EFFECT OF NITROGEN AND SULPHUR ON THE GROWTH AND YIELD OF BARI ONION- 4

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CERTIFICATE

This is to certify that the thesis enlightens, "**EFFECT OF NITROGEN AND SULPHUR ON THE GROWTH AND YIELD OF BARI ONION- 4**" submitted to the faculty of agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in SOIL SCIENCE** embodies the result of a piece of bonafide research work conducted by **SATHI TEERKI**, Registration no. **19-10261** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

Dated: DECEMBER, 2021

Dhaka, Bangladesh

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DEDICATED

TO

MY BELOVED PARENTS

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EFFECT OF NITROGEN AND SULPHUR ON GROWTH AND YIELD OF ONION

(BARI PIAZ-4)

ABSTRACT

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, during November 2020 to February 2021 to study the effects of nitrogen and sulphur on growth and yield of onion (BARI Piaz-4). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each treatment. The unit plot size was 3 m^2 (2.5 m x 1.2 m). There were 12 treatments combinations in the experiment comprising 4 levels of N (0, 70, 110 & 140 kg/ha showed as N_0, N_{70}, N_{110} & N_{140}, respectively) and 3 levels of S (0, 15 & 30 kg/ha designated as S_0, S_{15} & S_{30}, respectively). The collected data on different parameters were statistically analyzed by MSTAT C Package and the mean comparison was made by DMRT (Duncun's Multiple Range Test) at 5% and 1 % level. In general the other parameters like number of leaves per plant, leaf length, fresh weight of leaves plant-1. fresh weight of' bulb plant-1. dry weight of leaves / plant, dry weight of bulb per plant, bulb diameter, length of' bulb and yield increased with increasing the N doses upto 140 kg N/ha (N_{140}). The maximum number of leaves per plant (8.39cm) whereas leaf length (23.01cm), fresh weight of leaves $plant^{-1}$(8.69cm) fresh weight of' bulb $plant^{-1}$(24.36cm), dry weight of leaves $plant^{-1}$ (0.79cm), dry weight of bulb per plant (4.68), bulb diameter (5.58cm) and length of' bulb (3.44cm) were recorded from N_{140} treatment. Minimum values of these parameters were obtained from N_0(control). However, the highest bulb yield (6.34 t/ha) was recorded from N_{140} and the lowest bulb yield (3.86 t/ha) was recorded from control condition. The highest moisture content in both leaf and bulb (92.00% and
89.20 %) and were recorded from N_{140} treatment while the lowest moisture content in leaf and bulb (85.10% and 85.36 %) was recorded from N0 (control) treatment. The maximum number of leaves per plant (7.20cm) whereas leaf length (24.25cm), fresh weight of leaves $plant^{-1}$(7.21cm) fresh weight of' bulb $plant^{-1}$(26.30cm), dry weight of leaves $plant^{-1}$ (0.77cm), dry weight of bulb per plant (3.44cm), bulb diameter (4.89cm) and length of' bulb (3.65cm) were recorded from S_{30} treatment. Minimum values of these parameters were obtained from S_0(control). However, the highest bulb yield (4.98 t/ha) was recorded from S_{30} and the lowest bulb yield (4.12 t/ha) was recorded from control condition. The highest moisture content in both leaf and bulb (93.00% and 89.10 %) and were recorded from S_0 treatment while the lowest moisture content in leaf and bulb (86.20% and 86.73 %) was recorded from S_{30} treatment. The soil properties such as soil pH and organic matter content were increased after the harvest of crop compared the nutrient status of the initial soil.

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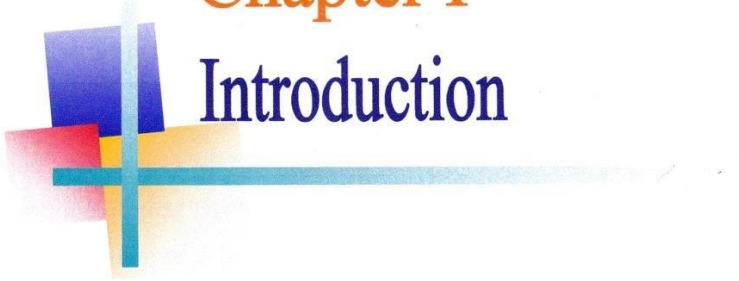
LIST OF ABBREVIATIONS AND ACRONYMS

AEZ	Agro- Ecological Zone
ANOVA	Analysis of Variances
BARI	Bangladesh Agriculturai Research Institute
BBS	Bangladesh Bureau of Statistics
BRRI	Bangladesh Rice Research Institute
Cm	Centimeter
DAS	Days After Sowing
DAT	Days After Transplanting
cv.	Cultivar (s)
CV	Coefficient of variance
et al.	And others
FAO	Food and Agriculture Organization
g	Gram(s)
Hr	Hour(s)
K	Potassium
K20	Potassium Oxide
kg	Kilogram (s)
LSD	Least Significant Difference
m^2	Meter Squares
mm	Millimeter
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Non significant
P205	Phosphorus Penta Oxide
S	Sulphur
SAU	Sher-e- Bangla Agriculturaj University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
var.	Variety
wt	Weight
tha^{-1}	Ton per heciare
° C	Degree Centigrade
%	Percentage



Chapter I

Introduction

CHAPTER I

INTRODUCTION

Onion (*Alliurn cepa*) variety (BARI Peyaj- 4) is one of the most important spices in Bangladesh as well as in the world, which belongs to the family Alliaceae (Jones and Mann, 1963). Generally onion is grown in all parts of Bangladesh in order to meet up the family demand but for commercial purposes it is cultivated in the greater districts of Faridpur, Pabna, Comilla, Rajshahi, Rangpur and Jessore (BBS. 2016). Among all the varieties BARI Peyaj-4 is a high yielding variety developed by Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. It is a winter variety. The production of onion in Bangladesh during the year 2016-2017 was 1099000 metric tones from 286000 cres of lands with an average yield of 2.09 Mt./ acre (BBS, 2016), which was very low as compared to that of onion growing countries of the world such as Spain, Pakistan. Australia, Korea, Japan, USA and Germany (FAO, 2005).

The demand of onion in Bangladesh is increasing day by day with the increasing population of the country. But the area under cultivation is not increasing in such way due to limitation of land. Total production of onion can be increased by increasing per hectare yield as in onion producing countries of the world. But during the last few years it has been found that the acreage and total production of onion in Bangladesh remained almost same. The production of onion is hampered due to many reasons such as suitable varieties, inadequate use of fertilizers such as nitrogen (N), phosphorus (P), sulphur (S), potash (K) and boron (B) fertilizers, negligible irrigation facilities and so on.

The production per unit area of onion can be increased by applying proper dose of fertilizers. Soil fertility is the main constituent for increasing production of any crop. Soil

nutrient management is therefore, a very essential area of research. In an integrated nutrient management homestead cropping pattern. One and only application of either organic manure or chemical fertilizers gave inferior results to their integrated use (BARI Annual Report, 2006-07). The necessitates an improvement of per hectare yield, which is possible through adoption of high yielding varieties and judicious application of fertilizer. Concerning fertilizer application sulphur is important since this element is highly deficient in our country's soils. Onion responded to N and S positively in term of yield and quality of bulbs (Patel and Patel, 1990).

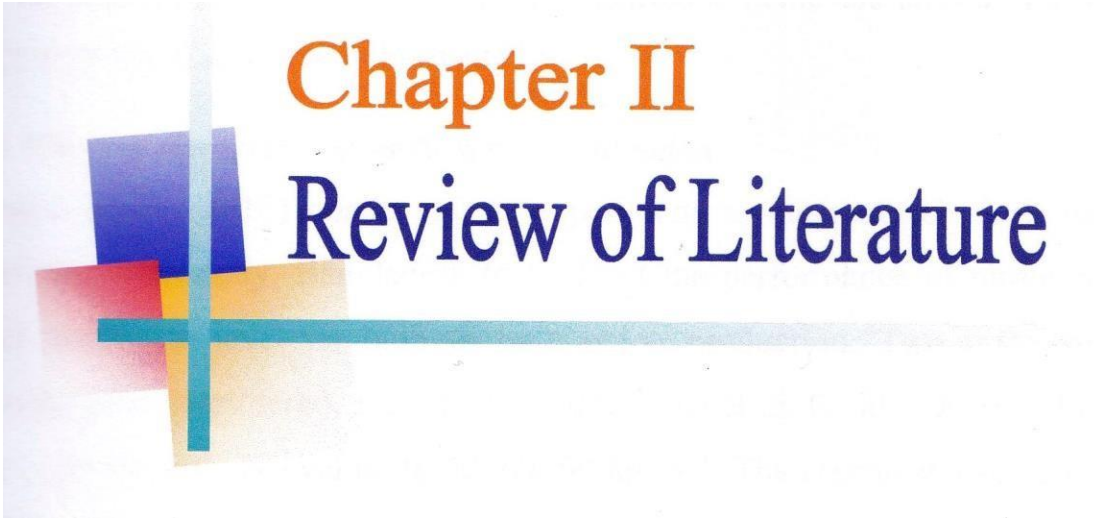
Nitrogen is an essential and important determinant for growth and development of crop plants (Tanaka *et al*., 1984). Nitrogen is constituent part of proteins, the basis of life, the nucleic acids (RNA, DNA), chlorophyll, phosphamide and other organic compounds. Nitrogen is essential for building up protoplasm and protein, which induce cell division and initial meristematic activity when applied in optimum quantity (Singh and Kumar, 1969). Nitrogen plays an important role for the vegetative growth of the crop which ultimately helps in increasing bulb size and total yield (Seward. 1963). Nitrogen imparts greenness to plants by enhancing chlorophyll synthesis and induces more photosynthetic production per unit photosynthetic area. Deficit of nitrogen results in poor growth and stunting of plants (Makasheva, 1983) and consequently reduction in crop yields (Machler *et al*., 1988; Radin *et al*., 1988).

Many researchers have noticed positive response of onion to S application. Sulphur deficiency of soils and crops is widespread in Bangladesh. Further, oil seed crops are sensitive to S deficiency. Generally, the farmers grow the traditional variety of sesame with imbalanced sulphur fertilization. The yield potentiality of sesame can be increased

through adoption of high yielding varieties (HYV) and balanced sulphur fertilization. Sulphur fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming eflCct on native soil organic matter (Marinari *et al.,* 2006).

In Bangladesh, there is limited information on the effect of nitrogen and sulphur on growth and yield of onion. In view of these limitations, a field experiment containing the treatments of nitrogen and sulphur was conducted with the following objectives:

- To observe the effect of nitrogen and sulphur on the maximum growth and yield of BARI Piaz-4.
- To observe the combined effect of nitrogen (N) and sulphur (S) on onion cultivation.



Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Onion is an important spice crop of Bangladesh as well as all over the world. Different types of chemical fertilizers play an important role on its growth, yield and quality. Many works have been done in the world on the effect of fertilizer on onion. In this chapter an effort has been made to review the research works related to this experiment.

2.1 Effect of nitrogen on the Growth and Yield of Onion

Agarwal *et al*., (1981) studied the yield of onion with N, P_20_5 and/ or K_2O at 80-160: 40 80: 40-80 kg ha-1. The highest yield was obtained from plots receiving 160:40:40 or 80:40:80 kg ha-1.

Gupta and Gaffar (1981) studied the effect of different row spacing tinder different combinations of nitrogen, phosphorus and potassium on the growth and yield of onion. Application of NIt exerted a significant effect on the yield and yield contributing characters olonion. Economic yield was obtained from Nitrogen application (I46:36:36 kg /ha.)

It was hypothesized by Li *et al*. (2003) that soil N variability, and fertilization and cropping management affect potato (*Solanum tuberosum* L.) growth and fertilizer N efficiency. The fertilizer N treatments consisted of a control, side-dress at rates of 70, 105 and 140 kg ha-1, and split applications (at seeding and bloom) at rates of 70+70, 105+70 and 140+70 kg ha-1, respectively. Soil acidity was corrected with limestone following the plow down of the sod. Years of cropping, main effect of N treatment, and year and fertilizer N interaction were significant on total and marketable tuber yields and N

uptake, which were significantly related to soil N, and root growth. In 23 years, the side-dress N (140 kg ha-1) increased significantly tuber yields (11.419.8%) compared to the split N (70+70 kg ha-1).

A field study was undertaken by Khalil *et al*. (2001) in Peshawar, Pakistan in the summer of 1995-96 to determine the appropriate nitrogen fertilizer for maximum tomato (cv. Peshawar Local) yield and its effects on various agronomic characters of tomato. Treatments comprised: untreated control; 150 kg ammonium nitrate/ha; 150 kg ammonium nitrate/ha + 100 kg P/ha + 50 kg K/ha; 150 kg ammonium sulfate; 150 kg ammonium sulfate/ha + 100 kg P/ha + 50 kg K/ha; 150 kg urea/ha; 150 kg urea/ha + 100 kg P/ha + 50 kg K/ha. Generally, ammonium sulfate fertilizer was the most efficient source of nitrogen for tomato production, followed by urea and ammonium nitrate. The ammonium sulfate + P + K treatment was the best among all treatments with respect to days to flower initiation (57 days), days to first picking (94 days), weight of individual fruit (50.8 g), weight of total fruits per plant (1990 g) and yield (21865 kg/ha). The control resulted in the significantly lowest response with respect to different agronomic characters under study.

A field experiment was conducted by Sinsinwar *et al*.(2004) during the 1999/2000 and 2000/01 rabi seasons in Bharatpur, Rajasthan, India, to determine the best cropping sequence and N fertilizer application rate (0, 30, 60 and 90 kg ha-1) of Indian mustard cv. RH-30 under brackish water situation. The cropping sequences did not affect the growth, yield and yield components (i.e. plant height, number of primary and secondary branches per plant, number of siliquae per plant), 1000seed weight and seed yield in both years. The seed yield of Indian mustard significantly increased with each increment of N

fertilizer up to 60 kg/ha, beyond which the increase was marginal. On an average, the increase in seed yield compared to the control was 33.3 and 83.8% with 30 and 60 kg N/ha, respectively.

Singh *et al* (1989) observed the effect of green manuring on the yield. They set up two types of lands, one without previous green manuring and another with green manuring by *Sesbania sp*. A combination 01120 kg N and 50 kg lCO gave the taller plants and the higher number of leaves per plant, maximum bulb weight and diameter per plant and higher bulb yield in the first experiment green manuring also greatly enhanced plant growth and bulb yield.

Rahim *et al*., (1992) conducted fertilizer trial with onion planted on 6th November at a spacing of 25 × 15 cm and supplied with 0-160 kg hi1 N and potassium 0-100 kg ha", where half fertilizers were applied before planting and half 30 days after planting. The combined application of higher rate of N and K gave the maximum yield of 11.11 t ha-1 compared with 4.5 t ha" from control.

Vachhani and Paid (1993) studied the effect of different levels of nitrogen (50, 100 or 150 kg ha-1), phosphorus (25. 50 or 75 kg P.O, ha-1) and potash (50, 100 or 150 kg K_2O ha-1) on the growth and yield of onion. They found that plant height, number of leaves plant", bulb weight and yield were the highest with 150 kg N ha-1, although bulb weight and yield with 100 kg N ha-1 were not significantly different. Increasing phosphorus application increased the number of leaves per plant and weight, size and yield of bulbs. Application of K increased only the number of leaves per plants.

Katwale and Saraf (1994) reported that the maximum bulb yield was obtained with the application of NPK at the rate of' 125: 60: 100 kg ha-1 respectively. This rate also gave the highest economic return.

Perilas and Nicor (1994) stated that the bulb weights of 12.34 and 45.72 1 ha" were found when 180 and 300 kg N ha" were applied respectively. They also reported that application of ISO to 240 kg N ha" showed an appreciable increase in diameter of bulbs from 2.85 (control) to 3.70 cm. The largest bulb diameter of 4.13 cm was observed when 300 kg N ha was applied.

Harun-or-Rasiiid (1995) conducted a field trial at Bangladesh Agricultural University, Mvinensingh to observe the effect of NPKS on growth and yield of onion at different plant spacing, He stated that the maximum bulb weight (40.50 g) and bulb yield (20.75 t ha-1) were found from the combination of 125-1 50-1 50-30 kg N. PO_5. 120. S 113d respectively. Application of NPKS increased the plant height, leaf number. bulb length, bulb diameter and bulb weight as well as the bulb yield. He recommended 100-1 50-200-30 kg N. P205. K20, S ha^{-1}. respcctively that the cultivation of BA RI piaz- 1 at BAU farm conditions.

Kumar *et al*. (1998) carried out an experiment in India during 1993/94 and 1994/95 and observed that N at 150 kg ha-1 gave the best results with regard to plant height, length and diameter of the longest leaf. diameter ol the thickest stem, number of leaves/plant, plant spread, time to bulb maturity, bulb diameler. bulb FW and DW, length of the longest root and bulb yield.

A field experiment was conducted by Patel *et al*. (2004) during the rabi season of 1999-2000 in Gujarat, India to investigate the effects of irrigation schedule, spacing (30 and 40 cm) and N rates (50, 75 and 100 kg/ha) on the growth, yield and quality of Indian mustard cv. GM-2. In combination treatments, 3 irrigation + N at 100 kg/ha + spacing of 45 cm resulted in a significant increase in yield. Growth, yield attributes and seed yield increased with increasing N levels, while oil content decreased with increasing rates. The highest benefit cost ratio was also obtained with N at 100 kg/ha.

Nitrogen and sulphur content both in seed and straw and total N and S uptake enhanced due to application of 90 kg N/ha over its preceding rates. The increased nitrogen and sulphur content enhanced the total uptake of nitrogen and sulphur.

Prasad *et al*. (2003) stated that N at 30 kg/ha + P at 20 kg/ha + Zn at 5 kg/ha, and N at 60 kg/ha + P at 30 kg/ha + S at 20 kg/ha produced the highest growth, yield and productivity, and also good cost : benefit ratio.

Field experiments were conducted by Abdin *et al*. (2003) in Rajasthan, Haryana and Uttar Pradesh, India to study the effects of S and N on the yield and quality of Indian mustard cv. Pusa Jai Kisan (V_1) and rape cv. Pusa Gold (V_2). The treatments comprised: T_1 [(S_0:N $_{(50 + 50)}$]; T_2 [S_{40}:N $_{(50 + 50)}$] for V_1 and [S_{40}:$N_{(50 + 25 + 25)}$ for V_2]; and T_3 [$S_{(20 + 20)}$:N(50 + 50) for V_1] and $S_{(20 + 10 + 10)}$:$N_{(50 + 25 + 25)}$ for V_2]. Split application of S and N (T_3) resulted in a significant increase in the seed and oil yield of both crops. The average seed yield obtained from the different experimental sites in the three states was 3.89 t/ha for V_1 and 3.06 t/ha for V_2 under T_3. The average oil yield under T_3 was 1.71 t/ha for V_1 and 1.42 t/ha in V_2. The oil and protein contents in the seeds of V_1 and V_2 also increased

with the split application of S and N. It may be concluded fromthese results that the yield and quality of rapeseed-mustard can be optimized with the split application of 40 kg S/ha and 100 kg N/ha during the appropriate phenological stages of crop growth and development.

Babu and Sarkar (2002) reported that mustard cultivars responded to N application up to 80 kg ha-1. Dry matter yield, N content and N uptake by mustard cultivars significantly increased with an increase in the level of fertilizer N. Successive levels of N also increased significantly the uptake of soil N by mustard cultivars clearly establishing the 'priming' or 'added nitrogen interaction effect' of applied nitrogen.

Budzynski and Jankowski, (2001) investigated the effects of pre-sowing application of NPK (161 kg/ha)+S (30 kg/ha) or Mg (5 kg/ha) and top dressing of N (0, 30, 25+5 and 60 kg/ha) on the yield, yield components and morphological features of white mustard [Sinapis alba] and Indian mustard seeds in an experiment conducted in Poland. N top dressing (30, 25+5 and 60 kg/ha) increased the height, diameter of stem base and branching of Indian mustard and white mustard stems. Both crops, however, exhibited lodging. The effects of NPKS and NPKMg on the yield potential of white mustard were not dependent on weather conditions. N applied at 30 kg/ha at the start of the flowering period gave the best results among the methods of white mustard top dressing. Splitting this rate to 25 kg N/ha as a solid fertilizer and 5 kg N/ha in a solution gave results similar to that of the whole rate of 30 kg N/ha as a solid fertilizer. N at 60 kg/ha appeared to be less productive. N applied as a solid fertilizer at a rate of up to 60 kg/ha increased the seed yield.

Greath and Schweiger (1991) have shown that cultivars of mustard may differ in nitrogen uptake and translocation. They classified cultivars into three types: type I- the higher the nitrogen application, the higher the yield; type II- as nitrogen is increased, yield increases at first, then remains stable; type III- as nitrogen is increased, yield increases at first, is stable for a while and then decreases. Nitrogen requirement varies from place to place. More cultivation of legume crops in the preceding year will not fulfill the requirement of nitrogen for normal growth and yield of rape. An application of 135 kg N ha-1 has produced maximum seed yield under irrigated condition in Bangladesh. A highly economic response for crop yield was obtained by applying 134 kg N ha-1 in fallow land than non-fallow land to give satisfactory yield. Nitrogen application upto 50 kg N ha-1 increases dry matter, N content and uptake of N and P. The use of nitrogen alone in excess may cause lodging, delayed maturity and decreased oil content and increased crude protein in mustard (Rahman, 1977; Bhatty, 1964 and Gupta *et al*., 1961).

Rodriguez e,al. (1999) carried out an experiments during 1993-94 and 1994-95 on onion to find out the effect of nitrogen, phosphorus and potassium rates, sources and forms upon onion (Al/mm cv/kl) bulb yield and quality. Yield, plant height, leaf number, and polar and equatorial diameters were measured in treatments with different rates, sources and fonns of N. P and K. Significant effects of P and K rates (applied tip to 98.2 and 200 kg ha1, respectively) could not be detected, nor significant interactions between N and P.

Dhannendra *et al*. (2001) 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.

2.2 Effect of Sulphur on the Growth and Yield of Onion

Qureshi and Lawande (2006) the effects of sulfur on the yield, quality and storability of onion cv. 8 780 were determined in a field experiment conducted in Maharashira. India during the kharif season of 2001-03. Elemental sulfbr (15. 30. 45. 60 and 75 kg/ha) was applied along with 100 kg N/ha, 50 kg P/ha and 50 kg K/ha. Onion responded significantly to 30-75 kg S/ha. The highest bulb yield of 39.1 t/ha was recorded with the application of 75 kg S/ha. Sulfi.ir content in bulbs increased by 48.0% due to the application of 75 kg S/ha over the NPK treatment.

Losak (2005) conducted an experiment and showed that the effects of N (g per pot, as ammoniuni nitrate) and S (mg/kg, as sulfate) fertilizers (0.0 + 25.0, 0.9 + 25.0, 0.9 + 40.0. or 0.9 ± 60.0) on the performance of onion (cv. Stutgartsk.a) were studied in a pot experiment. The application of 0.9 g N per pot and 25.040.0mg S/kg increased the weight and diameter of bulbs by 50.3-62.3 and 20.923.1%, respectively, and reduced the nitrate content of bulbs by 10.8-25.2% over the control (0.0 g N per pot + 25.0 mg S/kg, which is the amount of S in the soil). The increase in the level of sulfate to 40 and 60 mg/kg increased the bulb yield.

Jaggi *et al*., (2006) conducted an experiment during the winter (rabi) seasons of 2000-01 and 2001-02, at Palampur, Himachal Pradesh. India, to compare the effects of 2 sources of sulfur on onion (Allium cepa) under acidic soil and to work out their optimum doses.

The results showed the superiority of gypsum both at linear and curvature level by 0.0721 and 0.00066 tone/ha. The optimum level of Sc sub>95< sub> was detennined to be 42.14 kg/ha while that of gypsum was determined to be 55.17 kg/ha.The returns over fertilizer cost for S< sub>95'CI sub> and gypsum. The study clearly indicates that gypsum is a superior sulfur source for onion crop.

Jaggi (2005) conducted an experiment in Palampur. Hirnachal. Pradesh. India during 2000-01 and 2001 -02 to investigate the effect of S rates (0, 15, 30 and 60 kg/ha) and sources (595 and Gypsum) on the yield performance of onion cv. Patna Red. The fresh and dry weights of onion yield, plant height. leaf number/plant and weight per 10 bulbs increased with increasing S rates up to 30 kg/ha.

Jaggi (2004) conducted an experiment and reported that the effects of S (0. 15. 30 or 60 kg/ha) applied through gypsum or the slow released fertilizer S 95 on the composition and yield of onion (cv. Patna Red) were studied in Palanpor. Iliniachar Pradash. India during the winter at 2000-01 and 2001-02. Application significantly increased bulb and foliage yields and S content and uptake by foliage and bulb + foliage. The dry weight of bulb and foliage, and N and S uptake by bulbs and bulb + foliage increased with increasing S rate up to 30 kg/ha. At 30 kg/ha, the bulb yield increased by 105% over no S.

Josephine *et al*., (2006) conducted a field experiment during 2001 and 2002 in Annamalni. Tamil Nadu. India, to optimize the source (0. 30. 60 and 90 kg/ha) and close (super phosphate, gypsum and ammonium sulphate) of S for maximuin yield of onion in type Ustifluvent soil. Superphosphate at 60 kg'ha^{-1} gave maximum plant height. number

of leaves per plant, number of tillers per plant, bulb length, bulb diameter, number of bulbs per plant, individual bulb weight and bulb yield.

Poonam *et al*., (2004) conducted an experiment on onion cv. Pusa Red plants were treated with gibberellic acid (GA; 100, 150 and 250 ppm) and sulphur (15 and 30 kg/ha) in Uttar Pradesh, India during the winter season of 1998-99. Onion bulbs were biggest (20.20 cm) with the application of 250 ppm + GA 30 kg S ha. Application of 15 kg S/ha, 150 ppm GA - 15 kg S/ha and 150 ppm GA + 30 kg S/ha resulted in the highest moisture (89%). carbohydrate (27.62%) and protein conlent (1.40%) of onion respectively.

Ajay and Onkar (1999) conducted an experiment and reported that onion (cv. Afrifound Lighi Red) Plants were grown in pots under conditions of S sufficiency or S deficiency. Plants received S were healthy, had dark green leaves, developed it good root system and produced large bulbs which developed a good red color. Plants grown under S-deficient conditions had fëwer leaves which were shorter and paler in color, produced fiver rootlets and produced smaller bulbs which were light red in colour, compared with S-treated plants.

Anwer *et al*., (1998) observed that the application of nitrogen. phosphorus, potassium. sulphur and zinc increased the number or leaves plant along with higher bulb yield of onion with the increasing rates up to 150 kg N, 120 kg P_2O, 120 kg K, 70. 20 kg S and 5 kg Zn ha-^{1} at Jessore area.

Nagaieli *et al*., (1998) conducted a field experiment at Gwalior and reported that S was applied at 0, 20, 40 or 60 kg ha-1 and K at 0, 40, 80 or 120 kg/ha to Nasik Red onions.

Bulb yields increased with S rate and were the highest at and intermediate K rate (80 kg/ha).

Sulphur has been recognized for over 100 years as one of the essential elements required for the growth of plants. Global reports of sulphur deficiency and consequent crop responses are quite ostensible (Singh and Rathi, 1984).

. An experiment was conducted during 1987-88 and 1988-89 to study the effect of levels and modes of sulphur application on biochemical ehanges in leaves of mustard (Brassica juncea). Chlorophyll content (a, b and total) and peroxides activity in fresh head at 50% flowering increased significantly, but leaf-sap pH decreased significantly due to S application. Total chlorophyll content and peroxidase activity increased significantly up to 150 kg N ha-1 in pooled results (Khampara, *et al*., 1993).

Sulphur starved rape produced very low quality of oil (Rahman, 1977). In fact rapeseed and mustard required large amounts of sulphur to give a high seed yields. Sarker *et al*. (1992) carried out an experiment at the Bangladesh Agricultural University Mymensingh with four high yielding varieties of mustard BAU-M/12 (Sampad), BAU-M/248 (Sambol), M-257 and SS-75 (Sonali Sarisha) to investigate their response to five levels of sulphur viz. 0, 10, 20, 30 and 40 kg S ha-1. The seed yield was maximum in BAU-M/248 (Sambol) when-fertilized with sulphur at the rate of 40 kg S ha^{-1} in comparison to other varieties and rate of sulphur. The variety ‘Sampad’ followed ‘Sambol’ in respect of seed yield at this level of sulphur fertilizer. The seed yield of M/257 and SS-75 (Sonali Sarisha) were found to be maximum at 30 kg S ha^{-1}.

Sulphur is required by crops in about the same amounts as phosphorus and is therefore recognized by many agriculturists as the fourth important nutrient (BARC, 1986). Sulphur plays an important role in the synthesis of protein and the essential sulphur containing amino acids, methionine and cysteine, vitamins and chlorophyll. It is essential for the activation of certain enzymes and is a vital constituent of ferrodoxin which participate in the photosynthesis process. As sulphur is involved in photosynthesis, deficiency decreases chlorophyll content and young leaves turn yellow showing interveinal chlorosis. Growth is stunted and the flowers have smaller petals which are pale yellow.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

This chapter sorted-out the materials and methods including a brief descripuon of details of the experimental site, onion variety, soil. climate, land preparation, experimental design, treatments cultural operations and analytical methods used for the experiment. The experiment was conducted at the Research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during November 2020 to February 2021 to investigate the effect of nitrogen (N) and sulphur (S) on the growth and yield of onion (BARI Peyaj-4). The details of research procedure are described here.

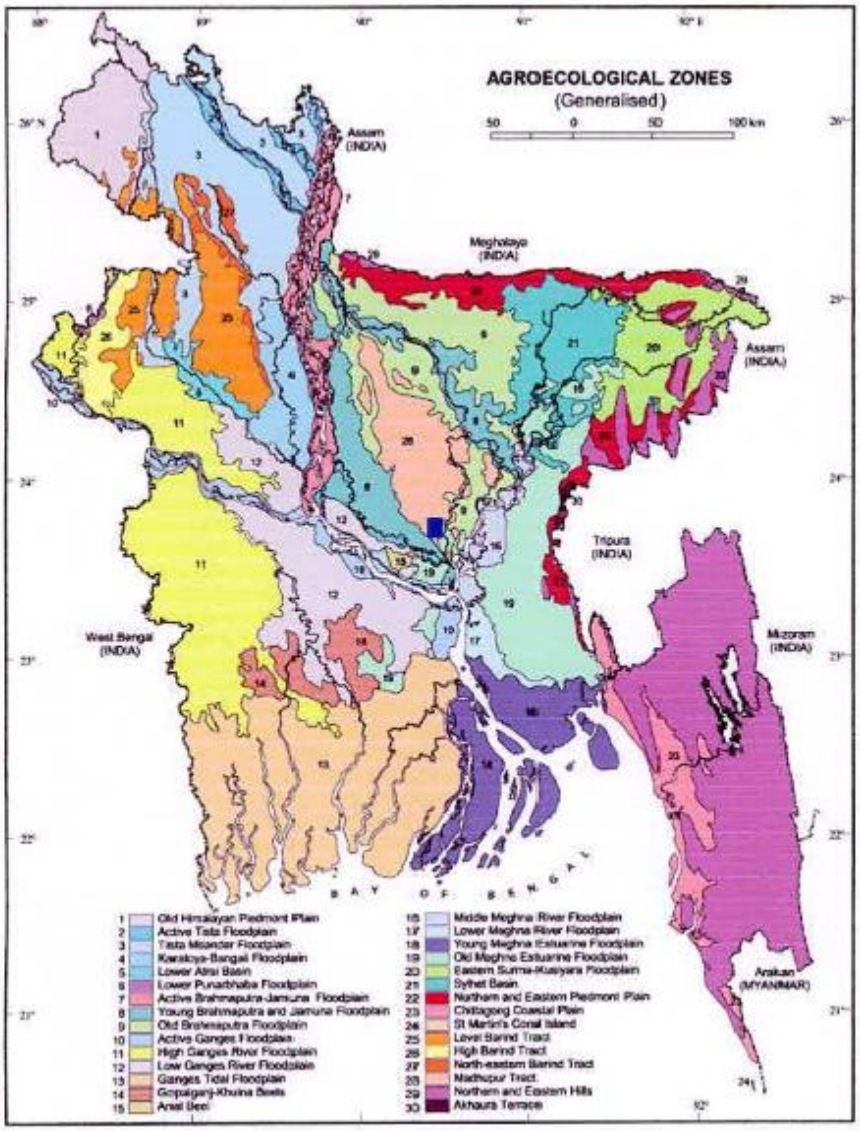
3.1 Description of the experimental site

3.1.1 Experimental site soil

The experimental site was located at $23^0$77' N latitude and $90^0$3' E longitude (Fig. 1). The soil of the experimental site belongs to Tejgaon series under the Agro-ecological zone, Madhupur Tract (AEZ -28).

3.1.2 Soil

Soil of the experimental area falls into Deep Red Brown Terrace Soil. Soil samples were collected from the experimental plots to a depth of 0-15 cm from the surface before initiation of the experiment and analyzed in the laboratory. The morphological characteristics of the experimental field and physical and chemical properties of initial soil are shown in Table 3.1 & 3.2.



Location of the experimental site

Figure 3.1 Map showing the experimental site under study

3.1.3 Climate

The experimental area has sub tropical climate characterized by heavy rainfall during May to September and scant rainfall during rest of the year. The annual precipitation of the site is 2152 mm and potential evapo-transpiration is 1297 mm. The average maximum temperature is 30.34^{o}C and average minimum temperature is 21.210C. The average

mean temperature is 25.17^{0}C. The experiment was done during the rabi season. Temperature during the cropping period was ranged between 12.20^{0}C to 29.2 ^{0}C. The humidity varies from 71.52 % to 81.2 5%. The day length was reduced to 10.5 – 11.0 hours only and there was a very little rainfall from the beginning of the experiment to harvesting (Appendix –I).

Table 3.1 Morphological Characteristics of experimental field

Morphological Features	**Characteristics**
Location	Sher-e Bangla Agril. University Farm, Dhaka
AEZ No. and name	AEZ-28, Modhupur Tract
General soil type	Deep Red Brown Terrace Soil
Soil Series	Tejgaon
Topography	Fairly leveled
Depth of Inundation	Above flood level
Drainage condition	Well drained
Land type	High land

Table 3.2 Physical and chemical properties of the experimental soil

Soil properties	Value
A. Physical properties	
1. Particle size analysis of soil. % Sand % Silt % Clay 2. Soil texture	 28.48 41.78 29.74 Clay loam
B. Chemical properties	
1. Soil pH 2. Organic carbon (%) 3. Organic matter (%)	6.01 0.78 1.34

3.1.4 Description of the cultivar

An improved onion variety (BARI Peyaj-4) was used in this experiment. The characteristics of this variety, the bulbs are flat-round, medium sized, blue colour,

pungent with shinning red, single non splitted and resistant to *Alternaria*., matures within 95-110 days and the yield ranged from 12-16 t/ha.

Figure 3.2 BARI Piaz-4

3.1.5 Collection and processing of soil sample

Soil samples from the study field were collected before land preparation to a depth of 0-15 cm from the surface of the basis of proper sampling method. The collected soil was air dried ground and passed through a 2-mm sieve and stored in a clean, dried plastic container for physical and chemical analysis.

3. 1.6 Land preparation

The selected land of the experimental plot was opened in the month of 01 November 2020 with the help of a tractor. Then, the land was prepared by 2-5 ploughings and cross

ploughings with a power tiller followed by laddering until the desired tilth was achieved for planting the seedlings. After removal of weeds and stubbles the land was finally brought into a good tilth by breaking larger clods into fine particles.

3.1.7 Recommended doses of fertilizers:

In this experiment manures and fertilizers were used according to the recommendation of BARI as follows:

Table 3.3 Fertilizer doses for onion cultivation

Nutrients	Fertilizer name	Rates of fertilizer
N	Urea	As per requirement
P	TSP	220kg/ha
K	MoP	170 kg/ha
S	Gypsum	As per requirement
B	Borax	100gm
Zn	Zinc sulphate	600gm

3.1.8 Application of fertilizers

The whole quantity of Cowdung, TSP, MoP, $ZnSO_4$, gypsum, boric acid and ¼ urea are applied during the final land preparation as basal dose. The rest of the urea will be applied in three equal installments will be applied as top dressing.

3.1.9 Raising of seedlings

The land selected for raising seedlings was light in texture and well drained. The land was ploughed ell and left for drying for 10 days. Bigger clods were broken into pieces and finally the soil was made loose and friable. All weeds and stubbles were removed and then the soil of seedbeds were mixed with well-decomposed cow dung @ 10 t ha'; applying Furudun 3 G @ 20 kg ha' were covered by polyihene for two days. The seedbeds were 2.5 in x 1.2 in size with height of about 20 cm. Onion seeds were soaked

overnight (12 hours) in water and allowed to flourish in a piece of moist cloth keeping in the sunshade for one day, then seed bulb were sown directly in the raised seedbed on 08 November 2020 for raising seedlings. Irrigation was provided regularly and seedbeds were always kept free from weeds. The young seedlings were exposed to dew by night and mild sunshine in the morning and evening. To retain the soil moisture and to save theseedlings from direct sunlight and rain. shades were given over the scedbeds. Seedlings were not attacked by any kinds of insects and diseases.

Figure 3.3 seed sowing

3.1.10 Transplanting of seedlings

Healthv and disease free equal sized 30 days old seedlings were up rooted from the seedbeds and transplanted in the main fieId with the spacing of line to line 25 cm and plant to plant 12 cm in the afterrnoon on 15 November 2020. The seedbed was watered at 13 November 2020 before uprooting the seedlings so as to minimize the damage of roots. The seedlings were watered immediately after transplanting.

3.2 Design and layout of experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each fertilizer treatment combinations. Fertilizer treatments consisted of 4 levels of N (0, 70, 110 and 140 kg N/ha designated as N_0, N_{70}, N_{110} and N_{140}, respectively) and 3 levels of S (0, 15 and 30 kg S/ha designated as S_0, S_{15} and S_{30} respectively). There were 12 treatment combinations. The treatment combinations wereas follows:

- N_0S_0 = Control (without N and S application and other fertilizers)
- N_0S_{15} = 0 kg N/ha+15 kg S/ha
- N_0S_{30} = 0 kg N/ha+30 kg S/ha
- $N_{70}S_0$= 70 kg N/ha+0 kg S/ha
- $N_{70}S_{15}$= 70 kg N/ha+15 kg S/ha
- $N_{70}S_{30}$= 70 kg N/ha+30 kg S/ha
- $N_{110}S_0$ =110 kg N/ha+ 0 kg S/ha
- $N_{110}S_{15}$ = 140 kg N/ha+15kg S/ha
- $N_{110}S_{30}$ = 140 kg N/ha+30 kg S/ha
- $N_{140}S_0$ = 140 kg N/ha+0 kg S/ha
- $N_{140}S_{15}$ = 140 kg N/ha+15 kg S/ha
- $N_{140}S_{30}$ = 140 kg N/ha+30 kg S/ha

Common dose for all treatment is $P_{45}\ K_{90}\ Zn_3\ B_{1.5}$

Fertilizer treatments were randomly distributed in each block. Each block consisted of 12 plots and individual plot was 2.5 m × 1.2 m i.e 3 sq. m in size. The row-to-row and plant to plant distance were 60 and 55 cm respectively accommodating 12 plants in each plot. The adjacent block and neighboring plots were separated by 0.75 m and 0.5 m, respectively. The layout of the experiment is shown in Fig. 3.4.

R1	R2	R3
$N_{110}S_0$	$N_{140}S_{15}$	$N_{140}S_0$
$N_{70}S_{15}$	N_0S_{30}	$N_{70}S_{15}$
N_0S_0	$N_{110}S_{30}$	$N_{70}S_0$
N_0S_{30}	$N_{140}S_{30}$	$N_{70}S_{30}$
$N_{70}S_0$	$N_{110}S_{15}$	N_0S_0
$N_{140}S_{30}$	N_0S_{15}	N_0S_{30}
$N_{140}S_0$	$N_{110}S_0$	$N_{110}S_{30}$
$N_{140}S_{15}$	$N_{140}S_0$	$N_{140}S_{30}$
$N_{110}S_{30}$	$N_{70}S_{15}$	$N_{110}S_{15}$
$N_{70}S_{30}$	$N_{70}S_0$	$N_{140}S_{15}$
N_0S_{15}	$N_{70}S_{30}$	$N_{110}S_0$
$N_{110}S_{15}$	N_0S_0	N_0S_{15}

Replication

R_1, R_2, R_3

Unit plot size:

2.5 m x1.2m

Spacing

60 cm x 55 cm

Block to plot

0.75 x 0.5

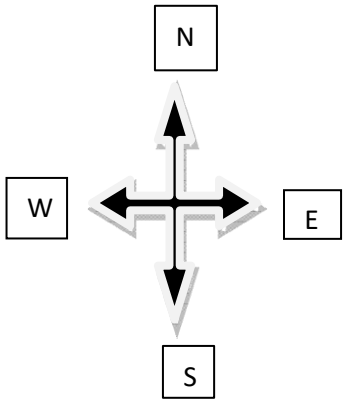


Figure 3.4 Layout of the experimental design

3.3 Intercultural operations

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

3.3.1 Gap fillings

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gaps filling were done by healthy plants from the border whenever it was required.

3.3.2 Irrigation

Irrigation was done at three times. The first irrigation was given in the field on 05 December 2020 at 20 days after transplanting (DAT) through irrigation channel. The second irrigation was given at the stage of maximum vegetative growth stage (35 DAT), on 20 December 2020.

Figure 3.5 Irrigation

The final irrigation was given at the stage of bulb formation (55 DAT) on 10 January, 2021. During each irrigation, the soil was made saturated with water. After rainfall. excess water was drained when necessary.

3.3.3 Weeding and mulching

Weeding was done three times after transplanting to keep the crop free from weeds and mulching was done by breaking the crust of the soil for easy aeration and to conserve soil moisture when needed, especially after irrigation. Weeds of different types were controlled manually for the first time and removed from the field on 22 November 2020. Second and third weeding were done on 07 December, 2020 and 23 December, 2020, respectively.

3.3.4 Prolection of plants

Against the soil born insect preventive measure was taken. For the prevention of Cutworm (*Agrotis ipsilon*). Soil treatment was done with Furadan 3G @20 kg ha After transplanting some plants were attacked by purple blotch disease caused by *Alternaria porri*.

Figure 3.6 Spraying against insect, pest and diseases

It was controlled by spraying Rovral 50 WP two times at 15 day's interval after transplanting.

3.4 Harvesting

The crop was harvested on 06 February 2020 according to their attainment of maturity showing the sign of drying Out of most o1 the Leaves and collapsing at the neck of bulb.

Figure 3.7 Maturity symptoms of onion

3.5 Collection of experimental data

Ten (10) plants from each plot were selected as random and were tagged for the data collection. The sample plants were uprooted and dried properly in the sun. Data were collected on the following parameters:

- Plant height (cm)
- Number of leaves/plant

- Length of leaves/plant (cm)
- Fresh weight of leaves/plant (g)
- Fresh weight ot bulb/plant (g)
- Dry weight of leaves/plant (g)
- Dry weight of bulb/plant (g)
- Diameter of bulb (cm)
- Length of bulb (cm)
- Yield of bulb (t/ha)

3.5.1 Plant height (cm)

The height of the randomly selected live plants in each plot was measured after harvesting. The height was measured in centimeter (cm) from the bottom of the bulb to the tip of the longest leaf and average height of the selected five plants was taken to observe the rate of growth.

3.5.2 Number of leaves per plant

Number of leaves per plant was counted after harvesting. Five plants were selected Randomly from each plot and averaged.

3.5.3 Leaf length (cm)

The length of leaf was measured in centimeter (cm) from pseudostem to the tip of the leaf from five randomly selected plants after harvesting and their average was recorded.

3.5.4 Fresh weight of leaves /plant (g)

Fresh weight of leaves /plant (g) was measured using electrical balance.

3.5.5 Fresh weight of bulb/ plant (g)

Fresh weight of bulb plant (g) was measured using electrical balance.

3.5.6 Dry weight of leaves /plant (g)

Dry weight of leaves /plant (g) was measured using electrical balance after drying the bulb in the desiccator.

3.5.7 Dry weight of bulb /plant (g)

Dry weight of bulbs /plant (g) was measured using electrical balance after drying the bulb in the desiccator.

3.5.8 Diameter of bulb (cm)

At harvest the diameter of bulbs were measured at the middle portion of bulb from five randomly selected plants with a slide calipers and averaged.

3.5.9 Lenglh of bulb (cm)

Length of harvested bulbs was measured with a slide calipers from the neck to the bottom of the bulb from five randomly selected plants and their average was taken.

3.5.6 Yield of bulb (t/ha)

Yield obtained from each unit plot was converted to get yield in tones /ha.

3.6 Collection of Soil samples

The initial soil sample was collected randomly from different Spots of the field selected for the experiment at 0-15 cm depth before the land preparation and mixed Thoroughlv to make a composite sample to analysis. Post harvest soil samples were collected from each plot at 0-15 cm depth on 15th February, 2021. The samples were air-dried, ground and sieved through a 2 mm 10 meshes) sieve and kept for analysis.

3.7 Soil sample analysis

The initial and post harvest soil sample were analyzed for soil physical and chemical properties. The properties studied included texture. pH. bulk density. particle density, organic matter, total N. available P. exchangeable K. available S and available Zn. The soil was analyzed by the following standard methods;

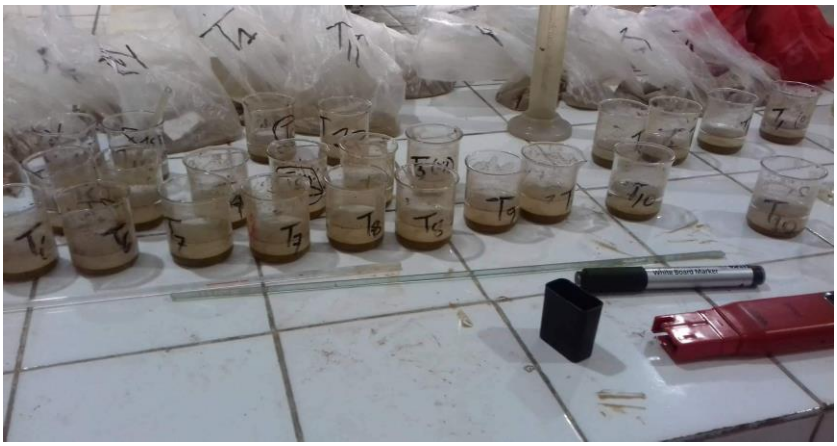


Figure 3.8 Soil sample analysis

3.7.1 Particle size analysis

Particle size analysis of soil sample was done by hydrometer method as outlined by Day (1965) and the textural class was ascertained using USDA textural triangle.

3.7.2 Soil pH

Soil pH was determined by glass electrode pH meter in soil water suspension having soil: water ratio of 1: 2.5 as outlined by Jackson (1958).

3.7.3 Organic Carbon

Soil organic carbon was determined by wet oxidation method described by Walkly and Black (1935).

3.7.4 Organic matter

The organic matter content was determined by multiplying the percent organic carbon with Van Bemmelen factor 1.73 as described by Piper (1942).

% organic matter = % organic carbon × 1.724

3.9 Statistical analysis

The collected data were statistically analyzed by using the MSTAT C Package. The test of significance of all parameters was done. The Duncan`s Multiple Range Test (DMRT) with Least Significant Difference (LSD) value was determined with appropriate levels of significance and the means were tabulated. The mean comparison was carried out by DMRT technique (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSIONS

The goal of the current experiment was to ascertain the impact of various nitrogen and sulphur levels on onion yield and yield-contributing characteristics (BARI Peyaj-4). The data on the various components were subjected to analyses of variance (ANOVA), and the findings are provided in Appendix I–IV. The results have been presented and discussed, and potential explanations have been provided under the following headings:

4.1 Effect of N and S on growth and yield of onion

4.1.1 Plant height (cm)

Different nitrogen levels significantly increased onion plant height (Table 3). The 140 kg N/ha produced the tallest plant (18.83 cm), while the control treatment gave the shortest plant (15.57 cm). As nitrogen doses were raised up to 140 kg N/ha, it was seen that plant height gradually increased.

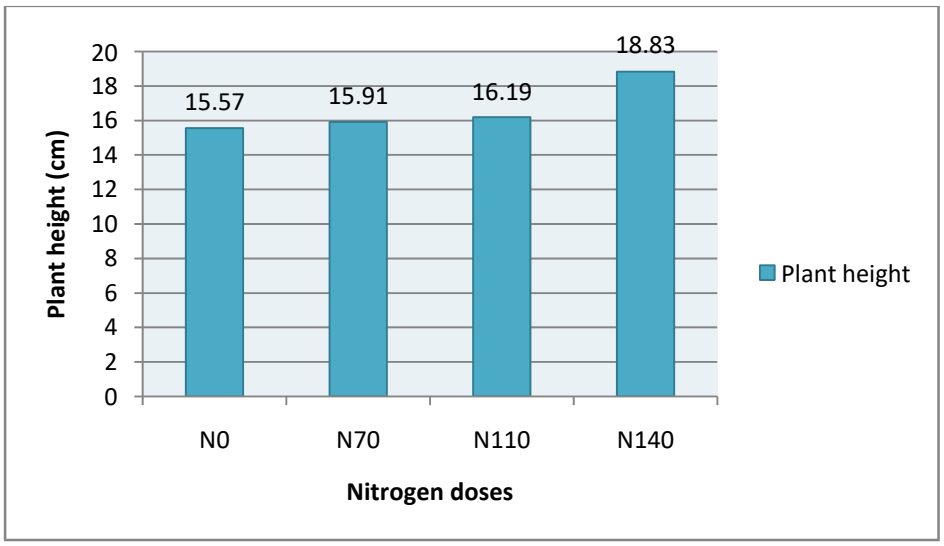


Figure 4.1 Effect of different level of nitrogen on plant height of onion

This might be due to higher availability of N and their uptake that progressively enhanced the vegetative growth of the plant. These are an agreement with those of Ali *et a*l. (1990), Mondal and Gaffer (1983), Gaffer and Razzaque (1983), who have reported that different levels of nitrogen significantly increased plant height.

Different level of sulphur exhibited statistically significant differences for plant height (Appendix II). With increasing the doses of S, the plant height increased significantly upto the highest dose 30 kg S/ha (S3) and the maximum plant height was 15.86 cm which was statistically similar with 15 kg of Sulphur(S2) On the other hand the shortest plant height (14.69 cm) was recorded from S0 treatment i.e. control condition under the present trial.

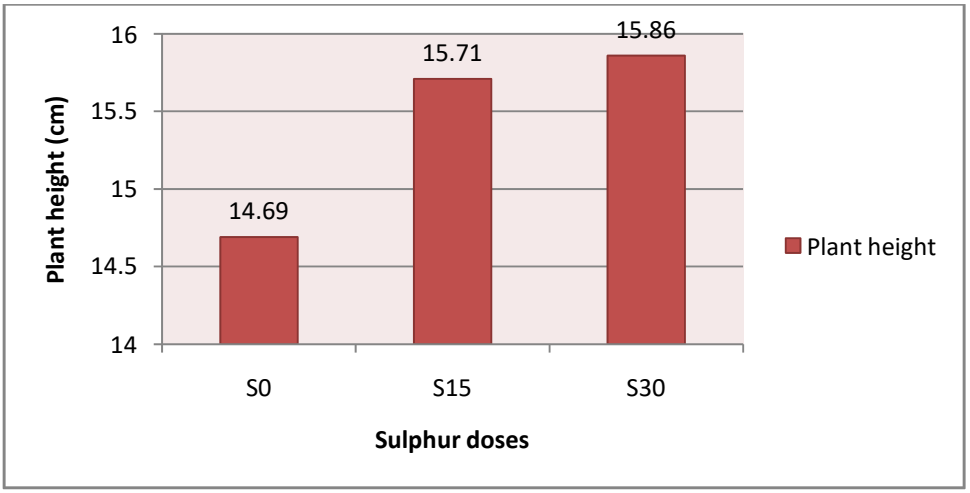


Figure 4.2 Effect of different level of Sulphur on plant height of onion

The treatment combinations of nitrogen and sulphur had significant effect on plant height (Table 1). The tallest plant (33.88 cm) was found in $N_{140}S_{30}$ (120 kg N and 40 kg S) treatment. The shortest plant (14.99 cm) was observed in the control treatment. The second highest plant (32.15 cm) was observed in the treatment of $N_{140}S_{15}$ which was

statistically similar with $N_{140}S_0$ treatment. These results revealed that higher dose of Nitrogen and medium dose of sulphur were influential nutrients for increasing the plant height.

Table 4.1 Combined effect of nitrogen and sulphur on Plant height (cm), No. of leaves/plant, Length of leaves/plant (cm), Fresh weight of leaves/plant (g)

Treatment combinations	Plant height (g)	No. of leaves/plant	Length of leaves/plant (cm)	Fresh weight of leaves/plant (g)
N_0S_0	14.99 f	5.12e	14.36 f	5.21 g
N_0S_{15}	15.10 f	5.23e	14.76 e	5.56 f
N_0S_{30}	15.86 f	5.35e	15.36 de	6.54 ef
$N_{70}S_0$	16.33 e	5.87d	15.99 d	6.87 e
$N_{70}S_{15}$	17.89 d	6.69d	16.45 d	6.99 de
$N_{70}S_{30}$	18.36 d	7.11c	21.21 c	7.16 de
$N_{110}S_0$	21.22 cd	7.29bc	23.21 bc	7.36 d
$N_{110}S_{15}$	25.32 c	7.59bc	24.25 bc	7.65 d
$N_{110}S_{30}$	26.12 bc	7.88bc	25.98 b	8.12 c
$N_{140}S_0$	27.36 b	8.1b	26.87b	8.88 bc
$N_{140}S_{15}$	32.15 b	8.33ab	27.35 ab	8.39 b
$N_{140}S_{30}$	33.88 a	8.56a	28.29 a	9.31 a
LSD	**2.632**	**0.697**	**3.98**	**1.22**
CV(%)	**4.67**	**5.98**	**6.12**	**9.87**

*LSD= Least Significant difference *CV = Co-efficient of variation

4.1.2 Number of leaves per plant

A statistically significant variation for number of leaves per plant of onion was recorded for the effect of nitrogen (Appendix II). The number of leaves per plant increased significantly with increasing N levels upto the treatment N_3 comprising of 140 kg N and the maximum number of leaves per plant (8.39) was obtained with this treatment (Figure 3). Probably 140 kg N/ha ensured the favorable condition for growth of onion and the ultimate results is the maximum number of leaves. Mondal and Gaffer (1983), Gaffer and Razzaque (1983) also reported the similar results from their experiment. They reported that different levels of nitrogen significantly increased leaves per plant. On the other hand the minimum number of leaves per plant (5.83) was observed from the N_0 (0 kg of N) treatment.

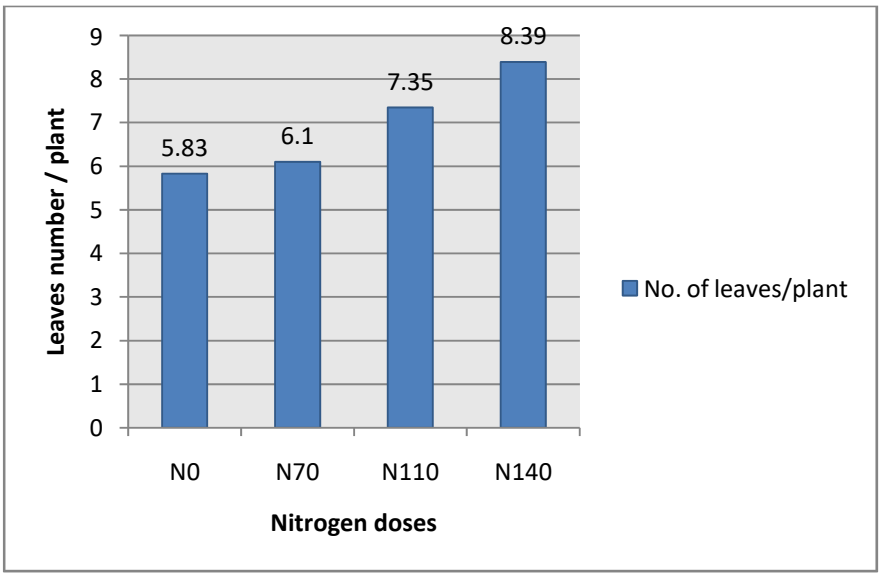


Figure 4.3 Effect of nitrogen on number of leaves/plant

Number of leaves per plant for different levels of sulphur also showed statistically significant variation (Appendix II). The highest significant increase in number of leaves

per plant (7.20) was recorded from S_3 treatment containing 30 kg S/ha. On the other hand the minimum number of leaves per plant (5.08) was observed from the S_0 treatment containing no sulphur.

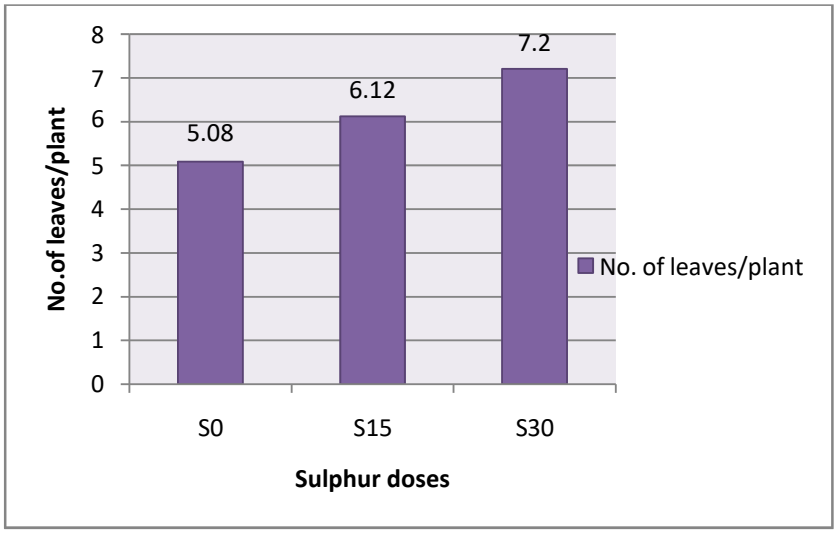


Figure 4.4 Effect of sulphur on number of leaves/plant

Interaction effect between nitrogen and sulphur showed a significant difference for the number of leaves per plant under the present experiment (Appendix II). The maximum number of leaves per plant (8.56) was observed from the treatment combination $N_{140}S_{30}$ having 140 kg N/ha + 30kg S/ha (Table 1). while N_0S_0 i.e. control produced the lowest number of leaves (5.12). According to Anwer *et al*. (1998) the application of nitroiten. sulphur increased the number of leaves plant with the increasing rates up to 140 kg N+20 kg S at Jessore area and Nehra et al., (1988) conducted an experiment with various levels of N and reported that the application of 40 and 80 kg N /ha' significantly increased plant height and number of leaves compared to the control.

4.1.3 Length of leaf (cm)

Leaf length was significantly influenced by different nitrogen treatments. From the single mean effect of nitrogen it was observed that N_{140} treatment i.e. 140 kg of N gave the highest leaf length (23.01 cm). The minimum leaf length (15.09 cm) was recorded in N_0 treatment where no nitrogen was applied.

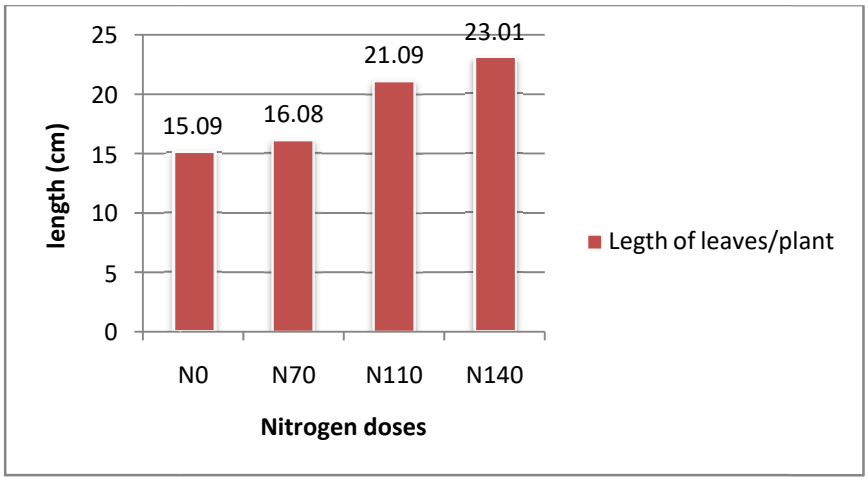


Figure 4.5 Effect of nitrogen on length of leaves/plant

On the other hand. maximum leaf length (24.25 cm) was observed in th treatment of S_{30} (30 kg of S ha^{-1}) which was statistically identical to S_{15} (15 kg of sulphur) treatment and the minimum length of leaf (21.21 cm)was observed in the treatment of S_0 (control).

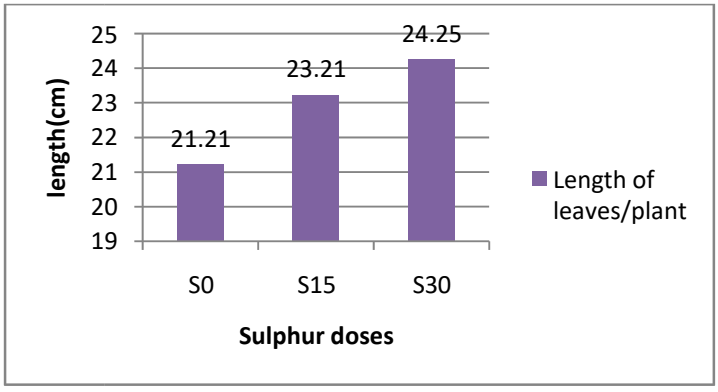


Figure 4.6 Effect of sulphur on length of leaves/plant

A significant interaction effect was also recorded between nitrogen and sulphur in consideration of leaf length under the present experiment (Appendix II). The maximum number of leaf length (28.29) was recorded from the treatment combination $N_{140}S_{30}$ comprising of 140 kg N/ha + 30 kg S/ha while the minimum leaf length (14.36) was obtained from N_0S_0 (no nitrogen+no sulphur) treatment.

4.2 Effect of nitrogen and sulphur on the yield and yield attributing characters of onion

4.2.1 Fresh weight of leaves/plant (g)

Nitrogen showed statistically significant differences for fresh weight of leaves /plant of onion under the present study (Appendix III). The fresh weight of leaves /plant increased with increasing levels of N upto N_{140} (140 kg N/ha) (Figure 4.7). The highest fresh weight of leaves /plant (8.69 g) was recorded from N_{140} treatment.

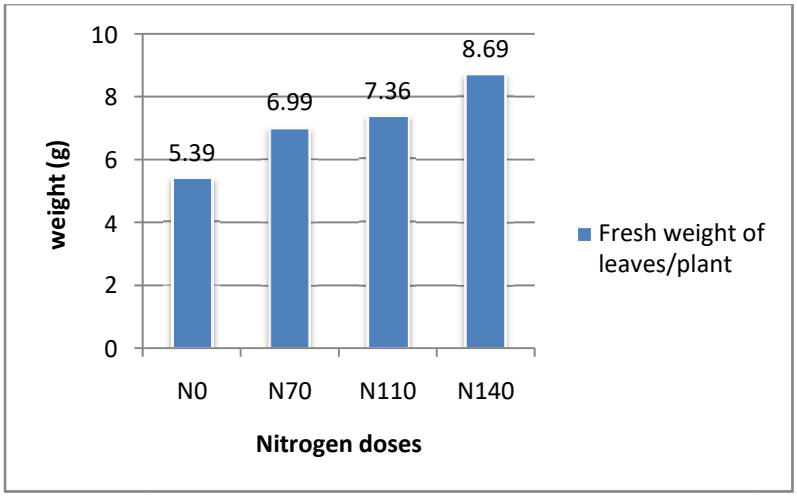


Figure 4.7 Effect of nitrogen on fresh weight of leaves/plant

Mondal and Gaffer (1983), Gaffer and Razzaque (1983), Sharawat *et al*. (2002), Mudhokar and Ahlawat (1981) also reported the similar results from their experiment.

On the othe other hand lowest fresh weight of leaves /plant (5.39 g) was found in the treatment of N_0S_0 containing no nitrogen and sulphur i.e. control.

Different level of sulphur showed statistically significant variation for fresh weight of leaves/ plant (Appendix III). It increased significantly with higher levels of S with the highest (7.29 g) at S30 treatment comprising of 30 kg S/ha while the lowest was obtained from (5.29 g) with treatment S_0 comprising of 0 kg S/ha (Figure 4.8).

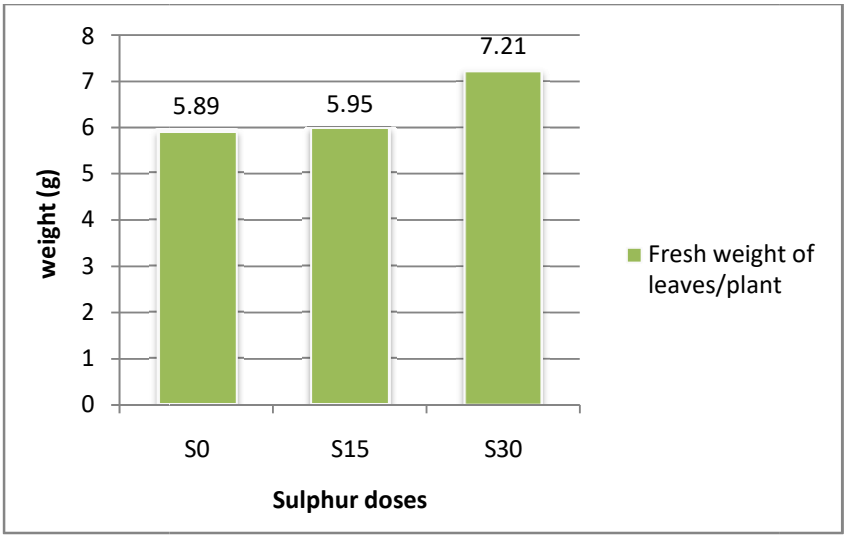


Figure 4.8 Effect of sulphur on fresh weight of leaves/plant

The result was in conformity with Jaggi (2005) who showed that the fresh and dry weights of onion yield, plant height, leaf number/plant and weight per 10 bulbs increased with increasing S rates up to 40 kg/ha.

Interaction effect of nitrogen and sulphur showed a significant variation for fresh weight of leaves /plant under the present experiment (Appendix III). The highe t fresh weight of leaves /plant (2.86 g) was recorded from the treatment combination $N_{140}S_{30}$ comprising of 140 kg N/ha + 30 kg S/ha and the lowest fresh weight of leaves /plant (1.60 g) was recorded from N_0S_0 (control treatment) where no nitrogen and sulphur were

4.2.2(Table 4.2). A result of present study was in agreement with the findings of Gamili *et al.*, (2000nd observed the application of both sulphur and nitrogen either individually or combined increased fresh weight of leaf.

4.2.2 Freash Weaghtof Bulb (g)

Fresh weight of bulb of onion was significantly affected by different levels of Nitrogen (Figure 4.11). Fresh weight of bulb increased with increasing level of N up to 140 kg/ha. Further deletion of N less than 140 kg/ha decreased fresh weight of bulb of onion. The highest Fresh weight of bulb (24.36 g) was obtained in N_{140} treatment and the lowest fresh weight of bulb (20.89 g) was obtained in control treatment.

g

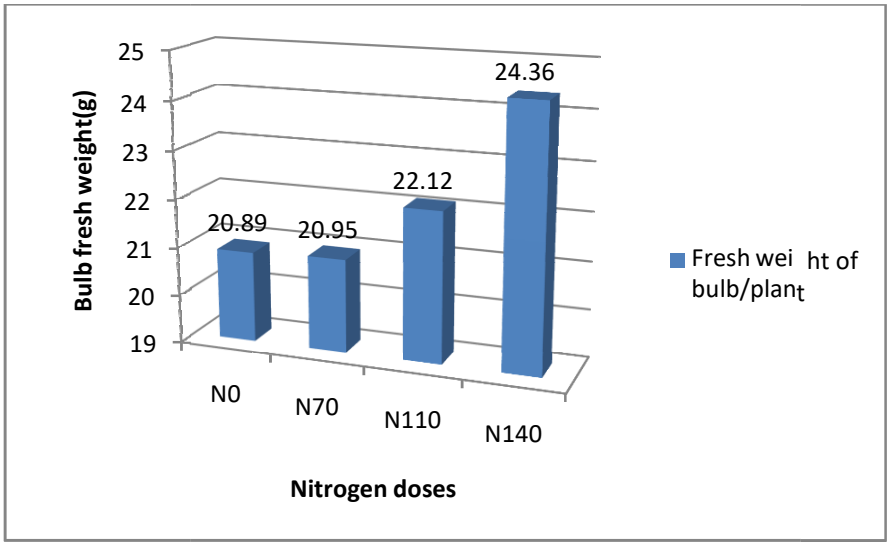


Figure 4.9 Effect of nitrogen on fresh weight of bulb/plant

Significant variation was observed on fresh weight of bulb of onion when different doses of sulphur were applied. The highest fresh weight of bulb (26.30 g/plant) was recorded under the S_{30} (30 kg S ha^{-1}) treatment which was statistically dissimilar with other treatments (figure 4.10).

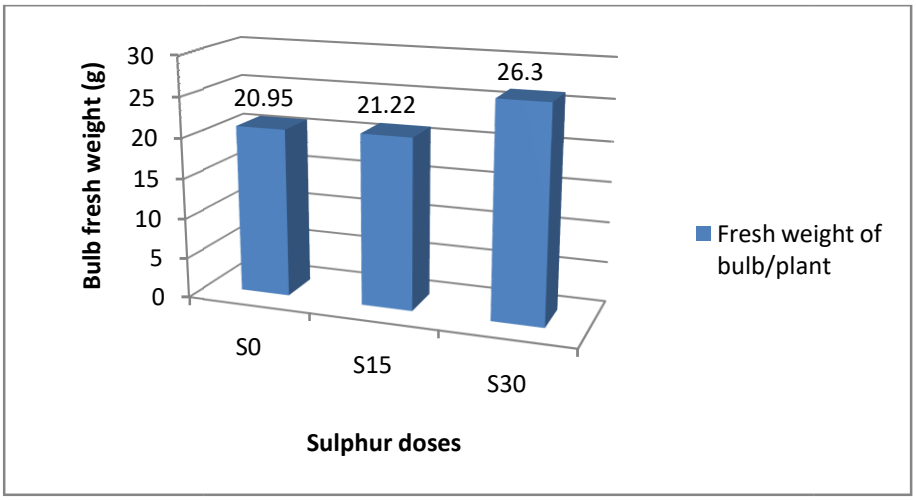


Figure 4.10 Effect of sulphur on fresh weight of bulb/plant

The lowest fresh weight of bulb (20.95 g/ plant) of onion was recorded in the S_0 treatment. Losak (2005) and Jaggi (2005) found similar result that showed that the fresh weight of onion bulb yield increased with increasing sulphur rates up to 40 kg/ha.

Table 4.2. Combined effect of nitrogen and sulphur on Fresh weight of bulb/plant, Dry weight of bulb/plant, Diameter of bulb, Length of bulb and Yield of bulb (t/ha).

Treatments	Fresh weight of bulb/plant (g)	Dry weight of bulb/plant(g)	Diameter of bulb (cm)	Length of bulb (cm)	Yield of bulb (t/ha)
N_0S_0	18.12 i	3.00 j	2.58 h	2.08 h	3.13 f
N_0S_{15}	20.00 h	3.12 i	2.77 g	2.13 g	3.23 e
N_0S_{30}	20.89 g	3.16 h	3.01f	2.34 e	3.15 e
$N_{70}S_0$	20.95 f	3.26 h	3.33 ef	2.58 d	3.86 d
$N_{70}S_{15}$	22.12 e	3.44 g	3.25 e	2.78 d	3.89 d
$N_{70}S_{30}$	24.36 d	4.19 f	4.56 d	2.88 cd	4.02 c
$N_{110}S_0$	24.78 c	4.39 e	4.89 d	3.26 c	4.22 c
$N_{110}S_{15}$	25.65 c	4.68 d	5.01 c	2.24 f	5.65 bc
$N_{110}S_{30}$	27.49 bc	5.12 c	5.23 c	3.45 ab	5.97 bc
$N_{140}S_0$	27.28 bc	5.55 c	5.58 c	3.65 ab	6.34 b
$N_{140}S_{15}$	28.39 b	5.63 b	5.99 b	3.44 b	6.43 b
$N_{140}S_{30}$	31.98 a	5.89 a	6.48 a	3.69 a	7.81 a
LSD	**3.39**	**0.12**	**0.671**	**0.563**	**0.789**
CV(%)	**5.86**	**7.63**	**4.89**	**11.84**	**7.12**

*LSD= Least Significant difference *CV = Co-efficient of variation

The combined effect of nitrogen and sulphur on fresh weight of bulb varied significantly among the different treatment combinations (table 4.2). The treatment combination of $N_{140}S_{30}$ produced the highest (31.98 g) fresh weight of bulb while the lowest (18.12) was found in control treatment. These results were agreed with Jaggi *et al*., (2005).

4.2.2 Dry weight of bulb (g)

Dry weight of bulb of onion was significantly affected by different levels of Nitrogen (Figure 4.11). Dry weight of bulb increased with increasing level of N up to 140 kg/ha. Further deletion of N less than 140 kg/ha decreased dry weight of bulb of onion. The highest dry weight of bulb (4.68 g) was obtained in N_{140} treatment and the lowest dry weight of bulb (2.26 g) was obtained in control treatment.

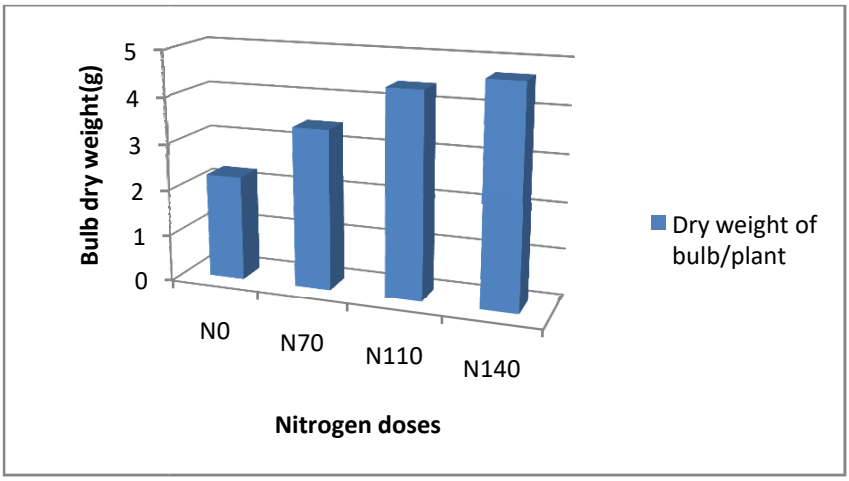


Figure 4.11 Effect of nitrogen on dry weight of bulb/pl nt

Significant variation was observed on dry weight of bulb of onion when different doses of sulphur were applied. The highest dry weight of bulb (3.44 g/plant) was recorded under the S_{30} (30 kg S ha^{-1}) treatment which was statistically dissimilar with other treatments. The lowest dry weight of bulb (2.23 g/ plant) of onion was recorded in the S_0 treatment (Figure 4.11). Losak (2005) and Jaggi (2005) found similar result that showed that the dry weight of onion bulb yield increased with increasing sulphur rates up to 40 kg/ha.

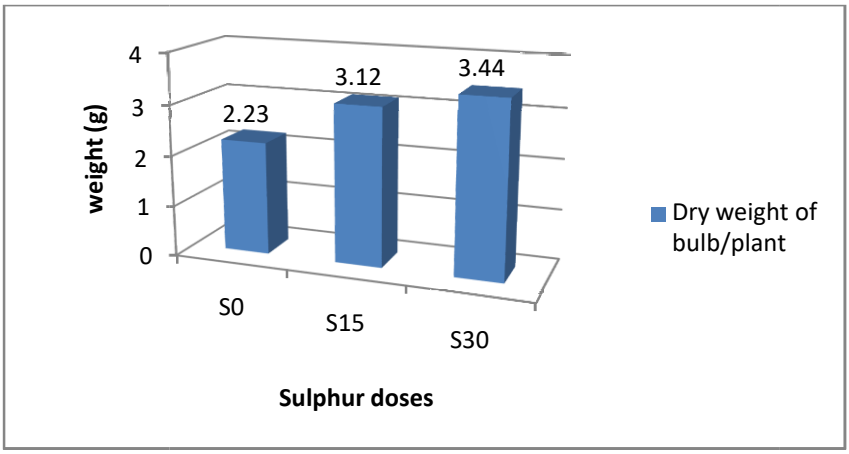


Figure 4.12 Effect of sulphur on dry weight of bulb/plant

The combined effect of nitrogen and sulphur on dry weight of bulb varied significantly among the different treatment combinations (Table 4.2). The treatment combination of $N_{140}S_{30}$ produced the highest (5.89 g) dry weight of bulb while the lowest (3.00 g) was found in control treatment. These results were agreed with Jaggi *et al*., (2005).

4.2.3 Diameter of bulb (cm)

Effect of nitrogen showed a statistically significant variation for diameter of bulb of onion (Appendix III). The diameter of bulb increased with increasing Nitrogen levels and maximum significant increase was found with the treatment N_{140} (140 kg N/ha, figure 4.13) Application of 140 kg N/ha ensured the congenial condition for growth of onion and also produced healthy bulb and the ultimate result is the maximum diameter (5.58 cm) of bulb. The result was in good conformity with Singh *et al*., (1994) who noticed that total marketable yield and total dry weight production were the best in the plots treated with N at 140 kg/ ha.

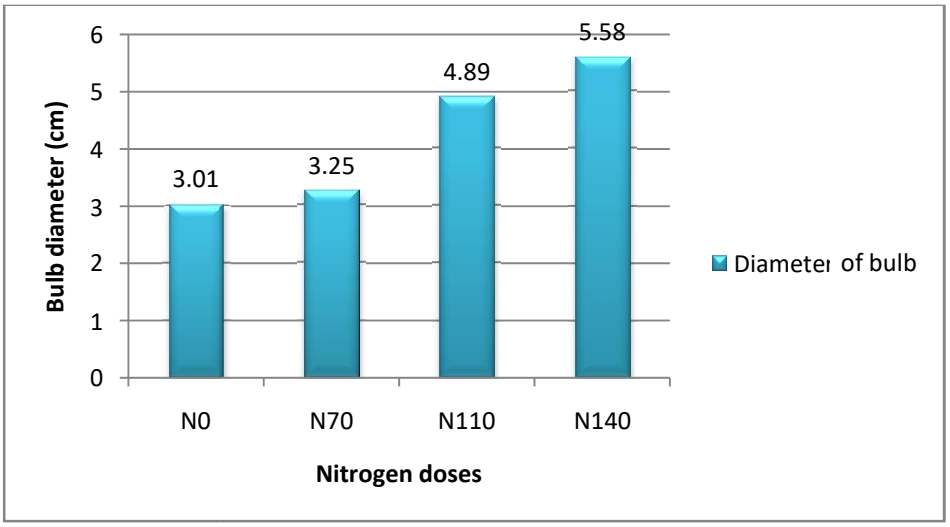


Figure 4.13 Effect of nitrogen on diameter of bulb

Statistically significant variation was recorded for different level of sulphur used in this experiment for diameter of bulb (Appendix III). The diameter of bulb increased with increasing levels of S and the maximum number of diameter of bulb (4.89 cm) was recorded from S_{30} treatment as application of 30 kg S/ha which was statistically dissimilar with other treatments S_{15} and S0 as of 15 kg S/ha and 0 kg/ha (Figure 4.14). The result was in good conformity with Singh *et al*., (1994).

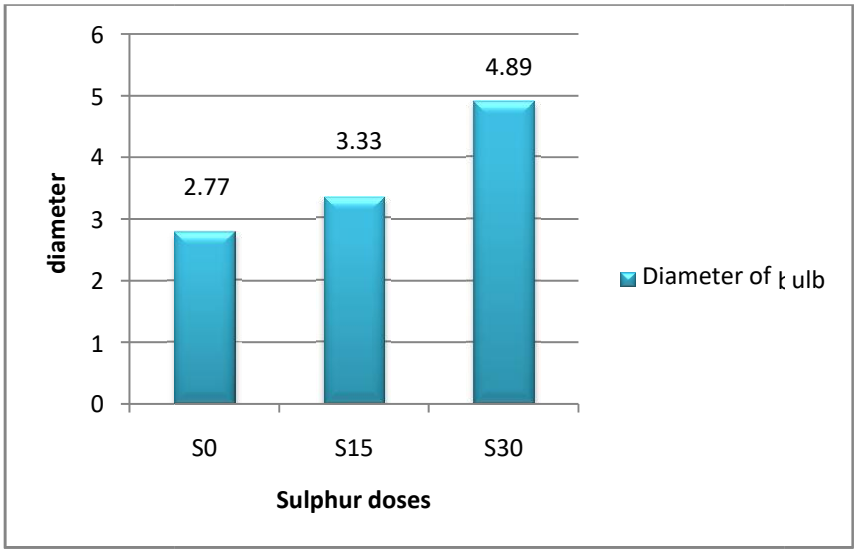


Figure 4.14 Effect of sulphur on diameter of bulb

A significant interaction effect was also recorded between nitrogen and sulphur in consideration of diameter of bulb per plant under the present experiment (Appendix III). The maximum diameter of bulb (6.48 cm) was recorded from the treatment combination $N_{140}S_{30}$ comprising of 140 kg N/ha + 30 kg S/ha whereas the maximum diameter of bulb (2.58 cm) was recorded from the treatment combination N_0S_0 comprising of 0 kg N/ha + 0 kg S/ha i.e. control. Similar result was found by Singh et al., (1989) w o conducted two types of experiments on onion production and showed that 120 kg N and 36 kg S gave maximum bulb weight and higher bulb yield in their first experiment.

4.2.4 Length of bulb (cm)

The effect of different levels of Nitrogen on the length of bulb per plant was significant (Figure 4.15). Length of bulb gradually increased with increasing levels of nitrogen up to N_{140} treatment. The highest length of bulb per plant (3.44 cm) was obtained with the application of 140 kg N/ha, which was statistically different from other treatments. The lowest length of bulb per plant (2.34 cm) was produced by control treatment. It was observed that the application of N up to 140 kg/ha increased number of fruits per plant. Further deletion or addition of N decreased the length of bulb per plant.

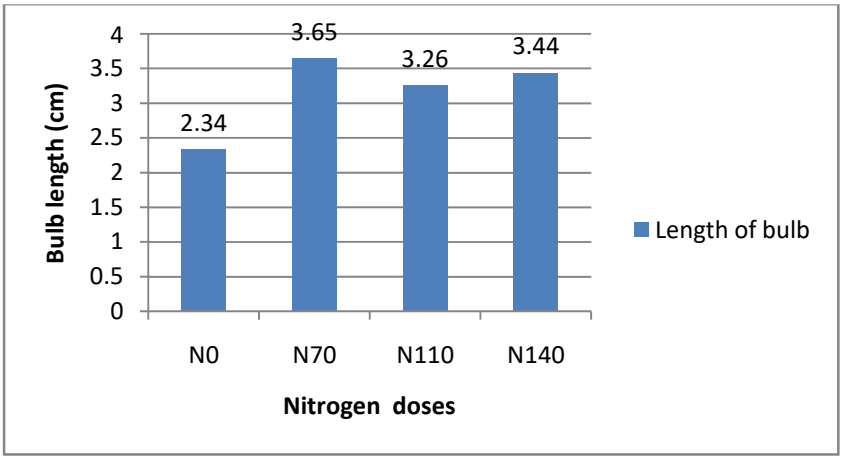


Figure 4.15 Effect of nitrogen on length of bulb/plant

The effect of different levels of sulphur on the length of bulb per plant was found positive and significant. Length of bulb per plant gradually increased with increasing level of S up to the highest level of the present trial. The highest length of bulb per plant (3.65 cm) was obtained with the application of 30 kg S/ha. The lowest length of bulb per plant (2.58 cm) was found in control treatment (Figure 4.16) Further it was observed that length of bulb per plant was increased with increasing level of sulphur up to higher level.

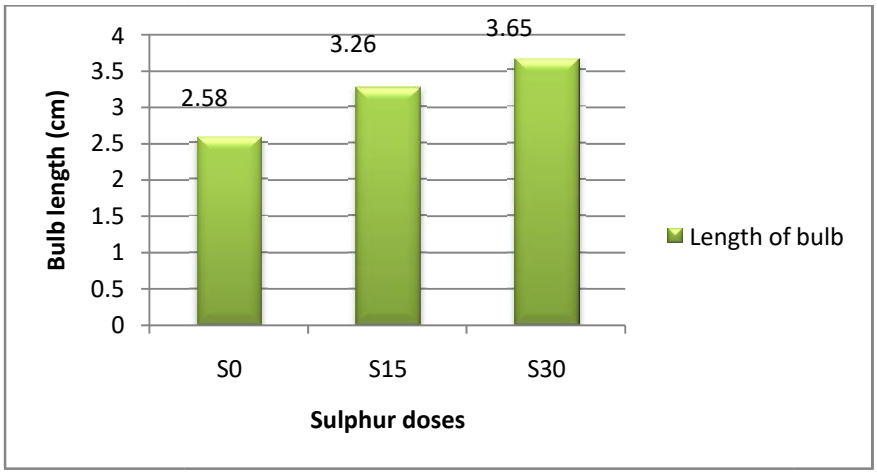


Figure 4.16 Effect of sulphur on length of bulb/plant

The interaction effect of the treatment combinations of nitrogen and sulphur on length of bulb per plant were significant (Table 4.2). The highest length of bulb (3.69 cm) was found in 140 kg N/ha along with 30 kg B/ha application, which was highly significant with all other treatments. The lowest length of bulb per plant (2.08 cm) was produced by the control treatment, which was statistically different from the effect of other treatment combinations. Probably integration of nitrogen and sulphur supplied the necessary requirements for the proper vegetative growth of plant that helps in obtaining the highest bulb length.

4.2.5 Yield of bulb per hectare

Bulb yield was significantly increased with increasing levels of N up to a certain level (140 kg/ha). Application of 140 kg N/ha produced the highest bulb yield (48.33 t/ha) which was significantly different from other treatments of nitrogen (Table 6 & Appendix Figure 4.17). It was further observed that 110 kg N/ha produced the second highest bulb yield (6.34 t/ha) and the lowest bulb yield (3.84 t/ha) was obtained in control treatment.

Pandey *et al*., (1996) reported that bulb yield increased as N rate increased up to 80 kg/ha. Banerjee *et al*., (1997) found highest bulb yield with 125 kg N/ha.

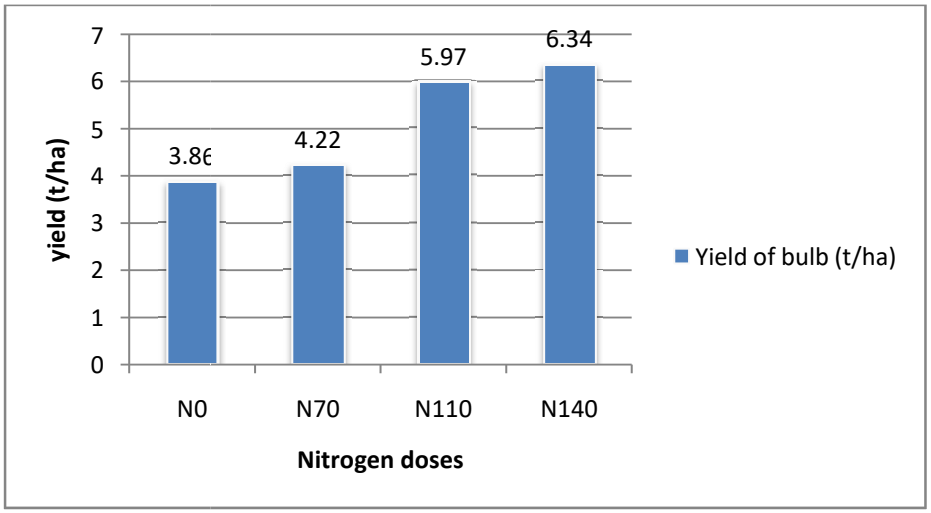


Figure 4.17 Effect of nitrogen on yield (t/ha)

The effect of S on bulb yield was found positive and significant (Figure 4.20 & Appendix III). bulb yield increased with increasing level of S up to higher level of S (30 kg S/ha). Application of 30 kg S/ha produced the highest bulb yield (4.98 t/ha). The minimum bulb yield (4.12 t/ha) was recorded in control treatment.

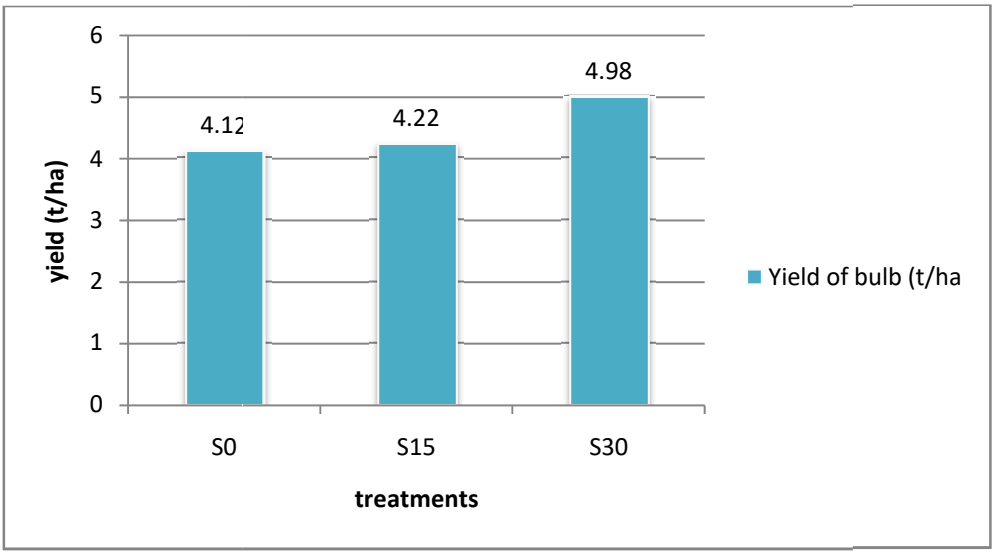


Figure 4.18 Effect of sulphur on yield of bulb

The combined effect of N and S on bulb yield was significantly influenced (Table 4.2 & Appendix III). The highest bulb yield (7.81 t/ha) was produced by the $N_{140}S_{30}$ treatment combination, which was statistically identical with other treatment combination. On the contray, the lowest bulb yield (3.13 t/ha) was obtained from no fertilizer treatment i. e. control. Probably integration of nitrogen and sulphur supplied the necessary requirements for the proper vegetative growih of plant that helps in obtaining the highest yield. The results of the present study are similar to the findings of Peterson (1979) who observed that the yield was increase by 22.45 percent with the application of sulphur at 17 kg/ha According to Anwer *et al*. (1998) the application of nitrogen, phosphorus, sulphur. nitrogen and sulphur increased the number of leaves/plant along with higher bulb yield of onion with the increasing rates tip to 150 kg N, 120 kg P_2O_5, 120 kg K_2O and 20 kg S ha^{-1} at Jessore area.

4.3 Nutrient status of soil after harvest of onion as affected by nitrogen and sulphur

4.3.1 Soil pH

Integrated application of nitrogen and sulphur showed significant effect in the case of soil pH after harvest of onion is showed in Table 4.3. Soil pH was varied significantly at 5.90 to 6.20. The highest pH of the soil (6.20) was recorded in treatment $N_{140}S_{30}$ and the lowest pH value (5.90) was observed in control treatment

4.3.2 Organic matter content of soil (%)

A significant variation was observed in organic matter content in soil after harvest of onion. Among the all treatments the highest organic matter content (1.45%) was obtained

where 140kg N and 30 kg S. On the other hand. the lowest OM content (1.03%) was observed in the N_0S_0 treatment (Table 4.3).

Table 4.3. Combined effect of nitrogen and sulphur on the pH, total N, available P, K, and S in the soil after harvest of onion

Treatments	pH	Organic matter (%)
N_0S_0	5.90	1.03
N_0S_{15}	5.93	0.89
N_0S_{30}	5.98	0.92
$N_{70}S_0$	5.99	0.86
$N_{70}S_{15}$	6.02	1.01
$N_{70}S_{30}$	6.08	1.05
$N_{110}S_0$	6.12	1.08
$N_{110}S_{15}$	6.12	1.12
$N_{110}S_{30}$	6.14	1.20
$N_{140}S_0$	6.15	1.23
$N_{140}S_{15}$	6.18	1.42
$N_{140}S_{30}$	6.20	1.45
LSD	NS	NS
CV(%)	3.15	3.65

*LSD= Least Significant difference *CV = Co-efficient of variation

In this study it was observed that treatment $N_{140}S_{30}$ (120 kg N and 40 kg S) always produce better results over the growth parameters and yield. So this treatment combination of nitrogen and sulphur may be helpful for onion cultivation.

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted in the experimental field of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2020 to February 2021 to determine the effect of different levels of nitrogen and sulphur on yield and yield contributing characters of onion (BARI Peyaj-4). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each treatment. The unit plot size was 3 m^2 (2.5 m x 1.2 m). There were 12 treatments combinations in the experiment comprising 4 levels of N (0, 70, 110 & 140 kg/ha designated as N_0, N_{70}, N_{110} & N_{140}, respectively) and 3 levels of S (0, 15 and 30 kg/ha designated as S0, S_{15} & S_{30}, respectively).

After emergence of onion seedlings, various intercultural operations were accomplished for better growth. Data were collected in respect of the plant growth characters and content and uptake by bulb, leaf and plant and available nutrients in soil for different levels of nitrogen and sulphur. The data obtained for different characters were statistically analyzed to find out the significance of the nitrogen and sulphur. The individual and combined effects of nitrogen (N) and sulphur (S) on growth, yield and nutrient content in plants of onion were studied.

Nitrogen and sulphur fertilization at different levels individually influenced plant characters. The individual and interaction effect of N and S on growth, yield and nutrient content was found positive.

The data were collected plot wise for plant height. leaf length, number of leaves $plant^{-1}$. fresh weight of' leaves $plant^{-1}$. fresh weight of' bulb $plant^{-1}$. dry weight of leaves $plant^{-1}$,

dry weight of bulb per plant, bulb diameter, length of' bulb and yield. The post harvest soil samples were analyzed for pH, organic matter, N, P, K and S contents. The collected data on different parameters were statistically analyzed by MSTAT C Package and the mean comparison was made by DMRT (Duncun's Multiple Range Test) at 5% and 1 % level. The salient results of the experiment are stated below:

Plant height of onion was significantly increased by different levels of nitrogen. The tallest plant (18.83 cm) was produced with 140 kg N/ha and shortest plant (15.57 cm) was found in control treatment. Plant height increased with increasing levels of sulphur up to higher level. The tallest plant (122.3 cm) was produced with 30 kg S/ha and shortest plant (15.86 cm) was found in control treatment. The treatment combinations of nitrogen and sulphur had significant effect on plant height. The tallest plant (33.88 cm) was found in N140S30 treatment and the shortest plant (14.99 cm) was observed in the control treatment.

In general the other parameters like number of leaves per plant, leaf length, fresh weight of leaves plant^{-1}, fresh weight of' bulb plant^{-1}, dry weight of leaves plant^{-1}, dry weight of bulb per plant, bulb diameter, length of' bulb and yield increased with increasing the N doses upto 140 kg N/ha (N_{140}). The maximum number of leaves per plant (8.39) whereas leaf length (23.01), fresh weight of leaves plant^{-1}(8.69) fresh weight of' bulb plant^{-1} (24.36), dry weight of leaves plant^{-1} (0.79), dry weight of bulb per plant (4.68), bulb diameter (5.58) and length of' bulb (3.44) were recorded from N_{140} treatment. Minimum values of these parameters were obtained from N_0(control). However, the highest bulb yield (6.34 t/ha) was recorded from N_{140} and the lowest bulb yield (3.86 t/ha) was recorded from control condition. The highest moisture content in both leaf and bulb

(92.00% and 89.20 %) and were recorded from N_{140} treatment while the lowest moisture content in leaf and bulb (85.10% and 85.36 %) was recorded from N0 (control) treatment.

The maximum number of leaves per plant (7.20) whereas leaf length (24.25), fresh weight of leaves plant^{-1}(7.21) fresh weight of' bulb plant^{-1}(26.30), dry weight of leaves plant^{-1} (0.77), dry weight of bulb per plant (3.44), bulb diameter (4.89) and length of' bulb (3.65) were recorded from S_{30} treatment. Minimum values of these parameters were obtained from S_0(control). However, the highest bulb yield (4.98 t/ha) was recorded from S_{30} (control) and the lowest bulb yield (4.12 t/ha) was recorded from control condition. The highest moisture content in both leaf and bulb (93.00% and 89.10 %) and were recorded from S_0 treatment while the lowest moisture content in leaf and bulb (86.20% and 86.73 %) was recorded from S_{30} treatment. The soil properties such as organic matter content and soil pH were insignificant to the treatments. The largest significant value was obtained from the treatment combination $N_{140}S_{30}$, which is 140 kg N/ha + 30 kg S/ha, while the lowest value was obtained from N_0S_0.

Given the circumstances of the current experiment, additional research in the following areas may be advised:

1. Individual effect of N and S on growth and yield of onion was found positive and significant.
2. The combined effect of N and S enhanced growth, yield and yield attributes of onion
3. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh to investigate regional adaptability and other performances;
4. Another level of nitrogen and sulphur may be included in the further study;
5. Another fertilizer may also included in the program for future study.

However the results are required to investigate more with different varieties and soil management practices.

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CHAPTER VI

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APPENDICES

Appendix I. Monthly records of meteorological observation at the period of experiment (November, 2020 to February, 2021)

Month	Temperature (Maximum, ^{O}C)	Temperature (Minimum, ^{O}C)	Humidity (%)	Precipitation (mm)
November	29.80	20.10	65.00	30
December	26.50	12.90	53.20	10
January	25.32	12.73	49.10	7
February	25.25	14.15	55.50	8

Appendix II. Analysis of variance of the data on Plant height, No. of leaves/plant, Length of leaves/plant Fresh weight of leaves/plant and Dry weight of leaves/plant

Source of variation	df	Mean squares				
		Plant height (cm)	No. of leaves/plant	Length of leaves (cm)	Fresh weight of leaf (g)	Dry weight of leaf (g)
Replications	2	3.616	0.360	0.422	0.001	1.274
Factor-A	3	16.066	0.585	139.222	0.006	82.705
Factor- B	2	26.333	1.247	22.174	0.052	19.221
AB	6	3.969	0.337	51.775	0.034	9.853
Error	22	1.741	0.133	0.441	0.001	1.127

Appendix III. Analysis of variance of the data on Fresh weight of bulb/plant, Dry weight of bulb/plant, Diameter of bulb, Length of bulb and Yield of bulb (t/ha).

Source of variation	df	Mean squares				
		Fresh weight of bulb/plant	Dry weight of bulb/plant	Diameter of bulb	Length of bulb	Yield of bulb (t/ha)
Replications	2	5.994	0.069	0.002	0.000	0.001
Factor-A	3	51.809	0.765	1.669	0.107	9.897
Factor- B	2	1.087	0.845	1.345	0.051	0.126
AB	6	11.708	0.304	0.663	0.511	2.094
Error	22	4.032	0.026	0.002	0.001	0.003

Appendix IV. Analysis of variance of the data on the pH and Organic matter in the soil

Source of variation	df	Mean squares	
		pH	OM
Replications	2	0.012	0.002
Factor-A	3	0.698	0.766
Factor- B	2	0.082	0.079
AB	6	0.036	0.042
Error	22	0.023	0.007