Baloch *et al*(1991). It was revealed that the treatment with the increased gradually higher dose of potassium and boron fertilizer gave the maximum fresh weight of bulb. Sufficient potassium and boron fertilizer supplied from treatment possibly favored plant growth along with the higher bulb. Nasiruddin *et al* (1993) found that the highest bulb yields fresh bulb weight from 100 kg potash and 30kg Sulphur ha^{-1}. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the weight of bulb increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

Table 05. Interaction Effect of K and B on the fresh weight of bulb (g) of onion

Treatment combinations	Bulb Weight
$B_0 \times K_0$	35.81 l
$B_0 \times K_1$	38.86 i
$B_0 \times K_2$	45.78 f
$B_0 \times K_3$	50.72 c
$B_1 \times K_0$	36.89 k
$B_1 \times K_1$	40.64 h
$B_1 \times K_2$	47.75 e
$B_1 \times K_3$	52.75 b
$B_2 \times K_0$	37.39 j
$B_2 \times K_1$	43.55 g
$B_2 \times K_2$	49.36 d
$B_2 \times K_3$	55.61 a
LSD (0.5)	**0.25**
CV	**0.34**

Here,
K_0 = 0 $kgha^{-1}$
K_1 = 60 $kgha^{-1}$
K_2 = 90 $kgha^{-1}$
K_3 = 120 kg ha^{-1}

B_0 = 0 $kgha^{-1}$
B1 = 1 kg ha^{-1}
B_2 = 2 kg ha^{-1}

4.6 Effect of K and B on the diameter of the bulb (cm) of onion

4.6.1 Effect of K on the diameter of the bulb (cm) of onion

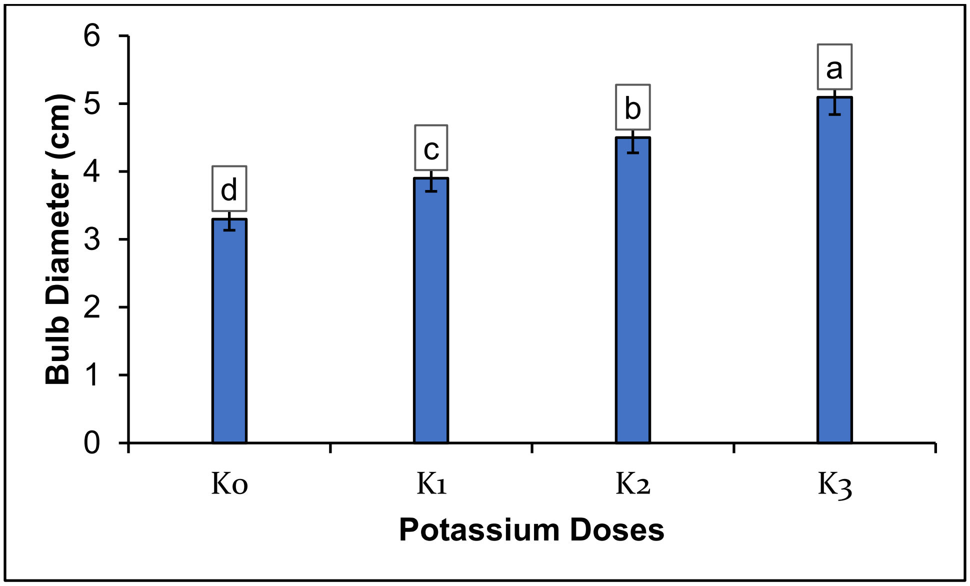

Figure 11. Effect of K on the diameter of the bulb (cm) of onion

The diameter of the bulb per plant showed a significant variation because of different levels of potassium (Figure 11). The highest bulb diameter (5.09 cm) was obtained from the grown with the dose of K_3 (120 kg ha^{-1}), and the lowest diameter (3.30 cm) was found when the plants were raised from the grown with the dose of K_0 (0 kg ha^{-1}). A similar result was reported by Baloch *et al* (1991). It was revealed that the treatment with the increased gradually higher dose of potassium gave the maximum diameter of the bulb. Sufficient potassium nutrients supplied from treatment possibly favored plant growth along with the higher bulb. Nasiruddin *et al* (1993) found that the highest bulb yield diameter was from 100 kg potash and 30kg Sulphur ha^{-1}.

4.6.2 Effect of B on the diameter of the bulb (cm) of onion

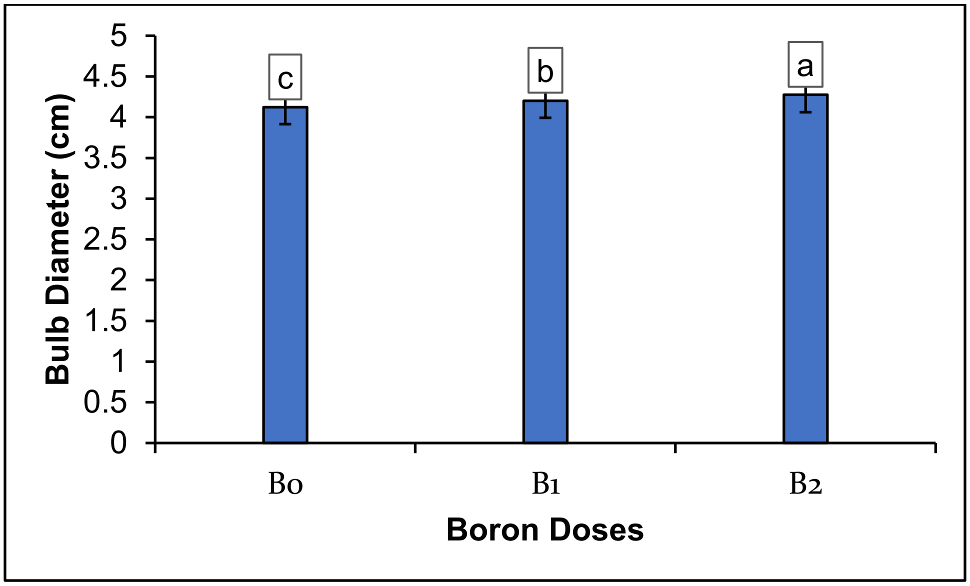

Figure 12. Effect of B on the diameter of the bulb (cm) of onion

Different doses of Boron showed statistically significant variation in respect of the bulb's diameter when fertilizers in different doses were applied (Figure12). However, among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest Diameter of the bulb of onion (4.28 g) whereas B_0(0 kg ha^{-1}) showed the lowest Diameter of the bulb (4.12 cm). The more Diameter of the bulb at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the bulb's diameter increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

4.6.3 Interaction Effect of K and B on the diameter of the bulb (cm) of onion

The interaction effect of different doses of Potassium and Boron showed statistically significant variation in the bulb's diameter when fertilizers in different doses were applied (Table 06). However, among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}) showed the highest Diameter of the bulb (5.25 cm) whereas $B_0 \times K_1$ (0 kg ha^{-1} and 60 kg ha^{-1}) showed the lowest Diameter of the bulb (3.75 cm), The most oversized diameter of a bulb of the plant at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the bulb's diameter increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

Table 06. Interaction Effect of K and B on the diameter of the bulb (cm) of onion

Treatment combinations	**Bulb Diameter (cm)**
$B_0 \times K_0$	3.45 j
$B_0 \times K_1$	3.75 i
$B_0 \times K_2$	4.35 f
$B_0 \times K_3$	4.93 c
$B_1 \times K_0$	3.30 k
$B_1 \times K_1$	3.91 h
$B_1 \times K_2$	4.50 e
$B_1 \times K_3$	5.10 b
$B_2 \times K_0$	3.15 l
$B_2 \times K_1$	4.05 g
$B_2 \times K_2$	4.65 d
$B_2 \times K_3$	5.25 a
LSD $_{(0.5)}$	**0.02**
CV	**0.24**

Here,

K_0 = 0 kgha^{-1} | B_0 = 0 kgha^{-1}
K_1 = 60 kgha^{-1} | B1 = 1 kg ha^{-1}
K_2 = 90 kgha^{-1} | B_2 = 2 kg ha^{-1}
K_3 = 120 kg ha^{-1}

4.8 Effect of K and B on length of the bulb (g) of onion

4.8.1 Effect of K on length of the bulb (g) of onion

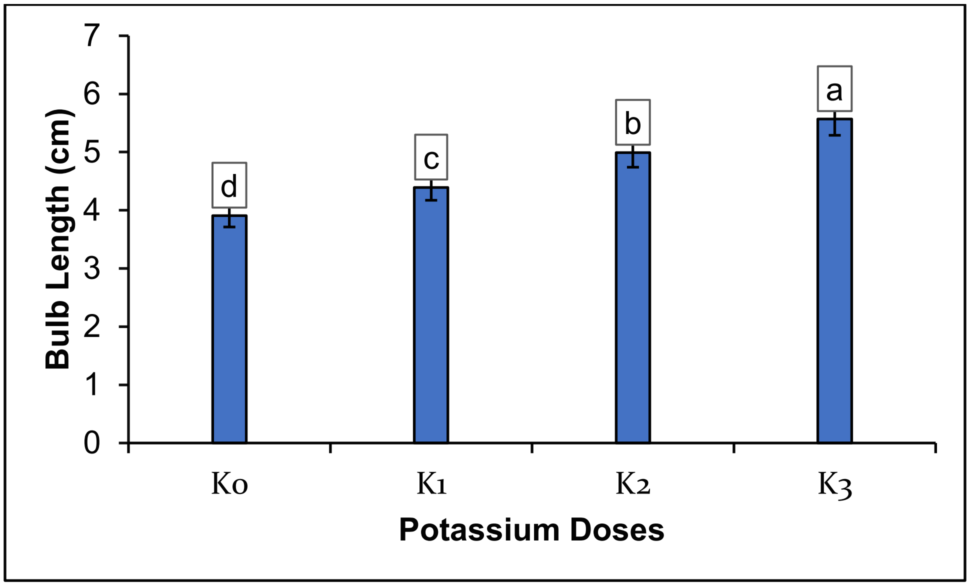

Figure 13. Effect of K on length of the bulb (g) of onion

The application of different potassium fertilizer doses showed a significant difference in the length of the bulb (Figure 13). Along with the different fertilizer doses of K treatment, K3 treatment showed the highest length of the bulb (5.57 cm), and the lowest length of the bulb (3.91 cm) was recorded with K_0 treatment where an increasing amount of fertilizer doses applied might be increased the vegetative growth and development of onion that leads to the highest length of the bulb. The highest level of potash showed more increase in bulb length.

4.8.2 Effect of B on length of the bulb (g) of onion

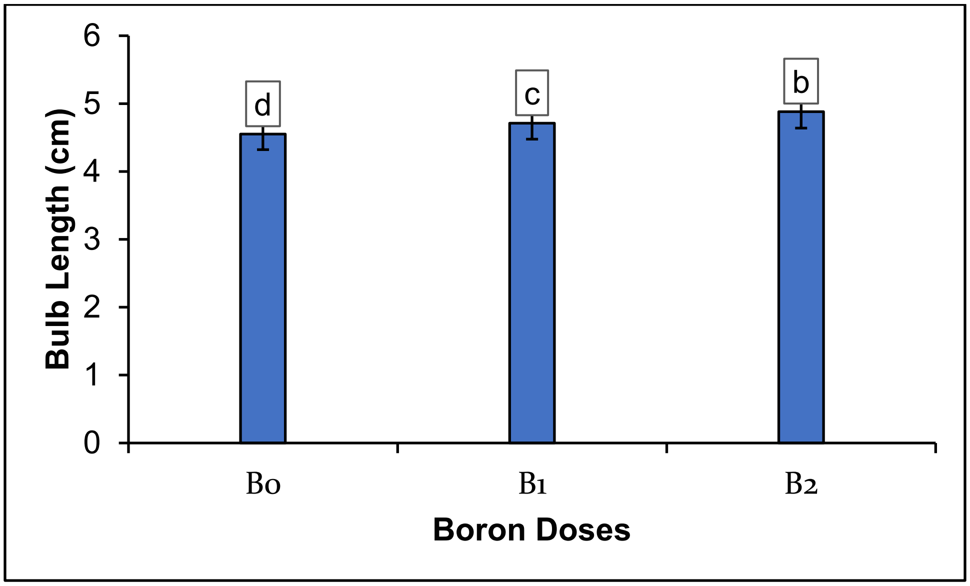

Figure 14. Effect of B on length of the bulb (g) of onion

Different doses of Boron showed statistically significant variation in respect of the bulb's Diameter when fertilizers in different doses were applied (Figure 14). However, among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest length of the bulb of onion (4.88 cm) whereas B_0 (0 kg ha^{-1}) showed the lowest Diameter of the bulb (4.55 cm). The length of the bulb at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the length of the bulb increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

4.8.3 Interaction Effect of K and B on length of the bulb (g) of onion

The interaction effect of different doses of Potassium and Boron showed statistically significant variation in respect of the length of the bulb when fertilizers in different doses were applied (Table 07). However, among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}) showed the highest length of the bulb (5.75 cm) whereas $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1}) showed the lowest plant height (3.74 cm), The highest length of the bulb at the highest doses received more nutrients which might have encouraged more vegetative growth. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the length of the bulb increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

Table 07. Interaction Effect of K and B on length of the bulb (g) of onion

Treatment combinations	Bulb Length (g)
$B_0 \times K_0$	3.74 l
$B_0 \times K_1$	4.25 i
$B_0 \times K_2$	4.85 f
$B_0 \times K_3$	5.35 c
$B_1 \times K_0$	3.90 k
$B_1 \times K_1$	4.38 h
$B_1 \times K_2$	4.99 e
$B_1 \times K_3$	5.60 b
$B_2 \times K_0$	4.08 j
$B_2 \times K_1$	4.55 g
$B_2 \times K_2$	5.15 d
$B_2 \times K_3$	5.75 a
LSD $_{(0.5)}$	**0.05**
CV	**0.66**

Here,

K_0 = 0 kgha^{-1}
K_1 = 60 kgha^{-1}
K_2 = 90 kgha^{-1}
K_3 = 120 kg ha^{-1}

B_0 = 0 kgha^{-1}
B1 = 1 kg ha^{-1}
B_2 = 2 kg ha^{-1}

4.9 Effect of K and B on yield (t ha^{-1}) of onion

4.9.1 Effect of K on yield (t ha^{-1}) of onion

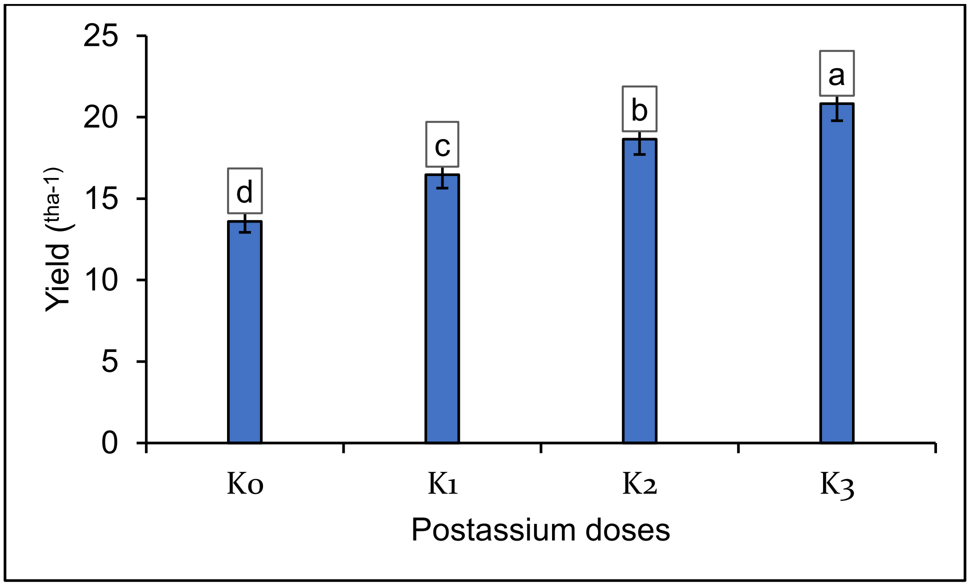

Figure 15. Effect of K on yield (t ha^{-1}) of onion

The results of the yield effects from different levels of potassium have been shown in (Figure 15). This figure shows that the K_3 (120 kg ha^{-1}) treatment gave the highest yield (20.83 t ha^{-1}). On the contrary, the lowest yield of the bulb (13.61 t ha^{-1}) was observed with K_0 (0 kg ha^{-1}) where no potash was applied. This result agreed with the findings of Rizk (1997) who reported that increased NPKS increased bulb yield. Pandev*et al* (1990) and Bereniewiez and Nowosiceski (1986) also found similar results.

4.9.2 Effect of B on yield (t ha^{-1}) of onion

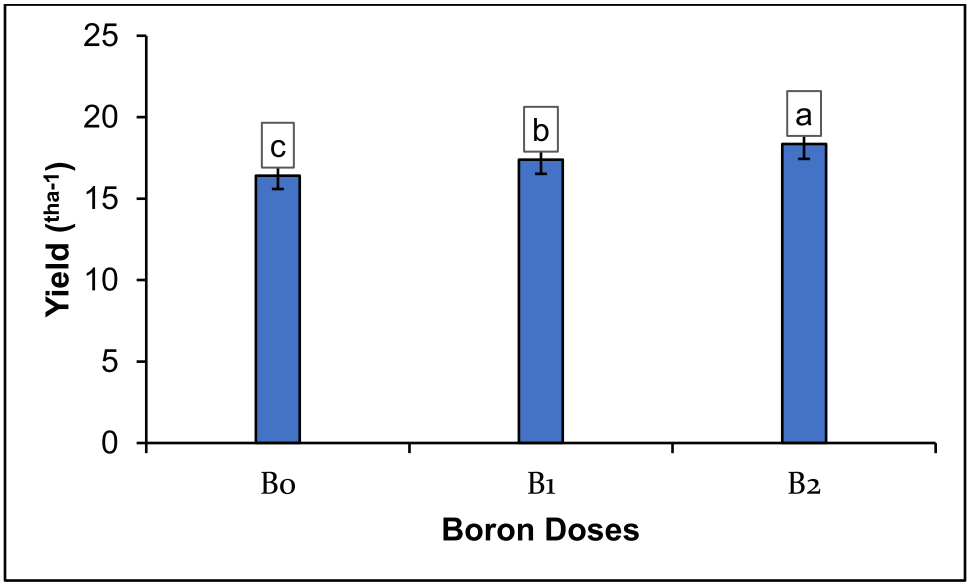

Figure 16. Effect of B on yield (t ha^{-1}) of onion

Different doses of Boron showed statistically significant variation in yield when fertilizers in different doses were applied (Figure 16). However, among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the maximum yield of onion (18.36 t ha^{-1}) whereas B_0 (0 kg ha^{-1}) showed the minimum yield of onion (16.41 t ha^{-1}). The yield of onion at the highest doses received more nutrients which might have encouraged more vegetative growth and yield. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the yield of onion increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

4.9.3 Interaction Effect of K and B on yield (t ha^{-1}) of onion

The interaction effect of different doses of Potassium and Boron showed statistically significant variation in yield when fertilizers in different doses were applied (Table 08). However, among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}) showed the highest yield (22.407 t ha^{-1}) whereas $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1})

showed the lowest yield (13.185 t ha^{-1}), which is statistically similar to the treatment combination of $B_1 \times K_0$ (1.9 kg ha^{-1} and 0 kg ha^{-1}) obtained yield (13.53 t ha^{-1}). The maximum yield gained at the highest doses received more nutrients which might have encouraged more vegetative growth and yield. Miah, M. S. *et al* (2020) and Haque. M. R. *et al* (2014) reported that the length of the bulb increased with the increasing levels of Boron. A similar result was also found by Manna. D. *et al* (2014) These results agree with the findings of Bhuyan (1979) and Yadav *et al.* (2003).

Table 08. Interaction Effect of K and B on yield (t ha^{-1}) of onion

Treatment combinations	**Yield(tha^{-1})**
$B_0 \times K_0$	13.19i
$B_0 \times K_1$	15.26 g
$B_0 \times K_2$	18.07 d
$B_0 \times K_3$	19.14 c
$B_1 \times K_0$	13.53i
$B_1 \times K_1$	16.74 f
$B_1 \times K_2$	18.38 d
$B_1 \times K_3$	20.93 b
$B_2 \times K_0$	14.13 h
$B_2 \times K_1$	17.42 e
$B_2 \times K_2$	19.48 c
$B_2 \times K_3$	22.41 a
LSD $_{(0.5)}$	**0.56**
CV	**1.91**

Here,

K_0 = 0 $kgha^{-1}$
K_1 = 60 $kgha^{-1}$
K_2 = 90 $kgha^{-1}$
K_3 = 120 kg ha^{-1}

B_0 = 0 $kgha^{-1}$
B1 = 1 kg ha^{-1}
B_2 = 2 kg ha^{-1}

Table 09. Effect of different doses of potassium (K) and Boron (B) fertilizer on post-harvest soil properties

Treatment combinations	pH	Organic carbon (%)	Available P (ppm)	Exchangeable K (meq/100g)	Available S (μg/g)
$B_0 \times K_0$	6.10	0.41	12.00e	0.11cde	12.50d
$B_0 \times K_1$	6.20	0.49	14.98b	0.12bcd	18.04b
$B_0 \times K_2$	6.16	0.50	14.17bc	0.17b	17.12bc
$B_0 \times K_3$	6.13	0.50	13.90bcd	0.15ab	15.61c
$B_1 \times K_0$	6.20	0.49	12.26e	0.13abcd	17.50ab
$B_1 \times K_1$	6.20	0.49	14.98a	0.12bcd	18.04b
$B_1 \times K_2$	6.16	0.50	14.17bc	0.17b	17.12bc
$B_1 \times K_3$	6.13	0.50	13.90bcd	0.15ab	15.61c
$B_2 \times K_0$	6.22	0.49	12.26e	0.13abcd	17.50bc
$B_2 \times K_1$	6.20	0.49	14.98b	0.12bcd	18.04b
$B_2 \times K_2$	6.16	0.50	14.17bc	0.17b	17.12bc
$B_2 \times K_3$	6.00	0.65	15.90a	0.19a	19.61a
Significance level	NS	NS	**	**	**
LSD	0.17	0.99	0.0028	0.04	0.48
CV (%)	2.87	11.37	4.80	17.43	10.06

Here,
K_0 = 0 $kgha^{-1}$ | B_0 = 0 $kgha^{-1}$
K_1 = 60 $kgha^{-1}$ | B1 = 1 kg ha^{-1}
K_2 = 90 $kgha^{-1}$ | B_2 = 2 kg ha^{-1}
K_3 = 120 kg ha^{-1}

4.10 Chemical properties of post harvest soils

After collecting soil, the Chemical Properties of soil, a composite soil test from 30 cm profundity was collected applying estimates from eight diverse focuses of the test range and a few of its chemical properties sometime recently and after collect was decided as displayed in table 9.

4.10.1 Soil pH

There was a non-significant variation recorded for pH in post-harvest soil due to different doses of K and B fertilizer. The maximum pH (6) was observed from $B_2 \times K_3$ treatment though the most negligible pH (6.10) was observed from $B_0 \times K_0$ treatment (Table 5)

4.10.2 Organic Carbon (%)

Different doses of K fertilizer influenced the organic carbon of soil. From the data, the highest value of organic carbon was recorded (0.65%) from $B_2 \times K_3$ treatment, and the lowest organic carbon value was (0.41%) from the $B_0 \times K_0$ treatment. So, there was a non-significant variation between the two of them.

4.10.4 Available P (ppm)

The phosphorus content of the post-harvest soil was non-significant due to different doses of K and B applied in all treatments (Table 9). Available phosphorus content in soil varied from 12.00 to15.90 ppm due to similar phosphorus applications. The highest phosphorus content 15.90 ppm was observed in the treatment $B_2 \times K_3$ which was (14.98 ppm) followed by $B_0 \times K_1$. The lowest phosphorus content (12.00 ppm) was observed in $B_0 \times K_0$.

4.10.5 Exchangeable K (meq/100 g soil)

The exchangeable potassium (K) content of the post-harvest soil significantly varied due to different treatments (Table 9). The exchangeable K content of initial soil was 0.10 meq/100 g soil, and ranged from 0.09 to 0.17meq/100 g soil. The highest exchangeable K 0.19meq/100 g soil was found in the treatments of $B_2 \times K_3$. The lowest value 0.11meq/100 g soil was found in the treatments $B_0 \times K_0$. The transferrable K enlarged in soils due to the source of nutrients from cow dung throughout the growing period. A similar observation was made by Horuchi*et al.* (2008) who reported that using a compost of pea rests enhanced soil NPK and other nutrients in the soil.

4.10.6 Available S (ppm)

The Sulphur content of the post-harvest soil significantly varied due to the similar amount of S applied in all treatments (Table 9). Available Sulphur content in soil varied from 12.50 to 19.61 (µg/g)due to applied different sources of K and B fertilizer. The maximum sulfur content 19.61 (µg/g) was observed in the treatment $B_2 \times K_3$, which was statistically identical to $B_2 \times K_0$ and $B_1 \times K_0$treatment. The lowest phosphorus content 12.50 (µg/g) was observed in $B_0 \times K_0$ treatment.

CHAPTER V

SUMMARY AND CONCLUSION

This experiment will be conducted at the Farm division of Sher-e-Bangla Agricultural University, during the rabi season of December 2021 under AEZ 28 (Madhupur tract), Sher-e-Bangla Nagar, Dhaka-1207 to examine the effects of Potassium and Boron on the performance of Onion (*Allium cepa* L.). This experiment utilized BARI Peyaj-4 as the test crop. The experiment consisted of two variables. A: Potassium Doses (four levels); K_0 is a 0 kg Potassium ha^{-1}, K_1 is 60 kg Potassium ha^{-1}, K_2 is 90 kg Potassium ha^{-1} , and K_3 is 120 kg Potassium ha^{-1} . B: Boron Doses (three levels): B_0: 0 kg Boron ha^{-1}, B_1: 1.0kg Boron ha^{-1}, and B_3: 2 kg Boron ha^{-1}. A randomized complete block design with three replications was used to set up the experiment, gathering information on various growth parameters, yield characteristics, and yields.

Data were noted specifically Plant height (cm), Number of leaves, Length of leaves (cm), Fresh weight of leaves (g), Fresh weight of bulb (g), Diameter of the bulb (cm), Dry weight of bulb (g), Length of the bulb (cm) and Yield (t ha^{-1}). The collected data and the differences between the means were evaluated by Duncan's Multiple Range Test. The experimental results are summarized as follows.

The result of the experiment exposed that the application of potassium had a statistically significant effect on plant height. Potassium showed statistically a significant variation in respect of the plant height when fertilizers in different doses were applied. At harvesting time, different doses Potassium showed statistically significant variation on plant height when fertilizers in different doses were applied. However, among the different doses of fertilizer, K_3 (120 kg ha^{-1}) showed the highest plant height (59.11 cm) and K_1 (0 kg ha^{-1}) showed the lowest plant height (53.13 cm). Different doses of Boron showed statistically significant variation in respect of the plant height when fertilizers in different doses were applied. However among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest plant height (47.49 cm) whereas Bo (0 kg ha^{-1}) showed the lowest plant height (43.54 cm). The taller plants at the highest doses received more nutrients which might have encouraged more vegetative growth. Interaction effect of different doses of

Potassium and Boron showed statistically significant variation in respect of the plant height when fertilizers in different doses were applied However among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kg Boron ha^{-1} and 120 kg Potassium ha^{-1}) showed the highest plant height (61.09 cm) whereas $B_0 \times K_0$ (0 kg Boron ha^{-1} and 0 kg Potassium ha^{-1}) showed the lowest plant height (30.30 cm), The taller plants at the highest doses received more nutrients which might have encouraged more vegetative growth.

There was a significant variation observed in the number of leaves of onion $plant^{-1}$ when different doses of potassium were applied. Among the different doses of fertilizers K_3 (120 kg ha^{-1}) treatment showed the highest number of leaves (7.02) $plant^{-1}$. On the contrary, the lowest number of leaves (4.65) was observed with K_0 (0 kg Potassium ha^{-1}), where no fertilizer was applied.Different doses of Boron showed statistically significant variation in respect of the plant height when fertilizers in different doses were applied. However among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest number of leaves of onion (5.97) whereas B_0 (0 kg Boron ha^{-1}) showed the lowest plant height (5.64). The more leaves of the plant at the highest doses received more nutrients which might have encouraged more vegetative growth. Interaction effect of different doses of Potassium and Boron showed statistically significant variation in respect of the plant height when fertilizers in different doses were applied However among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kgboron ha^{-1} and 120 kgpotassium ha^{-1}) showed the highest number of leaves of Onion (7.67) whereas $B_0 \times K_0$ (0 kg Boron ha^{-1} and 0 kg Potassium ha^{-1}) showed the lowest plant height (4.49), followed by $B_1 \times K_0$ (1.0kg Boron ha^{-1} and 0 kg Potassium ha^{-1}) show no. of leaves of the plant is 4.72. The more leafy plants at the highest doses received more nutrients which might have encouraged more vegetative growth.

The application of potassium fertilizer at different doses showed a significant variation in the length of the onion leaves. Among the different fertilizer doses K_3 (120 kg Potassium ha^{-1}) showed the highest leaf length was (55.33 cm), and the second highest was (48.18 cm) statistically dis-similar to the fertilizer dose of K_2 (90 kg Potassium ha^{-1}). On the other hand, the lowest leaf length (31.07 cm) was recorded with K_0 (0 kg Potassium ha^{-1})

treatment where no potash was applied. Optimum fertilizer doses might be increased the vegetative growth of onion which lead to the highest leaf length. Different doses of Boron showed statistically significant variation in respect of the length of leaves when fertilizers in different doses were applied However among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest length of leaves of onion (44.37 cm) whereas B_0 (0 kg Boron ha^{-1}) and B_1 (1.0kg Boron ha^{-1}) showed the statistically similar length of leaves (42.99 cm) and (45.21 cm) respectively. The more length of leaves at the highest doses received more nutrients which might have encouraged more vegetative growth.

Interaction effect of different doses of Potassium and Boron showed statistically significant variation in respect of the plant height when fertilizers in different doses were applied. However among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kg Boron ha^{-1} and 120 kg Potassium ha^{-1}) showed the highest plant height (57.82 cm) which is statistically similar with the treatment combination of $B_0 \times K_3$ (0 kg Boron ha^{-1} and 120 kg Potassium ha^{-1}), $B_1 \times K_3$ (1.0kg Boron ha^{-1} and 120 kg Potassium ha^{-1}), and $B_2 \times K_2$(2 kg Boron ha^{-1} and 90 kg Potassium ha^{-1}), showed the length of leaves is (32.96 cm), (55.65 cm) and (50.74 cm) respectively. On the other hand, $B_2 \times K_0$ (2 kg Boron ha^{-1} and 0 kg Potassium ha^{-1}) showed the lowest length of leaf (25.52 cm) which is statistically similar to the treatment combination of ($B_1 \times K_0$), and ($B_0 \times K_0$) showed the length of the leaf is (34.73 cm) and (32.96 cm) respectively. The most extended length of the leaf of plants at the highest doses received more nutrients which might have encouraged more vegetative growth.

The fresh weight of leaves as influenced by diverse measurements of K application appeared. The maximum fresh weight of leaves was (54.44 g) with K_3 (120 kg ha^{-1}), and the lowest fresh weight of leaves was found from(38.59 g) with K_0 (0 kg ha^{-1}) treatments. Different doses of Boron showed statistically significant variation in respect of the fresh weight of leaves when fertilizers in different doses were applied However among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest fresh weight of leaves of onion (47.90 cm) whereas B_0 (0 kg ha^{-1}) showed the lowest fresh weight of leaves (44.78 cm). The more fresh weight of leaves at the highest doses received more nutrients which might have encouraged more vegetative growth. The interaction effect of different doses of Potassium and Boron showed statistically significant variation in the fresh weight of leaves when fertilizers in different doses were applied. However, among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}) showed the highest fresh weight of leaves (55.42 cm) whereas $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1}) showed the lowest fresh weight of leaves (36.69 cm), The heaviest plants in respect of fresh weight at the highest doses received more nutrients which might have encouraged more vegetative growth.

The fresh weight of bulb (g) of onion was influenced by diverse doses of K application. The highest fresh weight of bulb plant^{-1} was (53.02 g) gotten with K_3 (120 kg ha^{-1}) treatment, and the lowest fresh weight of bulb plant^{-1} was (36.69 g) gotten with K_0 (0 kg ha^{-1}) treatment. Different doses of Boron showed statistically significant variation in respect of the fresh weight of the bulb when fertilizers in different doses were applied However among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest fresh weight of bulb of onion (46.48 g) whereas B_0 (0 kg ha^{-1}) showed the lowest fresh weight of bulb (42.79 cm). The more fresh weight of the bulb at the highest doses received more nutrients which might have encouraged more vegetative growth. The fresh weight of the bulb per plant showed a significant variation because of different potassium and boron levels. The highest bulb fresh weight (55.61 g) was obtained from the grown with the dose of $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}), and the lowest fresh weight of bulb (35.81 g) was found when the plants were raised from the grown with the dose of $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1}). A similar result was reported by Baloch *et al.* (1991). It was revealed that the treatment with the increased gradually higher dose of potassium and boron fertilizer gave the maximum fresh weight of bulb. Sufficient potassium and boron fertilizer supplied from treatment possibly favored plant growth along with the higher bulb.

The diameter of the bulb plant^{-1} showed a significant variation because of different levels of potassium. The highest bulb diameter (5.09 cm) was obtained from the grown with the dose of K_3 (120 kg ha^{-1}), and the lowest diameter (3.30 cm) was found when the plants were raised from the grown with the dose of K_0 (0 kg ha^{-1}). Different doses of Boron showed statistically significant variation in respect of the bulb's Diameter when fertilizers in different doses were applied. However, among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest Diameter of the bulb onion (4.28 g) whereas B_0 (0 kg ha^{-1}) showed the lowest Diameter of the bulb (4.12 cm). The more Diameter of the bulb at the highest doses received more nutrients which might have encouraged more vegetative growth. The interaction effect of different doses of Potassium and Boron showed statistically significant variation in the bulb's diameter when fertilizers in different doses were applied. However, among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}) showed the highest Diameter of the bulb (5.25 cm) whereas $B_0 \times K_1$ (0 kg ha^{-1} and 60 kg ha^{-1}) showed the lowest Diameter of the bulb (3.75 cm), The most oversized diameter of a bulb of the plant at the highest doses received more nutrients which might have encouraged more vegetative growth.

The application of different potassium fertilizer doses showed a significant difference in the length of the bulb. Along with the different fertilizer doses of K treatment, K_3 treatment showed the highest length of the bulb (5.58 cm), and the lowest length of the bulb (3.91 cm) was recorded with K_0 treatment where an increasing amount of fertilizer doses applied might be increased the vegetative growth and development of onion that leads to the highest length of the bulb. The highest level of potash showed more increase in bulb length. Different doses of Boron showed statistically significant variation in respect of the bulb's Diameter when fertilizers in different doses were applied. However, among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the highest length of the bulb of onion (4.88 cm) whereas B_0 (0 kg ha^{-1}) showed the lowest Diameter of the bulb (4.55 cm). The length of the bulb at the highest doses received more nutrients which might have encouraged more vegetative growth. The interaction effect of different doses of Potassium and Boron showed statistically significant variation in respect of the length of the bulb when fertilizers in different doses were applied. However, among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}) showed the highest length of the bulb (5.75 cm) whereas $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1}) showed the lowest plant height (3.74 cm), The highest length of the bulb at the highest doses received more nutrients which might have encouraged more vegetative growth.

The results of the yield effects from different levels of potassium have been shown. This figure shows that the K_3 (120 kg ha^{-1}) treatment gave the highest yield (20.83 t ha^{-1}). On the contrary, the lowest yield of the bulb (13.61 t ha^{-1}) was observed with K_0 (0 kg ha^{-1}) where no potash was applied. Different doses of Boron showed statistically significant variation in yield when fertilizers in different doses were applied. However, among the different doses of fertilizer, B_2 (2 kg ha^{-1}) showed the maximum yield of onion (18.36 t ha^{-1}) whereas B_0 (0 kg ha^{-1}) showed the minimum yield of onion (16.41 t ha^{-1}). The yield of onion at the highest doses received more nutrients which might have encouraged more vegetative growth and yield. The interaction effect of different doses of Potassium and Boron showed statistically significant variation in yield when fertilizers in different doses were applied. However, among the different doses of fertilizer combination, $B_2 \times K_3$ (2 kg ha^{-1} and 120 kg ha^{-1}) showed the highest yield (22.41 t ha^{-1}) whereas $B_0 \times K_0$ (0 kg ha^{-1} and 0 kg ha^{-1}) showed the lowest yield (13.19 t ha^{-1}), which is statistically similar to the treatment combination of $B_1 \times K_0$ (1.0kg ha^{-1} and 0 kg ha^{-1}) obtained yield (13.53 t ha^{-1}). The maximum yield gained at the highest doses received more nutrients which might have encouraged more vegetative growth and yield.

From the above discussion, it can be concluded that applying K at the rate of 120 kg $ha^{-1}$and B at the rate of 2 kg ha^{-1} was favorable for the maximum yield of onion. However, the results must substantiate further with different varieties and soil management practices. Since the present study was conducted in only one agroecological zone, further investigations must be carried out in other areas of Bangladesh.

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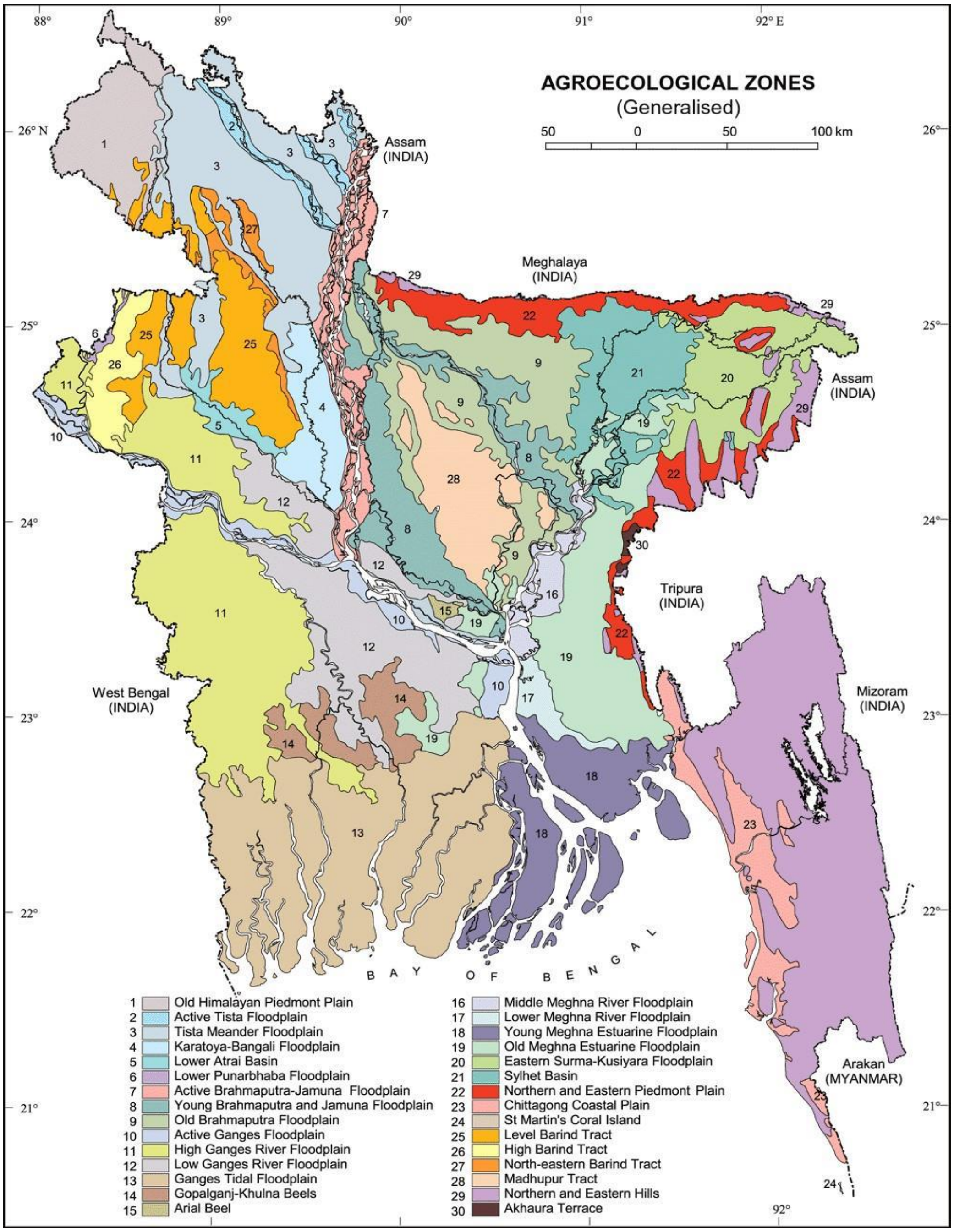
CHAPTER VI

APPENDICES

Appendix I: Map Showing the experimental site under study



Appendix II: Characteristics of soil of experimental field

A. Morphological characteristics of experimental field

Morphological features	Characteristics
Location	Agronomy field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physiological properties of the initial soil

Characteristics	Value
Particle size analysis	
Sand%	25
Silt%	45
Clay%	30
Textural Classes	Silty -Clay
pH	6.00
Particle density (g/cc)	2.68
Organic carbon (%)	0.47
Organic matter (%)	0.80
Available P (ppm)	22.00
Exchangeable K (meq/100g soil)	0.121

Appendix III. Monthly average of relative humidity, air temperature, and total rainfall of the experimental site during the period from November 2021 to March 2022

Month	Average RH%	Average temperature (C^0)		Total Average Rainfall(mm)
		Min.	Max.	
November, 2021	50.45	8.56	24.87	00
December, 2021	52.41	6.04	23.35	00
January, 2022	59.13	12.45	21.32	00
February, 2022	53.66	16.34	24.12	4.34
March, 2022	46.37	19.41	28.54	1.22

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix IV: Schedule of cultural operation in the experiment

Serial No.	Cultural preparation	Date
1.	Transplanting of seedlings to the main field	06.01.2022
2.	Gap fillings	16.01.2022
3.	1st Irrigation	01.02.2022
4.	Tagging	03.02.2022
5.	1st Weeding with mulching	08.02.2022
6.	2nd Irrigation	8.03.2022
7.	Drainage	12.03.2022
8.	2nd Weeding	26.03.2022
9.	Fencing with Net	27.03.2022
10.	Data collection with different parameters	26.03.2022
11.	Final Harvesting	13.04.2022
12.	Collection post-harvest soil	30.04.2022
13.	Analysis of soil sample	20.05.2022

Appendix V: Analysis of variance of some parameters with different doses of potassium (K) and boron (B) fertilizer application

Source of variance	DF	Mean sum of square							
		Plant height (cm)	**Number of leaves**	**Length of leaves (cm)**	**Fresh weight of leaves (g)**	**Fresh weight of bulb (g)**	**Diameter of bulb (cm)**	**Length of bulb**	**Yield (t ha^{-1})**
Replication	2	0.53482	0.53	30.33	0.38	0.38	0.029	0.018	0.06
B	2	0.313	0.31	15.02	29.54	29.54	0.07	0.335	11.34
K	3	8.47	8.47	948.42	406.35	406.35	5.36	4.67	85.49
B×K	6	0.25	0.25	33.98	0.66	0.66	0.07	0.0029	0.89
Error	22	0.009	0.009	30.19	0.06	0.06	0.0001	0.0009	0.12

Appendix VI: Analysis of variance of different doses of potassium (K) and boron (B) fertilizer on post-harvest soil properties

Source of variance	DF	Mean sum of square				
		P^H	Organic carbon (%)	Available P (ppm)	Exchangeable K (meq/100g)	Available S (µg/g)
Replication	2	0.00042	0.016	0.803	0.001	0.024
B	2	0.378	0.00037	2.478**	0.002**	3.113**
K	3	0.00042	0.016	0.803	0.001	0.024
B×K	6	0.578	0.00057	3.478**	0.002**	4.113**
Error	22	0.032	0.00314	0.433	0.001	3.148

Appendix VII: Some photos document during experiment

Plate 01. Transplanting of Seedlings

Plate 02. Onion Data collection

Plate 03. Early vegetative stage of seedlings

Plate 04. Field View after Harvesting

Plate 05. Harvesting in a poly Bag

Plate 06. Plots after harvesting

Plate 07. Transportation of harvested Onion

Plate 08. Stored Onion after Harvest

Plate 09. A Single Bulb of Onion

Plate 10. Few Bulbs of Onion

Plate 11. Onions after cutting of leaves

Plate 12. Stored Onion

Plate 13. Soil Physio-chemical analysis

Plate 14. Soil Preparation of analysis

Plate 15. Soil Sample collection

Plate 16. Lab Work