# EFFECT OF NITROGEN AND SULPHUR ON THE GROWTH AND YIELD OF SUMMER ONION (*Allium cepa* L.)

**BY**

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**REG, NO. 00953**

116 05/10/09

A Thesis

*Submitted to the Department of Horticulture and Postharvest Technology*
*Sher-e-Bangla Agricultural University, Dhaka*
*In partial fulfillment of the requirements*
*for the degree*
*of*

**MASTER OF SCIENCE (MS)**
**IN**
**HORTICULTURE**

**SEMESTER: JANUARY-JUNE, 2008**

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# *CERTIFICATE*

*This is to certify that thesis entitled, "EFFECT OF NITROGEN AND SULPHUR ON THE GROWTH AND YIELD OF SUMMER ONION (Allium cepa L.)" submitted to Dept.of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, impartial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN HORTICULTURE , embodies the result of a piece of bona fide research work carried out by MD. JAHANGIR ALAM Registration No. 00953 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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DEDICATED TO MY

BELOVED PARENTS

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DEPARTED GRANDPARENTS

## *ACKNOWLEDGEMENTS*

*The author first wants to express his enormous sense of gratefulness to the Almighty Allah for His countless blessing, love, support, protection, guidance, wisdom and assent to successfully complete M S degree.*

*The author would like to express his heartfelt respect and deepest sense of gratitude to his respected Supervisor, Professor M. A. Mannan Miah, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, encouragement, valuable suggestions and kind advice during the research work and preparation of the thesis.*

*The author also expresses his gratefulness and best regards to his respected Co-Supervisor, Md. Hassanuzzaman Akand, Associate Professor , Department of Horticulture & Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and preparation of the thesis.*

*I like to record special word of gratefulness to Professor A. K. M. Mahtab Uddin, Professor Md. Ruhul Amin and all the teachers of the Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka. For their valuable suggestions, instructions and cordial help during the period of study.*

*The author expresses his sincere appreciation to his brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.*

***The Author***

# EFFECT OF NITROGEN AND SULPHUR ON THE GROWTH AND YIELD OF SUMMER ONION *(Allium cepa* L.)

**BY**

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**ABSTRACT**

A field experiment was carried out to study the effect of Nitrogen and Sulphur on the growth and yield of summer onion at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from February to July 2007. The experiment was conducted with two factors; Factor A: Nitrogen (four levels ) i.e. $N_0$ (0 kg N/ha), $N_1$ (60 kg N/ha), $N_2$ (120 kg N/ha) and $N_3$ (180 kg N/ha) kg N/ha and Factor B : Sulphur (four levels) i.e. $S_0$ (0 kg S/ha), $S_1$ (10 kg S/ha), $S_2$ (20 kg S/ha) and $S_3$ (30 kg S/ha).The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In case of Nitrogen, $N_2$ produced the highest diameter of bulb (3.86 cm), dry matter content of bulb (8.71%) and yield (17.58 t/ha) and the lowest from $N_0$. In case of Sulphur, $S_3$ produced the highest diameter of bulb (3.99 cm), dry matter content (9.03%) and yield (16.05 t/ha) and the lowest from $S_0$. For combined effect $N_2S_3$ produced the highest diameter of bulb (4.95 cm), dry matter content of bulb (8.71%) and yield (19.10 t/ha) and the lowest from $N_0S_0$. Considering above findings, the application of 120 kg N/ha with 30 kg S/ha is best for growth and yield of summer onion cultivation.

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## LIST OF ABBRIVIATIONS AND ACRONYMS

| ABBREVIATION | FULL WORD |
|---|---|
| Agril. | Agriculture |
| AEZ | Agro-Ecological Zone |
| @ | At the rate |
| BARI | Bangladesh Agricultural Research Institute |
| BBS | Bangladesh Bureau of Statistics |
| $^0C$ | Degree Celsius |
| cc | Cubic centimeter |
| Cm | Centimeter |
| conc. | Concentrated |
| $CuSO_4.5H_2O$ | Green vitriol |
| CV. | Cultivar(s) |
| CV% | Percentage of Coefficient of Variance |
| DAT | Days after transplanting |
| DMRT | Duncan's Multiple Range Test |
| *et al* | and others |
| Fig | Figure |
| g | Gram |
| $HClO_4$ | Percholoric acid |
| Hort. | Horticulture |
| i.e. | That is |
| J. | Journal |
| K | Potassium |
| KCl | Potassium chloride |
| kg | Kilogram |
| $K_3PO_4$ | Potassium phosphate |
| LSD | Least Significant Difference |
| TSP | Triple Super Phosphate |
| m | Meter |
| ml | Milliliter |
| Mm | Millimeter |
| MOP | Muriate of Potash |
| NaOH | Sodium Hydroxide |
| NPKS | Nitrogen, Phosphorus, Potassium and Sulphur |
| NS | Non Significant |
| nm | Nanometer |
| OM | Organic matter |
| pH | Hydrogen ion concentration |
| % | Percent |
| RCBD | Randomized Complete Block Design |
| RH | Relative humidity |
| SAU | Sher-e-Bangla Agricultural University |
| t $ha^{-1}$ | Tone per hectare |
| q | Quintal |
| USDA | U.S.Department of Agriculture Sysem. |
| viz. | Namely |

# Chapter I

# Introduction

# CHAPTER 1

# INTRODUCTION

The Onion (*Allium cepa* L.) is one of the most important spices in Bangladesh. It is an important spices belongs to the family Alliaceae (Jones and Mann, 1963). It is one of the most important cash crops in Bangladesh. Among the thirteen vegetable and spices crops listed by FAO, onion stands third in terms of annul world production (FAO, 1997). It is used in the preparation of different kinds of food of our daily diet. Onion is mainly used as spices but it is also used as condiments for flavoring food. It is also used as vegetables. Onion contains high medicinal properties having adequate vitamin B & C. Iron & Calcium (Vohora *et al.* 1974). It is relished for its pungency which is due to present of volatile oily substance known as allyl propyl disulphide (Yawalkar, 1985).Onion reduces the blood sugar by 25 percent as a diabetic drug in Arabian folk medicine (Mossa and Yawalkar, 1985).

Central Asia is the primary center of its origin and the Mediterranean is the seconder center for large type onion (McCullum, 1976). Now, onion is cultivated all over the world. The leading onion growing countries of the world are the Netherlands, Korea, Israel, Japan, Turkey, Syria, Iran, Egypt, USA, Lebanon, Austria and India (FAO, 2003). In Bangladesh it is commercially cultivated in the greater districts of Faridpur, Rajshahi, Dhaka, Comilla, Mymensingh, Jessore, Rangpur and Pabna (BBS, 2006).

Onion is a thermal and photosensitive crop and optimum temperature for its cultivation is 13-24$^0$(Rashid, 1983). In Bangladesh, it is mainly produced in winter season. Onion cultivation during summer season is constrained due to adverse weather along with absence of summer tolerant varieties and proper cultural practices. Demand for its use is ever increasing irrespective of season. Among the spice crops grown in the country, onion ranks second (318000 Acres) next to chilli (349000 Acres) in area and first (894000 mt) in production during the year 2006-2007(BBS, 2008). The average yield of onion in Bangladesh is far below being 4 t/ha (BBS, 2004) as compared to world average yield of 17.45 t/ha (FAO, 1998). The statistical information revealed that Bangladesh produce only 269 thousand metric tons of onion against the total requirement of 580 thousand metric tons on an area of 286 thousand acre of land (BBS, 2006). Virtually, Bangladesh is deficit in onion production. In 2003, Bangladesh has to import 33.452 thousand MT of onion worth about 6.9 million US dollar (FAO, 2003). To fulfill this requirement we need production of summer onion. Formerly, summer onion was not successfully cultivated in Bangladesh. Recently BARI has released two summer onion varieties BARI Peaj-2 and BARI Peaj-3 for growing in kharif season as its genetic potentiality proved to be suitable for this climate. There is a significant response of onion to both inorganic and organic fertilizer (Nasreen and Hossain, 2001; Ullah, 2003) and their yielding ability under our summer climatic condition (Anon., 2000).

An approved summer onion variety released by National Seed Board as BARI Peaj-3 was selected for the present study. This variety was released in 2000. The variety produces plants 35-50 cm tall with 9-10 leaves plant$^{-1}$. The diameter of bulb is 4-5 cm, mature within 90-120days, and yield of bulb is about 15 to 19 t ha $^{-1}$.The germination percentage of the seed was 85(Anon., 2000).

Nitrogen play an important role on onion production. An increased level of nitrogen was reported to increase the weight of bulb (Satter and Haque, 1975). Nitrogen plays the most important role for the vegetative growth of the crop which ultimately helps increasing bulb size and total yield (Singh and Kumar, 1969, Rai, 1981) Nitrogen is very important element due to its influence for plant height, number of leaves per plant, bulb weight and yield per plant (Vachhani and Patel, 1993).

Sulphur is also considered important in onion production. Sulphur is essential for building up Sulphur containing amino acids in plant cells, particularly in the early stage of plant growth. But most of the soils of Bangladesh have been reported to be deficient in sulphur (De Datta, 1981). Suitable dressing of Sulphur fertilizer improved growth, yield, and pungency and increased the availability of trace elements (Misra and Prasad, 1966).

The importance of nitrogen, phosphorus, potassium and sulphur, zinc and boron for the growth and yield of vegetable crops is well established. Among the nutrients, Nitrogen and Sulphur plays an important role on onion production. Nitrogen and Sulphur have been reported to be essential for a good vegetative growth and bulb development in onion (Islam and Haque, 1977; Balasubramonian *et al.*, 1979; Paterson, 1979).

Considering the above facts the present investigation was under taken with the following objectives:

I) To determine the optimum dose of nitrogen for maximizing the yield.
II) To determine the optimum doses of sulphur for maximizing the yield.
III) To find out the combined effect of nitrogen and sulphur for ensuring the higher yield.

# Chapter II

# Review of Literature

## CHAPTER - 2

## REVIEW OF LITERATURE

Onion is one of the most important bulb crops in Bangladesh as well as all over the world. Nitrogen and Sulphur are the two major important macro nutrients which responsible for controlling growth and yield of onion. Appropriate doses of these are related to the best growth and yield of onion. A number of research works have been done on different levels of nitrogen and sulphur on the yield of onion in various parts of the world which have been made in this regard in Bangladesh. The present study has been taken to investigate the effect of and sulphur on the yield of onion. In the chapter an attempt has been made to research findings related to the present study have been reviewed here.

### Effect of nitrogen on onion

Agarwal *et al.* (1981) observed that the plant received N, $P_2O_5$ 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 $ha^{-1}$.

Guptta and Gaffar (1981) studied that 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. Economic yield was obtained from NPK application @46:36:36 kg $ha^{-1}$.

Rashid (1983) recommended 10 tons cow dung, 175 kg urea, 125 kg TSP and 150 kg MP per hectare for successful onion cultivation in Bangladesh.

Satyanarayana and Arora (1984) reported that onion bulb yield increased with direct application of nitrogen up to 60 kg $ha^{-1}$. Potash at 40 kg as $K_2O$ $ha^{-1}$, onion did not affect its bulb yields.

Amin (1985) reported that nitrogen at 60 kg $ha^{-1}$ coupled with potash at 100 kg $ha^{-1}$gave the best performance in respect of bulb diameter (5.86 cm), bulb weight (64.70 g) and yield of onion (27.47 t $ha^{-1}$).

Madan and Sandhu (1985) 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 $ha^{-1}$. They also reported in another trial (1983) that P and K at higher rate improved the storage quality of onion.

Lang(1987) 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 was found to reduce N losses and costs, but the yield increased.

Saimbhi *et al.* (1987) reported that applying NPK at the highest rate gave greatest bulb size, maximum yield (33.89 t $ha^{-1}$) and best quality of dehydrated onions. The highest NPK combination was 100 kg N, 60 kg $P_2O_5$ and 60 kg $K_2O$ per hectare.

Srinivas and Nail (1987) observed that the bulb yield was increased from 16.51 t/ha at zero N to 56.30 t/ha at the highest N rate (200 kg/ha)

Duque *et al.* (1989) 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 early growth stages, whereas demand for P was continuous through out the development. Uptake levels were 38.8, 38.6and 71.3 kg N, $P_2O_5$ and $K_2O$, respectively, for the yield of 2.5 t $ha^{-1}$.

Pandey *et al.* (1991) studied with four levels of nitrogen (0, 50, 100 and 150 kg $ha^{-1}$), three levels of phosphorus (0, 40, or 80 kg $ha^{-1}$) and two levels of potash (0 and 50 kg $ha^{-1}$), to determine the yield and quality of *kharif* onion. They found maximum yield and net return with N: P: K @ 105:40:50 kg $ha^{-1}$.

Baloch *et al.* (1991) obtained maximum bulb yield (22.66 t ha-1) with the application of 125 kg N+75 kg K2O ha-1. The highest plant height (38.5 cm), highest leaf height(34.5 cm), number of leaves plant-1 (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 + 100 kg K2O ha-1.

Jitendra *et al.* (1991) in their trial of onion CVs applied N @ 80, 120 and 160 kg $ha^{-1}$, $K_2O$ @ 100+ $ZnSO_4$ @ 2.5 kg $ha^{-1}$. Higher N levels increased plant growth and yield. K alone and with Zn also increased plant growth, yield and dry matter contents. The highest yield (27.48-32.68 t $ha^{-1}$) was obtained with the higher rate of N along with K and Zn.

Rahim *et al.* (1992) conducted fertilizer trial. Onion sets were planted on $6^{th}$ November at a spacing of 25 X 15 cm and supplied with 0-160 kg $ha^{-1}$ N and potassium 0-100 kg $ha^{-1}$, while 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 $ha^{-1}$ from control.

Sharma (1992) reported that the economic optimum doses were 81 kg nitrogen and 59 kg $K_2O$ $ha^{-1}$. The response of optimum level of N and K was up to 43.3 t $ha^{-1}$.

Vachhani and Patel (1993) studied the effect of different levels of nitrogen (50, 100 or 150 kg $ha^{-1}$), phosphorus (25, 50 or 75 kg $P_2O_5$ $ha^{-1}$) 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 $plant^{-1}$, bulb weight and yield were 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. The rate also gave the highest economic return.

Patel and Vachhani (1994) a field experiment was conducted at Navsari, India on the Effect of NPK fertilization on the yield and quality of onion. They worked with combinations of N (50, 100 or 150 kg/ha), P (25, 50 or 75 kg $P_2O_2$/ha) and K (50, 100 or 150 kg $K_2O$/ha) were applied to an onion crop. They reported that yield and bulb diameter and weight increased with dose rate for N and P, but did not differ significantly with rate of K application.

Halder *et al.* (1998) in a field experiment on onion with applied N fertilizer at 0, 70, 80 and 90 kgN/ha and P fertilizer at 0, 50, 60 and 70 kg $P_2O_5$/ha. N application improved dry matter production and contributed to maximum uptake of nutrient elements from soil. But application of P alone at higher rates gave no better results than with N. N applied at 90 kg/ha gave the highest response in respect of nutrient uptake and bulb dry matter content. Combined application of N and P at higher rates also produced excellent performance.

Sing and Mohanty (1998) studied on the growth and yield of onion in Orissa, India, in 1995-96 and 1996-97. Nitrogen (80, 120 or 160 kg $ha^{-1}$), $K_2O$ (80, 100 or 120 kg $ha^{-1}$) and $P_2O_5$ (60 kg $ha^{-1}$) were applied in a randomized block to give a total of 9 Treatments. With the increasing N level plant height became increased in both years. Nitrogen and K at 160 and 80 kg $ha^{-1}$, respectively (160:80 NK) resulted in the maximum plant height and 120:80 NK produced the minimum plant height. Bulb girth and number of leaves $plant^{-1}$ were greatest with 160:80 NK and least with 80:80 NK. Bulb weight was greatest with 160:80 NK followed by 120:120 NK and 160:100 NK; a significantly lower bulb weight was achieved with 80:80 NK. The highest yield (295.8 q $ha^{-1}$) was achieved with 160:80 NK. Based on these results, the recommended rates for commercial onion production in and around Bhubaneswar are 160 kg N, 80 kg $K_2O$ and 60 kg $P_2O_5$ $ha^{-1}$.

Rodriguez *et 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 (*Allium cepa*) 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 $ha^{-1}$, respectively) could not be detected, nor significant interactions between N and P.

Singh *et al.* (2000) conducted an experiment at Rajasthan, during 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 $ha^{-1}$.

Dharmendra *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 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.

Mohanty and Das (2001) observed that the application of 90 kg N and 60 kg $K_2O$ ha$^{-1}$ was better for obtaining higher yield with larger bulbs, while 30 kg ha$^{-1}$ each of N and $K_2O$ was suggested to realize medium bulbs with moderate yield and better keeping quality in long term storage.

Deho *et al.* (2002) conducted a field experiment to determine the optimum dose of NPK fertilizers for the onion (*Allium cepa*), variety Phulkara on a loamy soil. The bed size was 4.5 x 4.0 m. Six fertilizer treatments were tested in RCBD for the height of plant (cm), number of leaves plant$^{-1}$, single plant weight, bulb diameter (horizontal and vertical), bulb size (volume) and yield ha$^{-1}$. Compared to other fertilizer treatments, the application of 80 N + 60 $P_2O_5$ + 40 $K_2O$ kg ha$^{-1}$ produced more leaves and largest bulb size and gave the highest onion yield.

Tiwari *et al.* (2002) studied the effects of N (0, 40, 80 and 120 kg/ha) and plant spacing (45 x 30, 60 x 30 and 60 x 45) on the yield of onion (cv. Pusa Red). They stated that Plant height, length of flowering stalk, number of umbels per bulb, 1000-seed weight, purple blotch and seed yield increased with increasing rates of N up to 80 kg/ha. Spacing of 60 x 45 gave the highest number of leaves per plant (12.10) and 1000-seed weight (2.88 g), whereas the spacing of 60 x 30 and 45 x 30 gave the highest length of flowering stalk (93.45 cm) and seed yield (9.28 q/ha), respectively. The interaction effects between application of N at 80 or 120 kg/ha, in combination with the closest spacing resulted in the highest yield and cost:benefit ratio.

Yadav *et al.* (2002) conducted an experiment on onion cultivars Puna Red, White Marglobe, Nasik Red and Rasidpura Local which were supplied with 50, 100 or 150 kg N and K ha-1 in Jaipur, Rajasthan, India during the rabi seasons of 1998-2000. Yield, fresh weight of 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.

Mandira and Khan (2003) carried out an experiment with different levels of nitrogen (at 0, 100, 150 and 200 kg $ha^{-1}$) and potassium (0, 75 and 150 kg $ha^{-1}$) given as soil application, to study their effect on the growth, yield and yield attributes of onion cv. N-53 in a study conducted in Tripura, India during rabi 2001. Nitrogen at 150 kg $ha^{-1}$, potassium at 75 kg $ha^{-1}$ and their combination recorded the best performance in terms of yield and growth. All other treatments and their combinations were superior to control.

Naik and Hosamani (2003) a field experiment was conducted during 1997-98 and 1998-99 to investigate the effect of spacing (15 x 10, 15 x 15 and 15 x 20 cm) and N level (0, 50, 100 and 150 kg/ha) on the growth and yield of kharif onion. Narrow spacing of 15 x 10 cm with application of 150 kg N/ha was found optimum for enhancing yield (169.02 q/ha) and other growth and quality parameters, such as plant height, leaf number per plant, bulb length, bulb diameter and bulb total soluble solid content. The maximum net return and benefit cost ratio were also recorded from this treatment combination.

Qureshi *et al.* (2003) studied the effects of Nitro gold (slow-release, granulated ammonium sulfate), and of standard N sources like urea and ammonium sulfate, on the yield and quality of onion in Maharashtra, India. They reported, Urea + SSP were the most effective in the enhancement of the number of leaves. The application of Nitro gold (RR) along with DAP significantly improved bulb polar diameter. The highest yields of grade A and B bulbs were obtained with Nitrogold and urea. On the other hand, the highest total marketable yield was obtained with Nitrogold + SSP. The N fertilizers did not significantly affect plant height, and the neck size and total soluble solid content of bulbs.

Sharma *et al.* (2003) conducted a field experiment in Leo, Himachal Pradesh, India, to study the effect of combined use of NPK and farmyard manure (FYM) on yield attributes, yield, nutrient uptake by onion (*Allium cepa*) as well as on build up of available N, P, K during the summer seasons of 1998 and 1999. The treatments involved 3 levels of FYM (0, 10 and 20 t $ha^{-1}$) and 4 levels of NPK (0, 50, 100 and 150 % of the recommended dose, which is 125 kg N, 33 kg P and 50 kg K $ha^{-1}$). Application of fertilizers at the rate of 100 (125 kg N, 33 kg P and 50 kg K $ha^{-1}$) and 150 % (187 kg N, 49 kg P and 75 kg K $ha^{-1}$) of recommended dose registered an increase of 42 and 56 % over 50 % NPK level in bulb yield of onion. Similarly, application of FYM at 10 and 20 t $ha^{-1}$ increased bulb yield by 9 and 19 % over 100 % NPK alone, respectively. Bulb yield recorded in the case of 100 % NPK along with 20 t FYM $ha^{-1}$ (19.87 t $ha^{-1}$) was at par with 150 % NPK alone (18.82 t $ha^{-1}$) thereby signifying the savings of chemical fertilizers of 52 kg N, 16 kg P and 25 kg K $ha^{-1}$. Use of NPK fertilizers along with FYM also resulted with significant improvement in available N, P and K status of the soil.

Gunjan *et al.* (2005) conducted a field experiment on a sandy loam soil in Jobner, Rajasthan, India during the *rabi* season of 1999-2000 to study the effect of 4 levels of N (25, 50, 75 and 100 kg $ha^{-1}$) and 2 sources of biofertilizer, i.e. *Azotobacter* ($A_1$) and *Azospirillum* ($A_2$) as seedling dipping, seed and soil treatments, on yield and quality of onion bulb (A. cepa). The application of N at 100 kg $ha^{-1}$ significantly increased bulb yield and quality attributes. The treatment combination $N_4A_1S_2$ (100 kg N $ha^{-1}$+*Azotobacter* as seedling dipping) gave the highest bulb yield and fresh weight of bulb, followed at par by $N_3A_1S_2$ (75 Kg N $ha^{-1}$+*Azotobacter* as seedling dipping). A higher benefit: cost ratio (2.26:1) was recorded with the treatment combination of $N_3A_1S_2$ compared to $N_4A_1S_2$, with a lower benefit:cost ratio (2.24:1) due to additional cost of urea and non significant difference between these 2 treatments regarding yield of bulbs. Thus, the treatment combination $N_3A_1S_2$ was the best.

Qiao-HongXia *et al.*(2005) showed that application of 20 kg N, P and K/666.7 $m^2$ increased the yield of Welsh onions by 3.1-24.4% (34.6-270.9 kg/666.7 $m^2$), whereas foliar application of organic fertilizer increased the yield of the crop by 14.2-32% (186-425.9 kg/666.7 $m^2$).

Yadav *et al.* (2005) studied the effects of N fertilizer (50, 75 or 100% of the recommended N rate of 100 kg/ha) with or without inoculation of *Azospirillum* in Durgapura, Jaipur, Rajasthan, India, during the *rabi* of 1999-2000, 2000-01 and 2001-02. N was applied in 3 equal splits at 30-day intervals starting at 20 days after transplanting. Before sowing, seeds were treated with *Azospirillum* at 500 g/ha. Seedlings were dipped for 15 minutes in *Azospirillum* slurry (1 kg *Azospirillum* dissolved in 50 liters of water/ha). Before transplanting, *Azospirillum* (2 kg/ha) was mixed with farmyard manure and incorporated into the soil. Pooled data showed that bulb yields were highest with N at 75 (328.4 quintal/ha) and 100 kg/ha (336.5 quintal/ha); under these treatments, bulb yields increased by 11.4 and 14.1%, respectively, over the control. The inoculation of *Azospirillum* resulted in a higher bulb yield (323.7 quintal/ha) over the control (310.9 quintal/ha). The available N in the soil slightly increased with the increase in the N rate. A significant increase in available N was observed during the first sampling of the second year, and during the second sampling of the second and third years. *Azospirillum* inoculation increased the available N during the second sampling of the third year, and during the third sampling of the first year. The highest net profits were obtained with *Azospirillum* combined with N at 100 (32792 rupees/ha) or 75 kg/ha (31 288 rupees/ha). [1 quintal=100 kg]

Kadam and Sonar (2006) conducted an experiment 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 field experiment was conducted on post-monsoon onion (cv. N2-4-1) on Otur 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 $P_2O_5$ (0, 50, 100, 150 kg/ha) and three levels of $K_2O$ (0, 50, 100 kg/ha) with 6 control treatments. Farmyard manure was also applied to all the plots at 10 Mg/ha ten days before planting of onion. The nutrient requirement of onion crop was 1.314 kg N, 1.172 kg $P_2O_5$ and 20.4 kg $K_2O$/Mg production. Efficiency of soil nutrients was 11.25, 55.35 and 7.37% of N, $P_2O_5$ and $K_2O$ while that of fertilizer N, $P_2O_5$, $K_2O$ were 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 Otur (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 50 t/ha yield target of onion followed by 40 t/ha targeted yield treatment.

May *et al.* (2007) carried out an experiment in Sao Jose do Rio Pardo, the onion producing area in Sao Paulo State, Brazil, from 7 March to 8 August 2004 to evaluate the effects of N (at 0, 50, 100 and 150 kg/ha) and K (at 0, 75, 150 and 225 kg/ha) on the yield of 2 onion cultivars (Optima and Superex), growing in different plant populations (60, 76, 92 and 108 plants/m2). The effects of N and K levels on the yield were cultivar-dependent. Average individual bulb mass increased with decreasing plant population and N level. To reach 90% of the maximum expected crop yield of 71 t/ha for Superex and

64.8 t/ha for Optima, N levels of 125 and 105 kg/ha should be applied, respectively, without K application.

## Effect of Sulphur on the growth and yield of onion

Platenius and Knott (1941) observed that the pungency is associated with the content of volatile sulphur, higher the volatile sulphur content the greater the pungency.

Fosket and Peterson (1950) found a good correlation between the refractive index of juice of different varieties of onion and their storage quality. High dry matter content and high voltage sulphur content (pungency) are also known to be associated with good keeping quality.

Thomson and Kelly (1957) reported that there is association between the pungency and content of sulphur in onion. The higher content of sulphur the greater the pungency or the stronger the flavour. The content of sulphur (pungency) was also found to be associated with good keeping quality.

Misra and Prasad (1966) studiet a field trial with sulphur fertilizer on pungency and yield of onion. They showed that suitable dressing of sulphur fertilizer improved growth, yield, pungency and also increased the availability of trace element.

Freeman and Mossadeghi (1970) in their sand culture experiment in USA, reported that maximum growth of White Lisbon onions was obtained as $SO_4$ levels above meq/1. At lower concentration sulphur deficiency symptoms developed and the growth response was directly related to the $SO_4$ concentration in the nutrient.

Katyl (1977) suggested to 15 to 20 tons FYM and 100 kg ammonium sulphate, 175 kg super phosphate and 130 kg of potassium sulphate per hectare before transplanting in early stage of growth of onion crop.

Sulphur is found to be an important fertilizer having significant contribution to the yield of onion cv. Yellow Granex. Peterson (1979) found that the yield was increased by 22.48 percent with the application of sulphur at 17 kg/ha.
Rajas *et al.* (1992) studied with different levels of sulphur, spacing and frequencies of irrigation on total volatile sulphur content of onion cultivar Pusa Red. They worked with 4 rates of S (0, 40, 60 or 80 kg/ha), 3 plant spacings (10 X 15, 15 X 15 or 20 X 15 cm) and 3 levels of irrigation (water applied at intervals of 5, 10 or 15 days). They reported that all plots received a basal dressing of 30 t FYM, 175 kg urea, 150 kg single super phosphate and 125 kg muriate of potash/ha. The total volatile S content of harvested, dry bulbs was highest (65.00 mg/100 g) with a combination of 80 kg S/ha, spacing at 20 X 15 cm and irrigation at an interval of 5 days.

Another experiment conducted by Rajas *et al.* (1993) with effect of varying levels of sulphur and spacing compared with frequencies of irrigation on yield of onion grown in India on onion cv. Pusa Red. They worked with 4 rates of sulfur (0, 40, 60 and 80 kg/ha), 3 plant spacings (10, 15 and 20 X 15 cm) and irrigation at intervals of 5, 10 or 15 days. They reported that the highest yield (28.11 t/ha) was obtained with 80 kg S/ha, a plant spacing of 10 X 15 cm and an irrigation interval of 5 days.

Nasiruddin *et al.* (1993) reported that the effect of potassium and sulphur on growth and yield of onion showed that either individually or combined with K and S increased plant height, leaf production ability, bulb diameter and weight as well as the bulb yield. They recommended 100 kg potash and 30 kg sulphur per hectare for cultivation of onion.

Kumar and Singh (1995) was conducted with a sand culture experiment on onions to study the effect of sulfur deficiency on plant growth and yield. They reported that plants received either complete nutrient solution or nutrient solution without S. S deficiency resulted in poor growth and a considerable reduction in individual bulb weight.

Singh and Pandey (1995) carried out an experiment with cv. Pusa Red on the effects of S (0, 20 and 40 p.p.m.) and soil type on the yield of onions. The soils were sandy to sandy clay loam in texture with available S in the range 5-22 p.p.m. They found that applied of S had no significant effect on yield, but S uptake increased with increasing rate of S. Soil type significantly affected yield and S uptake. The highest S uptake (118.9 mg/pot) was observed from a sandy loam soil (Holambi Nabha) amended with S at 40 p.p.m.
Singh *et al.* (1996) carried out a field experiment in Agra, India to observe the effects of S (0,20, 40 or 80 kg/ha ) on the growth of onions (Cv. Pusa Red). The yield and plant N content were significantly increased with N application.

Hamilton *et al.* (1997) a greenhouse study was conducted to test the effects of sulfur nutrition on pungency, sugar content, and bulb weight of six cloned lines of cv. TG 1015Y onions. They reported that onion bulbs grown under the low-S treatment (0.1 meq/litre or 2 ppm S) contained 1.9 æmol pyruvic acid/g fresh weight, while those under the high-S treatment (7.7 meq/litre or 123 ppm S) contained 5.5 æmol/g fresh weight. Total sugar content was higher in the low-S treatment than in the high-S treatment (45.2 vs. 43.1 mg/g) with a large variation among the clones under both treatments. Bulb weight was significantly less at low S rates (311 vs. 504 g) with a great variation among the clones. Total S content in leaf (0.26 vs. 0.85%) and bulb tissues (0.13 vs. 0.43%) were significantly lower in the low-S treatment and indicated S deficiency.

Kumar *et al.* (1997) conducted a research work on interaction between sulphur and zinc on the yield and yield attributes of onion in 1994-96 at Kalyani, India. The highest fresh onion yield (18.40 t/ha) was achieved on plots treated only with Zn-EDTA at 10 kg Zn/ha, followed by those given only S at 30 kg/ha. Combined applications of Zn and S reduced yield, plant height and number of leaves per plant and increased neck thickness compared to their application alone. Application of 60 kg S/ha + 20 kg Zn/ha even reduced yield, average plant height and fresh and dry weight of leaves compared to the control treatment.

Sumantra *et al.* (1997) conducted an experiment on the effect of sulphur on growth and yield of onion (cv. Pusa Red.). They used, CaSO4 (8, 16 or 24 kg/ha), elemental sulphur (2, 4 or 6 kg/ha), single super phosphate (16.7, 25 or 50 kg/ha) or $(NH4)_2SO_4$ (8, 16, 24 kg/ha). They observed that Sulfur fertilizers significantly increased all vegetative growth parameters compared to the control except number of leaves/plant at 70 DAT. Application of $CaSO_4$ at 24 kg/ha gave the highest values for the following characteristics: number, length, fresh weight and dry weight of leaves; number, length and fresh weight of roots; length, diameter, fresh weight, dry weight and volume of bulbs. All fertilizer sources and application rates significantly increased the bulb yield at harvest compared to the control, but the highest yield was again obtained after application of $CaSO_4$ at 24 kg/ha.

Kumar *et al.* (1998) study to the effect of zinc and sulphur application on the yield and post harvest quality of onion (cv. N-53) under different methods of storage. The plant received Zn at 0, 10 or 20 kg/ha as Zn-EDTA and 0, 30 or 60 kg S/ha as elemental sulfur. They found that Zn alone at 10 kg/ha gave the highest bulb yield (18.4 t/ha) and the lowest incidence of sprouting (1.9%), rotting (12.2%) and physiological weight loss (5.6%) when bulbs were stored in perforated paper sacks for up to 90 days. Zn application decreased bulb neck thickness and moisture content while S application increased them. Storing bulbs in paper sacks gave better results than hanging them in bunches.

Nagaich *et al.* (1998) obsearved in a field experiment at Gwalior where S was applied @ 0, 20, 40 or 60 kg $ha^{-1}$ and K was 0, 40, 80 or 120 kg $ha^{-1}$ to Nasik Red onions. Bulb yields increased with the increasing of S rate and it was maximum at an intermediate K rate (80 kg $ha^{-1}$).

Nasreen and Farid (2002) conducted a study on dry matter production and yield of onion (BARI Piaz-1 and Taherpuri) as influenced by sulphur fertilization with 4 levels of sulphur from (0, 20, 40 and 60 kg/ha). They indicated that dry matter was higher in Taherpuri at all growth stages. Variety Taherpuri also gave higher bulb yield. Application of 40 kg S per hectare produced tallest plant, maximum leaves per plant and highest amount of dry matter. The partitioning of dry matter into leaves accumulated more from 45 to 75 DAT for both the varieties which influenced the subsequent crop growth. There was a close relationship between dry matter and bulb yield. Diameter of bulb, single bulb weight and yield were significantly increased with application up to 40 kg per hectare and beyond this a negative response of sulphur was recorded. However, economic optimum doses of sulphur were worked out to be 36 and 39 kg per hectare giving onion yield 13.48 and 15.79 tons per hectare for BARI Piaz-1 and Taherpuri, respectively in prevailing agro-climatic conditions.

Shakirullah *et al.* (2002) conducted an experiment on the effect of different levels of sulphur on yield and pungency of onion(c.v. Swat-1 ). They found that most of the parameters were significantly affected by different levels of sulphur. The mean data indicated that maximum fresh yield (60.66 t/ha) was obtained with 160 kg S/ha while minimum fresh yield (46.500 t/ha) was obtained at 20 kg S/ha. Maximum plant height (66.44 cm) observed in plot with 100 kg S/ha and minimum plant height (56.66 cm) was observed in control. Minimum days (145.33) to harvesting were taken by crop receiving 160 kg S/ha while maximum days (186.66) to harvesting were taken by the crop receiving no sulphur. Maximum bulbs weight (156.66) was examined in treatment where sulphur was applied @ 160 kg/ha while minimum bulbs weight (120.77 gm) observed in treatment with 80 kg S/ha. Minimum number of bulbs/kg (8.633) were obtained with 160 kg S/ha while maximum number of bulbs (11.433 per kg) obtained with no sulphur. Maximum pungency (6.767 points) was found in the treatment where 160 kg S/ha was applied, while minimum pungency (3.567 points) was noted in the control.

Shamima *et al.* (2005) conducted a field experiments in Gazipur, determine the yield, content and uptake of onion cv. Faridpuri, applied with sulfur (S) at 0, 15, 30, 45, 60, 75 and 90 kg/ha. They found that S content in leaves at 45 days after transplanting (DAT) and in bulbs at 110 DAT was the highest. S content in the leaves decreased with advancement in crop age. The uptake of S into the leaves increased up to 75 DAT while bulb uptake continued to increase up to 110 DAT in all treatments. Increasing S levels up to 45 kg/ha increased the S content, uptake throughout the season and also produced the highest bulb yield. Zero kg S/ha produced the lowest bulb yield and S uptake by the plant.

## Combined effect of nitrogen and sulphur

Smittle (1984) worked on N and S nutrition on the yield, quality and storage life of Granex onion and reported that sulphur application as gypsum (600 lb gypsum/acre) consistently onion pungency and usually resulting in a lower preference for the bulbs.

A field trial was conducted by Soto (1988) with critical level for P, K and S and response to N the rate was 100 kg $ha^{-1}$ for each of N, $P_2O_5$ and $K_2O$ and 50 kg S $ha^{-1}$. The applied nitrogen @ 0, 55, 100 and 150 kg $ha^{-1}$ and observed that 50 kg N $ha^{-1}$ was the best for yield response.

Ahmed *et al.* (1988) studied different level of nitrogen (0, 60, and 120 kg /ha ) and sulphur (0. 12, 24 and 36 kg /ha ) on a local cultivar of onion, Faridpur Bhati. Both N and S significantly increased the yield. However, the combined application of N and S produced higher yield than N or S alone. Nitrogen at 60 kg /ha with Sulphur at 36 kg /ha produced maximum yield.

Singh and Dhankhar (1988) stated that higher level of N reduced bolting and increased plant growth, ascorbic acid content and yield. Potassium also reduced bolting and neck thickness and increased plant growth, yield and ascorbic acid, dry matter, sugar and S content of the bulbs.

Singh *et al.* (1996) reported that the effects of N (0, 60, 120 or 180 kg/ha) and S (0, 20, 40 or 80 kg/ha) on the growth of onions (cv. Pusa Red) were investigated in the field at Agra during 1991-93.The yield and plant N content significantly increased with increasing rate of N. Yield and plant S content significantly increased with increasing rate of S up to 40 kg S/ha. Combined addition of N + S significantly affected yield.

Anwer *et al.* (1998) observed that the application of nitrogen, phosphorus , potassium, sulphur and zinc increased number of leaves/plant along with higher bulb yield of onion with the increasing rates up to 150 kg N $ha^{-1}$, 120 kg $P_2O_5$ $ha^{-1}$, 120 kg $K_2O$ $ha^{-1}$, 20 kg S $ha^{-1}$ and 5 kg Zn $ha^{-1}$ at Jessore area.

Bybordi and Malakouti (1998) conducted two experiments on the effects of different nitrogen sources and its interaction with sulfur on onion yield and nitrate accumulation. In the first phase treatments were: control (N=0, S=0), 200 kg N/ha as urea, 200 kg N/ha as urea + 150 kg S/ha, 200 kg N/ha as ammonium nitrate + 150 kg S/ha, 200 kg N/ha as sulfur-coated urea (SCU) + 150 kg S/ha. In the second phase Fe, Mn and Zn (0, 0.002 mg/kg) and urea, ammonium nitrate and ammonium in three replications. In the first experiment results showed that ammonium nitrate and sulfur in Shabestar and urea and sulfur in Khosroshahr had the highest yield (75, 71 t/ha respectively). There was no significant difference between SCU, urea and ammonium nitrate treatments. Results of second experiment showed that 500 kg N/ha as urea+ Fe + Mn + Zn (0.002 mg/kg) has the highest yield (78.5 t/ha). The greatest accumulation (1388 mg/kg dry weight) treatment was on the urea plot. The least NO3 (325 mg/kg dry weight) was ammonium + (0.002 mg Fe/kg + 0.002 mg Mn/kg) with 71.5 t/ha yield.

Field studies with the cv. Monaich were conducted by Brown et al. (1998). They compared preplant-banded sulphur coated urea(SCU) with preplant-banded split applications of urea and found total and large bulb (  76 mm in diameter) yields, and N uptake of bulbs and leaves from SCU were significantly higher under N condition that with preplant urea, but did not significantly from those in the split urea treatments.

Harun-or-Rashid (1998) carried out a field experiment at the Bangladesh Agricultural University, Mymensingh on the effect of NPKS on growth and yield of onion at different plant spacing. He reported that the maximum bulb weight (40.50 g) and bulb yield (20.75 t $ha^{-1}$) were found from the combination of 125-150-150-30 kg N, $P_2O_5$, $K_2O$, S $ha^{-1}$, respectively whereas the minimum bulb yield (16.75 t $ha^{-1}$) was recorded from the control treatment. Application of NPKS increased the plant height, leaf number, length of bulb, bulb diameter, and bulb weight as well as the bulb yield. He recommended 100-150-200-30 kg N, $P_2O_5$, $K_2O$, S $ha^{-1}$, respectively for the cultivation of BARI peaj-1 at BAU Farm conditions.

# Chapter III

# Materials and Methods

# CHAPTER-3

# MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in the execution of the experiment.

## 3.1 Experimental Site

The experiment was carried out at the field of Horticulture Farm Sher-e-Bangla Agricultural University, Dhaka during the period from February-July, 2007. The location of the site is 23.77° N and 90.34° E Latitude and at an attitude of 8.2m from the Sea level (Anon, 1989).

## 3.2 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 $p^H$ and CEC were 5.6 and 2.64 meq/100g soil respectively. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Dhaka and details of the recorded soil characteristics were presented in Appendix I.

## 3.3 Climate

The experimental area was under the sub-tropical climate which was characterized by heavy rainfall during the months from April to September (Kharif season) and scanty in the months from October to March (Rabi season). Details of the metrological data related to the temperature, relative humidity and rainfall during the period of the experiment was collected from the Bangladesh Meteorological Department (climate division) Agargaon, Dhaka and presented in Append II.

### 3.4 Onion variety

An approved summer onion variety released by National Seed Board as BARI Peaj-3 was selected for the present study. This variety was released in 2000. The variety produces plants 35-50 cm tall with 9-10 leaves plant$^{-1}$. The diameter of bulb is 4-5 cm, mature within 90-120days and yield of bulb is about 15 to 19 t ha$^{-1}$ (Anon., 2000). The germination of the seed was 85%. Seed were collected from BARI, Joydebpur, Gazipur.

### 3.5 Treatment of the experiment

The experiment consists of 2 factors nitrogen and sulpher fertilizer. Each fertilizer has four levels. Details of factors and their combinations are presented below:

**Factor: 2 factors**

Factor A: N (4 levels of N)

1. $N_0$ = No application (0.0 kg urea/ha, control)
2. $N_1$ = 60 kg N/ha (130.43 kg urea/ha)
3. $N_2$ = 120 kg N/ha (260.86 kg urea/ha)
4. $N_3$ = 180 kg N/ha (391.29 kg urea/ha)

**Factor B**: S (4 levels of S)

1. $S_0$ = No application (control)
2. $S_1$ = 10 kg S/ha (55 kg zypsum/ha)
3. $S_2$ = 20 kg S/ha (111.10 kg zypsum/ha)
4. $S_3$ = 30 kg S/ha (166.65 kg zypsum/ha)

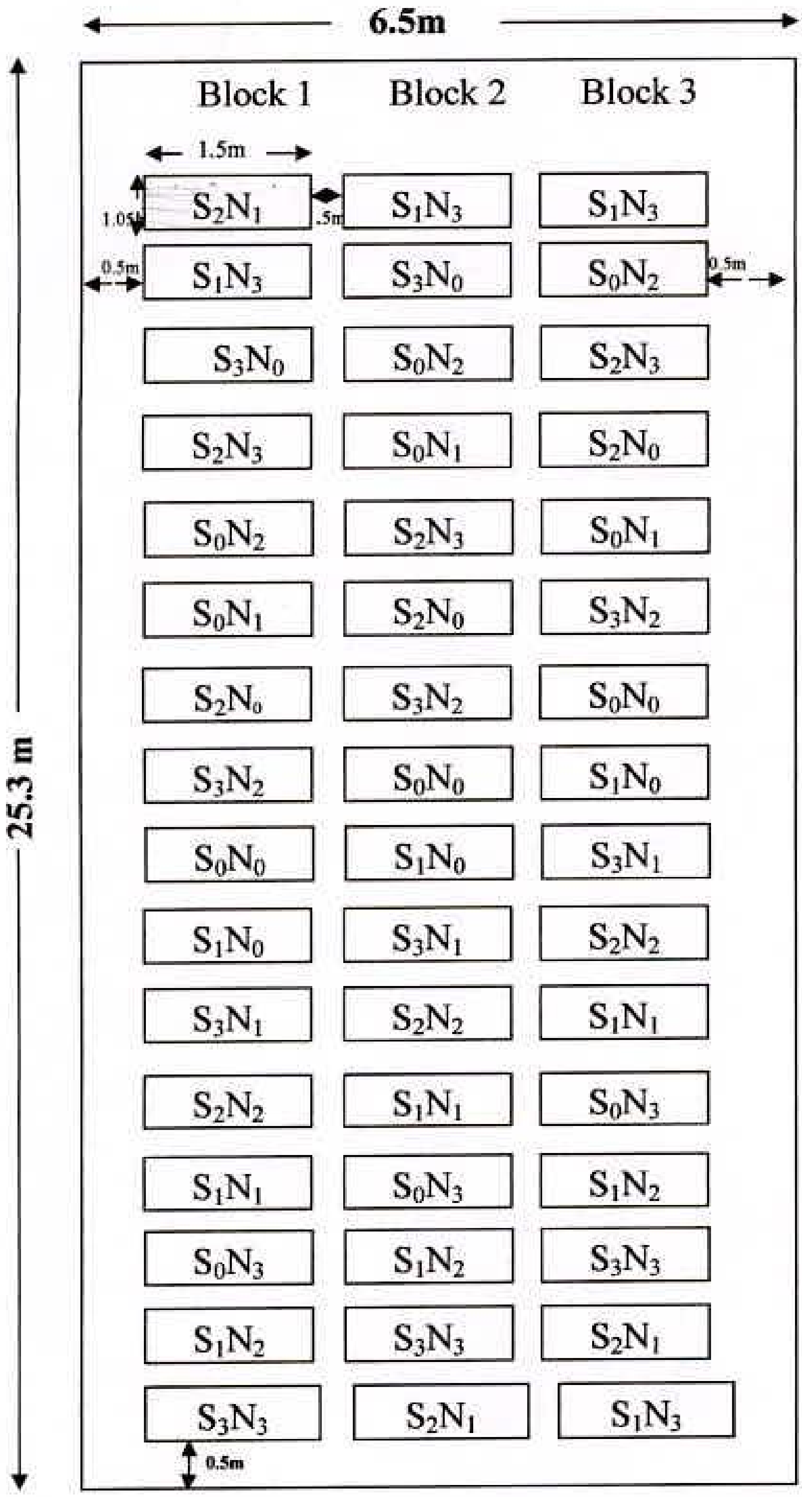
**Thus the Treatment combinations were as Follows:**

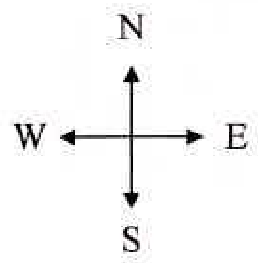
$N_0S_0$, $N_0S_1$, $N_0S_2$, $N_0S_3$, $N_1S_0$, $N_1S_1$, $N_1S_2$, $N_1S_3$, $N_2S_0$, $N_2S_1$, $N_2S_2$, $N_2S_3$, $N_3S_0$ $N_3S_1$, $N_3S_2$, $N_3S_3$.

### 3.6 Design and layout of the experiment

The experiment was laid out in a two factor Randomized Complete Block Design with three replications. The total number of plots was 48, each measuring 1.5m × 1.05m. The treatment combinations of the experiment were assigned at random into 16 plots of each at 3 replications. The spacing between plant to plant and row to row was 10cm and 15cm respectively and each unit plot containing 105. The distance maintained between two plots was 50 cm and between blocks was 50cm.Thelayout of the experiment is presented in Figure-I.

**Layout of the experiment:**




Plot size =1.50 m × 1.05 m
Spacing: 15 cm × 10 cm
Plant to plant spacing =10 cm
Row to row spacing =15 cm
Plot spacing = 0.5 m
Between replication=0 .5 m

Factor A:
$N_0$: Control 0kg N/ha
$N_1$: 60 kg N/ha
$N_2$: 120 kg N/ha
$N_3$: 180 kg N/ha

Factor B:
$S_0$: Control 0 kg S/ha
$S_1$:10 kg S/ha
$S_2$: 20 kg S/ha
$S_3$: 30 kg S/ha

Figure 1. Field layout of two factors experiment in the Randomized Complete Block Design (RCBD)

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### 3.7 Seedbed preparation

The land selected for raising seedlings was fine texture and well drained. The land was opened and drying for 10 days. Large sized clods were broken into pieces and finally the soil was made loose, friable, until good tilth . All weeds and stubbles were removed and the soil was mixed with decomposed cowdung during final land preparation. Applying Furadan 3 G @ 20 kg $ha^{-1}$ was covered by polythene for two days. The seedbed was 3 m × 1 m in size with a height of about 20 cm. Onion seeds were soaked overnight (twelve hours) in water and allowed to sprout in a piece of moist cloth keeping in the sunshade for one day.

### 3.8 Seed sowing

The date of seed sowing was 07th March 2007. The sprouted seeds (3-4 in number) were sown directly in the raised seedbed for raising seedling which will be transplanted. The young seedlings were exposed to dew by night and mid sunshine in the morning and evening. Shade was given over the seedbeds to retain soil moisture and to save the seedlings from direct sun and rain. When the seedlings of the seedbeds attained a height of about 10 cm, thinning operation was done keeping only healthy seedling in right place.

### 3.9 Land preparation

The experimental plot was opened in the month of April 2007 with the help of a tractor. Thereafter, the land was prepared by several ploughings and cross ploughing with a power tiller followed by laddering. Weeds and stubbles were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of friable soil for transplanting the seedlings.

### 3.10 Manures and fertilizers:

Manures and fertilizers were used in the experiment according to the recommendation of BARI (Anon., 2000) as follows:

| | |
|---|---|
| Manures/fertilizer | : Dose/ha |
| Cow dung | : 20/t /ha |
| Urea | : as per level of treatment. |
| Zypsum | : as per level of treatment. |
| Triple super phosphate (TSP) | : 250 kg/ha |
| Muriate of potash (MP) | : 120 kg/ha |

### 3.11 Application of fertilizers and manure

Total cowdung + full amount of TSP + full amount of MP + full amount of Zypsum are applied in the field as basal dose during final land preparation. Urea was applied as top dressing in 3 equal splits at 15 days intervals.

### 3.12 Transplanting of seedlings

Healthy and disease free uniform sized 40 days old seedlings were uprooted from the seedbeds and transplanted in the main field with the line to line of spacing 15 cm and plant to plant spacing of 10 cm in the afternoon on 16th April 2007. The seedbed was watered before uprooting the seedlings so as to minimize the damage of roots. The seedlings were watered immediately after transplanting. Some seedlings were also transplanted adjacent to the experimental area to be used for gap filling.

### 3.13 Intercultural operation

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

### 3.14 Gap filling

Damaged or dead seedlings were replaced by healthy plant within one week of transplantation.

### 3.15 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.

### 3.16 Irrigation and drainage

Irrigation was given when needed. First irrigation was given just after transplanting and also at 20 days after transplanting. During this time care was taken so that irrigated water could not pass from one plot to another. Mulching was also done after each irrigation at appropriate time by breaking the soil crust. During each irrigation, the soil was made saturated with water. After rainfall excess water was drained out when necessary.

### 3.17 Plant protection

**Insects:** Preventive measure was taken against soil borne insects. For the prevention of cutworm, Furadan 3 G @ 20 kg $ha^{-1}$ was applied. No insect pest infestation was found in the field after pesticide application.

**Disease:** Few days after transplanting some plants were attacked by purple blotch disease caused by *Alternaria puri.* It was controlled by spraying Ruvral 50 WP four times at 10 days interval after transplanting.

### 3.18 Harvesting

The crops were harvested on 20 July, 2007 according to their attainment of maturity showing the sign of drying out of most of the leaves and collapsing at the neck of the bulbs.

### 3.19 Sampling at harvest

Ten plants were randomly selected from each plot to record data at harvesting period, i.e. diameter of bulb per plant (cm), length of bulb per plant (cm), single weight of bulb (g) and yield of bulb (t $ha^{-1}$).

### 3.20 Collection of data

Data were recorded on the following parameters from the sample plants during the course of experiment. Five plants were randomly selected from each plot to record data, in such a way the border effect was avoided for the highest precision.

1. Plant height (cm)
2. Leaf height (cm)
3. Number of leaves per plant
4. Length of bulb (cm)
5. Fresh weight of single bulb (g)
6. Pseudostem diameter(cm)
7. Diameter of bulb per plant (cm)
8. Dry mater content of bulb (%)
9. Yield of bulb per plot(kg)
10. Yield of bulb per hectare (t)

#### 3.20.1 Plant height (cm)

The height of the randomly selected 10 plants in each plot was recorded after 40, 55, 70 and 85 days after transplanting (DAT). The height was measured in centimeters (cm) from the neck of the bulb to the tip of the longest leaf and average heights of the selected Ten plants were taken to observe the rate of growth.

### 3.20.2 Leaf length (cm)

The length of leaf was measured in centimeter from pseudostem to the tip of the leaf from Ten randomly selected plants at 40, 55 , 70 and 85 DAT and their average was recorded.

### 3.20.3 Number of leaves per plant

The numbers of leaves per plant from randomly selected plants were recorded at 40, 55, 70 and 85 DAT and the average of 10 plants was taken as the number of leaves per plant.

### 3.20.4 Length of bulb per plant (cm)

At harvest the length of bulb was measured with a slide caliper from the neck to the bottom of the bulb from ten randomly selected plants from each plot and their average was taken.

### 3.20.5 Diameter of bulb (cm)

At harvest the diameter of bulb was measured at the middle portion of bulb from 10 randomly selected plants from each plot with a slide caliper and their average was recorded.

### 3.20.6 Pseudostem diameter (cm)

Diameter of pseudostem was measured at the neck of Ten randomly selected plants with a slide caliper at harvest and their average was taken as the diameter of pseudostem.

### 3.20.7 Fresh weight of single bulb

Ten randomly selected plants from each unit plot were harvested. The top was removed by cutting pseudostem keeping only 2.5 cm with the bulb.Ten bulbs were weighed by an electric balance and their average was considered as the individual bulb weight.

### 3.20.8 Dry mater content of bulb (%)

Hundred gram of fresh onion was collected from the sliced of 10 unit bulbs. The bulbs were sliced with a sharp knife. The fresh sample was dried in the sun and then it was kept in an oven at $70^0$C for 72 hours until constant weight. The percentage of bulb dry matter content was calculated by the following formula.

$$\% \text{ Dry matter content of bulb} = \frac{\text{Constant weight of bulb}}{\text{Fresh weight of bulb}} \times 100$$

### 3.20.9 Yield of bulb per plot (kg)

All the leaves along with pseudostem were removed from the plant keeping only 2.5 cm neck. Then the weight of the bulbs was taken by a simple balance in kilogram (kg) from each unit plot separately.

### 3.20.10 Yield of bulb per hectare (ton)

The yield of bulb per plot was converted to get yield in tones per hectare.

### 3.21. Statistical analysis

The collected data on various parameters under study were statistically analysed to find out the statistical significance of the experimental results The means of all the treatments were calculated and analyses of variance or all the characters were performed by F-test variance . The significance of the difference among the mean was evaluated by Duncann's Multiple Range Test (DMRT) ( Gomez and Gomez, 1984).

# Chapter IV

# Results and Discussion

# CHAPTER -4

# RESULTS AND DISCUSSION

The experiment was conducted to investigate the effects of nitrogen and sulphur on the growth and yield of summer onion. Data on different parameters were analyzed statistically and results have been presented in tables 1 to 6 and figures 2 to 9. The results of the present study have been presented and discussed in this chapter under the following heading.

## 4.1 Plant height

Plant height was significantly variation was found due to the application of different levels of nitrogen treatment at different days after transplantation except 55 DAT. The plant height increased gradually with the advancement of time and continued up to 70 days after transplanting (DAT) and then after decreasing trends due to senescence of plant. The tallest plant (37.50cm) was produced by $N_2$ (120 kg N/ha) and the shortest plant (32.98 cm) was recorded from no. at 40 DAT. At 55 DAT the longest (47.82 cm) plant was found from $N_2$ while the shortest plant (43.97 cm) was found from $N_0$. The tallest plant (54.55cm) was performed by $N_2$ where the shortest plant (47.06 cm) was recorded from control treatment at 70 DAT. At 85 DAT, with the application of 120 kg N/ha ($N_2$) showed that plant tallest height (36.78) and the control treatment gave the shortest (34.02cm) plant height (Fig. 2). Bhordwaj *et al.* (1991) and Hoque and Mamum (2000) also found taller plants with increasing levels of nitrogen.

Plant height was significantly varied due to the application of different levels sulphur treatment at 40, 55, 70 and 85 DAT. The plant height increased gradually with the advancement of time and continued up to 70 days after transplanting (DAT) and decreasing trends due to senescence of plant. The longest (39.44cm) plant was obtained from $S_3$ when as the shortest (33.38cm) plant was found from $S_0$ (control condition) at 40 DAT. At 55 DAT the tallest (50.04cm) plant was recorded from $S_3$ (30 kg S/ha) and the shortest (40.13cm) plant was found from control ($S_0$). At 70 DAT, the longest (56.87cm) plant was performed by treatment $S_3$ while the shortest (47.83cm) was obtained from $S_0$. The longest (40.47cm) plant was recorded from $S_3$ treatment and treatment $S_0$ (control condition) gave the shortest (29.80cm) plant height (Fig. 3). This result is agreed with the findings of Nasiruddin *et al.* (1993).

Due to combined effect of different levels of nitrogen and sulphur treatment showed significant variation on plant height at different date. The highest plant height (45.87cm) was obtained from $N_2S_3$ (120 kg N/ha and 30 kg S/ha) treatment while the lowest plant height (17.23cm) was obtained from the treatment combination of $N_0S_0$ (control nitrogen and sulphur) treatment at 40 DAT. At 55 DAT, the longest (60.67 cm) plant was obtained from treatment combination of $N_2S_3$ where as the shortest (22.20 cm) was obtained from control ($N_0S_0$) condition. The tallest plant height (66.63cm) was recorded from $N_2S_3$ and the treatment combination of $N_0S_0$ gave the shortest (25.67 cm) plant height at 70 DAT. At 85 DAT, the longest (43.86cm) plant height was recorded from $N_2S_3$ while the shortest (20.33cm) was found from $N_0S_0$. The plant height increased at different days with different combined treatments (Table 1). This result is agreed with the findings of Harun-or-Rashid (1998).

### 4.2 Number of leaves per plant

Number of leaves was significantly variation was found due to the application of different levels of nitrogen treatment at 55, 70 and 85 DAT except 40 DAT. The number of leaves per plant increased gradually with the advancement of time and continued up to 70 days after transplanting (DAT) and then after decreasing trends due to senescence of plant. The number of leaves per plant was the maximum (6.75) number of leaves produced by $N_2$ (120 kg N/ha) when the minimum number of leaves (5.33) from $N_0$ (control condition) at 40 DAT.

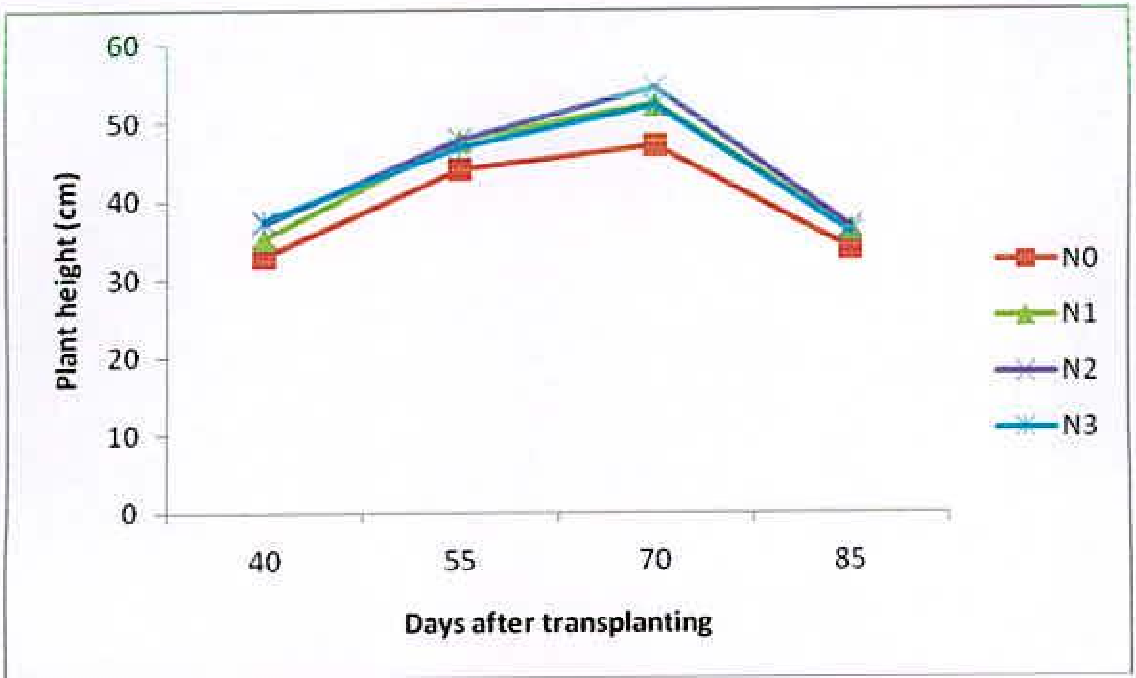


**Figure 2. Effect of nitrogen on the plant height of onion at different days after transplanting.**

**$N_0$=0 kg N/ha, $N_1$=60 kg N/ha, $N_2$=120 kg N/ha and $N_3$=180 kg N/ha**

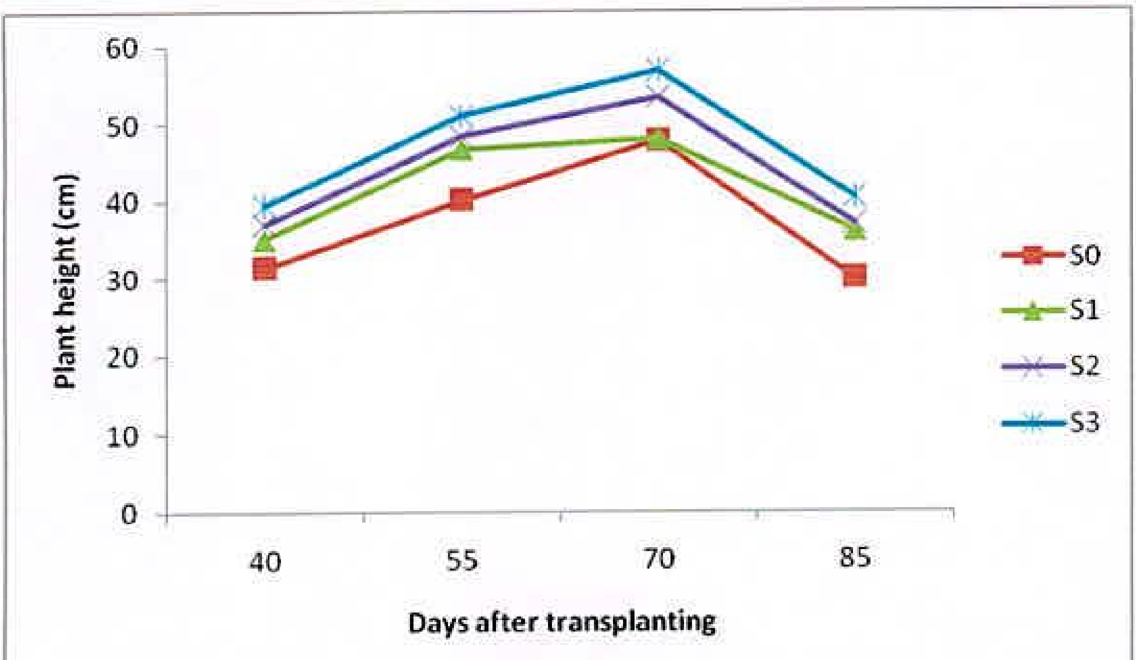


**Figure 3. Effects of sulphur on the plant height of onion at different days after transplanting.**

**$S_0$=0 kg S/ha, $S_1$=10 kg S/ha, $S_2$=20 kg S/ha and $S_3$=30 kg S/ha**

**Table 1.Combined effect of level of sulphur and level of nitrogen on the plant height of onion**

| Treatment | Plant height | | | |
|---|---|---|---|---|
| | 40 DAT | 55 DAT | 70 DAT | 85 DAT |
| $N_0S_0$ | 17.23i | 22.20j | 25.67 | 20.33i |
| $N_0S_1$ | 39.40bcd | 47.81ef | 48.77efg | 35.53de |
| $N_0S_2$ | 40.22bc | 52.43bcd | 55.67bcd | 39.67bc |
| $N_0S_3$ | 35.13ef | 53.43b | 58.13b | 40.53b |
| $N_1S_0$ | 38.42cde | 48.37ef | 56.07bcd | 36.42d |
| $N_1S_1$ | 25.72h | 47.22efg | 42.73hi | 33.97ef |
| $N_1S_2$ | 40.39bc | 49.17ef | 57.36bc | 36.37d |
| $N_1S_3$ | 36.96de | 46.03fg | 53.27cde | 38.82bc |
| $N_2S_0$ | 39.37bcd | 50.16de | 57.57bc | 30.44h |
| $N_2S_1$ | 33.69f | 38.76i | 45.77gh | 34.42ef |
| $N_2S_2$ | 29.79g | 41.80hi | 48.23fg | 38.53c |
| $N_2S_3$ | 45.87a | 60.67a | 66.63a | 43.86a |
| $N_3S_0$ | 30.92g | 39.87i | 52.05def | 32.07gh |
| $N_3S_1$ | 41.26b | 53.35bc | 54.93bcd | 40.07bc |
| $N_3S_2$ | 38.04cde | 50.13cd | 52.57def | 33.43fg |
| $N_3S_3$ | 39.90bcd | 44.07gh | 49.43efg | 38.73c |
| $LSD_{(0.05)}$ | 2.760 | 3.009 | 4.192 | 1.676 |
| Level of significant | * | * | * | * |
| CV (%) | 4.82 | 7.42 | 6.93 | 5.44 |

In a column same letter(s) do not significantly differ at 0.05 level of probability.

* Significant at 5% level

$N_0$=0 kg N/ha $S_0$=0 kg S/ha

$N_1$=60 kg N/ha $S_1$=10 kg S/ha

$N_2$=120 kg N/ha $S_2$=20 kg S/ha

$N_3$=180 kg N/ha $S_3$=30 kg S/ha

At 55 DAT the maximum (6.82) number of leaves was found from $N_2$ while the minimum number of leaves (5.53) was found from $N_0$. The maximum (7.43) number of leaves was performed by $N_2$ where the minimum (5.3) number of leaves was recorded from control treatment at 70 DAT. At 85 DAT, with the application of 120 kg N/ha ($N_2$) showed that maximum (5.91) number of leaves and the control treatment gave the minimum (4.08) number of leaves (Fig. 4). This finding agrees with the results of Bhuiyan (1979) who obtained higher number of onion leaves with application of nitrogen.

Number of leaves was no significantly varied due to the application of different levels sulphur treatment at 40, 55, 70 DAT except 85 DAT. The number of leaves increased gradually with the advancement of time and continued up to 70 days after transplanting (DAT) and decreasing trends due to senescence of plant. Maximum number (6.78) of leaves produced by $S_3$ (30 kg S/ha) when the minimum number of leaves (5.38) from $S_0$(control condition) at 40 DAT. At 55 DAT the maximum number (6.98) of leaves at $S_3$ (30 kg S/ha) and the minimum number of leaves (5.55) from control ($S_0$). At 70 DAT, the maximum number (6.92) of leaves at treatment $S_3$ while the minimum number (5.69) of leaves from $S_0$. The maximum number (5.79) of leaves was recorded from $S_3$ treatment and treatment $S_0$ (control condition) gave the minimum number (3.65) of leaves (Fig. 5).

Due to combined effect of different levels of nitrogen and sulphur treatment showed significant variation on number of leaves per plant at different DAT. The maximum (8.53) number of leaves was obtained from $N_2S_3$ (120 kg N/ha and 30 kg S/ha) treatment while the minimum (3.00) number of leaves was obtained from the treatment combination of $N_0S_0$ (control nitrogen and sulphur) treatment at 40 DAT. At 55 DAT, maximum (8.73) number of leaves was obtained from treatment combination of $N_2S_3$ where as the minimum (4.82) number of leaves was obtained from control ($N_0S_0$) condition. The maximum (8.80) number of leaves was recorded from $N_2S_3$ and the treatment combination of $N_0S_0$ gave the minimum (4.82) number of leaves at 70 DAT. At 85 DAT, the highest number of leaves was recorded from $N_2S_3$ whereas the lowest number of leaves per plant was found from $N_0S_0$ (Table 2). This result is agreed with the findings of Anwer *et al.* (1998)

**4.3 Length of leaf**

Length of leaf was significantly variation was found due to the application of different levels of nitrogen treatment at different days after transplanting except 55 and 85 DAT. The plant height increased gradually with the advancement of time and continued up to 70 days after transplanting (DAT) and then after decreasing trends due to senescence of plant. The maximum (33.61cm) length of leaf was produced by $N_2$ (120 kg N/ha) and the minimum (30.82cm) length of leaf was recorded from no. at 40 DAT. At 55 DAT the highest (44.34 cm) length of leaf was found from $N_2$ while the shortest length of leaf (35.90 cm) was found from $N_0$. The highest length of leaf (50.38 cm) was performed by $N_2$ where the shortest length of leaf (44.89 cm) was recorded from control treatment at 70 DAT. At 85 DAT, with the application of 120 kg N/ha ($N_2$) showed that maximum (34.88cm) length of leaf and the control treatment gave the minimum (29.18cm) length of leaf(Fig. 6). This finding agrees with the results of Baloch et al. (1991) who obtained highest leaf height of onion leaves with application of nitrogen.

Length of leaf was significantly varied due to the application of different levels sulphur treatment at 40, 55, 70 and 85 DAT. The length of leaf increased gradually with the advancement of time and continued up to 70 days after transplanting (DAT) and decreasing trends due to senescence of plant. The maximum (34.88cm) length of leaf was obtained from $S_3$ when as the minimum (30.30cm) plant was found from $S_0$(control condition) at 40 DAT. At 55 DAT the highest (43.72cm) leaf length was recorded from $S_3$ (30 kg S/ha) and the lowest (38.81cm) leaf length was found from control ($S_0$).

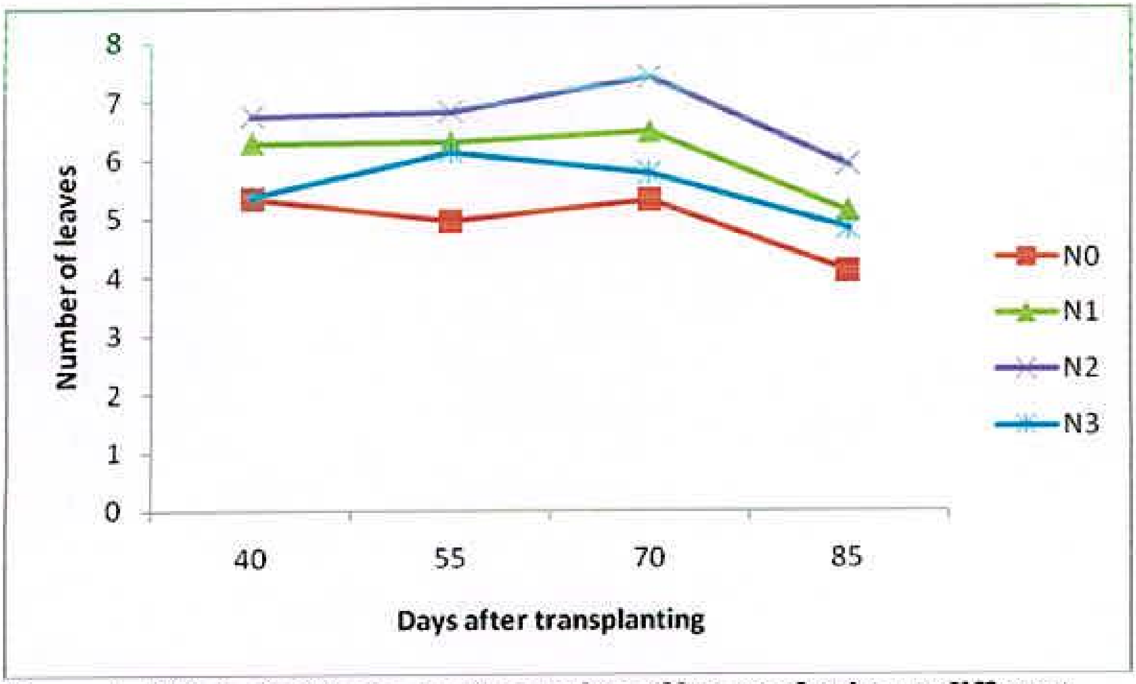


**Figure 4. Effect of nitrogen on the number of leaves of onion at different days after transplanting.**

**$N_0$=0 kg N/ha, $N_1$=60 kg N/ha, $N_2$=120 kg N/ha and $N_3$=180 kg N/ha**

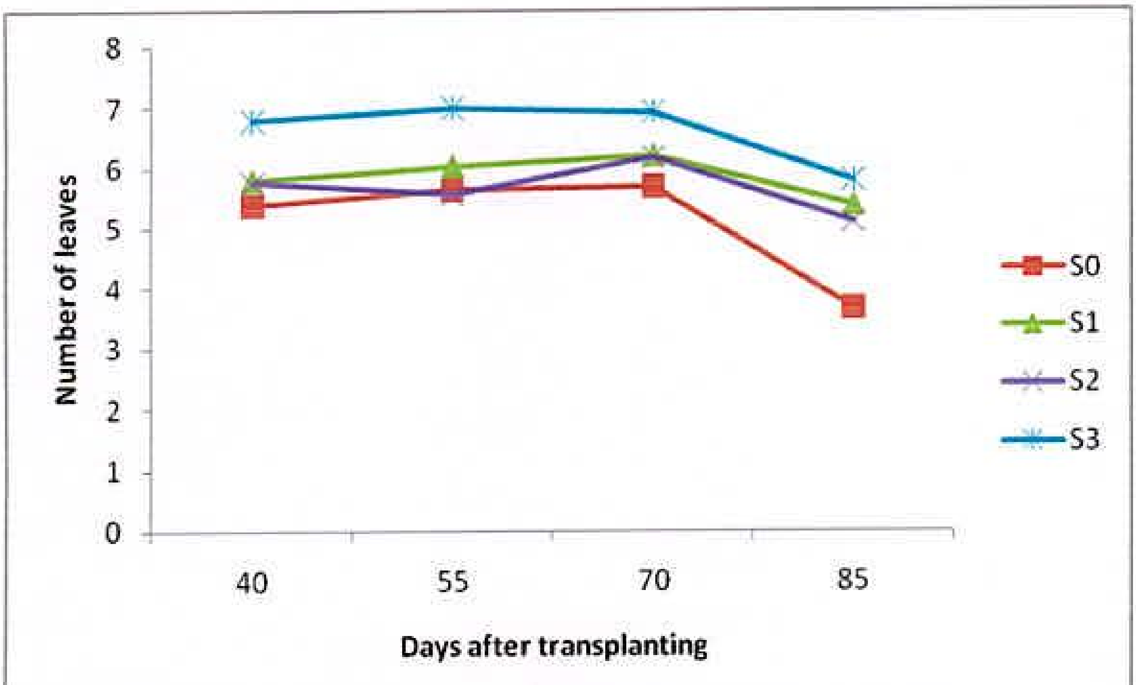


**Figure 5. Effects of sulphur on the number of leaves of onion at different days after transplanting.**

**$S_0$=0 kg S/ha, $S_1$=10 kg S/ha, $S_2$=20 kg S/ha and $S_3$=30 kg S/ha**

**Table 2. Combined effects of nitrogen and sulphur on the leaf number of onion.**

| Treatment | number of Leaves | | | |
|---|---|---|---|---|
| | 40 DAT | 55 DAT | 70 DAT | 85 DAT |
| $N_0S_0$ | 3.00e | 3.13e | 3.73e | 2.27f |
| $N_0S_1$ | 5.67bcd | 5.81bcd | 5.84de | 4.93bcd |
| $N_0S_2$ | 5.97bcd | 4.67d | 5.85bcd | 4.67cde |
| $N_0S_3$ | 6.67bc | 6.20bc | 6.73b | 4.47cde |
| $N_1S_0$ | 6.13bcd | 6.41b | 6.97b | 4.40de |
| $N_1S_1$ | 5.53bcd | 5.81bcd | 6.13bcd | 5.21bcd |
| $N_1S_2$ | 5.93bcd | 6.67b | 6.33bcd | 5.73bc |
| $N_1S_3$ | 7.53ab | 6.33bc | 6.47bc | 5.13bcd |
| $N_2S_0$ | 6.53bc | 7.08b | 6.87b | 4.27de |
| $N_2S_1$ | 6.47bc | 5.93bc | 7.08b | 6.00b |
| $N_2S_2$ | 5.47cd | 5.07cd | 6.47bc | 5.33bcd |
| $N_2S_3$ | 8.53a | 9.27a | 9.37a | 8.03a |
| $N_3S_0$ | 5.87bcd | 6.03bc | 5.20cd | 3.67e |
| $N_3S_1$ | 5.53bcd | 6.60b | 6.73b | 5.40bcd |
| $N_3S_2$ | 5.67bcd | 5.80bcd | 6.07bcd | 4.67cde |
| $N_3S_3$ | 4.37de | 6.13bc | 5.16cd | 5.53bcd |
| $LSD_{(0.05)}$ | 1.719 | 1.121 | 1.284 | 1.085 |
| Level of significant | * | * | * | * |
| CV (%) | 9.76 | 8.99 | 8.55 | 9.06 |

In a column same letter(s) do not significantly differ at 0.05 level of probability.

* Significant at 5% level

$N_0$=0 kg N/ha $S_0$=0 kg S/ha

$N_1$=60 kg N/ha $S_1$=10 kg S/ha

$N_2$=120 kg N/ha $S_2$=20 kg S/ha

$N_3$=180 kg N/ha $S_3$=30 kg S/ha

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At 70 DAT, the longest (50.45cm) length of leaf was performed by treatment $S_3$ while the shortest (45.92cm) was obtained from $S_0$. The highest (34.94cm) plant was recorded from $S_3$ treatment and treatment $S_0$ (control condition) gave the shortest (29.98cm) plant height (Fig. 7). Increasing level of nutrient increased the plant height as well as the length of leaf. This result is agreed with the findings of Harun-or-Rashid (1998).

Due to combined effect of different levels of nitrogen and sulphur treatment showed significant variation on length of leaf at different date. The highest length of leaf (38.90cm) was obtained from $N_2S_3$ (120 kg N/ha and 30 kg S/ha) treatment while the lowest length of leaf (25.27cm) was obtained from the treatment combination of $N_0S_0$ (control nitrogen and sulphur) treatment at 40 DAT. At 55 DAT, the maximum (54.50cm) length of leaf was obtained from treatment combination of $N_2S_3$where as the minimum (27.80 cm) was obtained from control ($N_0S_0$) condition. The highest (60.53cm) length of leaf was recorded from $N_2S_3$ and the treatment combination of $N_0S_0$ gave the shortest (38.00 cm) length of leaf at 70 DAT. At 85 DAT, the maximum (40.20cm) length of leaf was recorded from $N_2S_3$while the minimum (23.93 cm) was found from $N_0S_0$ (Table 3).

### 4.4 Diameter of bulb

There is no significant variation was found in the diameter of bulb of onion due to application of different levels of nitrogen (appendix iv). The highest (3.857 cm) diameter of bulb was recorded obtained from 120 kg N/ha $N_2$ and the lowest (3.09 cm)was found from control ($N_0$) treatment (Table 4). The diameter of bulb increased with the increase in the level of nitrogen. Verma *et al.* (1972) observed that bulb increased in response of N at 200 kg/ha .The higher rate of nitrogen was not found economic. Vacchani and Patel (1993) observed the highest bulb diameter from the application of 150 kg N/ha.

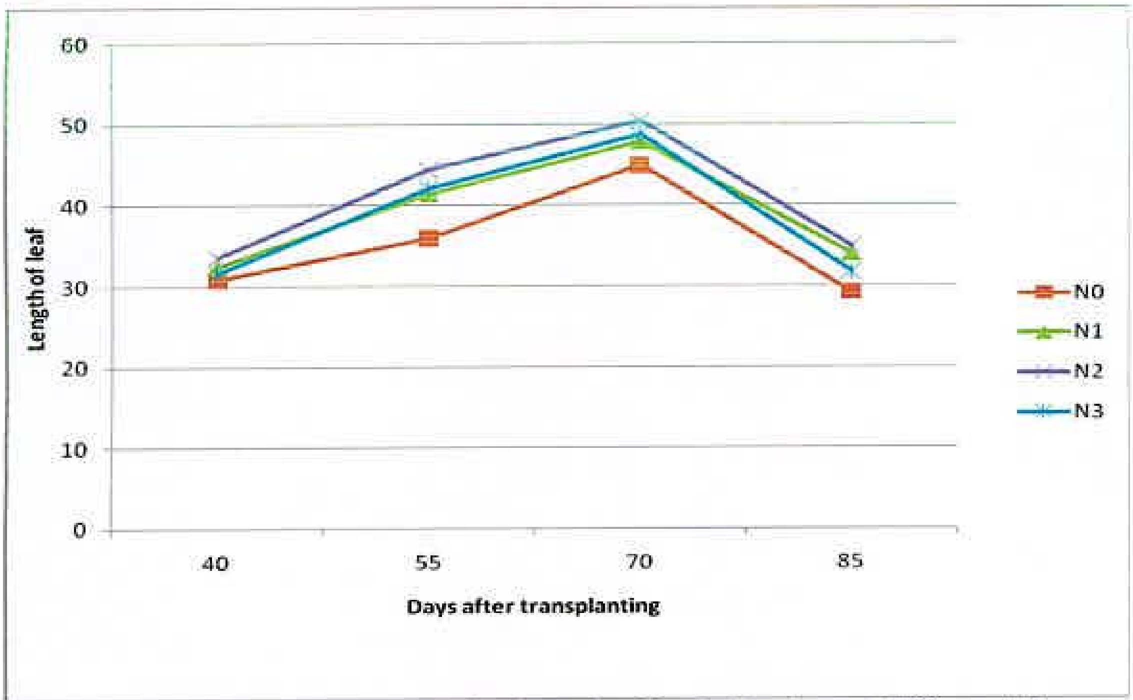


**Figure 6. Effect of nitrogen on the length of leaf of onion at different days after transplanting.**

**$N_0$=0 kg N/ha, $N_1$=60 kg N/ha, $N_2$=120 kg N/ha and $N_3$=180 kg N/ha**

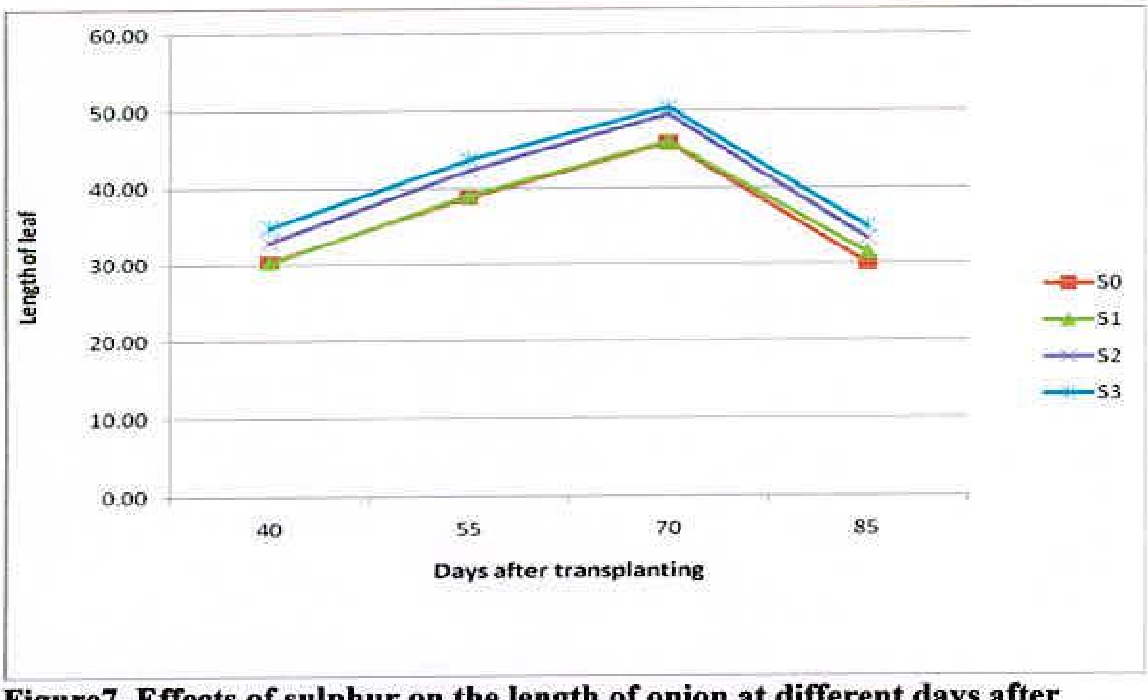


**Figure7. Effects of sulphur on the length of onion at different days after transplanting.**

**$S_0$=0 kg S/ha, $S_1$=10 kg S/ha, $S_2$=20 kg S/ha and $S_3$=30 kg S/ha**

**Table 3. Combined effects of nitrogen and sulphur on the length of leaf of onion.**

| Treatment | Leaf length | | | |
|---|---|---|---|---|
| | 40 DAT | 55 DAT | 70 DAT | 85 DAT |
| $N_0S_0$ | 25.70hi | 27.80j | 38.00i | 23.93i |
| $N_0S_1$ | 35.37b | 38.83fg | 47.13d-g | 29.47gh |
| $N_0S_2$ | 34.57bc | 39.47fg | 47.73def | 31.60efg |
| $N_0S_3$ | 27.63gh | 37.50gh | 46.70d-h | 31.73d-g |
| $N_1S_0$ | 32.60cde | 43.53de | 48.70c-f | 33.40c-f |
| $N_1S_1$ | 31.77de | 34.13i | 43.33gh | 31.00fgh |
| $N_1S_2$ | 34.80bc | 43.93d | 50.77bcd | 37.87b |
| $N_1S_3$ | 30.30ef | 44.10d | 48.47c-f | 33.63cde |
| $N_2S_0$ | 35.43b | 47.03bc | 51.90bc | 33.20c-f |
| $N_2S_1$ | 31.60de | 35.03hi | 42.80h | 31.20e-h |
| $N_2S_2$ | 28.50ef | 40.80ef | 46.27e-h | 34.90c |
| $N_2S_3$ | 38.90a | 54.50a | 60.53a | 40.20a |
| $N_3S_0$ | 27.60gh | 36.87ghi | 45.23fgh | 29.40gh |
| $N_3S_1$ | 40.80a | 47.83b | 50.40b-e | 34.27cd |
| $N_3S_2$ | 33.77bcd | 44.77cd | 53.27b | 29.03h |
| $N_3S_3$ | 24.43i | 38.77fg | 46.10fgh | 34.20cd |
| $LSD_{(0.05)}$ | 2.443 | 2.77 | 3.679 | 2.256 |
| Level of significant | * | * | * | * |
| CV (%) | 7.34 | 5.95 | 6.97 | 5.47 |

In a column same letter(s) do not significantly differ at 0.05 level of probability.

* Significant at 5% level

$N_0$=0 kg N/ha $S_0$=0 kg S/ha

$N_1$=60 kg N/ha $S_1$=10 kg S/ha

$N_2$=120 kg N/ha $S_2$=20 kg S/ha

$N_3$=180 kg N/ha $S_3$=30 kg S/ha

No significant variation on diameter of bulb of onion due to application of different levels sulphur(appendix iv). The highest (3.99 cm) diameter of bulb was recorded from 30 kg S/ha ($S_3$) and the lowest (3.16 cm) by the control ($S_0$) treatment (Table 5). The diameter of bulb increased with the increase in the level of sulphur. Nasiruddin *et al.* (1993) found that the highest bulb diameter from 100 kg MOP and 30 kg S/ha.

The combined effect showed significant effect of on diameter of bulb due to application of different levels of nitrogen and sulphur (appendix iv). The diameter of bulb ranged from 2.6 to 4.95 cm. The highest (4.95 cm) diameter of bulb was recorded from the treatment combination of $N_2S_3$ (120 kg N/ha and 30 kg S/ha), whereas the lowest (2.16 cm) bulb diameter was observed from $N_0S_0$ (control nitrogen and sulphur) (Table 6). This result is agreed with the findings of Harun-or-Rashid (1998)

**4.5 Length of bulb**

The variation in length of bulb among different levels of nitrogen was not found to be statistically significant (appendix iv). The maximum (4.09 cm) length of bulb was found from the rate of 120 kg N/ha and the minimum (3.204 cm) was observed from control (Table 4). Rodriquez *et al.* (1999) reported significant effect N application on the number of leaves and plant height, and significant increase in bulb length with N applications.

The length of bulb of onion was no significantly influenced by the application of different levels of sulphur (appendix iv). The length bulb of onion was observed to be gradually increased with increasing levels of sulphur. The length of bulb was produced the highest (4.26 cm) when applied 30 kg S/ha ($S_3$). However, the lowest length of bulb (3.41 cm) was obtained from $S_0$ treatment (Table 5).

**Table 4. Main effect of nitrogen on the growth and yield of onion**

| Treatment | Diameter of bulb (cm) | Length of bulb (cm) | Pseudostem diameter (cm) | Fresh weight of bulb (gm) | Dry matter content of bulb (%) | Bulb yield (kg/plot) |
|---|---|---|---|---|---|---|
| $N_0$ | 3.09 | 3.20 | 1.32 | 41.88b | 8.42 | 4.39 |
| $N_1$ | 3.75 | 3.51 | 1.47 | 48.01a | 8.48 | 4.82 |
| $N_2$ | 3.86 | 4.09 | 1.61 | 49.38a | 8.71 | 5.45 |
| $N_3$ | 3.60 | 3.86 | 1.41 | 46.27ab | 8.55 | 4.76 |
| $LSD_{(0.05)}$ | 2.063 | 2.750 | 0.789 | 5.733 | 0.963 | 0.482 |
| Level of significant | NS | NS | NS | * | NS | * |
| CV (%) | 9.28 | 8.12 | 8.75 | 7.79 | 8.13 | 9.16 |

In a column same letter(s) do not significantly differ at 0.05 level of probability.

NS- non significant

* Significant at 5% level

$N_0$=0 kg N/ha
$N_1$=60 kg/ha
$N_2$=120 kg/ha
$N_3$=180 kg N/ha

**Table 5. Main effect of sulphur on the growth and yield of onion**

| Treatment | Diameter of bulb (cm) | Length of bulb (cm) | Pseudostem diameter (cm) | Fresh weight of bulb (gm) | Dry matter content of bulb (%) | Bulb yield (kg/plot) |
|---|---|---|---|---|---|---|
| $S_0$ | 3.16 | 3.41 | 1.34 | 45.46 | 8.95 | 4.35 |
| $S_1$ | 3.35 | 3.46 | 1.42 | 44.03 | 8.98 | 5.01 |
| $S_2$ | 3.80 | 3.52 | 1.46 | 47.25 | 9.06 | 5.02 |
| $S_3$ | 3.99 | 4.26 | 1.58 | 48.80 | 9.30 | 5.05 |
| $LSD_{(0.05)}$ | 1.382 | 1.972 | 0.625 | 5.620 | 3.891 | 2.168 |
| Level of significant | NS | NS | NS | NS | NS | NS |
| CV (%) | 9.28 | 8.12 | 8.75 | 7.79 | 8.13 | 9.86 |

In a column same letter(s) do not significantly differ at 0.05 level of probability.

NS- non significant

$S_0$=0 kg S/ha
$S_1$=10 kg S/ha
$S_2$=20 kg S/ha
$S_3$=30 kg S/ha

**Table 6.Combined effects of nitrogen and sulphur on the yield components and yield of onion.**

| Treatment | Diameter of bulb | Length of bulb | Pseudostem diameter | Fresh weight of bulb | Dry matter content of bulb (%) | Yield (kg/plot) | Yield (t/ha) |
|---|---|---|---|---|---|---|---|
| $N_0S_0$ | 2.16d | 2.98b | 1.25b | 33.27g | 8.03 | 3.62b | 11.71b |
| $N_0S_1$ | 3.40c | 3.20b | 1.25b | 42.53def | 8.66 | 4.9ab | 15.81ab |
| $N_0S_2$ | 3.51bc | 2.88b | 1.40b | 43.47f | 8.51 | 4.6ab | 14.84ab |
| $N_0S_3$ | 3.29c | 3.76b | 1.69ab | 48.27bcd | 8.65 | 4.44ab | 14.32ab |
| $N_1S_0$ | 3.39c | 3.63b | 1.54b | 52.03ab | 8.81 | 4.42ab | 14.26ab |
| $N_1S_1$ | 3.08c | 3.00b | 1.46b | 41.53f | 8.60 | 4.33ab | 13.97ab |
| $N_1S_2$ | 4.46ab | 3.38b | 1.60b | 47.53cde | 8.55 | 5.1ab | 16.45ab |
| $N_1S_3$ | 4.05abc | 4.02b | 1.28b | 50.93abc | 8.67 | 5.44a | 17.55a |
| $N_2S_0$ | 3.84bc | 3.66b | 1.55b | 51.20abc | 8.91 | 5.03ab | 16.23ab |
| $N_2S_1$ | 3.14c | 3.34b | 1.30b | 43.87ef | 8.89 | 5.64a | 18.19a |
| $N_2S_2$ | 3.50bc | 3.88b | 1.49b | 49.20a-d | 8.93 | 5.21ab | 16.80ab |
| $N_2S_3$ | 4.95a | 5.48a | 2.08a | 53.27a | 10.30 | 5.92a | 19.10a |
| $N_3S_0$ | 3.25c | 3.35b | 1.33b | 45.33 | 8.84 | 4.31ab | 13.87ab |
| $N_3S_1$ | 3.76bc | 4.31ab | 1.36b | 48.20bcd | 8.76 | 5.17ab | 16.68ab |
| $N_3S_2$ | 3.73bc | 4.00b | 1.36b | 48.80bcd | 8.97 | 5.17ab | 16.68ab |
| $N_3S_3$ | 3.67bc | 3.80b | 1.30b | 42.73f | 8.97 | 4.4ab | 14.30ab |
| $LSD_{(0.05)}$ | 0.887 | 1.266 | 0.401 | 3.679 | 0.529 | 1.391 | 4.568 |
| Level of significant | * | * | * | * | * | * | * |
| CV (%) | 9.28 | 8.12 | 8.75 | 7.79 | 8.13 | 9.86 | 17.72 |

In a column same letter(s) do not significantly differ at 0.05 level of probability.

* Significant at 5% level

$N_0$=0 kg N/ha  $S_0$=0 kg S/ha
$N_1$=60 kg N/ha  $S_1$=10 kg S/ha
$N_2$=120 kg N/ha  $S_2$=20 kg S/ha
$N_3$=180 kg N/ha  $S_3$=30 kg S/ha

A significant variation was found on the length of bulb of onion due to combined effects different levels of nitrogen and sulphur (appendix iv). The length of bulb ranged from 2.98 to 5.48 cm. The length of bulb was produced the highest (5.48 cm) from the treatment combination of $N_2S_3$ (120 kg N/ha and 30 kg S/ha), whereas the lowest (2.98 cm) length of bulb was noted from $N_0S_0$ (control nitrogen and sulphur) treatment (Table 6). This result is agreed with the findings of Harun-or-Rashid (1998).

**4.6 Pseudostem diameter**

The different levels of nitrogen had no significantly influenced on the diameter of pseudostem (appendix iv). The highest (1.605 cm) diameter of pseudostem was recorded from $N_2$ (120 kg/ha). The minimum (1.32cm) in this regard was found in control treatment (Table 4).

The sulphur had no significantly influenced on the diameter of pseudostem (appendix iv). The highest (1.57 cm) diameter of pseudostem was recorded from $S_3$ (30 kg S/ha) treatment. The minimum (1.34 cm) in this regard was found in the treatment of $S_0$ (Table 5). Sulphur of 30 kg S/ha produced larger bulb as well as larger diameter of pseudistem. This result is agreed with the findings of Harun-or-Rashid (1998).

The significant interaction effect between different levels of nitrogen and sulphur in respect diameter of pseudostem was observed (appendix iv). The highest diameter of pseudostem (2.08 cm) was recorded from the treatment combination of $N_2S_3$ (120 kg N/ha and 30 kg S/ha), whereas the lowest (1.25 cm) diameter of pseudostem was performed by $N_0S_0$ (control nitrogen and sulphur) treatment (Table 6)

### 4.7 Fresh weight of bulb per plant

Significant variation was observed due to application of different levels of nitrogen on fresh weight of bulb (appendix iv). The maximum (49.38 g) fresh weight of blub per plant was obtain at $N_2$ (120 kg N/ha), while the minimum (41.88 g) fresh weight of blub per plant was obtained from control treatment (Table 4). The fresh weight of blub per plant was increased gradually with the level of nitrogen. Vacchani and Patel (1993) observed the highest bulb weight from the application of 150 kg N/ha.

The fresh weight of blub per plant was observed to be no significantly influenced by the different levels of sulphur (appendix iv). The maximum (48.80 g) fresh weight of blub per plant was recorded from $S_3$ (30 kg S/ha) and the minimum (44.03 g) gave the $S_1$ treatment of (10 kg S/ha) (Table 5).

The significant combined effect between different levels of nitrogen and sulphur treatment was observed on fresh weight of blub per plant (appendix iv). The highest (53.27 g) fresh weight of blub per plant was recorded from the treatment combination of $N_2S_3$ (120 kg N/ha and 30 kg S/ha), while the lowest (33.27 g) fresh weight of blub per plant was observed from $N_0S_0$ (control nitrogen and sulphur) treatment (Table 6). This result is agreed with the findings of Harun-or-Rashid (1998)

### 4.8 Dry matter content of bulb per plant

The dry matter content of bulb per plant also varied no significantly with the different dose of nitrogen (appendix iv). The maximum (8.71%) dry matter content of bulb per plant was found from $N_2$ (180 kg N/ha), while the minimum (8.42%) dry matter content of bulb per plant was noted from control treatment (Table 4). This result is agreed with the findings of Madan and Sandhu (1985)

The dry matter content of bulb also varied no significantly with the different levels of sulphur (appendix iv). The maximum (9.30 %) dry matter content of bulb per plant was obtain at $S_3$ (30 kg S/ha), while the minimum (8.95 %) dry matter weight of blub per plant was obtained from control condition (Table 5). This result is agreed with the findings of Nasreen and Farid (2002).

Combined effect showed significant variation on dry matter content due to application of different levels of nitrogen and sulphur (appendix iv). The maximum (10.32%) dry matter content of bulb per plant was recorded from the treatment combination of $N_2S_3$ (120 kg N/ha and 30 kg S/ha), while the minimum (8.03%) dry matter content of bulb per plant was obtained from $N_0S_0$ (control nitrogen and sulphur) (Table 6). This result is agreed with the findings of Singh and Dhankhar (1988)

**4.9 Yield of bulbs**

The yield of bulb was significantly varied due to application of different levels of nitrogen (Appendix iv). The highest (5.05 kg/plot and 17.58 t/ha, respectively) yield was obtained from $N_2$ (120 kg N/ha) treatment while the control treatment ($N_0$) was produced the lowest (4.39 kg/plot and 14.17 t/ha, respectively) (Table 4 and Fig.8 respectively). It was clearly observed that yield increased with increasing level of nitrogen (N) at certain level. Different doses of nitrogen produced significantly different yields. These results also supported by Ramamoorthy *et al.* (1999).

The yield of bulb was no significantly influenced due to the different levels of sulphur (Appendix iv). The highest (5.05 kg/plot and 16.05 t/ha, respectively) yield was obtained from $S_3$ (30 kg S/ha) treatment, where as the lowest yield of onion (4.345 kg/plot and 14.015 t/ha, respectively) was found from $S_0$ (control) treatment. (Table 5 and Fig 9 respectively). This result is agreed with the findings of Singh and Pandey (1995).

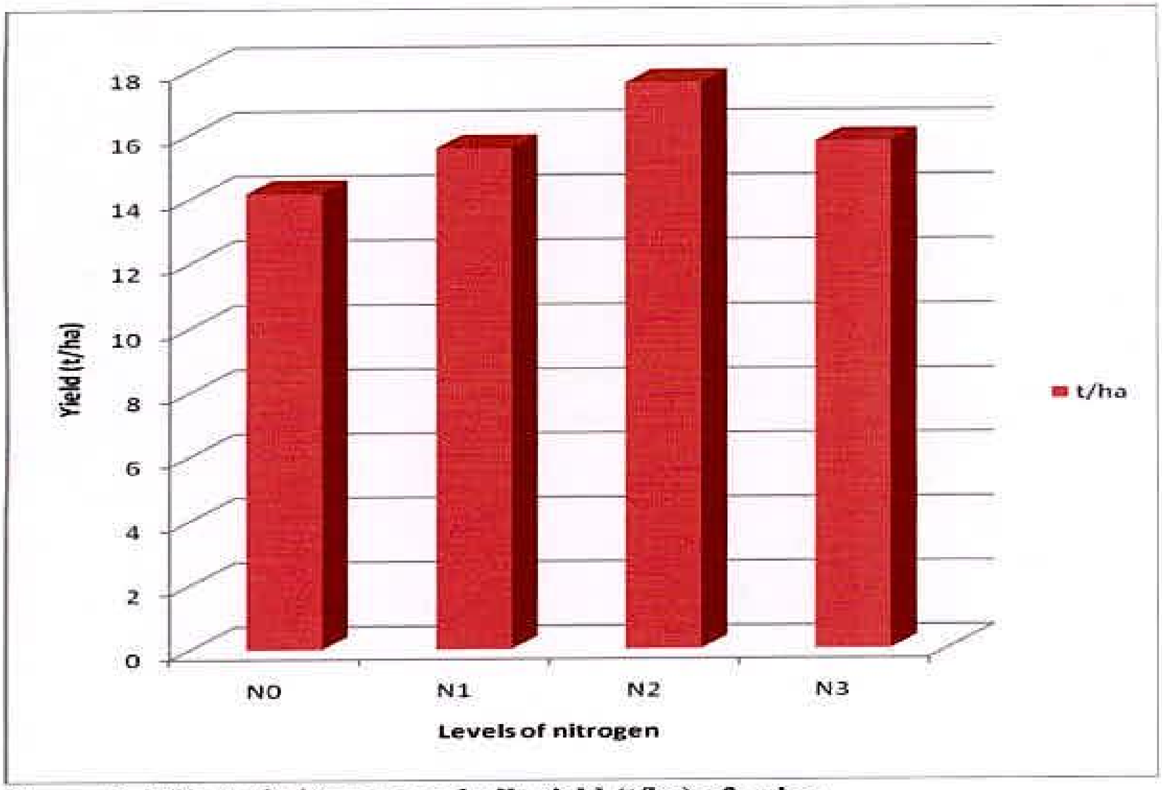


**Figure 8. Effect of nitrogen on bulb yield (t/ha) of onion**

**$N_0$=0 kg N/ha, $N_1$=60 kg N/ha, $N_2$=120 kg N/ha and $N_3$=180 kg N/ha**

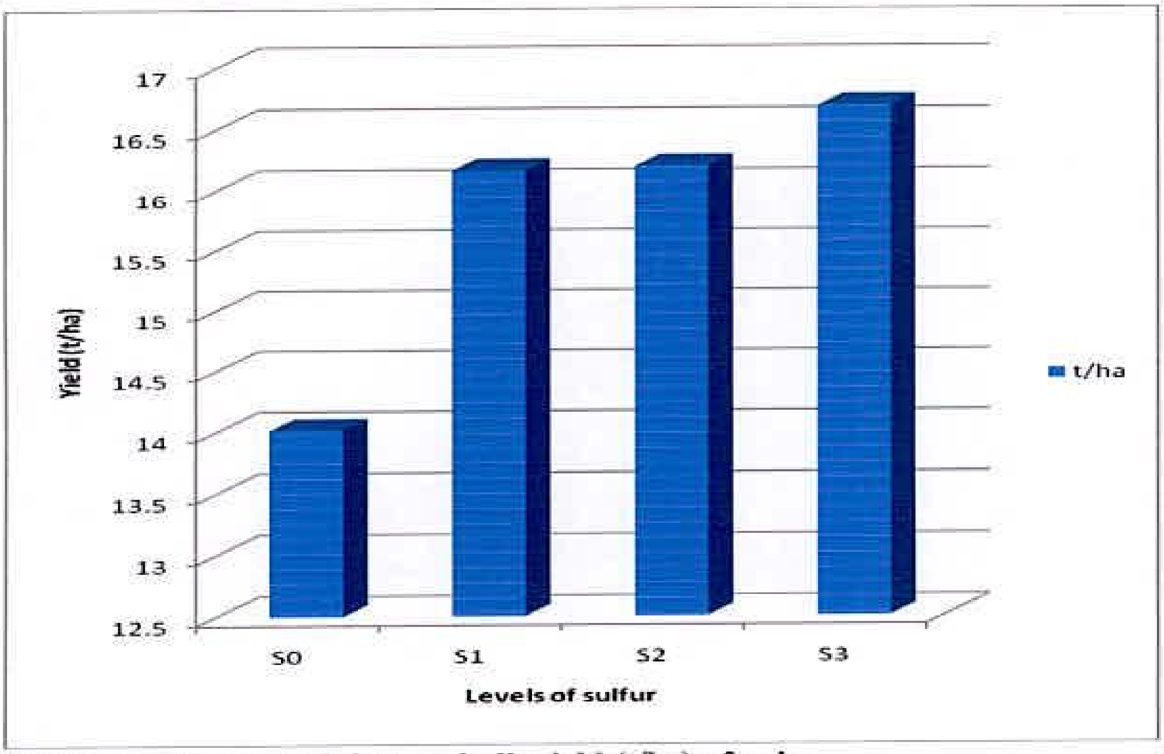


**Figure 9. Effect of sulphur on bulb yield (t/ha) of onion**

**$S_0$=0 kg S/ha, $S_1$=10 kg S/ha, $S_2$=20 kg S/ha and $S_3$=30 kg S/ha**

The combined effect of different levels of nitrogen and sulphur showed signification variation on yield (Appendix iv). The highest (5.92 kg/plot and 19.10 t/ha, respectively) yield of bulb was recorded from the treatment combination of $N_2S_3$ (120 kg N/ha and 30 kg S/ha), while the lowest (3.62 kg/plot and 11.71 t/ha, respectively) yield of bulb was observed from $N_0S_0$ (0 kg N/ha with 0 kg S/ha) (Table 6 ). This result is agreed with the findings of Singh et al. (1996)

# Chapter V
# Summary and Conclusion

# CHAPTER- 5

# SUMMERY AND CONCLUSION

The present experiment was carried out at the field of Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka-1207 to evaluate the effect of nitrogen and sulfur on the yield and yield contributing characters of summer onion during the pried from February to July 2007. The experiment consisted of four levels of sulfur (viz. 0, 10, 20 and 30 kg S/ha) and four levels of nitrogen (viz. 0, 60, 120, 180 kg N/ha).

The two-factor experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. There were 16 treatment combinations in this study. A unit plot was 1.5 m×1.05 m and the treatments were distributed randomly in each block. There were single plot maintaining a spacing of 15 cm × 10 cm. The experimental plot was fertilized at the rate of 20 tons Cowdung, 250 kg Triple Super Phosphate (TSP) and 120 kg Murate of Potash per hectare and nitrogen and sulphur were used as per treatment. The onion seed were sown March 07, 2007. The crop was harvested on July 20, 2007. Ten plants were randomly selected for data collection from each plot. Data on growth and yield parameters were recorded and analyzed statistically. The differences were evaluated by Duncans Multiple Range Test (DMRT).

Nitrogen has significant effect on the growth and yield contributing characters of onion. The highest plant height (37.50, 47.82, 54.55 and 36.78 cm at 40, 55, 70 and 85 DAT, respectively), number of leaves (6.75, 6.82, 7.43 and 5.91 at 40, 55, 70 and 85 DAT, respectively), length of leaf (33.61, 44.34, 50.38 and 34.88 cm at 40, 55, 70 and 85 DAT, respectively), diameter of bulb (3.85 cm), length of bulb (4.09 cm), diameter of pseudostem (1.61 cm), fresh weight of blub per plant (49.38 g), dry matter content of bulb (8.71%) and yield per plot and yield per hectare (5.45 kg/plot and 17.58 t/ha, respectively) were obtained from application of 120 kg N/ha ($N_2$).

Sulphur had no significant effect on the growth and yield contributing characters of onion except plant height and length of leaf of onion. The highest plant height (39.44, 51.04, 56.84 and 40.47 cm at 40, 55, 70 and 85 DAT, respectively), The highest number of leaves (6.78, 6.98, 6.92 and 5.79 at 40, 55, 70 and 85 DAT, respectively), length of leaf (34.88, 43.72, 50.45 and 34.94 cm at 40, 55, 70 and 85 DAT, respectively), diameter of bulb (3.99 cm), length of bulb (4.26 cm), diameter of pseudostem (1.58 cm), fresh weight of blub per plant (48.80 g), dry matter content (9.30%) and yield per plot and yield per hectare (5.05 kg/plot and 16.05 t/ha, respectively) were obtained from application of 30 kg S/ha ($S_3$).

Combined effect of different levels of nitrogen and sulphur produced significant variation in respect of yield and yield contributing characters. The highest plant height (45.87, 60.67, 66.63 and 43.80 cm at 40, 55, 70 and 85 DAT, respectively), number of leaves (8.53, 9.27, 9.37 and 8.03 at 40, 55, 70 and 85 DAT, respectively), length of leaf (38.90, 54.50, 60.53 and 40.20 cm at 40, 55, 70 and 85 DAT, respectively), diameter of bulb (4.95 cm), length of bulb (5.48 cm), diameter of pseudostem (2.08 cm), fresh weight of bulb per plant (53.27 g), dry matter content of bulb (10.30%) were obtained from the treatment combination of $N_2S_3$ (120 kg N/ha and 30 kg S/ha). The yield per plot and yield per hectare were highly interacted with the different level of nitrogen and sulfur. The highest yield per plot and yield per hectare (5.92 kg/plot and 19.10 t/ha, respectively) were recorded when 120 kg N/ha with 30 kg S/ha ($N_2S_3$) and the lowest was from 0 kg N/ha with 0 kg S/ha.

**Conclusion:**

The study was conducted under AEZ NO 28. So such type of trail may be studied in different agrological zones of Bangladesh for final recommendation. However, from the present study it may be concluded that, the most suitable combination for a higher yield of onion cv. BARI Peaj-3 was $N_2$ (120 kg N/ha) with $S_3$ (30 kg S/ha).

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# *Appendices*

## APPENDICES

**Appendix I. Characteristics of the entire farm soils analyzed by Soil Resources and Development Institute (SRDI), Farmgate, Dhaka.**

**A. Morphological Characteristics of the research field**

| Morphological Features | Characteristics |
|---|---|
| Location | Horticulture farm of SAU, Dhaka |
| AEZ | AEZ no.28 (Madhupur Tract) |
| Land Type | Medium High Land |
| General Soil Type | Shallow red brown terrace soil |
| Soil Series | Tejgaon |
| Topography | Fairly leveled |
| Flood Level | Above Flood level |
| Drainage | Well Drained |
| Cropping Pattern | Winter Vegetable – Summer Vegetable |

**B. Physical and Chemical Properties of the soil**

| Properties of Soil | Value |
|---|---|
| **Mechanical analysis** | |
| Sand (%) | 27.10 |
| Silt (%) | 42.30 |
| Clay (%) | 30.60 |
| Textural class | Silty loam |
| **Chemical analysis** | |
| $P^H$ | 5.6 |
| Organic carbon (%) | 0.71 |
| Organic matter (%) | 1.29 |
| Total N (%) | 18.90 |
| Available P (ppm) | 33.25 |
| Exchangeable K (me/100g soil) | 0.17 |
| Available S (ppm) | 41.40 |
| Available B (ppm) | 0.29 |

**Source: SRDI, Farmgate, Dhaka.**

**Appendix II. Monthly records of Temperature, Relative humidity, Rainfall, of the experimental site during the period from January to July, 2007**

| Year | Month | Air Temperature ($0^0c$) | | | Relative Humidity (%) | Rainfall (mm) |
|---|---|---|---|---|---|---|
| | | Maximum | Minimum | Mean | | |
| 2007 | **March** | 31.4 | 19.6 | 25.5 | 54 | 11 |
| | **April** | 33.60 | 23.50 | 28.55 | 69.50 | 163 |
| | **May** | 34.90 | 25.13 | 30.01 | 70.00 | 185 |
| | **June** | 32.60 | 25.5 | 29.05 | 81.70 | 628 |
| | **July** | 35.80 | 26.60 | 31.20 | 87.30 | 710 |

**Source: Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka-1207.**

Appendix III Effects of sulfur and nitrogen on the growth and yield of onion.

| Sources of variancs | Degree of freedom | Mean square | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant height | | | | Leaf length | | | | number of Leaf | | | |
| | | 40 DAT | 55 DAT | 70 DAT | 85 DAT | 40 DAT | 55 DAT | 70 DAT | 85 DAT | 40 DAT | 55 DAT | 70 DAT | 85 DAT |
| Replication | 2 | 115.588 | 84.593 | 152.146 | 66.796 | 44.521 | 69.807 | 44.123 | 37.863 | 36.627 | 8.282 | 4.776 | 6.486 |
| Factor A | 3 | 52.47* | $38.561^{NS}$ | 121.075* | 18.232* | 16.781* | 153.834* | $63.566^{NS}$ | 77.61 * | $5.92^{ns}$ | 7.469* | 10.237* | 6.845* |
| Factor B | 3 | 140.194* | 258.867* | 231.884* | 236.936* | 58.805* | 71.5* | $67.117^{NS}$ | 56.147* | $4.226^{ns}$ | $5.18^{ns}$ | $3.062^{ns}$ | 10.419* |
| A x B | 9 | 180.658* | 264.993* | 281.495* | 61.205* | 80.342* | 125.719* | 83.014* | 26.062* | 4.048* | 3.702* | 3.06* | 1.58* |
| Error | 30 | 2.739 | 3.257 | 6.319 | 1.01 | 2.146 | 2.76 | 4.869 | 1.831 | 1.063 | 0.452 | 0.593 | 0.423 |

* Significant at 5% level

NS-non significant

Appendix IV Effects of sulfur and nitrogen on the yield components and yield of onion.

| Sources of variancs | Degree of freedom | Mean square | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Diameter of bulb | Bulb length | Pseudostem diameter | Fresh weight of bulb | Dry matter content of bulb | Yield kg/plot | Yield t/ha |
| Replication | 2 | 31.754 | 66.181 | 7.777 | 105.786 | 2.996 | 52.563 | 556.69 |
| Factor A | 3 | 1.376$^{NS}$ | 1.831$^{NS}$ | 0.163$^{NS}$ | 127.617* | 10.139$^{NS}$ | 2.319* | 23.538* |
| Factor B | 3 | 1.793$^{NS}$ | 1.934$^{NS}$ | 0.111$^{NS}$ | 51.878$^{NS}$ | 0.965$^{NS}$ | 1.39$^{NS}$ | 16.955 |
| A x B | 9 | 0.856* | 0.756* | 0.135* | 68.437* | 13.784* | 0.508* | 3.868* |
| Error | 30 | 0.283 | 0.576 | 0.058 | 4.868 | 1.746 | 0.696 | 7.804 |

* Significant at 5% level

NS-non significant

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