EFFECT OF NITROGEN AND ZINC ON THE GROWTH AND YIELD OF ONION (BARI Peyaj- 6)

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To

My Beloved Parents

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CERTIFICATE

This is to certify that the thesis entitled "**EFFECT OF NITROGEN AND ZINC ON THE GROWTH AND YIELD OF ONION (BARI Peyaj- 6)"** 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 (MS)** in **SOIL SCIENCE,** embodies the results of a piece of bona fide research work carried out by **MD. ARIFUL ISLAM**, **Registration No**. **19-10233** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

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The Author

EFFECT OF NITROGEN AND ZINC ON THE GROWTH AND YIELD OF ONION (BARI Peyaj- 6)

ABSTRACT

The research work was conducted at Sher-e-Bangla Agricultural University Farm, Sher-e-Bangla Nagar, Dhaka-1207 during the Rabi season of December 2021. The experiment was undertaken to investigate the effect of nitrogen and zinc on the growth and yield of onion. The experiment comprised of two factors; Factor A: 0 kg/ha (N_0), 60 kg/ha (N_1), 100 kg/ha (N_2), 140 kg/ha (N_3) and Factors B: Levels of zinc (3 levels) 0 kg/ha (Zn_0), 2 kg/ha (Zn_1), 4 kg/ha (Zn_2). The two factors experiment was laid out in randomized complete block design (RCBD) with three replications. Results of the experiment revealed that N and Zn significantly influenced yield parameters and yield of BARI Peyaj-6. The nitrogen level of N_3 (140 kg/ha) gave the tallest plant (48.29 cm) while the N_0 (0 kg/ha) treatment gave the shortest plant (43.83 cm). The maximum (8.02) number of leaves, highest leaf length (39.87 cm), highest length of bulb (4.81 cm), highest diameter of the bulb (4.40 cm), maximum stem diameter (1.50 cm), fresh leaf weight (22.82 g), dry leaf weight (11.94 g), maximum (48.70 g) fresh bulb, maximum (3.53 kg/plot) yield, and maximum (17.56 t/ha) total yield also performed by N_3 (140 kg/ha). Among all the growth as well as yield and yield attributing traits Zn_2 (4 kg Zn/ha) performed better than the other treatments. Among different combined treatments, N_3Zn_2 (140 kg N/ha and 4 Kg Zn/ha) performed the best in respect of all yield and yield contributing characteristics while the lowest value of those parameters was observed in the control treatment combination of N_0Zn_0 (kg N/ha and 0 kg Zn/ha). The combined effect of nitrogen and zinc was also significant in respect of several traits. However, the maximum height (54.32cm) of the plant, the highest (9.85) number of leaves, leaf length (43.17 cm), stem diameter (1.58) of the plant, maximum fresh leaf weight (25.30 g), dry leaf weight (13.56 g, maximum length of bulb (5.23 cm), highest diameter of the bulb (4.81 cm), maximum fresh bulb weight (57.68 g) of the, highest yield (3.96 kg/plot) of the plant, and the maximum total yield (19.78 t/ha) of the plant also found in N_3Zn_2 (140 kg N/ha and 4 kg Zn/ha) treatment combination. Therefore, it is concluded that the treatment combination N_3Zn_2 (140 kg N/ha and 4 kg Zn/ha) may be recommended for maximizing the yield of BARI Peyaj-6 at Tejgaon series soil.

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LIST OF ACRONYMS

Acronyms	Full form
AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
et al.	And others
TSP	Triple Super Phosphate
MOP	Muriate of Potash
DAS	Days after sowing
g	Gram
Kg	Kilogram
Cm	Centimeter
%	Percentage
P^H	Potential of Hydrogen
CV(%)	Percentage of coefficient of variance
LSD	Least Significant Difference
V	Variety
0_C	Degree Celsius
RCBD	Randomized Complete Block Design
NS	Non-Significant
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute

CHAPTER I

INTRODUCTION

Onion (*Allium Cepa* L.) belongs to the *Alliaceae* family and is one of the most important spices as well as vegetable crops (Yoldas *et al*. 2011). It is semi-perishable and may be transferred over a great distance without much harm. Every kitchen needs onions, both as a vegetable and a condiment. As a result, the onion is often referred to as the "Queen of the Kitchen." Onion is favored for its flavor and pungency because it contains the volatile oil "allyl propyl disulfide," an organic molecule high in sulfur (Zargar Shooshtari *et al*. 2020)

Onion originated mostly in central Asia with the Mediterranean serving as the second major origin region for giant onion varieties (Agnieszka *et al*. 2017). Now, it is growing across the globe. The world's leading onion-growing countries are China, Holland, Korea, Israel, Japan, Turkey, Syria, Iran, Egypt, the United States, Lebanon, Austria, and India (Ahmed 1982, Akanbi *et al*. 2007). In Bangladesh's larger Dhaka, Mymensingh, Rajshahi, Rangpur, Rajbari, Khustia, Khulna, Barishal and Pabna districts are major commercially onion growing area (BBS 2018). Among Bangladesh-grown spice crops, onion ranks top in terms of production and area (BBS 2018). The total production of onion in Bangladesh is about 1866502 metric tons under the total cultivated area of 458969 acres (BBS 2018). The total production of onion in Bangladesh is about 23.31 lakh metric tons under the total cultivated area of 2.08 lakh ha (AIS 2020). It is the most widely grown and popular vegetable crop among the alliums as well as cash crops.

The onion bulb is a great source of carbohydrates, calcium, and other nutrients. It also includes protein and vitamin C. It can be used in a variety of ways as fresh, frozen, dehydrated and green bunching sorts of bulbs (Ahmed 1982). It offers good therapeutic value. It contains several anti-cancer substances that have been proven to stop animals from getting cancer (Akanbi *et al*. 2007). An advantageous substance found in onions called quercetin is a potent antioxidant (Ali *et al*. 2008).

Onion has 11.0 g of carbohydrates, 1.2 g of proteins, 0.6 g of fiber, 86.8 g of moisture, and several vitamins, including 0.012 mg of vitamin A, 11 mg of vitamin C, 0.08 mg of thiamin, 0.01 mg of riboflavin, and 0.2 mg of niacin per 100 g. It also has some minerals, including phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg) and iron (Amare *et al*. 2020)

It has recently become evident that increased yields and better onion quality depend on the effective utilization of nutrients. Nutrient management is the primary element that greatly affects onion production and output under favorable soil and climatic conditions. Fertilizer is a significant portion of the expense of producing onions in modern agriculture. By using nutrients carefully, it is possible to produce higher yields of high-quality bulbs (Abdullah and 2018).

In Bangladesh, onion is typically grown during the Rabi season. The management of various nutrients significantly affects the growth and output of this crop. Fertilizer comes in two varieties: one is organic, and the other is inorganic. It is known that the use of inorganic fertilizer for crops has residual effects that are not particularly favorable to human health but that organic fertilizers do not have these issues and on the other hand, boost soil productivity as well as crop quality and yield (Asaduzzaman *et al*. 2015, Asgele *et al*. 2018). Onions are however over-fertilized with inorganic fertilizers to produce more bulbous plants (Aung et al. 2014). Onion production depends on particular environmental factors. Additionally, onion cultivars are quite sensitive to the conditions they grow in, particularly the temperature and photoperiod (Haque *et al*. 2014). Numerous parameters, such as optimizing fertilizer application (macro and micronutrients) and preserving soil moisture, have a significant impact on the plant growth and production of onion seed (Hassan et al.1983).

Nitrogen is an essential and important determinant for the growth and development of crop plants (Kumar *et al*. 2018). Proteins, the building blocks of life, nucleic acids (RNA, DNA), chlorophyll, phosphamide, and other organic molecules all include nitrogen. When used in the right amount, nitrogen promotes the formation of protoplasm and protein, which lead to cell division and the start of the meristematic activity (Kuroda *et al*. 2020). Onion output and quality are most affected by nitrogen (Xin *et al*., 1997). Additionally, it encourages onion flowering, fresh set and vegetative development. It dramatically boosts onion growth and production (Roy *et al*. 2019). Onion production depends heavily on nitrogen. The weight of the bulb was noted to grow as the nitrogen level rose (Lasmini *et al*. 2015). Nitrogen plays the most important role in the vegetative growth of the crop which ultimately helps increase bulb size and total yield (Kumar *et al*. 2018). Due to its impact on plant height, leaf number per plant, bulb weight, and yield per plant, nitrogen is a very significant ingredient (Khokhar 2014).

Another essential element for boosting onion yield is zinc. According to many experts, secondary and trace elements like zinc (Zn) and manganese (Mn) can significantly increase the yield of onion seed (Kumar *et al*. 2018). For the growth and development of plants, a relatively minimal amount of Zn is needed. According to (Kitila *et al*. 2022). Bangladeshi soils are becoming deficient in Zn (Khan *et al*. 2018). The application of micronutrients to the deficient soil in these soils has resulted in a notable improvement in the yield of many crops, particularly high-quality grain and seed production (Khokhar 2014). From cell wall growth to respiration, photosynthesis, chlorophyll generation, enzyme activity, nitrogen fixation and other aspects of plant metabolism, micronutrients play an essential role (Kitila *et al*. 2022). The most important of zinc's vital physiological activities in plants is its participation in a number of enzymes, including dehydrogenases. both peptidases and proteinases. In plants, auxins, RNA, ribosome, and the metabolism of proteins, carbohydrates and phosphate are all important (Akul *et al*. 1982)

Within plants Zn seems to affect the capacity for water uptake and transport (Kandil *et al*. 2013) and to reduce the adverse effects of short periods of heat stress (Lasmini *et al*. 2015) or of salt stress (Laware and Raskar 2014). Since Zn is required for the synthesis of tryptophan (Sorensen *et al*. 2001) which is a precursor of IAA, this metal also has an active role in the production of auxin, an essential growth hormone (Tekle 2015). An excess of Zn has been reported to have a negative effect on mineral nutrition (Chaoui *et al*. 1997). Onions of the contemporary variety BARI Peyaj-6 are commonly grown in Bangladesh. In some specific regions of the country, the bulb-to-seed process is used to produce this variety's seeds. The evidence that is currently available on the impact of plant nutrients, in particular Zn and N, on BARI Peyaj-6 production in Bangladesh is not entirely conclusive. There has been very little research on the effects of Zn and N on output in Bangladesh.

The following objectives were set for the current research, which examined the effects of Zn and N on onion production in light of the aforementioned circumstances:

1. To observe the effect of nitrogen and zinc on the growth and yield of onion.
2. To investigate the interaction effect of nitrogen and zinc on the growth and yield of onion.
3. To find out the suitable doses of nitrogen and zinc for the maximum yield of onion.

CHAPTER II

REVIEW OF LITERATURE

Onion (*Allium cepa*) is one of the major spice crops in Bangladesh and growing in cool winter season. Onion production influenced by climate, plant nutrients and many other factors. Fertilizers play an important role on the growth and yield of onion.Present study has been undertaken to investigate the effect of application of nitrogen and zinc fertilizers on the yield of onion. Some relevant findings have been reviewed in this chapter.

2.1 Effect of nitrogen on the growth and yield of onion

Ahmed (2009) studied the effect of different levels of nitrogen (0, 60 and 120 kg/ha) and sulfur (0, 12, 24 and 36 kg/ha) on local onion cv. Faridpur bhati. Both nitrogen and sulphur significantly increased the yield. Nitrogen at 60 kg/ha together with sulphur 36 kg/ha produced a maximum yield (10.44 tons/ha).

Abbey and Kanton (2004) experimented with various levels of N and reported that the application of 40 and 50 kg N/ha significantly increased plant height and number of leaves compared with the control. The differences in effect between 40 and 80 kg N were not significant except that 80 kg N increased the number of Leaves per plant over 40 kg N.

Akhtar *et al*. (2002) conducted a field experiment was carried out at the Sher-e-Bangla Agricultural University Farm, Dhaka, to study the effect of nitrogen and the number of plants per hill on the growth and yield of onion (*Allium Cepa* L.). He found 180 kg N/ha can be used to obtain higher growth as well as higher yield.

Agumas *et al*. (2014) carried out a field experiment on the application of fertilizer rates (no fertilizer, N: K: S at 100:120:40 and 150:180:60 kg/ha) to investigate the growth and yield of onion. The fertilizer rates of 150 kg N, 180 kg K and 60 kg S /ha gave the highest result in case of maximum yield of quality bulbs.

Ahmed (2009) conducted a field experiment to investigate the effects of soil fertility and an integrated plant nutrition system composed of different rates of

N (30, 60, 90 and 120 kg/ha) on the yield of onion. Crop yield, as well as nutrient uptake by the crops, increased with increasing rates of N.

Al-Tabbal *et al*. (2017) carried out an experiment to investigate the effects of nitrogen (100, 125 and 150 kg/ha) and irrigation (irrigation at 7, 14 and 21 Day intervals) on the growth and yield of onion cv. BARI Piaz-1. Plant height, the number of leaves per plant, bulb length, bulb diameter, neck thickness, single bulb weight, and crop yield increased with increasing rates of N up to 125 kg/ha and it decreased 7-day intervals, without for several leaves per plant and single bulb weight. The interaction effects between N rates 9 and irrigation were significant for all the parameters measured except for bulb diameter.

Almaroai *et al*. (2020) conducted a field experiment to determine the effects of nitrogen on the growth of onions. Three levels of N (50, 75 and 100 kg/ha) were applied and found that the bulb yield of onion cv. Pusa Red is significantly affected by the N levels. The application of 75 kg N/ha gave a higher yield than 100 kg N/ha.

Asaduzzaman *et al*. (2015) conducted a field experiment with four levels of N (0, 100, 125 and 150 kg/ha) at Spices Research Centre, BARI, Joydebpur. They found that the bulb yield of onion was significantly affected by Nitrogen. The application of 125 kg N/ha gave a better yield than 150 kg N /ha.

Etana *et al*. (2019b) experimented at Lari, Himachal Pradesh, India during the summer season of 1994. He worked with five levels of nitrogen (0, 40, 80, 120 and 160 kg/ha) and two levels of Farm Yard Manure (10 and 20 t/ha) and reported that increasing nitrogen application rates increased bulb yields up to 120 kg N/ha. Higher yields were also obtained with the higher rate of farmyard manure.

Hassan (1983) experimented at Agra, India. He reported the effects of N (0, 60,120 and 180 kg/ha) and S (0, 20, 40 and 80 kg/ha) on the growth of onions (cv. Pusa red). The yield and plant N content significantly increase with increasing rate of N. Yield and growth increased with increasing rate of S up to 40 kg/ha. The combined application of N and S significantly affected the yield.

Pellejero *et al*. (2017) conducted an experiment with various levels of N and reported that the highest yield of marketable bulbs (34.97 t/ha) was found by transplanting onion seedlings on January and applying 100 kg N/ha. Transplanting on 15 February and applying 50 kg N/ha gave the lowest marketable yield (10.38 t/ha).

Yadav *et al*. (2005) studied the effect of different row spacing under different combinations of nitrogen, phosphorus, and potassium on the growth and yield of onion. Application of NPK exerted a significant effect on the yield and yield contributing characters of onion. The economic yield was obtained from NPK application @46:36:36 kg/ha.

Yassen and Khalid (2009) reported that onion bulb yield increased with direct application of nitrogen up to 60 kg/ha Potash at 40 kg as K_2O kg/ha onion did not affect its bulb yields.

Thangasamy and Lawande (2015) noticed that effective plant growth and maximum bulb yield and dry matter yield were obtained with the application of N: P_2O_5: K_2O at 120: 60: 60 kg/ha. They also reported in another trial (1983) that P and K at a higher rate improved the storage quality of onion.

Woldeselassie *et al*. (2014) clarified that N fertilizer was required to make up the crops at different stages of growth. Flat rate applications of 193 kg N/ha were followed by considerable losses resulting from irrigation and cost were higher. Specific applications of N at 105 kg/ha were found to reduce N losses and costs, but the yield increased.

Hidangmayum and Sharma (2017) reported that applying NPK at the highest rate gave the greatest bulb size, maximum yield (33.89 t/ha) and best quality of dehydrated onions. The highest NPK combination was 100 kg urea, 60 kg P_20_5 and 60 kg K_2O per hectare.

Etana *et al*. (2019) studied the growth uptake of and nitrogen, phosphorus, and potassium uptake of onion. The results indicated that the plant demand for N and K was higher during the early growth stages, whereas demand for P was continuous throughout the development. Uptake levels were 38.8. 38.6 and 71.3 kg N and P_20_5 respectively, for the yield of 2.5 t/ha.

Sorensen *et al*. (2001) obtained maximum bulb yield (22.66 t/ha) with the application of 125 kg N+75 kg K_2O t/ha. The highest plant height (38.5 cm), highest leaf height(34.5 cm), number of leaves/plant (17.0), single bulb weight (82 g), vertical bulb diameter (4.80 cm) and horizontal bulb diameter (5.78) were obtained with 125 kg N and 100 kg P_2O_5 t/ha.

Yadav *et al*. (2005) studied the effect of different levels of nitrogen (50, 100 and 150 kg/ha), phosphorus (25, 50 and 75 kg t/ha), and potash (50, 100 and 150 kg/ha) on the growth and yield of onion. They founqd that plant height, the number of leaves per plant, bulb weight and yield were highest at 150 kg N/ha. Although bulb weight and yield with 100 kg N/ha were not significantly different. Increasing phosphorus application increased the number of leaves per plant and the weight, size and yield of bulbs. Application of K increased only the number of leaves per plant.

Yassen and Khalid (2009) experimented at Rajasthan during the summer season of 1993-95. Onion cv. N-53 was grown under factorial combinations of 3 levels each of nitrogen (50, 75 and 100 kg N), phosphate (13.2, 22.0 and 30.8 kg P), and potash (41.5, 62.2 and 83.0 kg K). It was concluded that onion productivity could be enhanced considerably by the application of 100 kg N, 30.8 kg P and 83.0 kg potassium per ha.

Zargar Shooshtari *et al*. (1992) investigated the effects of N fertilizer application (0, 65 and 130 kg/ha) on onion cv. Pusa Red during 1992-93 and 1993-94 in Uttar Pradesh, India. In both years, the application of 130 kg N/ha resulted in the highest percentage of seedling survival, plant height, number of green leaves, and pseudostem diameter, as well as the lowest number of days to maturity. This treatment also resulted in the greatest number of roots, length of the longest root, bulb diameter, bulb fresh weight and bulb yield, compared with the other application rate.

Qasem and Management (2006) conducted a field experiment to determine the optimum dose of NPK fertilizer for the onion variety Phulkara on loamy soil. Six fertilizer treatments were tested in RCBD for the height of plant (cm), a number of leaves per plant, single plant weight, bulb diameter (horizontal and vertical), bulb size (volume) and yield t/ha, Compared to other fertilizer treatments, the application of 80 N + 60 P_2O_5 and 40 K_2O kg per ha produced more leaves and largest bulb size and gave the highest onion yield.

Tehulie *et al*. (2015) experimented on onion cultivars Puna Red, and White Marglobe. Nasik Red and Rasidpura local were supplied with 50 and 150 kg N and Kg per ha in Jaipur. Rajasthan. India during the rabi seasons of 1998-2000. Yield, fresh weight of the bulb, total soluble solids and allyl propyl disulfide content increased, whereas ascorbic acid content decreased with the increase in N and K rates. Rasidpura Local recorded the highest values for the parameters measured except allyl propyl disulfide content which was highest in Nasik Red.

Thangasamy and Lawande (2015) studied the growth of nitrogen, phosphorus and potassium uptake at the onion. Resulting in the plant demand for N and K being higher during early growth stages. Whereas demand for P was continuous throughout the development. Uptake levels were 38.8 and 71.3 kg N/ha) P_20_5 and K_2O respectively the yield of 2.5 t/ha.

Yoldas *et al*. (2019) conducted two types of experiments on onion production. They set up two types of land: one without previously green manuring and another cropped with green manuring. A combination of 120 kg N and 50 kg K gave the tallest plants and the greatest number of leaves per plant, maximum bulb weight and bulb diameter and higher bulb yield in the first experiment. Green manuring also greatly enhanced plant growth and bulb yield.

Yohannes *et al*. (2013) stated that in the onion crop fresh weight (FW) increase was correlated with the increase in N level and the largest bulbs were 25-30 mm in diameter. Nitrogen rates in the ranges 299-358 kg gave 95% of the maximum yield. Dry matter of bulbs was not affected by N. Bulb size increased as the rate of applied N increased.

Ahmed (2009) stated that plant height was increased significantly with increasing levels of nitrogen. The main yield-containing components were the number of scalps per plant and the size of the umbel and the yield increase beyond 50 kg N/ha was not significant.

According to Akul *et al*. (1982) level of N increases the level of the leaf, bulb, and whole plant at the growth stages of the crop. The uptake of these nutrients continued until bulb maturity. They also revealed the total uptake of Ca, Mg and S were 16.66, 92.0 and 25.5 kg per ha respectively with 200 kg N per ha.

Almaroai *et al*. (2020) conducted a field trial to investigate the effect of N and plant spacing on the yield of onion cv. Pusa Red and found that plant height, length of the flowering stalk, the number of the bulb, 1000-seed weight, purple blotch and seed yield increased with increasing rates of N up to 80 kg per ha.

Abas *et al*. (2015) conducted a held trial to investigate the effects of four levels of nitrogen and three levels of phosphorus on the growth and keeping quality of Onions. They found that application of 90 and 135 kg N increased the growth and yield but reduced the post-harvest storage quality. Phosphorus at 60 kg per ha increased these attributes.

Tehulie *et al*.(2017) carried out an experiment during 1993-94 and 1994-95 on onion to find out the effect of nitrogen, phosphorus and potassium rates, sources upon onion bulb yield and quality. Yield, plant height, leaf number, and polar and equatorial diameters were measured in treatments with different rates, sources and forms of N, P and K. Significant effects of P and K rates (applied up to 98.2 and 200 kg/ha respectively) could not be detected, nor significant interactions between N and P.

Kumar *et al*. (2003) experimented at Rajasthan during the summer season of 1993-95. Onion cv. N-53 was grown under factorial combinations of 3 levels of nitrogen (50,75 and 100 kg N). It was concluded that onion productivity could be enhanced considerably by the application of 100 kg N and 30.8 kg P.

Thakur *et al*. (2013) investigated the effects of N fertilizer application (0, 65, and 130 kg/ha) on onion cv. Pusa Red during 1992-93 and 1993-94 in Uttar Pradesh, India. In both years, the application of 130 kg N/ha resulted in the highest percentage of seedling survival, plant height, number of green leaves, and pseudo stem diameter, as well as the lowest number of days to maturity. This treatment also resulted in the greatest number of roots, length of the longest root, bulb diameter, bulb fresh weight and bulb yield, compared with the other application rate.

Yadav *et al*. (2005) experimented in Maharashtra, India, to develop fertilizer prescription equations for onions and these equations were tested for their validity by conducting two follow-up trials. A standard-held experiment was conducted on post-monsoon onion (cv. N24-I) on Our soil series (Typic Chromusterts). There were 21 selected treatment combinations out of 5 levels of N (0, 50, 100, 150, 200 kg/ha), four levels of P_20_5 (0, 50, 100 and 150 kg/ha) and three levels of K_2O (0, 50 and 100 kg/ha) with 6 control treatments. Farmyard manure was also applied to all the plots at 10 t/ha ten days before planting onion. The nutrient requirement of the onion crop was 1.314 kg N. 1.172 kg P_20_5 and 20.4 kg K_2O production. The efficiency of soil nutrients was 11.25, 55.35 and 7.37% of N and K_2O while that of fertilizer N, and K_2O was 21.01. 29.35 and 66.18% respectively. Fertilizer rates increased with increasing yield targets of onion and fertilizer rates decreased with increasing soil test values. Results of the two follow-up trials on onion in Typic Chromusterts and Sawargaon series Vertic Ustropepts showed that yield targets of 30,40 and 5 t/ha were achieved. The highest yield (53.5 t/ha) and profit (Rs. 90 300/ha) were observed at the 50 t/ha yield target of onion followed by a 40 t/ha targeted yield treatment.

Pandey et al. (1992) conducted and experiment to find out the effect of nitrogen and spacing on kharif onion cv. Agrifound dark red at Jaipur, Rajasthan, India. They found that both 80 and 120 kg N/ ha gave significantly higher yields than the lower fertilizer rates but the higher N rates resulted in significantly larger umbels and less incidence of trips.

Tekeste *et al*.(2018) clarified that N fertilizer was required to make up the crops at different stages of growth. Flat rate applications of 193 kg N/ha were followed by considerable losses resulting from irrigation and cost were higher. Specific applications of N at 105 kg/ha were found to reduce N losses and costs but the yield increased.

Tekeste *et al*. (2018) reported that applying NPK at the highest rate gave the greatest bulb size, maximum yield (33.89 t/ha) and best quality of dehydrated onions. The highest NPK combination was 100 kg N, 60 kg P and 60 kg K per hectare.

Yassen and Khalid (2009) studied the growth and nitrogen, phosphorus and potassium uptake of onion. The results indicated that the plant demand for N and K was higher during the early growth stages, whereas demand for P was continuous throughout the development. Uptake levels were 38.8, 38.6 DB; and 71.3 kg N, P and K respectively for the yield of 2.5 t/ha.

Bekele *et al*. (2018) conducted a fertilizer trial. Onion sets were planted in November at a spacing of 25 X 15 cm and supplied with 0-160 kg N/ha and potassium 0-100 kg while half fertilizers were applied before planting and half 30 days after planting. The combined application of a higher rate of N and K gave the maximum yield of 11.11 t/ha compared with 4.5 t/ha from the control.

Brdar-Jokanović *et al*. (2011) experimented to study the response of onion cv. Taherpuri to a range of doses NPK under irrigated conditions. Five levels of N (0, 50, 100, 150 and 200 kg/ha) and four levels of P_20_5 (0, 40, 80 and 120 kg/ha) and K_2O (0, 50, 100 and 150 kg/ha) was applied. The highest bulb yield of 19.2 t/ha and highest marginal return was produced by the combined effect of 150:80:100 of N: P_20_5: K_2O. The diameter of the bulb, the weight of the individual bulb and bulb yield were significantly increased by N.

Demis *et al*. (2019) experimented in Tripura, India to study different nitrogen levels (0,100, 150 and 200 kg/ha) and potassium (0, 75 and 150 kg/ha) given as soil application to study their effect on the growth of a plant, yield and yield attributes of onion cv. N-53. Application of nitrogen at 150 kg/ha, potassium at 75 kg/ha and their combination effects show the best performance in terms of growth and yield. All other treatments and their combination were superior to control.

Rahim *et al*. (2021) conducted an experiment to obtain the maximum and good quality of onion bulbs to determine the optimum rate of potassium. Four cultivars (Pusa red, White Marglobe, Nasik Red, and Rasidpura Local) were given with three potassium rates (50, 100 and 150 kg/ha). The highest K rate showed the highest plant height, maximum leaf number per plant, highest leaf fresh weight, leaf dry weight, maximum neck thickness, bulb equatorial diameter, bulb polar diameter, fresh weight of the bulb and yield of the bulb. The lowest K rate showed the lowest neck thickness.

Roy *et al*. (2014) experimented with onion to find out the effect of different nitrogen, phosphorus and potassium rates, sources and forms upon onion (*Allium Cepa*) bulb yield and quality. Plant height, leaf number, polar and equatorial diameters, and yield were measured in treatments with different rates, sources and forms of N, P and K. Significant effects of P and K rates (applied up to 98.2 and 200 kg/ha, respectively) could not be detected, non-significant interactions between N and P.

2.2 Effect of zinc on the growth and yield of onion

Zinc is a micronutrient that is reputed for plant growth and development relatively in a small amount. zinc is involved in a diverse range of enzymes in the system. The function of Zn includes; auxin metabolism, influence on the activists of dehydrogenases and carbonic anhydrase enzymes, synthesis of cytochrome and stabilization of ribosomal fraction (Salo and Science 1999)**.**

Seran *et al*. (2010) reported that zinc deficiency is a global nutritional problem in crops grown in calcareous soils. In a greenhouse experiment, Zn requirement, critical concentrations in diagnostic parts and genotypic variation were assessed using four onion cultivars grown in Zn-deficient calcareous soil. Five rates of Zn, ranging from 0 to 16 mg Zn/kg soil, were applied as zinc sulphate ($ZnSO_4$) along with adequate basal fertilization of nitrogen and phosphorus, potassium, and boron. Zinc application significantly increased dry bulb yield and maximum yield was produced with 8 mg Zn/kg. The application of higher rates did not improve yield further. The cultivars differed significantly in Zn efficiency. Zinc content in mature bulbs also appeared to be a good indicator of soil Zn availability status.

Tekalign *et al*. (2012) conducted an experiment and showed that the response of onion growth and yield to different levels of nitrogen and zinc in Swat valley at Agricultural Research Station (North) Mingora Swat, during 2003-04. Nitrogen levels under trial were 0,100 and 200 kg per hectare, while zinc levels were 0, 5, 10 and 15 kg per hectare. The statistical analysis revealed that both nitrogen and zinc significantly affected all the growth parameters studied. Maximum leaf length (41.81 cm), was recorded in plots fertilized with 100 kg nitrogen and 10 kg zinc per hectare. whereas maximum plant height (56.33 cm), and bulb weight (136.5 g) and yield (22280 kg) per hectare were recorded in plots fertilized with 100 kg nitrogen per hectare and zinc 10 kg per hectare.

Tekle *et al*. (2017) conducted a study in Pantnagar, Uttaranchal, India to investigate the effect of Zn and B on the yield, quality and stability of garlic cv. Pant Lohit. Zn was supplied as zinc sulphate at 0, 0.2, 0.4, 0.6, 0.8, 1.0 and 1.2% while B was applied as boric acid at 0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0%. Yield, growth and quality parameters such as plant height, leaves per plant, leaf length, neck diameter, bulb yield per plot, bulb weight, total soluble solids content and total yield were assessed at 60 and 90. Boric acid at 0.2% resulted in the maximum bulb total soluble solids content. Zinc sulphate at 0.4% resulted in bulb yield and weight, while a rate of 1.2% resulted in maximum total soluble solids content.

Woldeselassie *et al*. (2014) conducted a completely randomized factorial block experiment with 27 treatments and 3 replications were carried out during the 2000-2003 growing seasons in Bonab and Khosroshahr regions of East Azarbayjan to determine the effect of rates of potassium, zinc and copper on the yield and quality of Azarshahr red onions under saline soil conditions. Each nutrient was applied at three rates, namely; 1-based on soil tests (200 kg potassium sulfate, 40 kg zinc sulfate and 20 kg copper sulfate), 2 - one and a half times the soil test levels (300 kg potassium sulfate, 60 kg zinc sulfate and 30 kg copper sulfate) and 3 - twice the recommended soil test levels (400 kg potassium sulfate, 80 kg zinc sulfate and 40 kg copper levels) at both locations of medium salinity conditions. The results showed that potassium and zinc significantly affected the onion yields (alpha 0.01), TSS contents, as the nitrate concentrations of the onion bulbs in the Bonab region. The effect of potassium, zinc and copper treatments on the onions protein contents were statistically significant at a 1% level. The highest protein content was obtained with the application of KI, Zn and Cu at rates twice the soil test requirements. The highest level of vitamin C [ascorbic acid] was measured with combined rates of 400 kg potassium sulfate, 80 kg zinc sulfate and 40 kg/ha of copper sulfate.

Tehulie *et al*. (2018) conducted field trials on garlic var. local during the rain (April-July) and autumn cropping (October-January, 1996) seasons in Nilgris. Tamil Nadu, India to study the effect of zinc, boron and molybdenum foliar sprays on yield and rubberization. Boron at 0. 1% (w/v) plus sodium molybdate at 0.05% (w/v) recorded the highest healthy bulb yield of 24 t/ha, the increase being 23.5% over unsprayed control and reduced premature field sprouting of cloves in the field itself instead of bulking and reduced production of spongy bulbs locally known as rubberization.

Kumar *et al*. (2003) conducted a field experiment on silty clay loam soil (to study the effect of Zn (0, 10 and 20kg/ha) and S (0, 30 and 60 kg/ha) application on their availability in soil concerning yield and nutrition of onion cv. N-53. The results showed that the amount of DWA extractable Zn and 0.15% $CaCl_2$ extractable SO_4-S in soil increased due to the application of Zn as Zn-EDTA and S as the element respectively. The yield of onions was highest (18.04 t/ha) in the Zn at 10 kg/ha treatment.

A field experiment was conducted at the Agricultural Research Station, Sids, Beni Sweif Oovernorate Egypt. during 2 successive seasons (1995-96 and 1996-97) by (Yassen and Khalid 2009) to study the elects of Fe, Mn, Zn and Cu applied as sulfates ($CuSO_4$ at 1 g/litre and the others at 3 g/litre) and B applied as borax (0.7 g/litre) on onion cv. Compost 16 yield and nutrient content. Two spray applications were made at 2 and 4 weeks after transplanting. The highest dry yield was obtained by foliar application of $ZnSO_4$; this treatment increased yield over the control by 23.6 and 27.8% over the 2 seasons, respectively.

Yoldas *et al*. (2019) conducted a field experiment at Kalyani on a silty clay loam of pH 6.7, onion cv. N-53 was given 0, 10 and 20 kg Zn/ha and 0, 30 or 60 kg S/ha. Bulb yield was highest (18.4 t/ha) when 10 kg/ha Zn alone was applied. Data are also tabulated on TSS, ascorbic acid, reducing sugar, moisture, pyruvic acid and anthocyanin contents.

Stone and management (2000) conducted field trials at Nadia, West Bengal, India, during 1994-96: onion cv. N-53 was grown as a Rabi crop on sandy loam soil. Three rates of Zn (0, 10 and 20 kg/ha. as Zn-EDTA) and S (0, 30 and 60 kg/ha, as elemental sulfur) were applied. The application of Zn alone at 10 kg/ha resulted in the highest yield (18.40 t/ha).

Asgele *et al*. (2018) carried out a study in 1997 in Venezuela with onions cv. Texas early garnet 502 sown in black polyethylene bags. Fertilizer treatments were different combinations of S (16 kg/ha), Mg (8 kg/ha), Zn (2.52 kg/ha) and B (5.25 kg/ha), with and without NPK (120 kg N/ha, 60 kg P_20_5/ha and 120 kg K/ha). One plot received 1000 kg S/ha, 30 days before transplanting. The application of 2.52 kg Zn/ha (as ZnS) significantly increased crop yield and bulb weights. S, Mg and B fertilizers had no significant results. The best treatments were NPK + Zn, NPK + ZnMg, NPK + B, NPK + ZnB and NPK + ZnSB.

Belay *et al*. (2015) conducted a pot experiment on a sandy Aridisol, a sandy clay loam Inceptisol and a clayey Vertisol during the rabi season of 1995- 96 raising onion as the test crop. The crop was grown to maturity. Dry weights were recorded for tops and bulbs separately. The results showed that S and Zn treatments significantly enhanced the dry weight of onion tops and bulbs.

Dapaah *et al*. (2014) experimented on sandy aridisol, a sandy clay loam inceptisol, and clay vertisol during the rabi season of 1995-96 raising onion. The result showed that S and Zn treatments significantly enhanced the dry weight of onion tops and bulbs. A higher level of 30 mg S caused an antagonistic effect. An S dose of 20 mg S kg/ha on S-deficient soils and 10 mg S with 5 mg Zn/kg for low S soils was appropriate for better onion yields. A total S uptake by onion crops on all three soils was enhanced significantly. The aridisol was the most responsive to sulfur followed by the inceptisol.

According to the experiments undertaken by Dingre *et al.* (2012) in West Bengal using onion cv. N-53 during the rabi [winter] seasons of 1994-96. 0, 10 and 20 kg Zn/ha as Zn and 0, 30 and 60 kg S/ha as elemental sulfur was applied before planting and studied the effect on yield and storage quality. The results showed that the application of Zn alone at 10 kg/ha gave the highest bulb yield (18.4 t/ha).

Etana *et al*. (2019) reported the results of an experimental trial with onion cv. Pusa Red plants in silty loam soil sprayed at 60 and 70 days after transplanting with 2 - 3 ppm Zn + 50, 100 and150 ppm Fe + 0.25, 0.50 or 0.75 ppm B. The highest bulb yield was 40 g polt (5 plants were obtained with 3 ppm Zn ± 100 ppm, Fe ± 0.75 ppm B).

Fatematuzzohora *et al*. (2020) conducted an experiment and reported that the application of Zn alone (10 kg/ha as Zn-EDTA) recorded the highest yield of onion (18.4 1/ha). This treatment exhibited a lower percentage of rooting (13.7 %) sprouting (2.1 %) and physiological weight loss (7.71 %) for up to 120 days storage in the perforated paper compared with other treatments. Application of Zn alone or in combination with S (30kg/ha) reduces rotting, sprouting, and physiological weight loss during storage.

Fatma *et al*. (2014) also conducted an experiment with Pusa Red onion seedlings, transplanted in mid-January and given foliar sprays of 1-3 ppm Zn, 50-150 ppm Fe and 0.25-0.75 ppm B at 60 and 70 days after transplanting (DAT). Sprays of 3 ppm Zn singly or combined with Fe and B were the most effective for increasing all the growth parameters studied at 90 and 120 days after transplanting (DAT) except leaf FW at 120 DAT. Plant height and bulb fresh weight (FW), equatorial and polar diameters, volume, and yield at 120 days - after transplanting (DAT) were highest with sprays of 3 ppm Zn, 100 ppm Fe and 0.75 ppm B.

Fawzy *et al*. (2012) examined the distribution of zinc fraction in the soil of Bangladesh Agricultural University Farm, Mymensingh. It was noticed that phosphorus reduced soil Zn concentration showing an interaction between two elements.

Khan *et al*. (2019) conducted an experiment with onion cultivars Pusa Red and Hisar 2 growing in the field and received different rates of N, K and Zn. After harvest, bulbs were stored in cloth bags under ambient conditions. Observation of storage quality was made at intervals of up to 120 days. Bulb's weight loss and the incidence of rooting ad sprouting were increased by increasing the application of N (80-160 kg ha) and reduced by the application of K_2O (100 kg/ha). Application of $ZnSO_4$ 25 kg/ha results in poorer storage quality than K_2O alone. Bulbs grown with 80 kg N/ha +100 kg K had the best storage quality.

Khokhar (2014) in their trial of onion applied N at 80, 120 and 160 kg/ha K_2O at 100kg/ha $ZnSo_4$ at 25 kg/ha. High N levels increased plant growth and yield. K and Zn also increased plant growth. Yield and DM contents, the highest yields (27.48-32.68 t/ha) were obtained with a higher rate of N.

Muhammad *et al*. (2021) in their trials with onions, applied $ZnSO_4$ $FeSO_4$ each at 25 and 50 kg/ha to the soil 0.5 and 1% to the foliage. Bulb yields were the highest (17.1 t/ha) with the soil application of Zn or Fe at the highest rate. With foliar applications, the yields were just over 13 t/ha.

Mrema *et al*. (2022) reported plant height, number of roots and leaves/plants, fresh and dry weight of plants and number of leaves/plant, bulb size, bulb fresh and dry weight were determined in 2-year trials with the onion cv. Poona Red has grown in sand and receives Zn at 1, 2 and 3 ppm. Bulb fresh and dry weights were greatest in plants receiving Zn at 3 ppm.

Molla *et al*. (2020) experimented and showed that in a field experiment at Kalyani on a silly clay loam of pH 6.7 onion cv. N-53 was given 0, 10 and 20 kg Zn/ha and 0, 30 and 60 kg N/ha. Bulb yield was highest (18.4 t/ha) when 10 kg/ha Zn alone was applied. Data are also tabulated on ISS, ascorbic acid and reducing sugar moisture, pyruvic acid and anthocyanin contents.

CHAPTER III

MATERIALS AND METHODS

This chapter arranges the materials and methods including a brief description of the experimental site, onion variety, soil, climate, land preparation, and experimental design treatments, cultural operations, collection of soil and plant samples, etc. and analytical methods used for the experiment. The details of the research procedure are described here.

3.1 Description of the experimental site

3.1.1 Location

The research work was conducted at Sher-e-Bangla Agricultural University Farm, Sher-e-Bangla Nagar, Dhaka-1207 during the Rabi season of December 2021. It is located at 90.335^0 E longitude and 23.774 latitudes. The specific location of the experimental site is presented in **(Appendix-I)**

3.1.2 Soil

The experimental site was located in the Madhupur Tract (AEZ-28) and it was medium-high land with adequate irrigation facilities. The soil was having a texture of silty loam with pH was 6.2. The characteristics of the soil under the experimental plot were analyzed in the Soil Science Laboratory, SAU and details of the recorded soil characteristics were presented in **Appendix II.**

3.1.3 Climate

The experimental area is situated in the sub-tropical climate zone, which is characterized by heavy rainfall from April to September (Kharif season) and scanty rainfall during the months from October to March (Rabi season), and storage during the months from March to July (Kharif season) of the year. Details of weather data in respect of temperature (0C), rainfall (mm), and relative humidity (%) for the study period were collected from Bangladesh Meteorological Department, Agargoan, Dhaka-1207 **(Appendix III).**

3.2 Planting Material used for the Experiment

Seeds of one onion variety “**BARI Peyaj-6**” were used for the experiment. The seeds were collected from Bangladesh Agricultural Research Institute (BARI).

Treatment of the experiment

There were two factors in the experiment. These were

Factor A: Four levels of nitrogen

1. 0 kg/ha (N_0)
2. 60 kg/ha (N_1)
3. 100 kg/ha (N_2)
4. 140 kg/ha (N_3)

The source of nitrogen was urea fertilizer

Factor B: Three levels of zinc.

1. 0 kg/ha (Zn_0)
2. 2 kg/ha (Zn_1)
3. 4 kg/ha (Zn_2)

The source of Zn was zinc sulphate (monohydrate)

In total there were 12 treatment combinations-

N_0Zn_0, N_0Zn_1, N_0Zn_2, N_1Zn_0, N_1Zn_1, N_1Zn_2, N_2Zn_0, N_2Zn_1, N_2Zn_2, N_3Zn_0, N_3Zn_1, N_3Zn_2

3.3 Design of the experiments

The two-factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

3.4 The layout of the field experiment

First, the experimental field was divided into three blocks. For the treatment combinations, each block was divided into 12 plots. There were 36 plots in total.

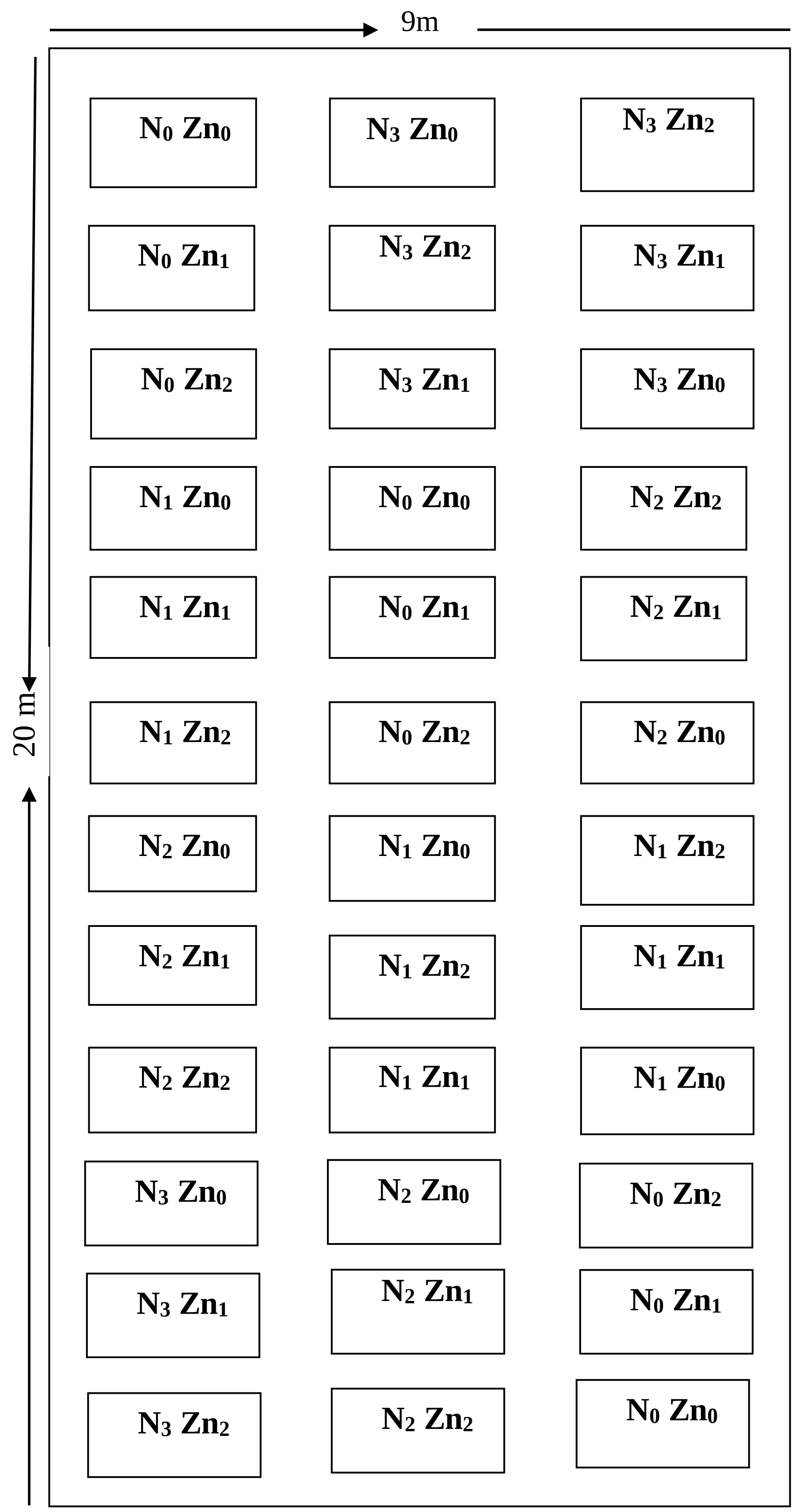
Each block was subsequently assigned to 12 treatment combinations according to the experimental design. The plot size was 2 m × 1 m. In each unit plot, a distance of 15 cm was maintained between the rows and 10 cm between the plants. The distance between the two plots was 0.5 m with blocks being 1 m. The field layout is shown in **Figure 1.**

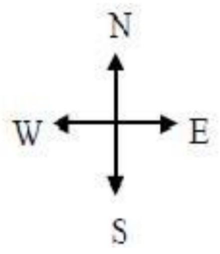
3.5 Details of the field operations

The particulars of the cultural operations carried out during the experiment are presented below:

3.5.1 Seedbed preparation

The land selected to raise seedlings was nicely textured and well-drained. The land had been opened up and dried for 10 days. The seedbed was made for the raising of seedlings on 28 October 2021 and the seedbed size was 3 m^2 with a reised bed of about 20 cm. The soil was well ploughed and converted to loose friable and dried masses to get good tilth for making seedbeds. The seedbed had removed weeds, stubbles, and dead roots. Cowdung @ 10 t ha^{-1}, was applied to the prepared seedbed. The application of Furadan 3G @ 20 kg ha^{-1} for two days was covered by polythene. Onion seeds were soaked overnight (12 hours) in water and allowed to sprout in a piece of moist cloth keeping in the sun shade for one day.





Layout
Plot size: (2 m × 1m) =2 m^2
Between plot: 0.5 m
Between block: 1 m
Between replication: 0.75 m
Plant to plant distance- 10 cm
Row to row distance- 15 cm

Treatments
Factor A: Levels of nitrogen (4)
N_0: 0 kg N ha^{-1} (control)
N_1: 60 N ha^{-1}
N_2: 100 kg N ha^{-1}
N_3: 140 kg N ha^{-1}

Factor B: Levels of zinc (3)
Zn_0: 0 kg Zn ha^{-1} (control)
Zn_1: 2 kg Zn ha^{-1}
Zn_2: 4 kg Zn ha^{-1}

Figure 1. Layout of the experiment

3.5.2 Seed treatment and sowing

Seeds were treated with Vitavax-200 @ 5g/kg seeds to protect against some seed-borne diseases. The seed sowing date was November 8, 2021. Seeds were sown in the seedbed to produce seedlings that were 35 days old. The seeds were seeded at a depth of 0.6 cm and covered with a thin layer of soil, followed by a light watering. The young seedlings were exposed to morning and evening dew by night and mild sunshine. Shade was given to retaining soil moisture over the seedbed and saved the seedlings from direct sun and rain.

3.5.3 Raising of seedlings

Light watering and weeding were done several times. No chemical fertilizer was used to raise the seedlings. When seedlings reached about 10 cm in height, the thinning operation was done. On 11 December 2021, healthy, 35 days old seedlings were transplanted into the main field.

3.5.4 Land preparation

The experimental area was first opened by a disc plough in direct sunshine to kill soil-borne pathogens and soil-inhabitant insects on 03 December 2021. Then the land was prepared to bring a good tilth by ploughing several times and cross ploughing with a power tiller followed by laddering. The land had been leveled, the corners had been formed, and the clods had been broken to pieces. The weeds, residues of crops, and stables were taken out of the field. At the final ploughing, the basal dose of fertilizers was applied. The plots were prepared according to the design and layout. The soil was treated by Sevin 50 WP @ 5 kg/ha to protect young plants from the attacks of mole crickets, ants, and cutworms.

3.5.5 Fertilizers applications

The BARI recommended doses for onion production of urea, triple super phosphate (TSP), and muriate of potash (MoP) according to soil analysis interpretation. However, the recommended doses of chemical fertilizer in the experimental plot for low fertile land were (P_{45} K_{100} S_{30} B_{01}) kg/ha were used in the experimental plot. The total amount of TSP, ½ MoP, full gypsum and full borax were applied at the final land preparation. Total urea and ½ MoP was applied in two installments. The first installments were applied 30 days after transplanting, second installments were applied 45 days after transplanting as a top dressing. The fertilizer was thoroughly mixed with the soil.

3.5.6 Transplanting of seedlings

On 11 December 2021, healthy and disease-free uniform 35 days old seedlings were removed from the seedbeds and transplanted to the main field as per treatment after a slight trimming of healthy seedlings' leaves and roots and maintaining a spacing of 15 cm × 10 cm. Before uprooting the seedlings, the seedbed was watered to minimize root damage. Following transplantation, the seedlings were watered immediately. There were also some seedlings transplanted adjacent to the experimental area to be used for gap fillings.

3.6 Intercultural operations

Whenever necessary, intercultural operations were carried out after seedlings were transplanted to achieve better plant growth and development. So, under careful observation, the crop was always kept.

3.6.1 Gap filling

The un-sprouted bulbs were replaced by healthy plants taken from the border after 20 DAP the main crop. The damaged plants were also replaced by border plants through gap filling.

3.6.2 Weeding

After the transplant, weeding was done three to four times to keep the crop free of weeds.

3.6.3 Earthing up

Earthing up has been provided through breakage of a soil crust, piling of soil at the base of a plant for ease of aeration, soil moisture and temperature preservation, improvement of germination and emergence, high yields, and quality, prolonged seasonal higher product nutritional benefits, improved storability, etc. This would also improve the onion seed quality.

3.6.4 Irrigation and drainage

Watering cane and hose pipe were used for irrigation when required. Immediately after transplantation, the first irrigation was given. During that time, care was taken to prevent irrigation water from passing between plots. Mulching was also done by breaking the soil crust after irrigation. The soil was saturated with water during the irrigation process. Excess water was drained if necessary after rainfall.

3.6.5 Plant protection

Preventive measures against soil-borne insects were taken. For preventing cutworm invasion, Furadan 3G @ 20 kg ha-1 was applied. No insect infestation was found in the field after the application of the pesticide. Some plants were attacked by purple blotch disease caused by *Alternaria porri* a few days after transplantation. It is controlled by spraying Rovral 50 WP @ 2 g/L of water at a 7- day interval

3.7 Harvesting

The crop was harvested on 28 March 2022 to their completion of maturity showing the sign of drying up most of the leaves and collapsing of the neck. With the help of a hand, onions were lifted and care was taken so that no bulb was injured during lifting. The tops were removed after harvesting by cutting off the pseudo stem and holding them with the bulb for 2.5 cm.

3.8 Storage of bulbs

The bulbs of each harvest had been dried in the field in shade for one day with the tops. The following day after harvesting, the tops were separated leaving 2 cm of the neck. Bulb curing was performed for 7 days in a room at ambient temperature (29.6 ± 2.60C) and then stored in a well-ventilated room.

3.9 Collection of data

Data were collected on the following parameters:

1. Plant height (cm)
2. Number of leaves
3. Length of leaves (cm)
4. Stem diameter (cm)
5. Fresh leaf weight (g)
6. Dry leaf weight (g)
7. Bulb length (cm)
8. Bulb diameter (cm)
9. Fresh bulb weight (g)
10. Yield kg/plot
11. Yield t/ha

3.10 Procedure of recording data

3.10.1 Plant height (cm)

After 30 days of transplantation, the height of the randomly selected six plants was measured from each plot to 60 DAT with an interval of 15 days. The height was measured by centimeters (cm) from the ground level to the tip of the longest leaf and the average height of six plants was calculated in centimeters.

3.10.2 Number of leaves plant^{-1}

The number of leaves plant^{-1} was calculated from the randomly selected six plants of each plot and the mean was recorded. After 30 to 60 DAT with 15 days of interval, the number of leaves plan^{-1} of each unit plot was measured.

3.10.3 Length of leaves (cm)

For the onion leaves the length of 6 randomly selected plants from each plot was measured at each plot. The length was measured in centimeters (cm) and the average length of the leaves was calculated in centimeters.

3.10.4 Stem diameter (cm)

The onion stem diameter of 6 randomly selected plants from each plot was measured at the time of harvest. The length was measured in centimeters (cm) and the average diameter of the stem was calculated in centimeters.

3.10.5 Fresh weight of leaves (g)

Fresh weights of leaves per plant were collected at ten randomly selected plants during the harvesting time of the bulb and were weight by a balance and their mean value was calculated in gram (g).

3.10.6 The dry weight of leaves (g)

For determination of the dry weight of leaves, leaves from selected five plants were kept in an oven at 70°C temperature for drying. It took 48 hours to reach the constant weight. Three replications were used for the determination of dry leaves' weight and their average was taken and calculated to find out the dry weight of leaves.

3.10.7 Length of Bulb (cm)

The length of the bulb was measured with a slide caliper from the neck to the base of the bulb from the five randomly selected plants from each plot. Their average was also recorded in centimeters (cm).

3.10.8 Diameter of the bulb (cm)

The diameter of the bulb was measured at the middle portion of the bulb from five randomly selected plants from each plot with the help of slide calipers at the time of harvest. Their average was recorded at the same time.

3.10.9 Fresh bulb weight (g)

Five randomly selected plants from each plot were harvested. The top of each plant was removed by cutting the pseudo stem keeping 2.5 cm with the bulb. Each of the five bulbs 28 were weighed through an electric balance and their average was recorded along with the individual bulb weight.

3.10.10 The yield of bulb per plot (kg)

Pseudo stem and all the leaves were removed from the plant remaining only 1.5 cm neck. Then with a simple balance bulb weights were taken in kilogram (kg) from each unit plot separately.

3.10.11 Yield of bulb (t/ha)

The bulb yield per hectare was computed based on bulb yield per plot and expressed in ton per hectare.

3.11 Post-harvest soil sampling

After harvesting composite soil samples were collected from each plot of the crop from 0-15 cm depth. After collection of soil samples, the plant roots, leaves etc. were removes carefully. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.12 Soil Analysis

The soil samples were analyzed by the following standard methods as follows:

3.13. Particle size analysis

Particle size analysis of soil sample was done by hydrometer metod as outline by day. The textural classes were ascertained using Marshall's Triangular co-ordinate as designated by USDA.

3.14 Chemical analysis of soil

3.14.1 pH

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

3.14.2 Soil Organic carbon content

Organic carbon in the soil sample was determined by the wet oxidation method. The underlying principle was used to oxidize the organic carbon with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_3 and titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$. To obtain the content of Organic carbon was by multiplyed the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage

3.14.3 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al*., 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity was measured calorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Akul *et al*. 1982)

3.14.4 Available sulphur

Available sulphur was extracted from the soil with Ca $(H_2PO_4)_2.H_2O$ Fox *et al* (1964). Sulphur in the extract was determined by the turbidimetric method as described by hunt (1980) using a Spectrophotometer (LKB Novaspee. 4049).

3.15 Statistical analysis

The data was illustrated as mean ± standard deviation from three independent analyses. One-way analysis of variance (ANOVA) was accomplished at the level of significance $P \leq 0.05$, according to the randomized complete block design (RCBD), the stage of development and maturity, and replicates as the main factors to identify if varieties were significantly different from each other for the traits. The analysis of variance of the different morphological and yield attributing parameters, Tukey's pairwise comparison, was conducted by using the Minitab 17 statistical software package (Minitab Inc., State College, PA, USA).

CHAPTER IV

RESULTS AND DISCUSSION

The results of the effects of nitrogen (N) and zinc (Zn) and their combined effects on the growth as well as 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), stem diameter (cm), fresh leaf weight (g), dry leaf weight (g), bulb length (cm), bulb diameter (cm), Fresh bulb weight (g), yield kg/plot, and yield t/ha 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 ease of discussion, comprehension, and understanding.

4.1 Effect of nitrogen and zinc on the growth parameters of onion

Results of the effects of nitrogen and zinc on various growth parameters of onion such as plant height, number of leaves/plant and length of leaves, stem diameter (cm), fresh leaf weight (g), and dry leaf weight (g), has been presented and discussed below:

4.1.1 Plant height (cm)

Plant height was recorded at harvest and it was observed that there were significant variations in plant height at different levels of nitrogen and zinc application. Single mean effects of different levels of N and Zn were found significant $p < 1\%$ on the plant height. The nitrogen level of N_3 (140 kg/ha) gave the tallest plant (48.29 cm) followed by the treatments of N_2 (46.29 cm) and N_1 (45.02 cm) while the N_0 (0 kg/ha) treatment gave the shortest plant (43.83 cm) **(Table 1)**.

On the other hand, the maximum plant height (50.52 cm) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum results (41.67 cm) were found in Zn_0 (0 kg/ha) **(Table 2)**.

The combined effect of nitrogen and zinc was also significant in respect of plant height. However, the maximum height (54.32cm) of the plant was obtained with a treatment combination of N_3Zn_2 which was found statistically identical to the treatment combinations of N_3Zn_1, and N_3Zn_0 similar. On the other hand, combinations of N_2Zn_1, N_2Zn_2, and N_2Zn_0 were statistically in the same group whereas the minimum plant height (40.06 cm) was found N_0Zn_0 treatment combination(**Table 3**). The increase in plant height might be due to a higher intake of nutrients from fertilizer by the plant and more tissue protein synthesis resulting in higher meristematic growth. (Kumar *et al*. 2003) reported that the height of the plant increased with increasing levels of nutrients. (Yaso *et al*. 2007) stated that maximum onion plant height was obtained at the highest dose of nitrogen and zinc. Ali *et al*. (2007) stated that nitrogen (N) increases vegetative growth and produces good quality foliage and promotes carbohydrate synthesis and zinc is essential for the photosynthesis activity of leaf, as it helps in the translocation of food. (Tilaye *et al*. 2018) supported the findings of this experiment and reported that 150 kg N with 80-120 kg K/ ha gave highest result in case of maximum plant height that increases the yield of quality bulbs as well.

4.1.2 Number of leaves plant^{-1}

The leaf production ability of the onion plant was greatly influenced by the application of zinc and nitrogen. The single effect of nitrogen, as well as zinc on leaf production, was significantly affected by the selected treatments. The nitrogen level of N_3 (140 kg/ha) showed a maximum (8.02) number of leaves followed by the treatments of N_2 (7.57) and N_1 (7.16) while the N_0 (0 kg/ha) treatment gave the minimum number of leaves (6.69).

Besides, the maximum number of leaves (9.19) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum results (6.69) were also found in Zn_0 (0 kg/ha) **(Table 1).**

From the result, it was observed that there were significant variations among most of the treatment combinations. The combined effect of nitrogen and zinc on the production of leaves/plants has been shown in (**Table 2).**

The treatment combination of N_3Zn_2 produced the highest (9.85) number of leaves which was identical to the N_3Zn_1 as well as N_3Zn_0 treatment combination while the N_0Zn_0 treatment combination produced the lowest number of leaves (5.50) **(Table 3).** Optimum level of nitrogen and zinc might have increased the availability of other plant nutrients to plants resulting in better performance of crop growth and ultimately produced a greater number of leaves plant^{-1}. Damarany, *et al*. (2016) reported that nitrogen (N) increases the vegetative growth and produces good quality foliage and promotes carbohydrate synthesis and potassium (K) as well as zinc (Zn) is essential for photosynthesis activity of leaf, as it helps in translocation of food. (Yoldas *et al*. 2011) stated that vegetative growth of onion plants was improved by zinc application. (Tekalign *et al*. 2012, Tilaye *et al*. (2018) found that plant height and number of leaves were increased by increasing of nitrogen application. (Ahmed 1982 and Ali 2008) supported the findings of this experiment and reported that 145 kg N/ha gave highest result in case of maximum yield of quality bulbs.

4.1.3 Length of leaves (cm)

The length of leaves was significantly influenced by nitrogen and zinc treatments. From the single mean effect of nitrogen was observed that N_3 (140 kg/ha) treatment gave the highest leaf length (39.87 cm) followed by the treatments of N_2 (38.82 cm) and N_1 (37.88 cm) while the N_0 (0 kg/ha) treatment gave the shortest length of leaves (36.62 cm) **(Table 1).**

On the other hand, the highest length of leaves (42.19 cm) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum result (34.31 cm) was also found in Zn_0 (0 kg/ha) **(Table 2).**

The combined effect of nitrogen and zinc on the length of leaves was statistically significant. The maximum leaf length (43.17 cm) was obtained with a treatment combination of N_3Zn_2 which was found statistically similar to the effect of N_3Zn_1 and N_3Zn_0. The minimum leaf length (32.97 cm) was found with the treatment combination of N_0Zn_0 **(Table 3)**. The findings of this experiment are in close conformity with Bekele *et al*. (2018) and reported that maximum application of N at 150 kg/ha increased mean leaf length per plants by about 16% when compared to control (33.51 cm) and Zn at 3 k/gha significantly increased the mean leaf length per plants by about 8%. Rahman, (2008) concluded that application of N 120 $kgha^{-1}$ with 3 or 3.7 kg Zn ha^{-1} gave highest leaf length (38.50cm). Ali *et al*. (2007) stated that nitrogen (N) increases the vegetative growth and produces good quality foliage and promotes carbohydrate synthesis and Zinc helps in the root development and increased the efficiency of leaf in the manufacture of sugar and starch. Similar findings were obtained by Akhtar *et al*. (2002), Rahman, (2011) and (Anchal, Sandal and Sidhuu 2020) and reported that optimum nitrogen and potassium fertilizer application might be increased the vegetative growth of onion that leads to the highest leaf length.

Table 1. Effects of nitrogen on plant height, number of leaves and length of leaves

Treatment	Plant height (cm)	Number of leaves/plant	Length of leaves (cm)
N_0	43.83 c	6.69 bc	36.62 bc
N_1	45.02 bc	7.16 b	37.88 b
N_2	46.29 b	7.57 ab	38.82 ab
N_3	48.29 a	8.02 a	39.87 a
CV%	4.89	4.46	5.79
Level of Significance	$p < 1\%^{**}$	$p < 1\%^{**}$	$p < 1\%^{**}$

Figure in the column, having the same letter(s) do not differ significantly at 5% level of probability. **= Significant at 1% level of significance analyzed by Tukey Test. CV% denotes Co-efficient of Variation, Here, N_0 = 0 kg/ha , N_1 = 60 kg/ha, N_2 = 100 kg/ha, N_3 = 140 kg/ha

Table 2. Effects of zinc on plant height, number of leaves and length of leaves

Treatment	Plant height (cm)	Number of leaves/plant	Length of leaves (cm)
Zn_0	41.67 b	5.88 b	34.31 ab
Zn_1	45.38 b	7.01 a	38.39 b
Zn_2	50.52 a	9.19 a	42.19 a
CV%	6.46	4.94	7.15
Level of Significance	$p < 1\%^{**}$	$p < 1\%^{**}$	$p < 1\%^{**}$

Figure in the column, having the same letter(s) do not differ significantly at 5% level of probability. **= Significant at 1% level of significance analyzed by Tukey Test. CV% denotes Co-efficient of Variation, Here, Zn_0 = 0 kg/ha, Zn_1 = 2 kg/ha, Zn_2 = 4 kg/ha

Table 3. Combined effects of of nitrogen and zinc on plant height , number of leaves and length of leaves

Treatment Combination	Plant height (cm)	Number of leaves/plant	Length of leaves (cm)
N_0 Zn_0	40.06 e	5.50 de	32.97 fg
N_0 Zn_1	41.22 de	5.69 cd	33.72 f
N_0 Zn_2	42.11d	5.96 d	34.01ef
N_1 Zn_0	43.27 cd	6.37 cd	36.55 e
N_1 Zn_1	44.32 c	6.43 c	36.75 de
N_1 Zn_2	44.47 bc	6.58 c	37.27d
N_2 Zn_0	45.45 bc	7.20 bc	39.65 cd
N_2 Zn_1	47.27 bc	7.84 b	39.88 bcd
N_2 Zn_2	47.10 b	8.15 b	40.14 bc
N_3 Zn_0	49.38 ab	9.21 ab	42.64 ab
N_3 Zn_1	51.30 a	9.54 ab	42.80 a
N_3 Zn_2	54.32 a	9.85 a	43.17 a
CV%	6.45	4.98	6.75
Level of Significance	$p < 5\%^{*}$	$p < 1\%^{**}$	$p < 5\%^{*}$

Figure in the column, having the same letter(s) do not differ significantly at 5% level of probability. *= Significant at 5% level of significance, **= Significant at 1% level of significance analyzed by Tukey Test. CV% denotes Co-efficient of Variation, Here, Zn_0 = 0 kg/ha, Zn_1 = 2 kg/ha, Zn_2 = 4 kg/ha, N_0 = 0 kg/ha , N_1 = 60 kg/ha, N_2 = 100 kg/ha, N_3 = 140 kg/ha

4.1.4 Stem diameter (cm)

The variations in respect of stem diameter due to the effects of different levels of nitrogen and zinc were found to be statistically significant. The maximum stem diameter (1.50 cm) was observed from the plants grown with the N_3 (140 $kgha^{-1}$) treatment which was statistically similar to N_2 (100 $kgha^{-1}$) treatment also produced (1.46 cm). The control treatment produced the minimum diameter (1.38 cm) of the stem **(Table 4).**

On the other hand, the maximum stem diameter (1.58 cm) was obtained with the treatment of Zn_2 (4 $kgha^{-1}$) and the minimum diameter (1.27 cm) with Zn_0 (0 $kgha^{-1}$) treatment **(Table 5).**

The combined effect of nitrogen and zinc was also significant in respect of stem diameter. However, the maximum stem diameter (1.58cm) of the plant was obtained with a treatment combination of N_3Zn_2 which was found to be statistically identical to the treatment combinations of N_3Zn_1, and N_3Zn_0 produced the highest stem diameter over the rest of the treatments. On the other hand, combinations N_2Zn_1, N_2Zn_2, N_2Zn_1, and N_2Zn_0 were statistically in the same group whereas the minimum stem diameter (1.17 cm) was found in combinations N_0Zn_0 treatment **(Table 6).** This result is similar results find out of (Almaroai *et al*. 2020), who noticed that highest Zn resulted increase diameter than control. Rizk (1997) found that increasing the NPK rate increased all vegetative growth parameters measured and increased the diameter (Asik *et al*. 2016) also found that all treatments and their combination were superior to control in case of equatorial diameter and stem diameter. (Rahim *et al*. 2021) also found the similar results

4.1.5 Fresh leaf weight (g)

The fresh leaf weight production ability of the onion plant was greatly influenced by the application of zinc and nitrogen. The single effect of nitrogen, as well as zinc on leaf production, was significantly affected by the selected treatments.

The nitrogen level of N_3 (140 kgha^{-1}) showed a maximum (22.82 g) fresh leaf weight followed by the treatments of N_2 (21.45 g) and N_1 (20.73 g) while the N_0 (0 kgha^{-1}) treatment gave the minimum fresh leaf weight (20.09 g) **(Table 4).**

Besides, the maximum fresh leaf weight (24.35 g) was observed with the treatment of Zn_2 (4 kgha^{-1}) and the minimum results (21.82 g) were also found in Zn_0 (0 kgha^{-1}) **(Table 4).**

The combined effect of nitrogen and zinc on the fresh leaf weight was not statistically significant. The maximum fresh leaf weight (43.17 g) was obtained with a treatment combination of N_3Zn_2 and the minimum fresh leaf weight (16.20 g) under the treatment combination of N_0Zn_0 **(Table 6).** Optimum level of nitrogen and potassium as well as zinc might have increased the availability of other plant nutrients to plants resulting in increased better performance of crop growth and ultimately increased the fresh weight of leaf plant^{-1}. Similar findings of this experiment reported by Ullah *et al.* (2004); (El-Hadidi *et al.* 2016) and Bekele *et al.* (2018),Ansary *et al.* (2006) and (El-Sayed 2018).

4.1.6 Dry leaf weight (g)

The single effect of nitrogen, and zinc was significantly affected by the selected dry leaf weight. The nitrogen level of N_3 (140 kgha^{-1}) showed a maximum (11.94 g) dry leaf weight followed by the treatments of N_2 (11.22 g) and N_1 (10.78 g) while the N_0 (0 kgha^{-1}) treatment gave the minimum dry leaf weight (10.31 g). **(Table 4).**

Besides, the maximum dry leaf weight (12.82 g) was observed with the treatment of Zn_2 (4 kgha^{-1}) and the minimum results (9.0 g) were also found in Zn_0 (0 kgha^{-1}) **(Table 5).**

The combined effect of nitrogen and zinc on the length of leaves was not statistically significant. The maximum dry leaf weight (13.56 g) was obtained with a treatment combination of N_3Zn_2 and the minimum dry leaf weight (8.16 g) under the treatment combination of N_0Zn_0 **(Table 6).** The results indicate that optimum levels of nitrogen and potassium application lead to a linear increase in the dry matter content of leaves (%). Mandira and khan, (2003), Rahaman (2011), Ullah *et al*. (2004), Bekele *et al*. (2018), Ansary *et al*. (2006) and (Dineshkumar *et al*. 2020) supported the findings of this experiment. Ali *et al*. (2007) reported that potassium helps in the root development but Zn increases the activity of potassium and increased the efficiency of leaf in the manufacture of sugar and starch. It is essential for the translocation of sugars. This element is import in grain formation and is absolutely necessary for tuber development. Mandira and khan, (2003) reported that N 150 kg ha^{-1} zn 3.2 kg ha^{-1} recorded the best performance in terms of yield and growth of onion.

Table 4. Effects of nitrogen on stem diameter , fresh leaf weight and dry leaf weight

Treatment	Stem diameter (cm)	Fresh leaf weight (g)	Dry leaf weight (g)
N_0	1.38 c	20.09 c	10.31 c
N_1	1.43 b	20.73 ab	10.78 bc
N_2	1.46 ab	21.45 ab	11.22 b
N_3	1.50 a	22.82 a	11.94 a
CV%	4.97	5.67	4.45
Level of Significance	$p < 1\%^{**}$	$p < 1\%^{**}$	$p < 1\%^{**}$

Figure in the column, having the same letter(s) do not differ significantly at 5% level of probability. **= Significant at 1% level of significance analyzed by Tukey Test. CV% denotes Co-efficient of Variation, Here, N_0 = 0 kg/ha , N_1 = 60 kg/ha, N_2 = 100 kg/ha, N_3 = 140 kg/ha

Table 5. Effects of zinc on stem diameter, fresh leaf weight and dry leaf weight

Treatment	Stem diameter (cm)	Fresh leaf weight (g)	Dry leaf weight (g)
Zn_0	1.27 c	17.65 b	9.00
Zn_1	1.48 ab	21.82 a	11.36
Zn_2	1.58 a	24.35 a	12.82
CV%	2.44	4.62	7.47
Level of Significance	$p < 1\%^{**}$	$p < 1\%^{**}$	$p < 1\%^{**}$

Figure in the column, having the same letter(s) do not differ significantly at 5% level of probability. **= Significant at 1% level of significance analyzed by Tukey Test. CV% denotes Co-efficient of Variation, Here, Zn_0 = 0 kg/ha, Zn_1 = 2 kg/ha, Zn_2 = 4 kg/ha

Table 6. Combined effects of nitrogen and zinc on on stem diameter , fresh leaf weight and dry leaf weight

Treatment Combination	Stem diameter (cm)	Fresh leaf weight (g)	Dry leaf weight (g)
N_0 Zn_0	1.17 f	16.20	8.16
N_0 Zn_1	1.25 e	16.80	8.43
N_0 Zn_2	1.30 de	17.25	8.98
N_1 Zn_0	1.36 d	20.32	10.43
N_1 Zn_1	1.44 c	20.63	10.63
N_1 Zn_2	1.45 bcd	21.26	11.35
N_2 Zn_0	1.49 bc	22.53	11.65
N_2 Zn_1	1.53 b	22.84	11.83
N_2 Zn_2	1.54 ab	23.42	12.13
N_3 Zn_0	1.58 ab	24.13	12.56
N_3 Zn_1	1.60 a	24.56	13.04
N_3 Zn_2	1.61 a	25.30	13.56
CV%	5.42	18.23	23.45
Level of Significance	$p < 5\%^{*}$	$p > 5\%^{NS}$	$p > 5\%^{NS}$

Figure in the column, having the same letter(s) do not differ significantly at 5% level of probability. *= Significant at 5% level of significance analyzed by Tukey Test. NS narrates Non-Significant, CV% denotes Co-efficient of Variation, Here, Zn_0 = 0 kg/ha, Zn_1 = 2 kg/ha, Zn_2 = 4 kg/ha, N_0 = 0 kg/ha , N_1 = 60 kg/ha, N_2 = 100 kg/ha, and N_3 = 140 kg/ha

4.2 Effects of nitrogen and zinc on yield and yield attributing traits of onion

Results of the effects of nitrogen and zinc on various growth parameters of onion such as length of bulb (cm), diameter of the bulb (cm), fresh bulb weight (g), yield per plot (kg), and yield t/ha has been presented and discussed below:

4.2.1 Length of bulb (cm)

Length of bulb was significantly influenced by nitrogen and zinc treatments. From the single mean effect of nitrogen was observed that N_3 (140 kgha^{-1}) treatment gave the highest length of bulb (4.81 cm) followed by the treatments of N_2 (4.67 cm) and N_1 (4.54 cm) while the N_0 (0 kg/ha) treatment gave the lowest length of bulb (4.45 cm) (**Figure 2).**

Besides, the highest length of bulb (5.07 cm) was observed with the treatment of Zn_2 (4 kgha^{-1}) and the minimum results (4.15 cm) were also found in Zn_0 (0 kg/ha) (**Figure 3).**

The combined effect of nitrogen and zinc on the length of bulb was statistically non-significant**.** The maximum length of bulb (5.23 cm) was obtained with a treatment combination of N_3Zn_2 and the minimum length of bulb (3.96 cm) under the treatment combination of N_0Zn_0 **(Table 7).** The experiment results indicated that optimum N and Zn application increase other nutrients availability which leads to increase onion plant growth and total bulb yield. The findings of this experiments are closely related with Rahman, (2011) and reported that N 150, Zn kg/ha, 4.5 kg/ha gave the highest number of plant height, length of leaf, number of leaves plant-^{1}, diameter of bulb, length of bulb, single bulb weight, yield of bulb, the highest N and Zn contents in bulb and leaf. Ullah *et al*. (2004),Mandira and khan, (2003), Bekele *et al*. (2018), Ansary *et al*. (2006) and Dilruba *et al*. (2006) supported the findings of this experiment.

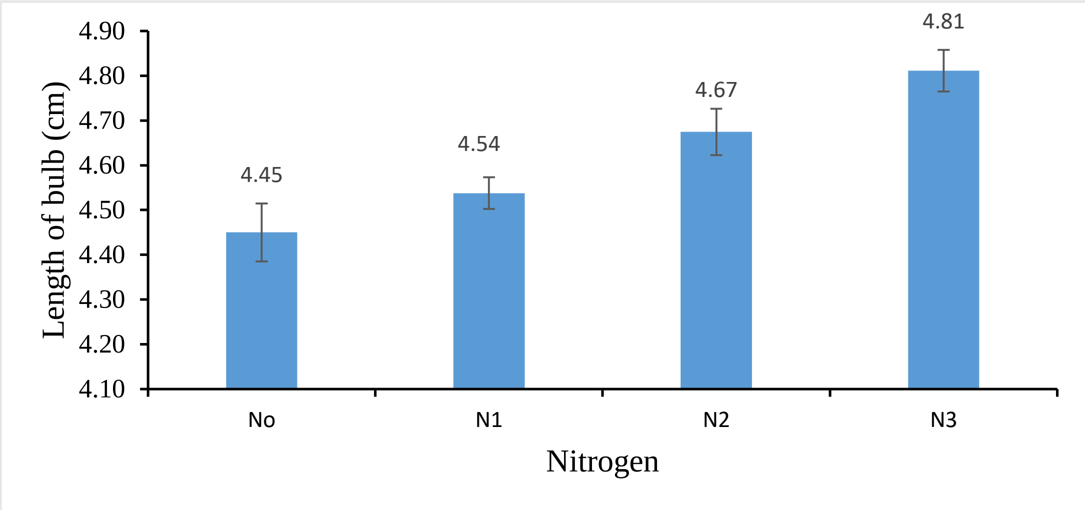


Figure 2. Graphical presentation of the effects of nitrogen on length of bulb (cm) where vertical bars indicate the standard error of the mean against each treatment. Here, $N_0 = 0$ kg/ha , $N_1 = 60$ kg/ha, $N_2 = 100$ kg/ha, $N_3 = 140$ kg/ha

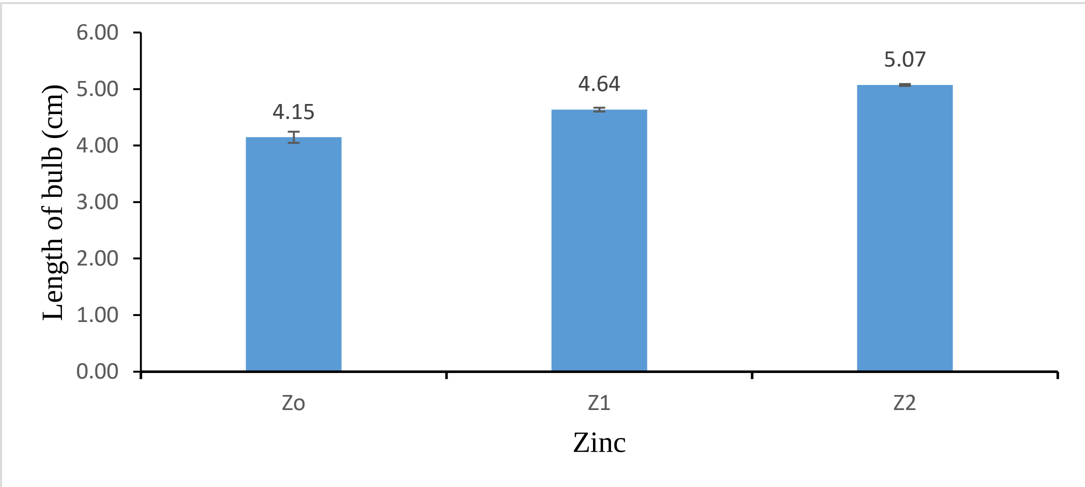


Figure 3. Graphical presentation of the effects of zinc on length of bulb (cm) where vertical bars indicate the standard error of the mean against each treatment. Here, $Z_0 = 0$ kg Zn /ha, $Z_1 = 2$ kg Zn/ha, $Z_2 = 4$ kg Zn/ ha

4.2.2 Diameter of the bulb (cm)

Diameter of the bulb was significantly influenced by nitrogen and zinc treatments. From the single mean effect of nitrogen was observed that N_3 (140 kgha^{-1}) treatment gave the highest diameter of the bulb (4.40 cm) followed by the treatments of N_2 (4.30 cm) and N_1 (4.22 cm) while the N_0 (0 kg/ha) treatment gave the lowest diameter of the bulb (4.04 cm) (**Figure 4).**

Besides, the highest diameter of the bulb (4.63 cm) was observed with the treatment of Zn_2 (4 kgha^{-1}) and the minimum results (3.77 cm) were also found in Zn_0 (0 kgha^{-1}) (**Figure 5).**

The combined effect of nitrogen and zinc was also significant in respect of diameter of the bulb. However, the maximum diameter of the bulb (4.81 cm) of the plant was obtained with a treatment combination of N_3Zn_2 which was found to be statistically identical to the treatment combinations of N_3Zn_1 and N_3Zn_0 produced the highest diameter of the bulb over the rest of the treatments. On the other hand, in combinations N_2Zn_0 , N_1Zn_2 N_2Zn_2, and N_2Zn_1, were statistically in the same group whereas the minimum diameter of the bulb (3.51 cm) was found in N_0Zn_0 treatment combination **(Table 7)**. The findings of these experiments are in close conformity with Kumar *et al*. (2006) and reported that the bulb yield was significantly higher with the application of 145 kg/ha and 3.2 kg/ha Zn. Optimum level of nitrogen and Zn might have increased the availability of other plant nutrients to plants resulting in increased better performance of crop growth and ultimately increased crop yield. (Hassan 1983) found that zinc application resulted an increased in nitrogen and zinc uptake by onion plants.(Erana, Tenkegna and Asfaw 2019); Ullah *et al*. (2004); Bekele *et al*. (2018), Ansary *et al*. (2006) and (Dudhat *et al*. 2010) supported the findings of this experiment.

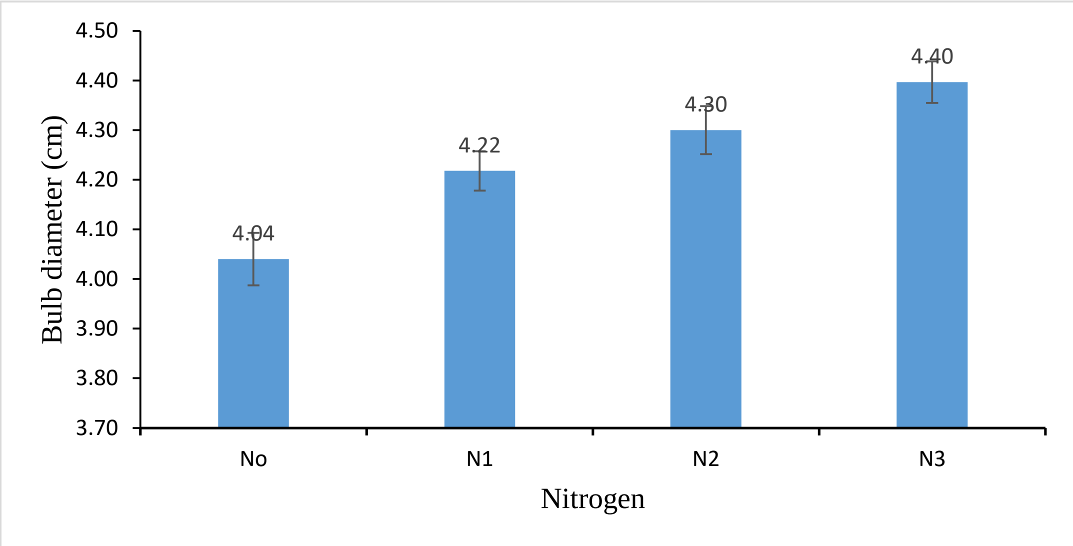


Figure 4. Graphical presentation of the effects of nitrogen on bulb diameter (cm) where vertical bars indicate the standard error of the mean against each treatment. Here, N_0 = 0 kg/ha , N_1 = 60 kg/ha, N_2 = 100 kg/ha, N_3 = 140 kg/ha

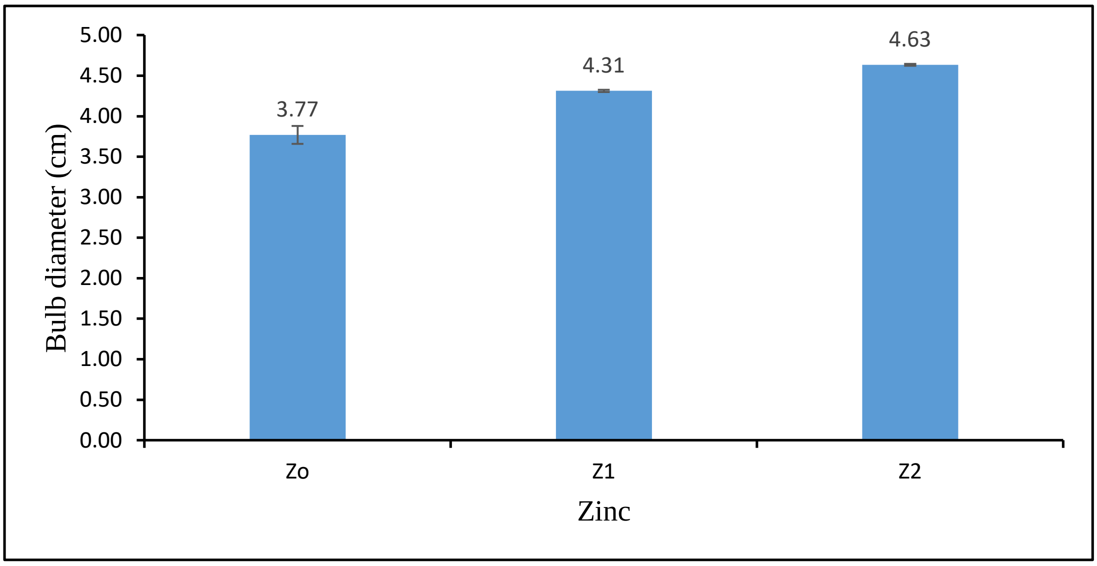


Figure 5. Graphical presentation of the effects of zinc on bulb diameter (cm) where vertical bars indicate the standard error of the mean against each treatment. Here, Z_0 = 0 kg Zn/ ha, Z_1 = 2 kg Zn /ha, Z_2 = 4 kg Zn/ ha

4.2.3 Fresh bulb weight (g)

The single effect of nitrogen and zinc was significant on fresh bulb weight. The nitrogen level of N_3 (140 kg/ha) showed a maximum (48.70 g) fresh bulb weight followed by the treatments of N_2 (45.77 g) and N_1 (44.36 g) while the N_0 (0 kg/ha) treatment gave the minimum fresh bulb weight (42.37 g). (**Figure 6).**

On the other hand, the maximum fresh bulb weight (53.84 g) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum results (37.46 g) were also found in Zn_0 (0 kg/ha) (**Figure 7).**

The combined effect of nitrogen and zinc was also significant in respect of fresh bulb weight. However, the maximum fresh bulb weight (57.68 g) of the plant was obtained with a treatment combination of N_3Zn_2 which was found statistically identical to the treatment combinations of $N_3Zn_{1,}$ and N_3Zn_0 produced the highest fresh bulb weight over the rest of the treatments. On the other hand, in $N_3Zn_{0,}$ $N_2Zn_{2,}$ $N_2Zn_{1,}$ and N_2Zn_0 in combinations were statistically in the same group whereas the minimum fresh bulb weight (35.30 g) was found in N_0Zn_0 treatment combination **(Table 7).** Experiment results indicated that fresh weight of bulb plant^{-1} increase gradually with increasing N and Zn fertilizer application and the lowest fresh weight of bulb Zn was obtained when no N and Zn fertilizer was used as treatment. The findings of this experiment are in close conformity with Kumar *et al*. (2006) who reported that the bulb yield was significantly higher with the application of 150 kg N/ha and 2.5 kg Zn/ha. Optimum levels of nitrogen and zinc might have increased the availability of other plant nutrients to plants resulting better performance of crop growth and ultimately increased the fresh weight of bulb plant^{-1}. Similar findings of this experiment were reported by Ullah *et al*. (2004); Mandira and khan, (2003); Bekele *et al*. (2018), (Etana *et al*. 2019a) and (Abdullah and 2018).

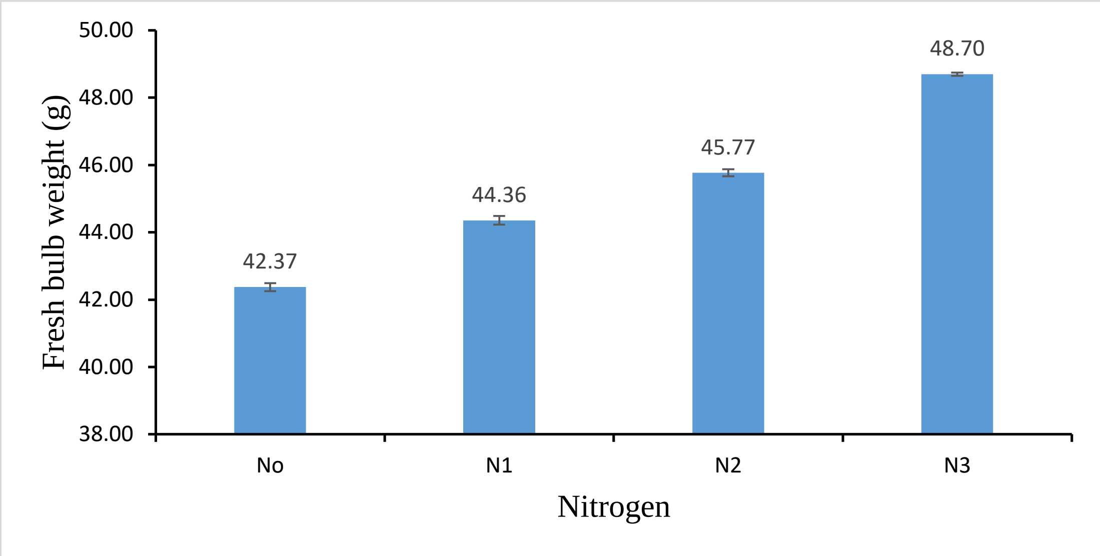


Figure 6. Graphical presentation of the effects of nitrogen on fresh bulb weight (g) where vertical bars indicate the standard error of the mean against each treatment. Here, $N_0 = 0$ kg/ha , $N_1 = 60$ kg/ha$^-$ $N_2 = 100$ kg/ha, $N_3 = 140$ kg/ha

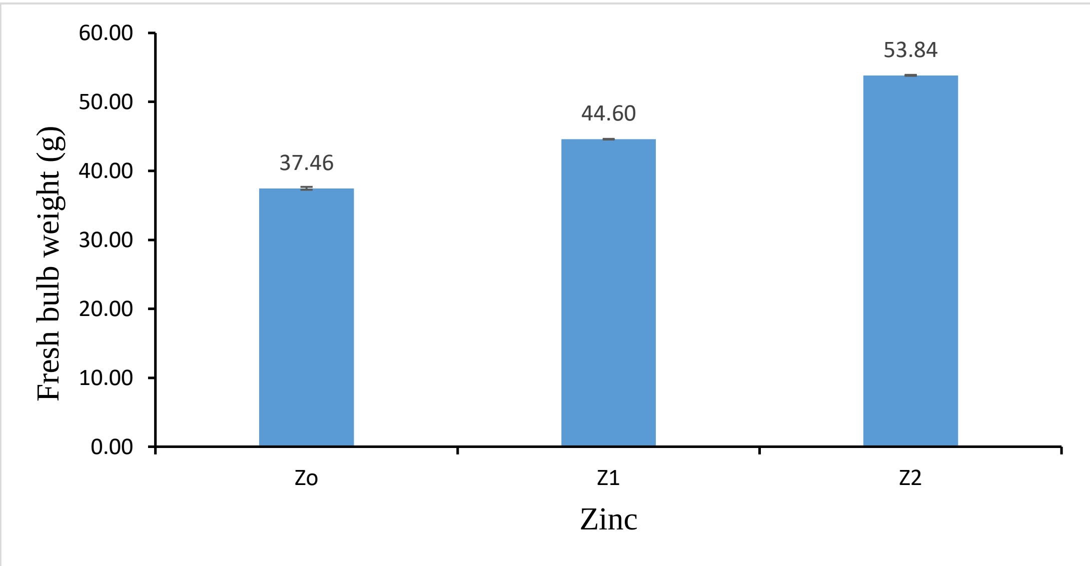


Figure 7. Graphical presentation of the effects of zinc on Fresh bulb weight (g) where vertical bars indicate the standard error of the mean against each treatment. Here, $Z_0 = 0$ kg Zn /ha, $Z_1 = 2$ kg Zn/ha, $Z_2 = 4$ kg Zn/ha

4.2.4 Yield per plot (kg)

The yield per plot production ability of the onion plant was greatly influenced by the application of zinc and nitrogen. The single effect of nitrogen, as well as zinc on leaf production, was significantly affected by the selected treatments. The nitrogen level of N_3 (140 kg/ha) showed a maximum (3.53 kg/plot) yield followed by the treatments of N_2 (3.42 kg/plot) and N_1 (3.33 kg/plot) while the N_0 (0 kg/ha) treatment gave the minimum yield (3.26 kg/plot) (**Figure 8).**

On the other hand, the maximum yield per plot (3.72 kg/plot) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum result (3.11 kg/plot) was also found in Zn_0 (0 kg/ha) (**Figure 9).**

The combined effect of nitrogen and zinc was also significant in respect of yield per plot. However, the maximum yield (3.96 kg/plot) of the plant was obtained with a treatment combination of N_3Zn_2 which was found to be statistically identical to the treatment combinations of N_3Zn_1, and N_3Zn_0 produced the highest yield per plot over the rest of the treatments. On the other hand, in N_3Zn_0, N_2Zn_2, N_2Zn_1, and N_2Zn_0 combinations were statistically in the same group whereas the minimum yield (2.90 kg/plot) was found in N_0Zn_0 treatment combination **(Table 7).** Experiment at results concluded that bulb yield increase gradually with increasing N and Zn fertilizer application and lowest bulb yield obtained when no N and Zn fertilizer used. The photosynthesis and other physiological process of plant depend on nitrogen and potassium. Vidigal *et al*. (2002) found that zinc application resulted an increased in nitrogen and potassium uptake by onion plants. The findings of this experiments closely similar with Rahaman, (2011) and reported that application of 150 kg N/ha, 3.7 kg Zn/ha and their combined application gave the highest number of plant height, length of leaf, number of leaves plant^{-1}, diameter of bulb, length of bulb, single bulb weight, yield of bulb, the highest N and Zn contents in bulb and leaf. Fatema, (2015), Gambo *et al*. (2008), (Ahmed 2009), El-Damarany, *et al*. (2016) and Bolandnazar *et al*.(2012) supported the results of this experiment.

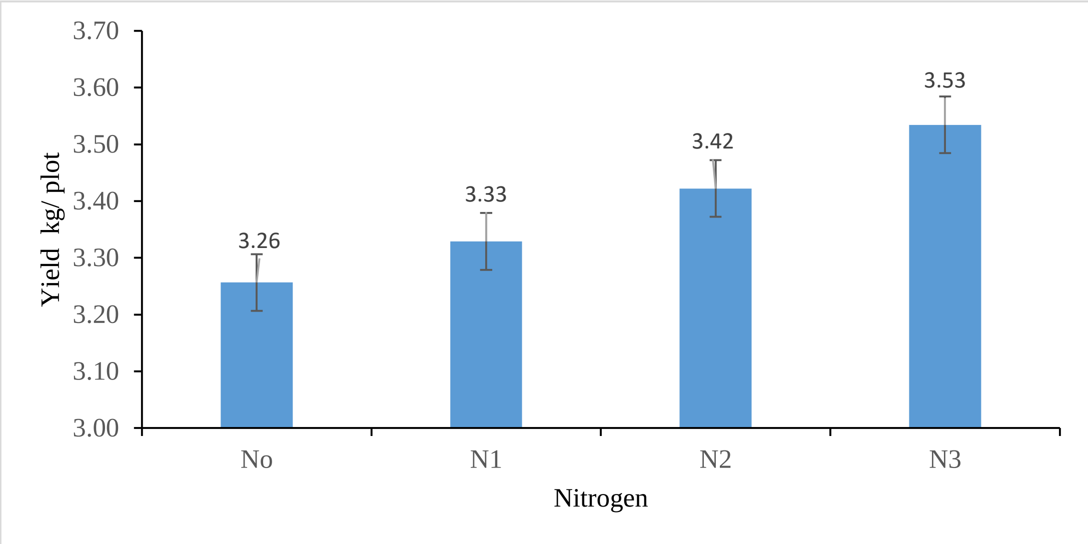


Figure 8. Graphical presentation of the effects of nitrogen on yield kg/plot where vertical bars indicate the standard error of the mean against each treatment. Here, N_0 = 0 kg/ha , N_1 = 60 kg/ha, N_2 = 100 kg/ha, N_3 = 140 kg/ha

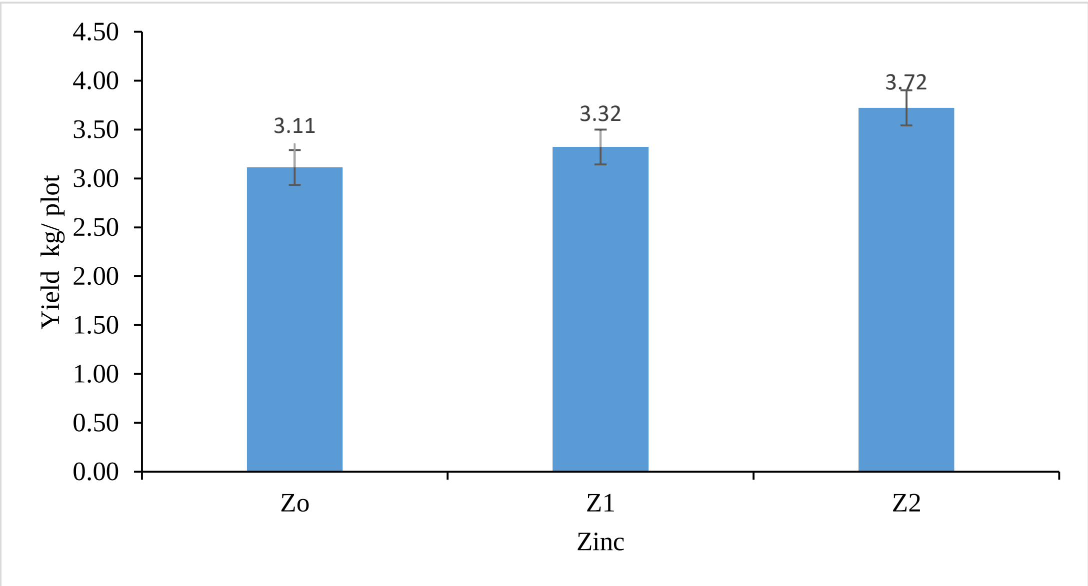


Figure 9. Graphical presentation of the effects of zinc on yield (kg/plot) where vertical bars indicate the standard error of the mean against each treatment. Here, Z_0 = 0 kg Zn/ha, Z_1 = 2 kg Zn/ha, Z_2 = 4 kg Zn/ha

4.2.5 Yield t/ha

The total yield ability of the onion plant was greatly influenced by the application of zinc and nitrogen. The single effect of nitrogen, as well as zinc on yield production, was significantly affected by the selected treatments. The nitrogen level of N_3 (140 kg/ha) showed a maximum (17.56 t/ha) yield followed by the treatments of N_2 (17.28 t/ha) and N_1 (16.86 t/ha) while the N_0 (0 kg/ha) treatment gave the minimum yield (16.29 t/ha) (**Figure 10).**

On the other hand, the maximum yield (18.65 t/ha) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum results (15.83 t/ha) were also found in Zn_0 (0 kg/ha) (**Figure 11).**

The combined effect of nitrogen and zinc was also significant in respect of total yield. However, the maximum yield (19.78 t/ha) of the plant was obtained with a treatment combination of N_3Zn_2 which was found to be statistically identical to the treatment combinations of $N_3Zn_{1,}$ and N_3Zn_0 produced the highest yield per plot over the rest of the treatments. On the other hand, $N_3Zn_{0,}$ $N_2Zn_{2,}$ $N_2Zn_{1,}$ and N_2Zn_0 treatment combinations were statistically in the same group whereas the minimum yield (15.03 t/ha) was found N_0Zn_0 treatment combination (**Table 7**). Experiment results indicated that nitrogen and zinc application increase yield gradually. Nitrogen and zinc improve plant photosynthesis, food translocation, and other physiological activity which increase crop yield. For the growth and development of plants, a relatively minimal amount of Zn is needed. According to Protch and Islam (1984), Bangladeshi soils are becoming deficient in Zn (Kandil *et al*. 2013). The application of micronutrients to the deficient soil in these soils has resulted in a notable improvement in the yield of many crops, particularly high-quality grain and seed production (Khokhar 2014). From cell wall growth to respiration, photosynthesis, chlorophyll generation, enzyme activity, nitrogen fixation, and other aspects of plant metabolism, micronutrients play an essential role Kitila *et al*. (2022). Buckland *et al*. (2013) reported that the application of 150 kg/ ha N and 3.8 kg Zn /ha favored the maximum productivity of bulbs. Akul *et al*. (1982), Bekele *et al*. (2018),Kumar *et al*. (2019); Ali *et al*. (2007) reported similar findings of this experiment and concluded that optimum N and Zn fertilizer application increase onion bulb yield.

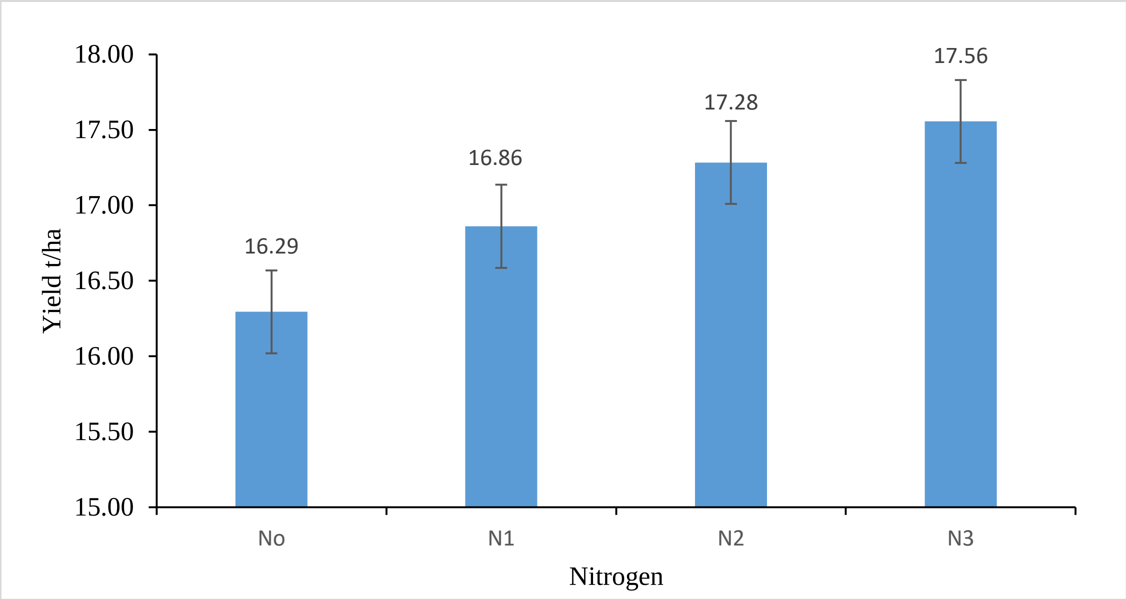


Figure 10. Graphical presentation of the effects of nitrogen on yield (t/ha) where vertical bars indicate the standard error of the mean against each treatment. Here, N_0 = 0 kg/ha , N_1 = 60 kg/ha, N_2 = 100 kg/ha, N_3 = 140 kg/ha

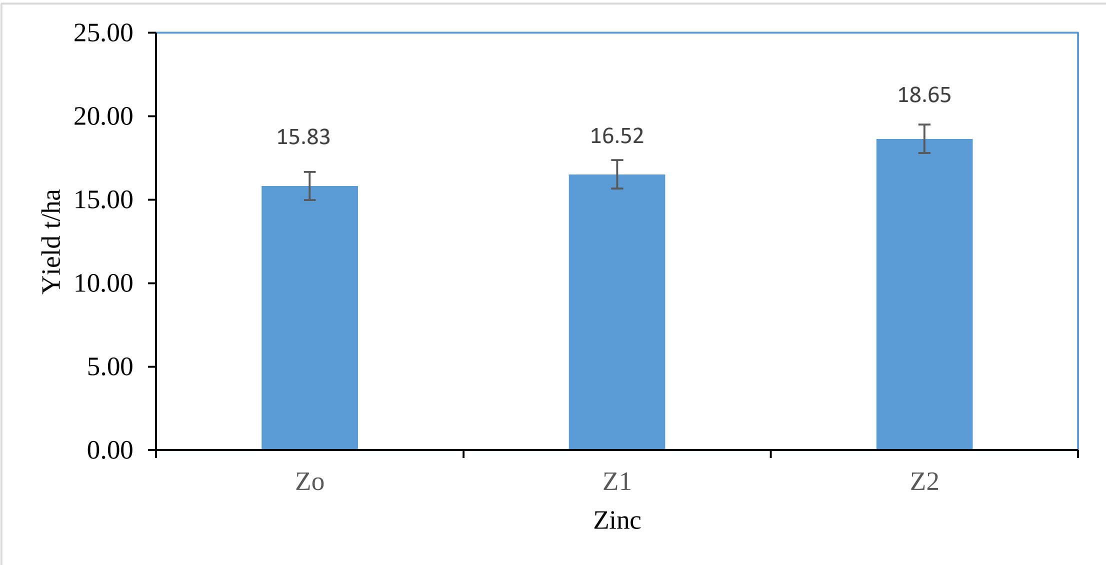


Figure 11. Graphical presentation of the effects of zinc on yield (t/ha) where vertical bars indicate the standard error of the mean against each treatment. Here, Z_0 = 0 kg Zn/ha, Z_1 = 2 kg Zn/ha, Z_2 = 4 kg Zn/ ha

Table 7. Combined effects of nitrogen and zinc on yield and yield attributing traits

Treatment Combination	Bulb length (cm)	Bulb diameter (cm)	Fresh bulb weight (g)	Yield (kg/plot)	Yield (t/ha)
N_0 Zn_0	3.96	3.51ghi	35.30 gh	2.90 ij	15.03 ij
N_0 Zn_1	4.07	3.76 efg	36.35 fgh	3.03ghi	15.13 ghi
N_0 Zn_2	4.19	3.84 g	37.02 gh	3.32 gh	15.85 gh
N_1 Zn_0	4.37	3.96 ef	41.16 fgh	3.21gh	16.03gh
N_1 Zn_1	4.48	4.10 e	42.25 fg	3.23 ef	16.15 ef
N_1 Zn_2	4.53	4.33 de	43.37 f	3.33 ef	16.67 ef
N_2 Zn_0	4.71	4.40 d	45.53 de	3.28 cde	16.42 cde
N_2 Zn_1	4.84	4.42 cd	47.26 cd	3.44 cd	16.85 cd
N_2 Zn_2	4.91	4.51 bc	49.56 c	3.64 c	17.70 c
N_3 Zn_0	5.01	4.56 ab	53.35 ab	3.63 c	18.33 c
N_3 Zn_1	5.13	4.66 b	54.76 ab	3.67 bc	18.78 bc
N_3 Zn_2	5.23	4.81 ab	57.68 a	3.96 ab	19.78 ab
CV%	24.6	7.87	4.69	7.15	5.65
Level of Significance	$p > 5\%^{NS}$	$p < 5\%^{*}$	$p < 1\%^{**}$	$p < 5\%^{*}$	$p < 5\%^{*}$

Figure in the column, having the same letter(s) do not differ significantly at 5% level of probability. *= Significant at 5% level of significance analyzed by Tukey Test. NS narrates Non-Significant, CV% denotes Co-efficient of Variation, Here, Zn_0 = 0 kg/ha, Zn_1 = 2 kg/ha, Zn_2 = 4 kg/ha, N_0 = 0 kg/ha , N_1 = 60 kg/ha, N_2 = 100 kg/ha, and N_3 = 140 kg/ha

4.3 Effect of N and Zn on post-harvest of soil

4.3.1 Effect of N and Zn on post-harvest soil pH

Statistically non-significant variation was recorded on post-harvest soil pH affected by N and Zn fertilizer application on onion field. Highest soil pH (6.36) was observed from treatment N_0Zn_0 combination and lowest soil pH (5.82) observed from N_3Zn_2 combination **(Table 8).**

4.3.2 Effect of N and Zn on post-harvest soil organic carbon

Statistically significant variation was recorded due to the interaction effect of different levels of N and Zn in terms of organic carbon in post-harvest soil **.**The highest Organic carbon in post harvest soil (0.55%) was obtained from treatment combination of N_3Zn_2 . while the lowest Organic carbon in post harvest soil (0.43%) was found from N_0Zn_0 treatment combination **(Table 8).**

4.3.3 Effect of N and Zn on post-harvest soil of available phosphorus

The effect of combined application of N and Zn showed no significant differences in respect of P content in soil after harvest. The highest P content (23.41ppm) was observed in N_1Zn_0 combination and the minimum value (20.90ppm) was found in the N_0Zn_0 treatment combination **(Table 8).**

4.3.4. Effect of N and Zn on post-harvest soil of available sulphur

The effect of combined application of N and Zn showed significant differences in respect of S content of soil after harvest. The highest S content (21.59 ppm) was observed in N_3Zn_2 combination and the minimum value (17.28ppm) was found in the treatment N_0Zn_0 combination **(Table 8)**.

Table 8. Combined effect of N and Zn on the soil pH, Organic carbon, P and S concentration in the soil after onion harvest

Treatment Combination	**pH**	**Organic carbon (%)**	**Available P (ppm)**	**Available S (ppm)**
N_0 Zn_0	6.36	0.43def	20.90	17.28ij
N_0 Zn_1	6.30	0.45cde	22.81	17.34ghi
N_0 Zn_2	6.25	0.48bc	23.29	17.47fgh
N_1 Zn_0	6.15	0.51bc	23.41	18.25fg
N_1 Zn_1	6.10	0.47cde	22.67	18.42def
N_1 Zn_2	6.00	0.45cde	22.95	18.67de
N_2 Zn_0	6.05	0.53ab	23.32	18.82de
N_2 Zn_1	6.00	0.49bc	23.07	19.17cd
N_2 Zn_2	5.96	0.53ab	21.31	19.70cd
N_3 Zn_0	5.87	0.50ab	22.67	20.15c
N_3 Zn_1	5.83	0.52ab	22.95	21.23b
N_3 Zn_2	5.82	0.55a	21.32	21.59a
Significance level	$p > 5\%^{NS}$	$p < 5\%^{*}$	$p > 5\%^{NS}$	$p < 5\%^{*}$
CV(%)	**24.23**	**10.96**	**21.26**	**9.66**

Figure in the column, having the same letter(s) does not differ significantly at 5% level of probability. **= Significant at 1% level of significance analyzed by Tukey Test. NS narrates Non-Significant, CV% denotes Co-efficient of Variation, Here, Zn_0 = 0 kg/ha , Zn_1 = 2 kg/ha, Zn_2 = 4 kg/ha, N_0 = 0 kg/ha , N_1 = 60 kg/ha, N_2 = 100 kg/ha, and N_3 = 140 kg/ha

CHAPTER V

SUMMERY AND CONCLUSION

5.1 Summery

The research work was conducted at Sher-e-Bangla Agricultural University Farm, Sher-e-Bangla Nagar, Dhaka-1207 during the Rabi season of December, 2021, to study the effect of nitrogen and zinc on growth and yield of BARI Peyaj-6. The selected plot was a medium high land. The experiment comprised of two factors; Factor A: 0 kg/ha (N_0), 60 kg/ha (N_1), 100 kg/ha (N_2), 140 kg/ha (N_3) and Factors B: Levels of zinc (3 levels) 0 kg/ha (Zn_0), 2 kg/ha (Zn_1), 4 kg/ha (Zn_2). The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. For the treatment combinations, each block was divided into 12 plots. There were 36 plots in total. Each block was subsequently assigned to 12 treatment combinations according to the experimental design. On 11 December 2021, healthy, 35 days old seedlings were transplanted into the main field. Intercultural operations were done as when necessary. At the time of final land preparation soil sample and after harvest soil sample were taken for chemical analysis and to assess the nutrient status. Results of the samples were also statistically analyzed. The individual and combined effects of nitrogen and zinc on growth, yield and nutrient stratus of soil of onion were studied. Data on plant characters were recorded at different stages. Nitrogen and zinc fertilization at different levels individually influenced plant characters. The individual and interaction effects of N and Zn on growth, yield and nutrient content were found positive. Both the growth and yield increased with increasing nitrogen and zinc.

Plant height was recorded at harvest and it was observed that there were significant variations in plant height at different levels of nitrogen and zinc application. Single mean effects of different levels of N and Zn were found significant on the plant height. The nitrogen level of N_3 (140 kg/ha) gave the tallest plant (48.29 cm) while the N_0 (0 kg/ha) treatment gave the shortest plant (43.83 cm). The nitrogen level of N_3 (140 kg/ha) showed a maximum (8.02) number of leaves per plant and the N_0 (0 $kgha^{-1}$) treatment gave the minimum number of leaves (6.69). From the single mean effect of nitrogen was observed that N_3 (140 kg/ha) treatment gave the highest leaf length (39.87 cm) followed by the treatments of N_2 (38.82 cm) and N_1 (37.88 cm) while the N_0 (0 kg/ha) treatment gave the shortest length of leaves (36.62 cm). The maximum stem diameter (1.50 cm) was observed from the plants grown with the N_3 (140 kg/ha) treatment which was statistically similar to N_2 (100 kg/ha) treatment also produced (1.46 cm). The control treatment produced the minimum diameter (1.38 cm) of the stem. The single effect of nitrogen, as well as zinc on leaf production, was significantly affected by the selected treatments. The nitrogen level of N_3 (140 kg/ha) showed a maximum (22.82 g) fresh leaf weight while the N_0 (0 kg/ha) treatment gave the minimum fresh leaf weight (20.09 g). The nitrogen level of N_3 (140 kg/ha) showed a maximum (11.94 g) dry leaf weight followed by the treatments of N_2 (11.22 g) and N_1 (10.78 g) while the N_0 (0 kg/ha) treatment gave the minimum dry leaf weight (10.31 g). From the single mean effect of nitrogen was observed that N_3 (140 kg/ha) treatment gave the highest length of bulb (4.81 cm) followed by the treatments of N_2 (4.67 cm) and N_1 (4.54 cm) while the N_0 (0 kg/ha) treatment gave the lowest length of bulb (4.45 cm). The single mean effect of nitrogen was observed that N_3 (140 kg/ha) treatment gave the highest diameter of the bulb (4.40 cm) and the N_0 (0 kg/ha) treatment gave the lowest diameter of the bulb (4.04 cm). The nitrogen level of N_3 (140 kg/ha) showed a maximum (48.70 g) Fresh bulb weight followed by the treatments of N_2 (45.77 g) and N_1 (44.36 g) while the N_0 (0 kg/ha) treatment gave the minimum fresh bulb weight (42.37 g). On the other hand, the maximum fresh bulb weight (53.84 g) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum results (37.46 g) were also found in Zn_0 (0 kg/ha). The single effect of nitrogen, as well as zinc on leaf production, was significantly affected by the selected treatments. The nitrogen level of N_3 (140 kg/ha) showed a maximum (3.53 kg/plot) yield followed by the treatments of N_2 (3.42 kg/plot) and N_1 (3.83 kg/plot) while the N_0 (0 kg/ha) treatment gave the minimum yield (3.26 kg/plot). The single effect of nitrogen, as well as zinc on leaf production, was significantly affected by the selected treatments. The nitrogen level of N_3 (140 kg/ha) showed a maximum (17.56 t/ha) yield followed by the treatments of N_2 (17.28 t/ha) and N_1 (16.86 t/ha) while the N_0 (0 kg/ha) treatment gave the minimum yield (16.29 t/ha).

The maximum plant height (50.52 cm) was observed with the treatment of zinc Zn_2 (4 kg/ha) and the minimum result (41.67 cm) was found in Zn_0 (0 kg/ha) where the maximum number of leaves (9.19) was observed with the treatment of zinc Zn_2 (4 kg/ha) and the minimum result (6.69) was also found in Zn_0 (0 kg/ha). The highest length of leaves (42.19 cm) was observed with the treatment of zinc Zn_2 (4 k/gha) and the lowest (34.31 cm) was also found in Zn_0 (0 kg/ha) as well as the maximum stem diameter (1.58 cm) was obtained with the treatment of Zn_2 (4 kg/ha) and the minimum height (1.27 cm) with Zn_0 (0 kg/ha) treatment. The maximum fresh leaf weight (24.35 g) was observed with the treatment of zinc Zn_2 (4 kg/ha) and the minimum result (21.82 g) were also found in Zn_0 (0 Kg/ha). The highest dry leaf weight (12.82 g) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum result (9.0 g) was also found in Zn_0 (0 kg/ha). The highest length of bulb (5.07 cm) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum result (4.15 cm) was also found in Zn_0 (0 kg/ha). The maximum diameter of the bulb (4.63 cm) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum result (3.77 cm) was also found in Zn_0 (0 kg/ha). The maximum fresh bulb weight (53.84 g) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum result (37.46 g) was also found in Zn_0 (0 kg/ha). On the other hand, the maximum yield per plot (3.72 kg/plot) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum results (3.11 kg/plot) were also found in Zn_0 (0 kg/ha) Finally in case of the total yield, the maximum yield (18.65 t/ha) was observed with the treatment of Zn_2 (4 kg/ha) and the minimum result (15.83 t/ha) was also found in Zn_0 (0 kg/ha).

The combined effect of nitrogen and zinc was also significant in respect of plant height. However, the maximum height (54.32cm) of the plant was obtained with a treatment combination of N_3Zn_2 which was found to be statistically identical to the treatment combinations of $N_3Zn_{1,}$ and N_3Z_0 produced the highest plant height over the rest of the treatments whereas the minimum plant height (40.06 cm) was found in N_0Zn_0 treatment. The treatment combination of N_3Zn_2 produced the highest (9.85) number of leaves which was identical to the combination of N_3Zn_1 as well as N_3Zn_0 treatment combination while the N_0Zn_0 treatment combination produced the lowest number of leaves (5.50). The combined effect of nitrogen and zinc on the length of leaves was statistically significant. The maximum leaf length (43.17 cm) was obtained with a treatment combination of N_3Zn_2 and the minimum leaf length (32.97 cm) was statistically similar to under the treatment combination of N_0Zn_0. The maximum stem diameter (1.58) of the plant was obtained with a treatment combination of N_3Zn_2 the minimum stem diameter (1.17 cm) was found N_0Zn_0 treatment combination. The maximum fresh leaf weight (43.17 g) was obtained with a treatment combination of N_3Zn_2 and the minimum fresh leaf weight (16.20 g) under the treatment combination of N_0Zn_0. The combined effect of nitrogen and zinc on the length of leaves was not statistically significant. The maximum dry leaf weight (13.56 g) was obtained with a treatment combination of N_3Zn_2 and the minimum dry leaf weight (8.16 g) under the treatment combination of N_0Zn_0. The combined effect of nitrogen and zinc on the length of leaves was also statistically non-significant**.** The maximum length of bulb (5.23 cm) was obtained with a treatment combination of N_3Zn_2 and the minimum length of bulb (3.96 cm) under the treatment combination of N_0Zn_0. However, the maximum diameter of the bulb (4.81 cm) of the plant was obtained with a treatment combination of N_3Zn_2 whereas the minimum diameter of the bulb (3.51 cm) was found N_0Zn_0 treatment combination. The maximum fresh bulb weight (57.68 g) of the plant was obtained with a treatment combination of N_3Zn_2 whereas the minimum fresh bulb weight (35.30 g) was found N_0Zn_0 treatment combination. The maximum yield (3.96 kg/plot) of the plant was obtained with a treatment combination of N_3Zn_2 minimum yield (2.90 kg/plot) was found in N_0Zn_0 treatment combination. The maximum yield (19.78 t/ha) of the plant was obtained with a treatment combination of N_3Zn_2 besides the minimum yield (15.03 t/ha) was found in N_0Zn_0 treatment combination.

5.2 Conclusion and Recommendation

From the findings it was found that the maximum yield (19.78 t/ha) of the onion bulb was obtained with a treatment combination of N_3 (140 kg/ha) and Zn_2 (4 kg/ha) that showed statistically high yield and best output of other growth and yield attributing traits as well.

So, it can be concluded that combination of N_3 (140 kg/ha) and Zn_2 (4 kg/ha) can be more beneficial for the farmers to get better yield for the cultivation of BARI Peyaj-6. Considering the above results of this experiment, further studies in the following areas may be suggested:

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

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

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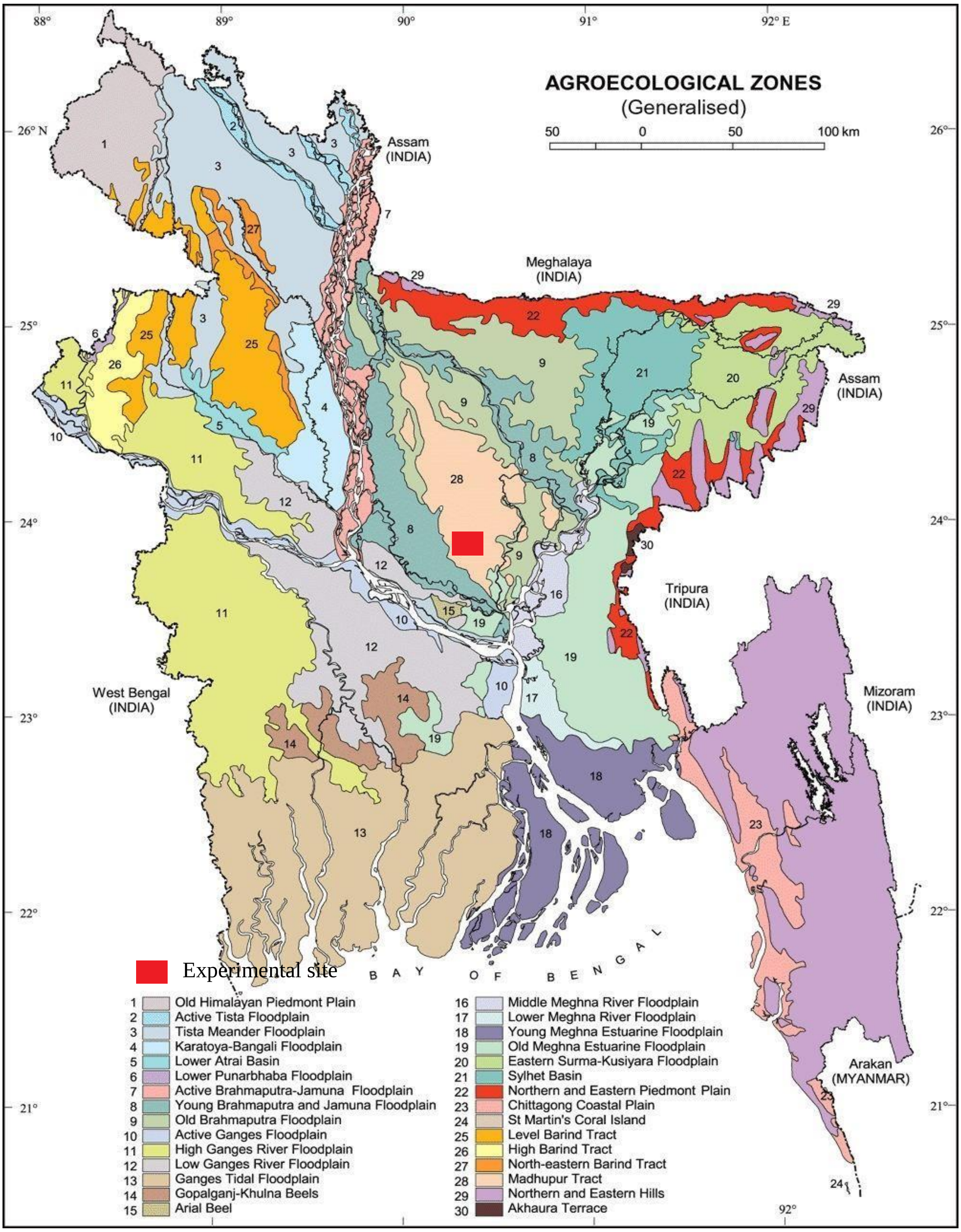
APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location



Appendix II. Monthly records of air temperature, relative humidity and rainfallduring the period from October 2021 to March 2022.

Year	Month	Air Temperature (ºC)			Relative humidity (%)	Rainfal (mm)
		Max	Min	Mean		
2021	October	28.60	8.52	18.56	56.75	14.40
2021	November	25.50	6.70	16.10	54.80	0.0
2021	December	23.80	11.70	17.75	46.20	0.0
2022	January	22.75	14.26	18.51	37.90	0.0
2022	February	35.20	21.00	28.10	52.44	20.4
2022	March	34.70	24.60	29.65	65.40	165.0

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

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

A) Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Soil science Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

B) Physical and chemical properties of the initial soil

Characteristics	Value
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (USDA)
pH	6.2
Organic carbon (%)	0.45
Available P (ppm)	20
Available S (ppm)	18

Appendix IV: Analysis of variance of the data on growth traits of BARI Peyaj-6 as influenced by different levels of Nitrogen and Zinc

Source of variation	Degrees of freedom (df)	Mean square of growth traits					
		Plant height (cm)	Number of leaves	Length of leaves (cm)	Fresh leaves weight (g)	Stem Diameter (cm)	Dry leaves weight (g)
Factor A (Nitrogen dose)	3	157.58**	25.12**	145.6**	104.25**	0.122**	33.37*
Factor B (Zinc dose)	2	3.98**	0.96**	1.45**	3.10**	0.244**	2.57*
Combination	6	0.251*	0.083**	0.892*	0.458^{NS}	0.321*	0.525^{NS}

**= Significant at 1% level of significance, *= Significant at 5% level of significance and NS narrates Non-Significant

Appendix V. Analysis of variance of the data on yield and yield attributing traits of BARI Peyaj-6 as influenced by different levels of Nitrogen and Zinc

Source of variation	Degrees of freedom (df)	Mean square of yield and yield attributing traits				
		Fresh bulb weight (g)	Bulb length (cm)	Bulb Diameter (cm)	Yield (kg/plot)	Yield (t/ha)
Factor A (Nitrogen dose)	3	586.28*	1.845*	0.203*	0.227*	9.151*
Factor B (Zinc dose)	2	28.45*	0.723*	1.585*	0.015*	0.601*
Combination	6	1.45**	0.241^{NS}	0.012*	0.028*	1.153*

**= Significant at 1% level of significance, *= Significant at 5% level of significance and NS narrates Non-Significant

Appendix VI: Analysis of variance of the data on pH, Organic carbon, N, P, K, and S, of postharvest soil of BARI Peyaj-6 as influenced by different levels of Nitrogen and Zinc

Source of variation	Degrees of freedom	Mean Square					
		pH	Organic carbon (%)	Total N (%)	Available P (ppm)	Exchangeable K (me/100gm)	Available S (ppm)
Factor A (Nitrogen dose)	3	0.084 NS	0.038 NS	0.001 NS	1.063 NS	0.001 NS	36.396*
Factor B (Zinc dose)	2	0.163	0.295 NS	0.001 NS	0.314 NS	0.001 NS	4.393*
Combination	6	0.021 NS	0.077 NS	0.001NS	4.229 NS	0.001 NS	1.490*

**= Significant at 1% level of significance, *= Significant at 5% level of significance and NS narrates Non-Significant

Plate 1. Experimental field

Plate 2. During data collection

Plate 3. Experimental plot

Plate 4. Onion's bulb

Plate 5. Lab work