INFLUENCE OF NITROGEN AND MULCHING ON THE GROWTH AND YIELD OF ONION

By

MD. ANIS-UR-RAHMAN
Registration No.: 05-01655

A thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE
IN
AGRICULTURAL BOTANY

SEMESTER: JANUARY-JUNE, 2011

Approved by:

.....
(Dr. Mohammad Mahbub Islam)
Associate professor
&
Research Supervisor

.....
Professor Asim Kumar Bhadra
Co-supervisor

.....
Professor Asim Kumar Bhadra
Chairman
Examination Committee

CERTIFICATE

This is to certify that the thesis entitled, "**INFLUENCE OF NITROGEN AND MULCHING ON THE GROWTH AND YIELD OF ONION**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURAL BOTANY,** embodies the results of a piece of bona fide research work carried out by **MD. ANIS-UR-RAHMAN,** Registration No. **05-01655** 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.

Dated:

Place: Dhaka, Bangladesh

Dr. Mohammad Mahbub Islam)
Research Supervisor
&
Associate Professor
Dept. of Agril. Botany , SAU

DEDICATE TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

Alhamdulillah, all praises are due to the almighty Allah Rabbul Al-Amin for His gracious kindness and infinite mercy in all the endeavors the author to let him successfully complete the research work and the thesis leading to Master of Science.

The author would like to express his heartfelt gratitude and most sincere appreciations to his research supervisor Dr. Mohammad Mahbub Islam, Associate Professor, Dept. of Agril. Botany, SAU for his valuable guidance, advice, immense help, encouragement and support throughout the study. Likewise grateful appreciation is conveyed to the research co-supervisor Professor Asim Kumar Bhadra, for his constant encouragement, cordial suggestions, constructive criticisms and valuable advices to complete the thesis.

The author would like to express his deepest respect and boundless gratitude to all the respected teachers of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, sympathetic co-operation, and inspirations throughout the course of this study and research work.

The author appreciate the assistance rendered by the staffs of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, who have helped him during the period of study.

The author wishes to extend his special thanks to Md. Jubaer-Al-Mahmud (Apu), Kh. Ashraf-Uz-Zaman (Rossi), Md. Rafiqul Islam, Abu Hasnat (Himel) and Md. Alam Hossain for their help during experimentation. Special thanks to all other friends for their support and encouragement to complete this study.

The author is deeply indebted to his father and grateful to his respectful mother, brother, sister and other relatives for their moral support, encouragement and love with cordial understanding.

The author

ABSTRACT

A field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during the rabi season from October 2010 to April 2011 to evaluate the influence of nitrogen (N) and mulching (M) on the growth and yield of onion (*Allium cepa*) cv. Taherpuri. The experiment was carried out with the application of four levels of nitrogen *viz*: 0 (N_0) , 60 (N_{60}), 120 (N_{120}) and 180 (N_{180}) kg ha^{-1} and three types of mulching such as no mulch or control (M_0), rice straw (M_s) and water hyacinth (M_w) with the following 12 treatment combinations N_0M_0, N_0M_s, N_0M_w, $N_{60}M_0$, $N_{60}M_s$, $N_{60}M_w$, $N_{120}M_0$, $N_{120}M_s$, $N_{120}M_w$, $N_{180}M_0$, $N_{180}M_s$, $N_{180}M_w$. This was laid out in randomized complete block design (RCBD) and replicated thrice. The results indicated that growth parameters such as plant height and number of leaves at different days after transplanting, dry weight of leaf, dry weight of pseudostem and dry weight of root were increased significantly with the application of both nitrogen (N) and mulching (M). As nitrogen, mulching of soil with straw (M_s) and water hyacinth (M_w) increased the length and diameter of bulb, fresh weight and dry weight of bulb and bulb yield. Interestingly, the bulb yield did not show differences between application of 120 kg N ha^{-1} (N_{120}) and application of 180 kg N ha^{-1} (N_{180}) as well as M_s and M_w. The maximum plant height and number of leaves per plant were found in $N_{180}M_w$ and $N_{120}M_w$ treatment combination whereas minimum plant height and number of leaves were showed at control. The yield components and yield such as maximum bulb diameter, individual bulb fresh weight and bulb yield were also significantly influenced with the combination of N and M. The results revealed that the highest bulb diameter and individual bulb fresh weight were obtained from $N_{120}M_w$ treatment and minimum values were observed in N_0M_0, control condition. The treatment combination $N_{120}M_w$ was found to provide with the best bulb yield (12.20 t ha^{-1}) whereas control, N_0M_0 showed the lowest yield (5.99 t ha^{-1}). In this study, 103 % increased bulb yield of onion was obtained from the treatment $N_{120}M_w$ in comparison to N_0M_0 treatment combination. Based on the above results it can be concluded that the use of 120 kg N ha^{-1} along with water hyacinth mulch ($N_{120}M_w$) increased onion bulb yield significantly under this locality.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AEZ	Agro- ecological zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BRRI	Bangladesh Rice Research Institute
cm	Centimeter
^{0}C	Degree Celcius
DAT	Days after transplanting
cv.	Cultivar
et al.	And others
FAO	Food and Agriculture Organization
g	Gram (s)
Hr	Hour(s)
kg	Kilogram (s)
LSD	Least Significant Difference
m^2	Meter Squares
M	Mulching
MOP	Muriate of potash
N	Nitrogen
No.	Number
NS	Non significant
S	Sulphur
SAU	Sher-e- Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
var.	Variety
wt.	Weight
t ha^{-1}	Ton per hectare

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Onion (*Allium cepa L.*) belongs to the family Alliaceae and is well known as the most important crop in the world including Bangladesh which is used as both vegetable and spice crop. Central Asia is the origin of onion (Mccullum, 1976) and it is cultivated as a biennial crop for the purpose of seed production and grown in both sub-tropical and temperate regions and generally cultivated as annual crop for bulb production.

Onion bulb is composed of carbohydrates (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g) and contains several vitamins like vitamin A (0.012 mg), vitamin C (11 mg), thiamine (0.08 mg), riboflavin (0.01 mg) and niacin (0.2 mg) and minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg) and potassium (157 mg) are also recorded per 100 g fresh material (MacGillivary, 1961; Vohora et.al., 1974; Suresh, 2007). The smell and pungency is due to the oil known as "Allyal propyl disulphide". Extracts of onion are being used for the prevention of 'atherosclerosis' and 'coronary heart disease' as they can inhibit the aggregation of human blood platelets to form the clots, which have the potential for arterial blocking. The bulb has wider use in manufacture of soaps, ketchups, onion flakes and food seasoning besides being used as salad and pickle (Suresh, 2007).

The area and production of bulb yield of onion in Bangladesh was 291000 acres and 872000 MT, respectively (BBS, 2010). It was also reported that the average bulb yield of onion in our country is less than 10 t/ha whereas the world yield is 17.46 t/ha (FAO, 2003) which is much lower than the other onion producing countries in the world. Many reasons such as deficiency of nutrition or judicious application of fertilizers, proper cultural and management practices and sufficient water i.e lack of effort to conserve moisture in the soil during cultivation, lack of improved varieties are the barriers to increase onion bulb production in Bangladesh. Meanwhile, the scientists have developed some varieties to increase the yield and quality of onion. In addition, several researchers are still working for improving the bulb yield of onion with different fertilizers and management practices.

It is well established that nitrogen (N) is the principal primary element for accelerating the growth of plants. Separately, N deficiency may also affect many physiological processes like respiration, chlorophyll development and cell size and specially cell division (Nason and Mc-Elrx, 1963). It was stated in many previous reports that N enhances the vegetative growth and bulb yield of onion by increasing plant height, leaf number, leaf length and bulb diameter and bulb size (Aliyu et al., 2008; Abdissa et al., 2011). It was reported that the bulb yield of onion increased with various doses of N ranging from 100 -125 kg/ha (Islam et al., 1999; Singh et al., 2000; Haquae et al., 2004). In addition, the application of 80-90 kg/ ha of N suggested to be adequate for onion production (Halvorson et al., 2002; Umar et al., 2003). Meena et al., (2007) also found that 150 kg /ha N produced higher bulb yield. These results suggest that the rate of application of N for onion production is not clear.

Previously, many authors reported that soil moisture and temperature are important factor which greatly influence bulb growth and yield of onion (Rashid, 1976). In Bangladesh, onion is mainly grown in rabi season and the deficiency of available water in the sub soil is common during rabi season that leads to lower bulb yield of onion and suggesting that application of water is essential for proper growth and development. Separately, sometime it becomes somewhat difficult and expensive to irrigate properly during cultivation.

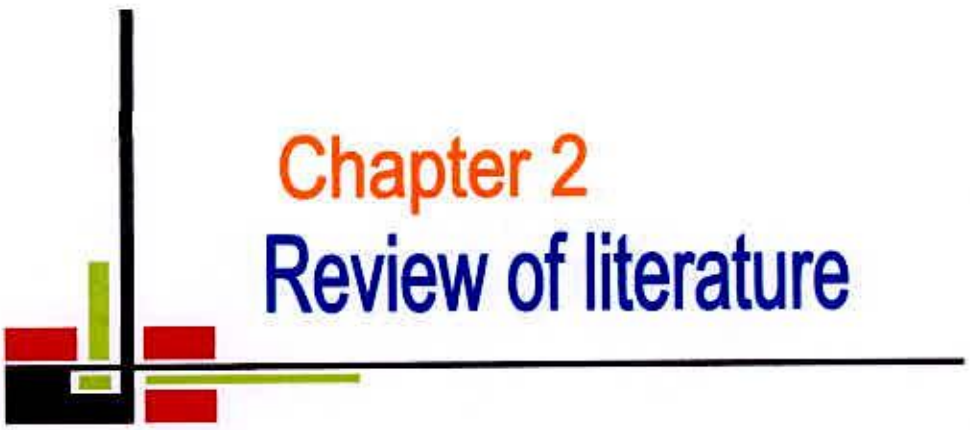
It has been reported that mulching (M) is an important technology which decreases the loss of soil water through evaporation and conserve soil moisture thus reduces the irrigation requirements, increasing root development, promoting faster crop development, reducing weed attack and inducing earlier harvest of crop (Vanderwerken et al., 1988; Adetunji, 1990; Amal et al., 1990; Zaman and Mallick, 1991; Gajri et al., 1994; Vavrina and Roka, 2000; Mahajan et al., 2007). In soil management relationships, M has been reported to influence organic matter content, activity of microorganisms, availability of soil nutrients, control of erosion and soil compaction and regulating soil temperature (Graham et al., 1995; Hassan, 1999; Stowell, 2000). These results suggest that M improves the soil environment for increasing crop growth, development and yield.

Rhee et al., (1990) showed that M increases the efficiency of applied N fertilizer by reducing leaching and evaporation loss of nutrients. Different types of mulches including rice straw and polythene significantly increased the growth and yield of onion (Islam et al., 2002). It was also stated that garlic yield were also increased with water hyacinth mulch or polythene mulch upto 39 % over control (Islam et al., 2007). However, to my knowledge little is known about the role of M on growth and bulb yield of onion especially in this region.

It has been reported that N uptake by plants depend on water availability in the rhizosphere and shortage of water reduced N uptake along with nitrogen reductase activity resulting in decrease of incorporation of N into protein (Brain et al., 1975; Harper, 1977; Haque and Jutzi, 1984; Eck, 1988; Pala et al., 1996). Onion is sensitive to moisture stress throughtout the growing season. Periods of dry soil conditions, especially during bulbing, will result in yield reductions and it was also reported that growth and yield of onion can be increased by judicious application of M which conserve moisture for increasing the form of availability of nutrients including N (Mia, 1996; Rekowska, 1997). However, information about interaction between N and M on the growth and yield of onion under Bangladesh conditions is unclear. The present study was undertaken with four different levels of N and three types of mulch. Considering the above mentioned issues, the present experiment was conducted with the following objectives:

Objectives:

1. To investigate the effects of nitrogen (N) and mulching (M) on the growth and bulb yield of onion.
2. To find out the better treatment combination/s with nitrogen (N) and mulching (M) which increase the growth and bulb yield of onion.



Chapter 2
Review of literature

CHAPTER 2

REVIEW OF LITERATURE

Onion is one of the most important photo and thermo sensitive bulb and spice crops of Bangladesh. A good number of research works have been done to study the effect of nitrogen fertilizer on growth and yield of onion. Unfortunately, research to observe the effect of mulching on growth and bulb production is very limited in the world as well as Bangladesh. For this reason, enough published works in respect of mulching effect on the growth and bulb yield of onion under Bangladesh conditions were not found. For this reason, with the addition of some other related crops, available literature on this aspect have been reviewed and stated in this chapter.

2.1 Nitrogen on the growth and yield of onion

Morsy et al., (2012) conducted a field experiment at Sids Agricultural Research Station, Bani-Suef Governorate during 2006/2007 and 2007/2008 seasons, to study the effect of application of two levels of nitrogen fertilization (90 and 120 kg /fed) under four combination of phosphorus and potassium fertilization (0 P_2O_5 +0 K_2O/fed, 30 kg P_2O_5 + 0 K_2O /fed, 30 kg P_2O_5 + 24 Kg K_2O /fed and 30 kg P_2O_5 + 48 Kg K_2O /fed.). They found that the higher nitrogen level (120 kg N/fed) achieved significant increase in plant height, number of leaves/plant, bulb diameter, bulb weight, TSS%, dry mater % and number of days to maturity, as compared to the lower nitrogen rate (90 kg N/fed).

Mishra and Gupta (2011) carried out a field experiment at National Horticultural Research and Development Foundation, Regional Research Station, Salaru, India to observe the effect of N doses and irrigation interval on onion. Three irrigation intervals viz. 4, 7, 10 days and

5 nitrogen doses i.e. 50, 75, 100, 125, and 150 kg/ha were evaluated on onion variety Agrifound Light Red . They found the result that at 10 days irrigation interval and high doses of nitrogen i.e. 125 kg/ha was reduced Stemphylium blight disease and increase bulb yield.

Abdissa et al. (2011) a field experiment was undertaken to study the effect of different levels of nitrogen (N) and phosphorus (P) fertilizers on the growth, biomass yield and fresh bulb yield of onion (*Allium cepa L.*) grown on vertisol of Shewa Robit, North east Ethiopia. Five rates of N (0, 69, 92, 115, 138 kg /ha) and five rates of P (0, 10, 20, 30, 40 kg /ha) used as treatment. Application of 69 kg N/ ha increased plant height and leaf length by about 10 and 11.5%, respectively over the unfertilized check. Number of leaves increased by about 8% in response to the application of 92 kg N/ ha over the control. Leaf diameter and bulb length were not influenced by N fertilization. N fertilization increased bulb diameter and average bulb weight over the control. Application of 69 kg N/ ha increased the development of splitted bulbs by about 45%, average bulb weight by 24%, total dry biomass by 20%, harvest index by about 4%, total bulb yield by 18%, and marketable bulb yield by 17% over the control. Application of 69 kg N/ ha enhanced the growth of onion plant and resulted in optimum fresh total and marketable bulb yield.

Aliyu *et al.* (2008) an experiments were carried out at the Usmanu Danfodiyo University Fadama Teaching and Research Farm, Sokoto in 2004 and 2005 dry seasons to determine the effect of different nitrogen levels (0, 50, 100 and 150 kg N ha-1) and intra-row spacing (10, 15, 20 and 25 cm) on the growth and yield of onion. Results revealed that nitrogen and intra-row spacing as well as their interaction, significantly affected plant height, number of leaves, crop growth rate, individual bulb weight, bulb diameter and total bulb yield per hectare. Nitrogen at the rate of 100 or 150 kg N ha-1 gave the best results and was statistically at par in

all the parameters measured. The optimum yield of onion bulbs (30.83 t ha-1) was obtained from 15 cm intra-row spacing combined with 100 kg N ha-1

Nasreen *et al.* (2007) observed the effect of nitrogen (0, 80, 120, and 160 kg/ha from urea) and sulphur (0, 20, 40, and 60 kg/ha from gypsum) fertilization on N and S uptake and yield performance of onion (var. BARI Piaz-1) at the research field of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during *rabi* seasons of 2002-2003 and 2003-2004. The experiment was laid out in a randomized complete block design under factorial arrangement with three replications. Addition of nitrogen and sulphur fertilizers exerted significant influence on the number of leaves, plant height, diameter of bulb, single bulb weight, and yield of onion. The uptake of N and S by bulb also significantly responded to the application of nitrogen and sulphur. The highest yield of onion and the maximum uptake of N and S were recorded by the combined application of 120 kg N and 40 kg S/ha

Meena *et al.* (2007) conducted an experiment to study the effect of nitrogen levels on the growth and yield attributes of onion cv. Nasik Red. The highest N level (150 kg ha^{-1}) gave the maximum plant height, length of the longest leaf, pseudostem diameter, number of leaves per plant, bulb diameter and bulb yield in comparison to its lower levels, i.e. 50 and 100 kg N ha^{-1}.

Anonymous (2007) conducted an experiment at Spices Research Centre, BARI, Bogra with four levels of nitrogen (0, 50, 100 and 150 kg ha^{-1}), phosphorus (0, 20, 40 and 60 kg ha^{-1}), potassium (0, 50, 100 and 150 kg ha^{-1}) and sulphur (0, 10, 20 and 30 kg ha^{-1}) for *kharif* onion cultivation. Among the fertilizer treatments, $N_{100}P_{40}K_{100}S_{30}$ gave the highest yield (22.33 t ha^{-1}) and the lowest yield (9.67 t ha^{-1}) was obtained in control.

Aliyu *et al.* (2007) studied the effect of nitrogen (N) and Phosphorus (P) on the growth and yield of irrigated onion in the Sudan Sananna of Nigeria during 2003/2004 and 2004/2005 in dry seasons. Results revealed that N and P as well as their interaction, significantly affected plant height, number of leaves per plant, crop growth rate and individual bulb weight. Nitrogen at the rate of 150 kgha^{-1} gave the best results.

Kumar *et al.* (2006) carried out a field experiment to determine the effects of N and K levels (0, 50, 100 and 150 kg ha^{-1} each) on onion bulb yield, quality and nutrient uptake. They observed that the bulb yield was significantly higher with the application of 150 kg N ha^{-1} and 100 kg K ha^{-1}. Similarly, the dry matter yield, protein percentage as well as N, P, K and S contents and uptakes were increased significantly over the control with the application of 150 kg N ha^{-1}.

An experiment was conducted by Islam *et al.* (2006) at the Horticultural Farm, Bangladesh Agricultural University, Mymensingh during the *rabi* season of 1999-2000 to evaluate the effects of nitrogen and potassium levels on the growth and yield of onion. The results revealed that the highest bulb yield (17.60 t ha^{-1}) was obtained when the plants were grown with nitrogen at 150 kg ha^{-1}, higher levels of N did not show any more increase in yield of onion. Application of potassium at 200 kg K ha^{-1} produced the highest bulb yield (16.69 t ha^{-1}).

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.

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 the 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]

Yamasaki and Tanaka (2005) investigated the role of N in the flower initiation of Welsh onion cv. Kincho. They found that low N rates retarded the growth but promoted leaf sheath bulbing and bolting of Welsh onions. It also reduced the nitrogen and carbon concentration but increased the C: N ratio in the crop.

Haque *et al.* (2004) investigated the effects of nitrogen and irrigation on the growth and yield of onion cv. BARI Piaz-1 during the *rabi* season of 2000-01. Plant height, number of leaves per plant, bulb length, bulb diameter, neck thickness, single bulb weight and crop yield increased with increasing rates of N up to 125 kg ha^{-1} and with irrigation at 7-day intervals and decreased thereafter. Interaction effects between N rates and irrigation were significant for all the parameters measured except for bulb diameter.

Singh *et al.* (2004) studied the effect of NK on the growth and bulb yield of onion crop. They reported that plant height at harvest (51.43 cm), leaf length (28.22 cm), fresh weight of leaves (25.21 g) and total chlorophyll content at 45 days after transplanting (1.33 mg) and 90 days after transplanting (1.67 mg) were highest upon treatment with the highest nitrogen rate (150 kg N ha^{-1}) and with the highest potassium rate (120 kg K ha^{-1}).

Jilani *et al.* (2004) conducted a field trial to study the effect of different levels of nitrogen on three onion cultivars (Faisalabad Early, Phulkara and Shah Alam). They observed that maximum value cost ratio was found in Shah Alam followed by Faisalabad Early and Phulkara and N at 120 kg ha^{-1} proved to be the best for all the parameters studied.

Muoneke *et al.* (2003) conducted a field trial to investigate the effects of four levels of nitrogen and three levels of phosphorus on growth and keeping quality of onions. They found that application of 90 and 135 kg N ha^{-1} increased the growth and yield but reduced the post

harvest storage quality. Phosphorus at 60 kg ha^{-1} increased these attributes but did not influence the keeping quality of the bulbs.

Mandira and Khan (2003) carried out an experiment with different levels of nitrogen (0, 100, 150 and 200 kg ha^{-1}) and potassium (0, 75 and 150 kg ha^{-1}) to study their effect on the growth, yield and yield attributes of onion cv. N-53 in Tripura, India during *rabi* season of 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.

Yadav *et al.* (2003) stated that application of 100 kg ha^{-1} N produced significantly the highest bulb yields over 50 kg ha^{-1} but 150 kg N ha^{-1} did not significantly increase the bulb yield. They also reported that 150 kg K_2O ha^{-1} produced significantly the higher bulb yield compared to lower rates of potash.

Naik and Hosamani (2003) conducted a field experiment 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 that 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

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.

Anonymous (2001) conducted an experiment at Spices Research Centre, BARI, Joydebpur during 2000-2001 with four levels of nitrogen (0, 100, 125 and 150 kg/ha). Influence of different levels of nitrogen was significant on different parameters of onion studied. Although 125 kg ha^{-1} and 150 kg ha^{-1} of nitrogen produced 10.91 t ha^{-1} and 8.70 t ha^{-1} of bulb, respectively whiles it was 5.74 t ha^{-1} in control.

A field experiment was carried out by Kumar *et al.* (2001) to study the effect of N fertilization (0, 65 and 130 kg ha^{-1}) on onion cv. Pusa Red during 1992-93 and 1993-94 in Uttar Pradesh, India. They stated that application of 130 kg N ha^{-1} 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 rates.

According to Mohanty and Das (2001), 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.

Dhamendra *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.

Singh *et al.* (2000) conducted an experiment at Rajasthan, India 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 application of 100 kg N, 30.8 kg P and 83.0 kg K ha^{-1}.

Hussaini and Amans (2000) carried out a field experiment during 1993-94 and 1994-95 dry seasons, at Kadawa in the Sudan Savannah ecological zone of Nigeria. They stated that nitrogen application positively increased the bulb yield, average bulb weight, and number of

large bulbs per plot and 7-day intervals irrigation produced higher bulb yield, average bulb weight, and number of large bulbs per plot.

According to Neeraja *et al.* (2000) increased level of N fertilizer significantly increased the leaf, bulb and whole plant uptake of Ca, Mg and S at different stages of crop growth. The uptake of these nutrients continued until bulb maturity. They also revealed that the total uptake of Ca, Mg and S was 16.66, 9.2 and 25.48 kg ha^{-1} with 200 kg N ha^{-1}, respectively.

Rodriguez *et al.* (1999) carried out 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 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.

Ramamoorthy *et al.* (1999) conducted a field experiment at Bhavanisagar, Tamil Nudu, in which Onion cv. CO4 was given 0, 30, 60 or 90 kg N ha^{-1} during the *kharif* and summer seasons of 1994 and 1995. They stated that bulb yield increased as N rate increased.

A field trial was conducted by Singh and Chaure (1999) on a sandy loam soil at Bilaspur, India. 5, 6 and 7 weeks old onion seedlings were supplied with N at 50, 100 or 150 kg/ ha in 1989-90 and with N at 50, 100, 150 or 200 kg ha^{-1} in 1990-91 and 1991-92. The optimum age of seedling and N application rate, in terms of leaf length, number of leaves per plant, bolting percentage, bulb weight and bulb yield were 6 weeks and 150 kg ha^{-1}, respectively. At an extra fertilizer rate of N 200 kg ha^{-1}, the additional yield did not compensate for the cost of extra fertilizer.

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

Harun-or-Rashid (1998) conducted a field trial at Bangladesh Agricultural University, Mymensingh on the effect of NPKS on growth and yield of onion at different plant spacing. He stated that the maximum bulb weight (40.50 g) and bulb yield (20.75 t/ha) were found from the combination of 125-150-150-30 kg N, P_2O_5, K_2O, S ha^{-1}, respectively. Application of NPKS increased the plant height, leaf number, bulb length, bulb diameter and bulb weight as well as the bulb yield. He recommended 100-150-200-30 kg N, P_2O_5, K_2O, S ha^{-1}, respectively for the cultivation of BARI piaz-1 at BAU farm conditions.

Singh and Mohanty (1998) studied the effect of NPK on growth and yield of onion in Orissa, India in 1995-96. With increasing N level, plant height increased in both the experimental period. Plant height, bulb girth, number of leaves plant^{-1}, bulb weight and highest yield (295.8 q ha^{-1}) were achieved with N and K at 160 and 80 kg/ha, respectively. Based on these results, 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}.

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

Singh *et al.* (1996) carried out a field trial in Agra, India to observe the effects of N (0, 60, 120 or 180 kg ha^{-1}) and S (0, 20, 40 or 80 kg ha^{-1}) on the growth of onions (cv. Pusa Red). The yield and plant nitrogen contents were significantly increased with increased nitrogen application. Combined application of N and S significantly increased its yield.

Amin (1995) worked on sandy loam soil in Mymensingh with onion cv. Taherpuri, planted on 20 December and 20 January and supplied with 0, 25, 50 or 100 kg N/ha. Yields were the highest from the planting of 20 December supplied with 100 kg N ha^{-1}. Individual bulb weight was also greater in this treatment

Singh *et al.* (1994) noticed that net plot yield, total marketable yield and total dry weight production were the best with N at 80 kg ha^{-1}. They also stated that plant mortality increased with increasing rates of nitrogen.

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

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

El-Oksh *et al.* (1993) observed that nitrogen application had no significant effect on plant height, number of leaves, fresh weight or dry weight, but bulbing ratio (the ratio of bulb to neck diameter) was decreased and total chlorophyll content was increased with increasing nitrogen application. High nitrogen increased bulb fresh weight at harvest.

Vachhani and Patel (1993) studied the effect of different levels of NPK on the growth and yield of onion. They found that plant height, number of leaves plant^{-1}, bulb weight and yield were the highest with 150 kg N ha^{-1}, although bulb weight and yield at 100 kg N ha^{-1} were not significantly different. Increasing phosphorus application increased the number of leaves per plant, weight, size and yield of bulbs. Application of K increased only the number of leaves per plants.

Pandey *et al.* (1992) conducted an experiment to find out the effect of nitrogen and spacing on *kharif* onion cv. Agrifound Dark Red at Jaipur, Rajasthan, India. They found that both 80 and 120 kg N ha^{-1} gave significantly higher yields, larger umbels and less incidence of thrips than the lower fertilizer rates, The incidence of purple blotch was unaffected by N application.

Rahim *et al.* (1992) conducted an experiment on the scope for increasing the total yield and fulfilling the demand of onions during the period of shortage in Bangladesh through the bulb-to-bulb (set) method of production. In a fertilizer trial, onion sets were planted on 6th November at a spacing of 25 × 15 cm and supplied with 0-160 kg K ha^{-1} and 0-100 kg N ha^{-1}, half before planting and half 36 days after planting. The combination of the highest application rates of N and K resulted the yield of 11.11 t ha^{-1} compared with 4.5 t ha^{-1} from unfertilized control plots

Kumar and Shama (1991) conducted an experiment with two onion cultivars N-53 and N-2-4-1, in the *kharif* season and reported that bulb yield increased linearly with increasing N application up to 75 kg ha^{-1}. The mean increase in the bulb and plant weight ratio was 1: 2.22 with 25 kg N, compared with 1: 1.95 for untreated controls; higher N rates reduced this ratio.

Jitendra *et al.* (1991) in their trial of onion CVs. applied N @ 80, 120 and 160 kg ha^{-1}, K_2O @ 100 and $ZnSO_4$ @ 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 (32.68 t ha^{-1}) was obtained with the higher rate of N along with K and Zn.

Singh and Sharma (1991) stated that soil moisture regimes and nitrogen application to onion crop influenced the diameter of bulb and yield significantly. They also reported that application of nitrogen at 80 kg ha^{-1} resulted in 38% increase in bulb weight over control.

Pandey *et al.* (1991) studied the effect of four levels of nitrogen (0, 50, 100, 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}) on the yield and quality of *kharif* onion. They found that the maximum yield and net return were achieved with N: P: K at 150: 40: 50 kg ha^{-1}.

Lang (1987) clarified the requirement of N fertilizer to make up the crops at different stages of growth. Flat rate applications of 193 kg N/ha caused considerable losses due to irrigation and the cost of production were higher. Specific application of N at 105 kg/ha was found to reduce N losses and costs and increase yield.

2.2 Effect of mulching on growth and yield of onion

Generally onion grown in Bangladesh during dry season of the year. It is soft succulent and herbaceous crop. So, moisture status of the soil is very important for growth and development of the crop. For this reason, onion requires frequent irrigation. But irrigation facility is not available all part of the country and irrigation also increase cost of production. In this situation moisture conservation through mulching ensure sufficient moisture supply to the growing crop.

Najafabadi *et.al.* (2012) reported that plastic mulch increased minimum temperature of soil, accelerated plant height, early growth, early yield, and bring satisfactory weed control without any application of herbicides. Two years experiment and interaction between year and mulches the usage of rice straw in rainy and cool season and plastic mulch in low rain fall and warm season recommended increasing garlic quality as second crop in rice field.

Anisuzzaman *et al.* (2009) conduct an experiment at Bangladesh Agricultural University , Mymensingh during rabi season about planting time and mulching effect on onion development and seed production. Black polythene, white polythene, water hyacinth and control treatment are used. The result revealed that the highest number of leaves per plant (27.07) was found in black polythene mulch, which was identically followed by water hyacinth (25.07) and white polythene (23.80) . The control treatment gave minimum number of leaves (18.48).

Melek and Dursun (2009) conduct an experiment at Turkey and reported that average marketable yield of melon increased by 25-28% in clear plastic mulch and 15% in black plastic mulch compared to the control application. Soil temperature in clear and black mulch applications were higher (5-8oC and 1-4oC respectively) than that of control application

Jamil *et al.* (2005) reported that garlic bulb weight was significantly affected by different type of mulches . Maximum bulb weight (385.9 g) was observed in straw mulch followed by plastic (373 g) and sawdust (311.77 g) mulch while minimum bulb weight (274.8 g) was measured in control plots.

Juan et al. (2004) conduct an experiment at the university of Georgias Blackshank Farm, Coastal plain experimental station , Tifton , Ga, America and result found that onion plants grown on bare soil gave height yield of onion . There were no consistent differences on yields of plants on plastic film mulch and those under wheat straw mulch. Bulb yield increase with the increased of seasonal root zoon temperature (RTZ) up to an optimum at 15.8 ^{0} C, followed by reductions in yield at >15.8 ^{0} C. Seasonal RZT of onion plants on bare soil was closer to the optimum seasonal RZT .

Haque *et al.* (2003) carried out an experiment to study the effect of natural and synthetic mulches on yield of local and exotic garlic cultivars during the period from November 2000 to march 2001. The results of the experiment revealed that significant variations exist among the different mulches in respect of morphological characters, yield contributing characters and yield of garlic. Water hyacinth mulch produced the tallest plant with higher number of leaves and roots per plant, higher fresh and dry weight of bulb, length of bulb and highest yield per hectare. Bulb diameter and number of cloves per bulb were higher in black polyethylene mulch. The exotic cultivar performed better than the local cultivar in respect of plant height, number of leaves and roots per plant, fresh and dry weight of bulb and yield per hectare.

Kebede et al. (2003) conduct an field experiment to evaluate the response of shallots (*allium cepa* var *ascalonicum* Baker) to mulching and nitrogen fertilization at eastern

Ethiopia . The mulch treatments were bare ground, wheat straw, black and clear polythene sheets, each with nitrogen application rates at 0, 75, 15 kg/ ha. The result revealed that nitrogen showed interactive effect with mulching on leaf number and bulb dry matter content. Unfertilized and black plastic mulched plots gave the highest number of leaf while unfertilized bare plots and clear plastics mulched plots gave the least. Straw mulched and bare plots at Nitrogen rates 75 kg/ha and clear plastic at nitrogen rate of 75 kg/ha gave height dry matter content of bulb

Islam *et al.* (2002) studied the effect of mulching and bulb size on growth of onion. Control, ridge method of mulch, straw and black polythene used as treatment. The result found that at each DAP, comparatively higher plant height was found by using straw mulch than other treatments of mulch.

Abu-Awad (1999) obtained the height onion yield from covered soil surface at low water levels. He also reported that water use efficiency was maximum in covered soil surface from the highest water level.

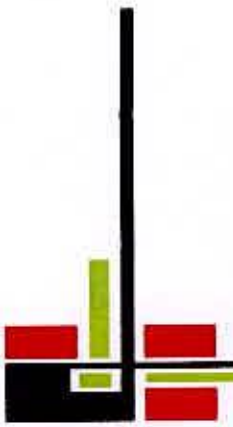
Rahman *et al.* (1996) reported that significant variations were observed due to the effect of different mulches on bulb diameter, bulbing ratio, individual bulb weight, yield, total biological yield, harvest index and percentage of splitted bulbs in onion. The yield of mulched plants was higher due to the production of higher bulb weight as they were positively related. The highest yield (10.07 t/ha) was found with ash mulch and the lowest (9.81 t/ha) was with control.

Mia (1996) found that plants grown with mulch gave higher bulb yield than non-mulch showing better performance in most of the yield contributing characters such as plant height, leaf number, pseudostem diameter and dry matter of roots etc. of onion.

Hwang *et al.* (1996) conduct an experiment to investigate the mulching effect on growth and yield of onion. The highest plant growth and yield was obtained with transparent polythene film mulch.

Hossain (1996) noted that plant height, leaf number, pseudostem and bulb diameter, dry matter content of foliage and bulb, bulb weight, bulb yield of garlic were significantly higher for mulched than for unmulched plants.

Castilla *et al.* (1994) studied the influence of soil mulching with polythene film on garlic. Single and double garlic rows mulched with polythene film were compared with bare soil (control). Soil temperature (10cm depth) was significantly higher in the mulched treatments than the control, increasing the growth and development in the first phase of the cycle. Yields of fresh green plants (harvested for fresh consumption) were significantly higher in the mulched treatment.



Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

This chapter includes a brief description about experimental period, site description, climatic and soil condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, intercultural operation, data collection and statistical analysis.

3.1 Experimental period

The experiment was conducted during the period from October 2010 to April 2011 in rabi season.

3.2 Site description

The experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, under the agro-ecological zone of Modhupur Tract, AEZ-28. For better understanding about the experimental site is shown in the Map of AEZ of Bangladesh in Appendix I.

3.3 Climatic condition

The experimental area under the sub-tropical climate is characterized by less rainfall associated with moderately low temperature during rabi season, October-March and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season April-September. The weather data during the study period at the experimental site are shown in Appendix II.

3.4 Soil condition

The soil of experimental area situated in the Modhupur Tract (UNDP, 1988) under the AEZ no. 28 and Tejgaon soil series (FAO, 1988) and the morphological, physical and chemical characteristics of the soil of experimental plot have been shown in the tables 3.4.1 and 3.4.2.

3.4.1 Morphological characteristics of experimental field

Morphological feature	Characteristics
AEZ	Madhupur Tract, AEZ 28
General Soil Type	Shallow red brown terrace soil
Land type	Medium high land
Flood level	Above flood level
Drainage	Well drainage condition

3.4.2 Physical and chemical properties of the soil

Characteristics	Value
Sand %	27
Silt %	43
Clay %	30
pH	5.6
Organic matter %	0.78
Total N %	0.03
Available P (ppm)	20
Exchangeable K (me/100gm soil)	0.10
Available S (ppm)	45

3.5 Planting material

Onion variety named as Taherpuri was used for this study. The seeds of this variety were collected from a seed dealer of Siddique Bazar, Gulistan, Dhaka on 15 October 2010.

3.6 Raising of seedlings

Onion seedlings were raised in two seedbeds situated on a relatively high land adjacent to the Horticultural Farm Office of SAU. High, well drained and sunny place was selected for seedbed preparation. The land was ploughed finely and dried for 10 to 15 days. Weeds and

stubbles were removed carefully. The soil was made into friable, loose and brought into good tilth condition. The size of each seedbed was 3 m × 1 m with height of about 10 cm. Seeds were soaked in water for one night and then kept in a piece of cloth for sprouting. After sprouting the seeds were sown in the seedbed at a depth of about 0.5 cm on 17 November 2010. Curator @ 6 kg/ha was dusted over the seedbed to protect the germinating seeds from ants. The germination was completed within 7 days after sowing. Light irrigation and weeding was done whenever it was necessary.

3.7 Treatments of the experiment

Factor A: Four different doses of N (N)

N_0 = without nitrogen

N_{60} = 60 kg N/ha

N_{120} = 120 kg N/ha

N_{180} = 180 kg N/ha

Factor B: Three different types of mulch materials

M_0 = without mulching

M_s = mulching with straw

M_w = mulching with water hyacinth

3.7.1 Treatment combinations

There were 12 treatment combinations of different N doses and mulch materials which were used in the experiment are as follows :

1. N_0M_0
2. N_0M_s
3. N_0M_w
4. $N_{60}M_0$
5. $N_{60}M_s$
6. $N_{60}M_w$
7. $N_{120}M_0$
8. $N_{120}M_s$
9. $N_{120}M_w$
10. $N_{180}M_0$
11. $N_{180}M_s$
12. $N_{180}M_w$

3.8 Design and layout of the experiment

The experiment consisted of 12 treatment combinations and was laid out following Randomized Complete Block Design (RCBD) with 3 replications. An area of 245 m^2 was divided into 36 plots . The size of each plot was 2 m × 1.5 m = 3 m^2. The distance between block to block is 1 m and distance between plot to plot is 0.5 m and plant spacing is 20 cm X 10 cm. The layout of the experiment is presented in Appendix III.

3.9 Preparation of the field

The experimental plot was opened on 2 December 2010 and afterwards the land was ploughed and cross-ploughed several times with the help of a power tiller followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and the large clods were broken into smaller pieces to obtain a desirable tilth of friable soil for transplanting of seedlings. According to the lay out of the experiment the entire experimental area was divided into blocks and subdivided into plots for the transplanting of onion seedlings. In addition, irrigation and drainage channels were prepared around the plots.

3.10 Rates and application of manures and fertilizers

In this experiment manures and fertilizers were used according to BARI and Miah (2008) as follows:

Manures and fertilizers	Rate of application per ha.
Cowdung (decomposed)	10 t
Urea	As per treatment
TSP	220 kg
MOP	200 kg
Gypsum	180 Kg

The well decomposed cow dung was applied after opening the land. The whole required amounts of Triple Super Phosphate (TSP) and gypsum were applied at the time of final land preparation. The total Muriate of Potash (MOP) was applied in two equal installments one at the

time of final land preparation and the remaining at 40 days after transplanting. Urea was used as top dressed in three equal splits at 30, 40, and 50 days after transplanting (DAT).

3.11 Transplanting of seedlings

The onion seedbed was watered before uprooting the seedlings so as to minimize the damage of roots. Healthy and disease free uniform sized 45 days old onion seedlings were uprooted from the seedbeds and transplanted in the main field by maintaining the spacing 20 cm between line to line and 10 cm between plant to plant in the afternoon on 1 January 2011. The transplanted seedlings were watered immediately after transplanting. Some seedlings were also transplanted contiguous to the experimental field as border crop to be used for gap fillings.

3.12 Intercultural operation

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

3.12.1 Gap filling

Damaged seedlings were replaced by healthy plants those were retransplanted from the border of the experiment.

3.12.2 Weeding and Mulching

Weeding was done three times after transplanting to harvest to keep the crop free from weeds and mulching was done as per treatment after 15 days of onion seedling transplanting.

3.12.3 Water application

To examine the effect of mulching minimum and equal water application was done in each treatment during excessive dryness of soil.

3.12.4 Protection of plants

Initially, preventive measure was taken against the soil borne insects. For the prevention of cutworm (*Agrotis ipsilon*), soil treatment was done with Furadan 3 G @ 20 kg ha^{-1}. Few days after transplanting small number of plants were attacked by purple blotch disease caused by

Alternaria porri. Rovral 50 WP @ 2.5 g per liter water was used as a curative measure against purple blotch disease at 15 days interval.

3.12.5 General observation of the experimental field

The field was investigated frequently in order to reduce losses with weeds competition and insects infestation and diseases infection.

3.13 Harvesting

The crop was harvested on 15 April 2011 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.

3.14 Collection of data

Collection of data were done randomly from five selected sample plants on the following parameters rather than yield per plot and yield per hectare and started at 40 DAT up to harvesting.

1. Plant height (cm)
2. Number of leaves per plant
3. Dry weight of leaves during harvesting (g)
4. Pseudostem dry weight during harvesting (g)
5. Dry weight of roots during harvesting (g)
6. Bulb length (cm)
7. Bulb diameter (cm)
8. Fresh bulb weight (g)
9. Dry weight of bulb (g)
10. Yield/plot (kg)
11. Yield (t/ha)

3.14.1 Plant height (cm)

Plant height was measured three times at 10 days interval such as 40, 50 and 60 DAT. The height of the plant was determined by measuring scale considering the distance from the soil

surface to the tip of the randomly five selected plants and mean value was calculated for each treatment.

3.14.2 Number of leaves per plant

Number of leaves per plant was counted three times at 10 days interval such as 40, 50 and 60 DAT of onion plants those were considered for measuring plant height. Mean value of the data were calculated and recorded.

3.14.3 Dry weight of leaves per plant (g)

The dry weight of leaves per plant was taken from previously selected plants of each treatment and weight of dry matter of leaves was measured in g with electric balance after drying in an oven at 70° C for 72 hours and mean value was calculated.

3.14.4 Dry weight of individual pseudostem (g)

The pseudostem of selected five plants from each unit plot were collected and recorded their weight as measured in g with electric balance after drying in an oven at 70° C for 72 hours and mean value was calculated

3.14.5 Dry weight of roots per plant (g)

The root of selected plants were collected randomly from each unit plot and recorded the dry weight of root as measured in g with electric balance after drying in an oven at 70° C for 72 hrs. and mean value was calculated

3.14.6 Bulb length (cm)

The length of bulbs measured with a slide calipers from the neck to the bottom of the bulb from previously selected five plants and their average was calculated and recorded.

3.14.7 Bulb diameter (cm)

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

3.14.8 Fresh bulb weight (g)

Bulbs were collected from selected five plants according to treatment. Bulb fresh weight was measured in g with an electric balance and then averaged and recorded.

3.14.9 Dry weight of bulb (g)

Bulbs were collected from selected five plants from each experimental unit and sliced finely and dried first in the sun and then in an oven at 70° C for 72 hrs. Bulb dry weight was recorded in g with an electric balance in a laboratory and mean value was calculated

3.14.10 Yield of bulb per plot (kg)

Pseudostem and all the leaves were removed from all bulbs including five selected plants which were collected separately from each treatment having 1.5 cm neck. Then a simple electric balance was used to measure the total bulb weight in kg and data were recorded.

3.14.11 Yield of bulb per hectare (t)

Yield obtained from each unit plot was converted to yield in t ha^{-1}.

3.15 Analysis of data

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT computer package program. The mean differences among the treatments were compared by least significant difference (LSD) test at 5% level of significance.

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The results obtained with different doses of nitrogen and different types of mulching are presented and discussed in this chapter. Data of growth, bulb yield contributing characters and bulb yield of onion have been presented in both Tables and Figures and analyses of variance and corresponding degrees of freedom have been shown in Appendix.

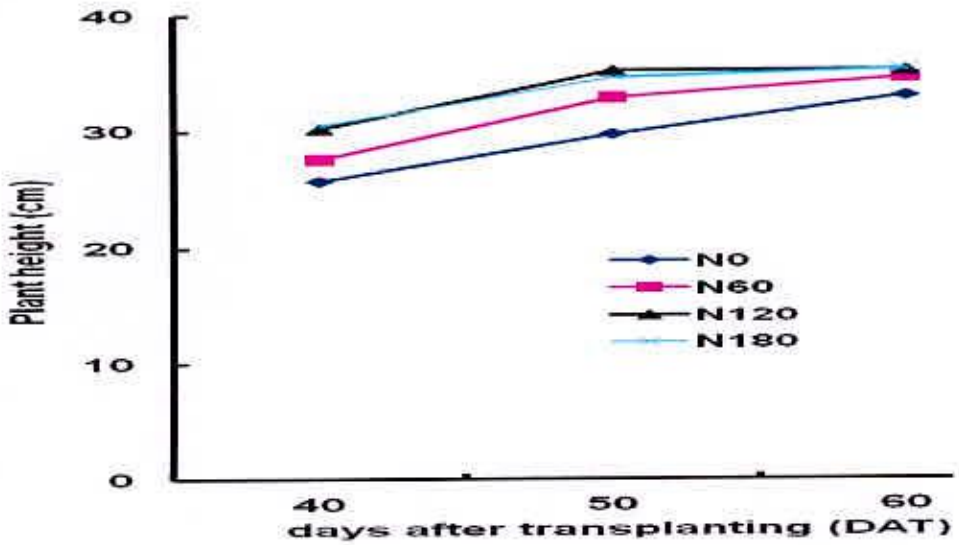
4.1 Plant height

It is well established that the nitrogen (N) enhances plant growth by increasing plant height, number of leaves, leaf area index etc (Aliya et al., 2008; Abdissa et al., 2011). The results of this study showed that N significantly increased plant height as dose dependent manner at different days after transplanting, DAT (Figure 1 and Appendix IV). The plant height increased with increasing the age of the plants. The tallest plant 31.93, 34.95 and 35.34 cm were recorded at 40, 50 and 60 DAT respectively with N_{180} (180 kg N ha^{-1}). Interestingly, no significant difference of plant height was found between N_{120} and N_{180} levels. In contrast, the smallest plants was recorded from control, N_0 at 40, 50, 60 DAT and height was 25.71, 29.74, 33.04 cm respectively. Similar findings were reported by Arboleya and Garcia, 1993; Amans et al., 1996; Kumar et al., 1998; Samaila, 2000; Khan et al., 2002; Aliyu et al., 2008 who showed that N increased onion plant height. All together, these results suggest that higher doses of N increase onion plant height at higher rate at different DAT.

Many previous reports showed that mulching (M) conserves soil moisture as well as provides desirable soil temperature thus promotes the vegetative growth of plant including onion plant height (Stowell, 2000; Mahajan et al., 2007). In this study, different mulch materials such as control (M_0), rice straw (M_s), water hyacinth (M_w) were used to investigate whether mulching regulates onion plant height. As shown in Figure 2 and Appendix IV, mulching significantly increased plant height at different DAT. The highest plant height 30.72, 33.69, 34.89 cm were found in water hyacinth mulched (M_w) at 40, 50 and 60 DAT, respectively but these values were not statistically dissimilar with rice straw mulched (M_s). The results also showed that the smallest plant 26.91, 31.88, 33.63 cm was recorded at control (M_0) at 40, 50, 60 DAT,

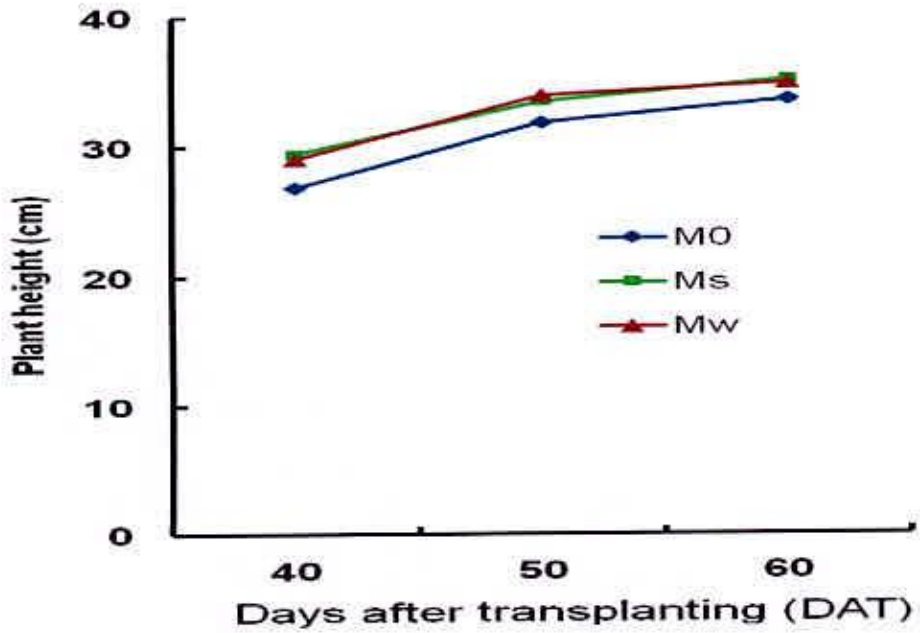
respectively. These results have the similarity with the previous reports of Islam et al., (2002) who stated that straw mulch showed better performance to promote onion plant height than other mulches. These results suggest mulching can promote onion plant height.

The results of the present study showed that N and M increased plant height independently. However, little is known about the interaction between N and M on regulation of onion plant height. Whether different levels of N and different types of M together regulate plant height of onion was investigated in this study. Combined use of N and M had influence the plant height which was found significant at 40, 50 and 60 DAT (Table 1 Appendix IV). The highest plant heights of 35.13, 36.14, 37.00 cm were recorded with the treatment combination of $N_{180}M_w$ at 40, 50, 60 DAT respectively while the minimum of 23.54, 28.03, 31.96 cm at control, the combined treatments of N_0M_0 at 40, 50, 60 DAT. Aliyu et al., (2008) reported that N is the main concerned nutrient for increasing the onion plant height and Khan et al., (2002) showed that M also increased onion plant height. All together these results indicate that onion plant height was increased with combined use of N and M.



N_0 = without nitrogen, N_{60} = 60 kg N/ha , N_{120} = 120 kg N/ha , N_{180} = 180 kg N/ha

Figure 1: Effect of different doses of nitrogen on the height of onion plant



M_0 = Without mulching, M_s = Mulching with straw, M_w = Mulching with water hyacinth

Figure 2: Effect of mulching on the height of onion plant

Table 1: Interaction effect of nitrogen (N) and mulching (M) on the height of onion plant

Treatment	Plant height (cm)		
	40 DAT	50 DAT	60 DAT
N_0M_0	23.54 i	28.03 f	31.96 e
N_{60} M_0	25.21 h	31.7 e	34.0 cd
N_{120} M_0	28.71 de	33.87 cd	34.50 c
N_{180} M_0	30.17 cd	33.90 cd	34.06 cd
N_0 M_s	26.97 fg	30.43 e	34.50 c
N_{60} M_s	29.20 cde	33.40 d	34.96 bc
N_{120} M_s	33.08 b	35.67 ab	36.30 ab
N_{180} M_s	30.5 c	34.80 bc	34.96 bc
N_0 M_w	26.63 g	30.77 e	32.66 de
N_{60} M_w	28.30 ef	33.58 cd	34.90 bc
N_{120} M_w	32.82 b	34.28 cd	35.00 bc
N_{180} M_w	35.13 a	36.14 a	37.00 a
LSD	1.404	1.224	1.607
Significance Level	**	*	*
CV %	3.62	2.43	2.75

In a column treatments having similar letter(s) do not differ significantly as per DMRT

N_0 = without nitrogen, N_{60} = 60 kg N/ha , N_{120} = 120 kg N/ha , N_{180} = 180 kg N/ha

M_0 = Without mulching, M_s = Mulching with straw, M_w = Mulching with water hyacinth

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

** = Significant at 1 % level

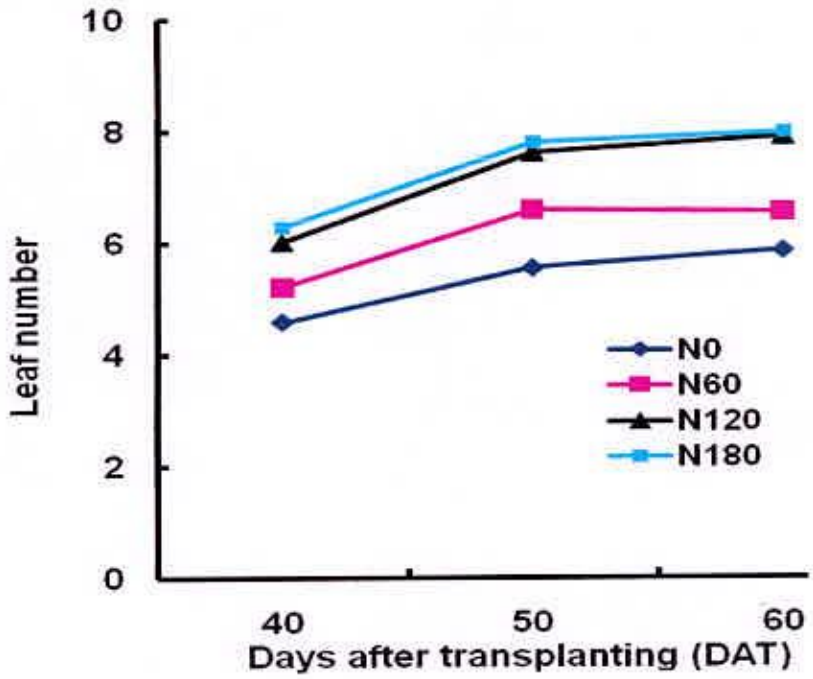
4.2 Number of leaves per plant

Generally N is one of the important primary nutrients which causes rapid vegetative growth of plant resulting in more number of leaves per plant (Khan et al., 2002). The result of this experiment showed that different doses of N have significant effect on number of leaves per plant of onion at different DAT such as 40, 50, 60 DAT (Figure 3 and Appendix V). Number of leaves in each plant was increased due to increasing level of N and increasing the age of onion plant. At 40, 50, 60 DAT maximum number of leaves 6.28, 7.80, 7.98 respectively was found with 180 kg N ha^{-1} (N_{180}) which was statistically similar of leaves number obtain from N_{120} treatment whereas the minimum number of leaves were observed at each DAT from control, N_0. Previous many results illustrated that N increased number of leaves per plant of onion with increasing N levels up to 150 kg ha^{-1} (Kumar et al., 1998; Khan et al., 2002; Aliyu et al., 2008). The present results of leaves number per onion plants in response to N did not show any conflict with other findings.

The nutrient availability induces greater number of leaves per plant reported by many authors. In addition, the higher nutrient availability by mulch was also well established in garli , Baten et al., (1995). In this study, the present results showed that M significantly increased leaves number of onion and maximum number of leaves 5.65, 7.10 and 7.28 was found from M_w at 40, 50, 60 DAT, respectively which was statistically similar with rice straw mulched (M_s) plots and minimum number of leaves was produced at control at each DAT (Figure 4 and Appendix V) and suggesting that leaves number of onion increased with mulch. These results are aggred with the findings of Anisuzzaman et al., (2009).

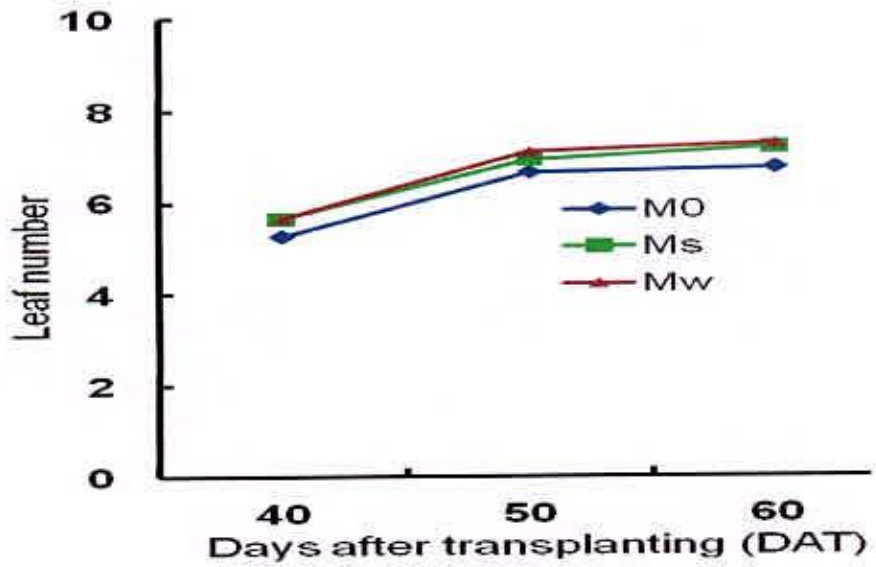
The growth of plants including number of leaves of plant increase may be attributed to combined use of N and M which might have acted as a source of nutrient and moisture supply. Mulching can facilitate quick and greater availability of plant nutrients and thus provides a better environment for root growth and proliferation, thereby creating more absorptive surface for uptake of nutrients. In this study, I used various doses of N and three types of M to find their

influence on number of leaves of onion plant. As shown in Table 2 and Appendix V the interaction between N and M appeared significant effect on number of leaves per plant. At 40 and 50 DAT the treatment combination $N_{180}M_0$ produced maximum number of leaves which is statistically similar with $N_{120}M_s$, $N_{180}M_s$, $N_{120}M_w$, and $N_{180}M_w$ treatment. In addition, the $N_{120}M_w$ treatment showed maximum number of leaves at 60 DAT which did not show any statistical differences with $N_{180}M_0$, $N_{120}M_s$, $N_{180}M_S$, $N_{180}M_w$ treatments, while the lowest values were obtained with M_0N_0 treatment at each DAT. These results suggest that combined use of N and M; or higher doses of N (180kg/ha) alone produced maximum number of leaves and also indicating that medium doses of N (120 kg/ha) along mulch either straw or water hyacinth produced higher number of leaves of onion plant.



N_0 = without nitrogen, N_{60} = 60 kg N/ha , N_{120} = 120 kg N/ha , N_{180} = 180 kg N/ha

Figure 3: Effect of different doses of nitrogen on number of leaves per onion plant



M_0 = Without mulching, M_s = Mulching with straw, M_w = Mulching with water hyacinth

Figure 4: Effect of mulching on number of leaves of onion plant

Table 2: Interaction effect of nitrogen (N) and mulching (M) on number of leaves per onion plant

Treatment	Leaves Number per ptant		
	40 DAT	50 DAT	60 DAT
N_0M_0	4.00 f	5.06 f	5.40 g
N_{60} M_0	4.66 e	6.20 dc	6.06 f
N_{120} M_0	5.93 ab	7.20 bc	7.40 cd
N_{180} M_0	6.46 a	8.133 a	8.13 ab
N_0 M_s	4.86 de	5.66 e	6.13 f
N_{60} M_s	5.33 cd	6.73 cd	6.93 de
N_{120} M_s	6.06 ab	7.66 ab	8.00 ab
N_{180} M_s	6.33 a	7.66 ab	7.73 bc
N_0 M_w	4.86 de	5.93 e	6.06 f
N_{60} M_w	5.60 bc	6.86 c	6.66 e
N_{120} M_w	6.06 ab	8.00 a	8.33 a
N_{180} M_w	6.06 ab	7.6 ab	8.06 ab
LSD	0.553	0.559	0.524
Significance Level	*	*	*
CV %	5.93	4.79	4.37

In a column treatments having similar letter(s) do not differ significantly as per DMRT

N_0 = without nitrogen, N_{60} = 60 kg N/ha , N_{120} = 120 kg N/ha , N_{180} = 180 kg N/ha

M_0 = Without mulching, M_s = Mulching with straw, M_w = Mulching with water hyacinth

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

4.3 Dry weight of leaves per plant

Dry matter production and its accumulation in plant achieved with the development of sound vegetative growth *viz.* plant height, leaves number etc. This study showed the significant influence of different doses of N on dry weight of onion leaves (Table 3 and Appendix VI). The maximum dry weight of leaves/plant (1.73 g) was noted with the application of 180 kg N ha^{-1} (N_{180}) which was statistically identical with N_{120} whereas the lowest dry weight (1.22 g) was recorded in control (N_0). All leaves of each plant were not fresh during harvesting period. For this reason I failed to collect the data of fresh weight of leaves/plant.

The increment of plant growth is associated with the availability of nutrients and moisture supply which may alter with both N and M. Similar information was published by Thakur et al., (2000) who reported that M increased leaf dry weight. In addition, Hossain., (1996) stated that more leaves dry weight obtained with M treatment in garlic. This present study showed a significant effect of M on dry weight of onion leaves per plant (Table 3 and Appendix VI). The plants under water hyacinth mulch produced maximum dry weight (1.59 g) of leaves per plant which was statistically similar with rice straw mulch. Besides, the lowest leaves dry weight per plant (1.31 g) was recorded from control. All together, it is suggested that M increased dry weight of leaves per plant of onion.

In interaction effect of N and M on leaf dry weight exhibits a non significant effect (Table 4 and Appendix VI). Although numerically highest (1.88 g) dry weight was recorded in $N_{180}M_w$ treatment, but lowest (1.14g) was noted in N_0M_0 treatment.

4.4 Dry weight of individual pseudostem

In this study, N had a significant effect on onion pseudostem dry weight (Table 3, Appendix VI). The maximum pseudostem dry weight (0.59 g) was noted from N_{180} treatment which was statistically similar with N_{120} treatment. Whereas the lowest pseudostem dry weight (0.44 g) was obtained from N_0 treatment.

M also increase growth of plant including pseudostem growth. M had a significant effect on onion pseudostem dry weight (Table.3 and Appendix VI). In this study, maximum pseudostem dry weight (0.57 g) was noted from M_s treatment which was statistically identical with M_w (0.55 g) treatment. But the minimum pseudostem dry weight (0.45 g) was found in M_0 treatment.

Interaction effect of N and M on onion pseudostem did not show statistical significant (Table.4 and Appendix VI). Meanwhile numerically maximum pseudostem dry weight (0.63 g) was found in $N_{180}M_s$ treatment whereas the minimum dry weight (0.34 g) was noted from N_0M_0 treatment combination.

4.5 Root dry weight per plant

A significant effect on root dry weight due to application of different doses of N (Table 3 and Appendix VI) was observed. In this study, maximum root dry weight (0.018 g) was recorded in N_{180} treatment which was statistically identical with N_{120} treatment. The lowest root dry weight was obtained from N_0 treatment.

M also showed a significant variation on root dry weight (Table 3 and Appendix VI) .Maximum root dry weight (0.017 g) was observed in M_w treatment. Meanwhile this result was statistically identical with both of the M_s (0.016 g) and M_0 (0.012 g) treatment.

Interaction effect of N and M on rood dry weight had a significant variation (Table 4 and Appendix VI). In this field experiment, it was observed that maximum dry root weight was identical among $N_{180}M_0$, $N_{120}M_s$, $N_{120}M_w$ and $N_{180}M_w$ treatment. But the minimum root dry weight was noted from M_0N_0 treatment.

Table 3: The effect of nitrogen and mulching on dry weight of leaves, dry weight of pseudostem and dry weight of roots per onion plant

Treatment	Dry weight of leaves (g) per plant	Pseudostem dry weight (g) per plant	Dry weight of roots (g) per plant
Effect of nitrogen			
N_0	1.23 b	0.45 c	0.016 a
N_{60}	1.38 b	0.50 bc	0.011 b
N_{120}	1.58 a	0.57 ab	0.017 a
N_{180}	1.74 a	0.60 a	0.018 a
LSD	0.174	0.075	0.003
Significance Level	**	**	**
Effect of mulching			
M_0	1.31 b	0.46 b	0.012 a
M_s	1.54 a	0.57 a	0.016 a
M_w	1.60 a	0.56 a	0.017 a
LSD	0.151	0.065	0.008
Significance Level	**	**	**
CV	12.12	14.27	17.71

In a column treatments having similar letter(s) do not differ significantly as per DMRT

N_0 = without nitrogen, N_{60} = 60 kg N/ha , N_{120} = 120 kg N/ha , N_{180} = 180 kg N/ha

M_0 = Without mulching, M_s = Mulching with straw, M_w = Mulching with water hyacinth

CV = Co-efficient of Variation

LSD = Least Significant Difference

** = Significant at 1 % level

Table 4: The interaction effect of nitrogen and mulching on dry weight of leaves, dry weight of pseudostem and dry weight of roots per onion plant

Treatment	Leaf dry weight (g) per plant	Pseudostem dry weight (g) per plant	Root dry weight (g) per plant
N_0M_0	1.14	0.35	0.010 d
N_{60} M_0	1.22	0.44	0.010 d
N_{120} M_0	1.34	0.50	0.010 d
N_{180} M_0	1.54	0.55	0.020 a
N_0 M_s	1.27	0.50	0.017 b
N_{60} M_s	1.36	0.55	0.013 c
N_{120} M_s	1.73	0.60	0.020 a
N_{180} M_s	1.78	0.63	0.013 c
N_0 M_w	1.27	0.50	0.020 a
N_{60} M_w	1.56	0.51	0.010 d
N_{120} M_w	1.67	0.62	0.020 a
N_{180} M_w	1.88	0.60	0.020 a
LSD			0.0005
Significance Level	NS	NS	**
CV %	12.12	14.27	17.71

In a column treatments having similar letter(s) do not differ significantly as per DMRT

N_0 = without nitrogen, N_{60} = 60 kg N/ha , N_{120} = 120 kg N/ha , N_{180} = 180 kg N/ha

M_0 = Without mulching, M_s = Mulching with straw, M_w = Mulching with water hyacinth

CV = Co-efficient of Variation

LSD = Least Significant Difference

NS = Non-significant

** = Significant at 1 % level

4.6 Bulb length

The high values of plant height, number of leaves per plant under higher rate of N reflect the role of N in enhancing biochemical process which in turn enhanced the vegetative growth in the plant. Separately, the higher doses of N sometime failed to increase onion bulb length (Haque et al., 2004). The application of N had a significant variation on bulb length of onion (Table 5 and Appendix VII). The result of this study showed that, application of N up to 120 kg ha^{-1} increased bulb length such as 3.53 cm. Further increased level of N 180 kg ha^{-1} was not increase bulb length (3.46 cm) and statistically similar with N_{120} treatment whereas the minimum bulb length (2.78 cm) was obtained from N_0 treatment. Haque et al. (2004) stated that bulb length of onion increased with increasing rate of N up to 125 kg ha^{-1}. All together, present results indicate that N enhances the onion bulb length up to 120 kg ha^{-1} but not with 180 kg ha^{-1}.

Mulching conserve soil moisture and provide optimum soil temperature which cause rapid growth of onion plant and proper development of onion bulb resulting in higher length of bulb (Vavrina and Roka, 2000). In this study, M had significant effect on bulb length (Table. 5 and Appendix VII). Highest 3.40 cm bulb length was noted from M_w treatment which was statistically identical with Ms (3.38 cm) treatment. But lowest 2.99 cm length was obtained from M_0 treatment. These results agreed with Baten et al., 1995; Haque et al., 2003. All together it is suggested that M gave higher bulb length compare to control.

This present above mentioned results showed that N and M increased bulb length independently. However, the effect of interaction between N and M on bulb length of onion is not clear. A significant effect was found on bulb diameter due to interaction of N and M. Bulb length of onion had no statically significant variation due to interaction effect of N and M (Table. 6 and Appendix VII). Although numerically highest length (3.64 cm) was noted from $N_{120}M_w$ treatment and lowest 2.42 cm was obtained from N_0M_0 treatment and also representing that N 120 kg ha^{-1} along with water hyacinth mulch capable to increase bulb length of onion. It is better to conduct further trial to verify present results.

4.7 Bulb Diameter

Nitrogen accelerates the growth of onion plant and higher growth ensure large onion bulb resulting in higher bulb diameter. In this experiment, N had significant effect on onion bulb diameter (Table 5 and Appendix VII). N positively affected and increase bulb diameter with the increasing N up to 120 kg ha^{-1}. Highest bulb diameter (3.6 cm) was recorded with application of 120 kg N ha^{-1} (N_{120}), whereas the lowest bulb diameter (2.67 gm) was found from control plots (N_0) . This findings was agreed with Kumar et al., (1998), Khan et al., (2002), Aliyu et al., (2008) and all together, it is suggested that the bulb diameter of onion increase with the increasing rate of N.

Mulching conserve soil moisture and regulate soil temperature thus induce rapid growth of onion plant and proper development of onion bulb resulting in higher bulb diameter (Jamil et al., 2005). In this study showed that M had significant effect on diameter of onion bulb (Table. 5 and Appendix VII). The highest bulb diameter (3.47 cm) was recorded with water hyacinth mulch (M_w), followed by straw mulch (Ms) and bulb diameter was 3.45 cm which was statistically similar with water hyacinth mulch (M_w). Whereas the lowest bulb diameter (2.97 cm) was obtain from control plots. Sumi et al. (1986) reported that M produced higher bulb diameter compare to un-mulched condition. In case of garlic, Beten et al. (1995) and Mia (1996) also reported similar results of higher bulb diameter with water hyacinth mulch. All together, it is suggested that bulb diameter of onion increased with mulching.

Onion bulb diameter significantly increased with N and M separately. However, to my knowledge the interaction effect between N and M on bulb diameter of onion is unclear. Therefore, I discussed about interaction effect of N and M on bulb diameter. Interaction effect of N and M on bulb diameter varied significantly (Table 6, Appendix VII). The highest bulb diameter (3.75 cm) was recorded from $N_{120}M_w$ treatment which was statistically similar with $N_{60}M_s$, $N_{120}M_s$, $N_{180}M_s$, $N_{60}Mw$, $N_{180}M_w$ treatment. Therese the lowest bulb diameter (2.35 cm) was obtained from M_0N_0 treatment. These results suggest that combined use of N and M i.e medium doses of N (120 kg/ha) along with mulch either straw or water hyacinth produced higher bulb diameter rather than higher doses of N (180 kg ha^{-1}) with mulch either straw or water hyacinth.

4.8 Fresh weight of bulb

Previous reports illustrated that N is an essential element for onion growth to build up protoplasm and proteins, which induce cell division and the meristematic activity (Devlin, 1979; Al-Fraihat, 2009). In addition, it was also stated that N is an important macro nutrient needed for proper growth and development of every plant which enhances bulb formation and development resulting in higher fresh weight of bulb (Aliyu etal., 2008). The present results of this study showed that bulb fresh weight of onion was significantly affected by application of N (Table 5 and Appendix VII). The application of N up to 120 kg ha^{-1} resulted into an increase in individual bulb fresh weight and produced 22.83 g. But further increase to 180 kg ha^{-1} (N_{180}) failed to increase fresh weight of onion and which was statistically not differ with the result obtained from application of 120 kg N ha^{-1}. This result has no conflict with Nasreen et al. (2007) who observed that 120 kg ha^{-1} N gave significantly higher fresh weight of onion than lower fertilizer rates. Similar result was also reported by Greenwood et al. (2001) and Khan et al. (2002) for onion. Ramamoorth et al. (1999), Kashi and Frodi (1998) also reported the similar result. Control plots produced the lowest fresh weight of bulb (14.10 gm). All together it is suggested that application of N up to 120 kg ha^{-1} (N_{120}) increase bulb fresh weight.

Covering the soil with mulch material assures better water retention, improves its aggregation and protects from sudden temperature changes which positively influence yield component resulting increased bulb weight (Zaongo et al., 1997; Kesik et al., 2006). M had significant effect on fresh weight of individual bulb of onion (Table 5 and Appendix VII). The highest bulb weight (22.42 g) was observed with water hyacinth mulch (M_w), whereas the lowest (14.99 gm) was observed at non-mulched (M_0) plots and straw mulched produce 20.96 g of bulb. The result of this present study was supported by the findings of Abdel, (1990); Hossain, (1996); Rekowska, (1997) who stated that M increased bulb fresh weight of onion. Similar observation also found in garlic observed by Sumi et al., (1986), Jamil et al., (2005) who concluded that the highest fresh weight garlic was obtained from those plants which were grown under mulch. All together it is suggested that M increase bulb fresh weight of onion bulb.

The present results of this study showed that N and M increased bulb fresh weight of onion independently. However, to my knowledge the interaction effect between N and M on bulb fresh weight of onion is not understood clearly. I investigated whether different levels of N and different types of M together regulate bulb fresh weight of onion. The present result of this study showed the Interaction effect of N and M on bulb diameter varied significantly (Table 6, Appendix VII). The highest bulb fresh weight (26.13 g) of bulb was recorded from the treatment combination of $N_{120}M_w$, (120 kg N $ha^{-1}$with water hyacinth mulch) which was statistically similar with $N_{120}M_s$, $N_{180}M_s$, $N_{60}M_w$ and $N_{180}M_w$ treatment. While the lowest weight (12.83 gm) of bulb was observed from N_0M_0 (without nitrogen and mulching)

4.9 Dry weight of bulb

Abdissa et al., (2011) concluded that mean bulb weight improvement in response to N could be attributed to the increase in plant height, number of leaves produced, leaf length, and extended physiological maturity in response to the fertilization, all might have increased assimilate production and allocation to the bulbs and increased bulb dry weight. In this study, showed that dry weight of onion bulb varied significantly with the different doses of N (Table 5, Appendix VII). Maximum dry weight per onion bulb (2.422 g) was noted from N_{120} whereas the minimum dry weight (1.60 g) was recorded in control . Kumer et al. (2006), Miah (2008) reported that 100 to 150 kg N ha^{-1} produced more dry matter content compare to control condition.

Mulch conserved adequate soil moisture which increases chlorophyll content of plant (El-oksh et al., 1993). Rate of photosynthesis increased with the increase level of chlorophyll content. For this reason higher amount of dry matter was accumulated in onion bulb. In this study, M had significant effect on dry weight of onion bulb (Table 5 and Appendix VII). Plant grown under water hyacinth mulch (M_w) produced the highest dry weight (2.25 g) which was statistically similar with straw mulch treatment. Lowest dry weight (1.66 g) was observed in control treatment. In case of garlic, M increase dry matter content (Abdel, 1990; Haque et al., 2003). All together, it is suggested that dry weight of onion bulb increased with M.

Combined effect of N and M was significant in respect of bulb dry weight (Table. 6 and Appendix VII). Highest bulb dry weight (2.77 g) was recorded in $N_{120}M_w$ treatment which was statistically not differ with $N_{120}M_s$, $N_{180}M_w$ treatment. But lowest bulb dry weight(1.44 g) was noted in N_0M_0.

Table 5: The main effect of nitrogen and mulching on diameter and length of bulb, fresh and dry weight of bulb and bulb weight per plot

Treatment	Bulb length (cm)	Bulb diameter (cm)	Bulb fresh weight (g)	Bulb dry weight (g)	Bulb weight (kg/plot)
	Effect of nitrogen				
N_0	2.78 c	2.67 c	14.10 c	1.60 d	1.97 d
N_{60}	3.26 b	3.36 b	19.50 b	1.89 c	2.73 c
N_{120}	3.54 a	3.61 a	22.83 a	2.41 a	3.19 a
N_{180}	3.46 a	3.57 a	21.39 a	2.24 b	2.99 b
LSD	0.141	0.097	1.44	0.151	0.20
Significance Level	**	**	**	**	**
	Effect of mulching				
M_0	2.99 b	2.98 b	14.99 c	1.66 b	2.09 c
M_s	3.38 a	3.46 a	20.96 b	2.19 a	2.93 b
M_w	3.40 a	3.47 a	22.41 a	2.26 a	3.13 a
LSD	0.122	0.084	1.255	0.131	0.173
Significance Level	**	**	**	**	**
CV	4.48	3.00	7.62	7.59	7.55

In a column treatments having similar letter(s) do not differ significantly as per DMRT

N_0 = without nitrogen, N_{60} = 60 kg N/ha , N_{120} = 120 kg N/ha , N_{180} = 180 kg N/ha

M_0 = Without mulching, M_s = Mulching with straw, M_w = Mulching with water hyacinth

CV = Co-efficient of Variation

LSD = Least Significant Difference

** = Significant at 1 % level

Table 6: The interaction effect of N and M on diameter and length of bulb , fresh and dry weight of bulb and bulb weight per plot

Treatment	Bulb length (cm)	Bulb diameter (cm)	Bulb fresh weight(g)	Bulb dry weight(g)	Bulb yield kg/plot
N_0M_0	2.42	2.35 d	12.83 e	1.45 f	1.79 e
N_{60} M_0	2.86	2.84 c	14.07 de	1.63 ef	1.97 de
N_{120} M_0	3.32	3.34 b	16.66 c	1.81 cde	2.33 c
N_{180} M_0	3.35	3.38 b	16.40 cd	1.75 de	2.29 cd
N_0 M_s	2.94	2.84 c	14.16 cde	1.67 ef	1.98 de
N_{60} M_s	3.45	3.60 a	20.00 b	2.04 c	2.80 b
N_{120} M_s	3.64	3.73 a	25.70 a	2.66 ab	3.60 a
N_{180} M_s	3.49	3.66 a	23.96 a	2.40 b	3.35 a
N_0 M_w	2.97	2.84 c	15.30 cde	1.69 ef	2.14 cde
N_{60} M_w	3.48	3.64 a	24.43 a	2.01 cd	3.42 a
N_{120} M_w	3.64	3.76 a	26.13 a	2.77 a	3.66 a
N_{180} M_w	3.53	3.65 a	23.80 a	2.55 ab	3.33 a
LSD		0.169	2.209	0.262	0.347
Significance Level	NS	**	**	**	**
CV %	4.48	3.00	7.62	7.59	7.55

In a column treatments having similar letter(s) do not differ significantly as per DMRT

N_0 = without nitrogen, N_{60} = 60 kg N/ha , N_{120} = 120 kg N/ha , N_{180} = 180 kg N/ha

M_0 = Without mulching, M_s = Mulching with straw, M_w = Mulching with water hyacinth

CV = Co-efficient of Variation

LSD = Least Significant Difference

NS = Non-significant

** = Significant at 1 % level

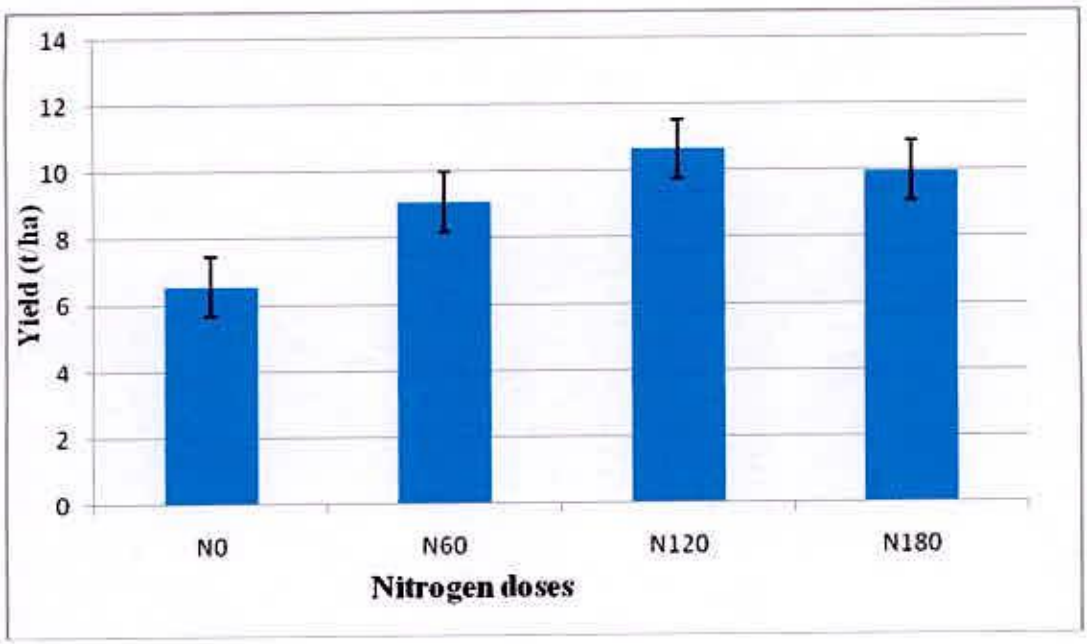
4.10 Bulb yield of onion

The highest values of average bulb weight and bulb yields under higher rate of nitrogen were mainly due to the role of nitrogen in enhancing the growth characters. These results were in agreement with that found by Abdissa et al., (2011) who concluded that mean bulb weight improvement in response to N could be attributed to the increase in plant height, number of leaves produced, leaf length, and extended physiological maturity in response to the fertilization, all might have increased assimilate production and allocation to the bulbs. Also, many researchers reported bulb yields improvement in response to N fertilization (Singh et al., 1989; Patel and Patel, 1990; Pandey and Ekpo, 1991; Vachhani and Patel, 1993; Patel and Vachhani, 1994; Nasreen et al., 2007; Abdissa et al., 2011). In this study, N affects significantly on onion bulb yield and increasing N dose also increased bulb yield per plot as well as per hectare and highest bulb yield (3.19 kg/plot and 10.65 t/ha) was recorded by applying 120 kg N per hector ,N_{120} (Table 5, Figure 5 and Appendix VII). Meanwhile further increase N dose (N_{180}) did not showed increased bulb yield. These results are aggred with Woldetsadik et al., (2003) who found that additional nitrogen to onion plants delayed bulb growth and development. The lowest yield (1.97 kg/plot and 6.57 t/ha) was obtain from control, N_0 . This result is consistant with values of bulb length, bulb diameter, bulb fresh weight and bulb dry weight with N of this study (Table 5 and Appendix VII). The yield difference between the highest and the lowest yielding treatments was 62%. All together, it is suggested that bulb yield of onion might increase with application of N upto 120 kg ha^{-1}.

The mulching favors the reduction of evaporation leading to higher soil moisture content, a reduction in weed growth and the decomposition of added mulches might have also contributed to increase the supply of nutrients and moisture for overall increase in crop yields (Gupta, 1985, Gupta and Gupta, 1986, Vander Zaag et al.,1986). In this study, significant difference in bulb yield was obtain due to the effect of M. The highest bulb yield (3.139 kg / plot and 10.46 t /ha) was recorded from water hyacinth mulched (M_w) , followed by rice straw mulch and yield was (2.93 kg / plot and 9.78 t /ha) whereas the lowest yield (2.09 kg / plot and 6.99 t /ha) was obtain from control plot (Figgure 6 and Appendix VII) . This result is consistant with values of bulb length, bulb diameter, bulb fresh weight and bulb dry weight with M of this study (Table 5 and

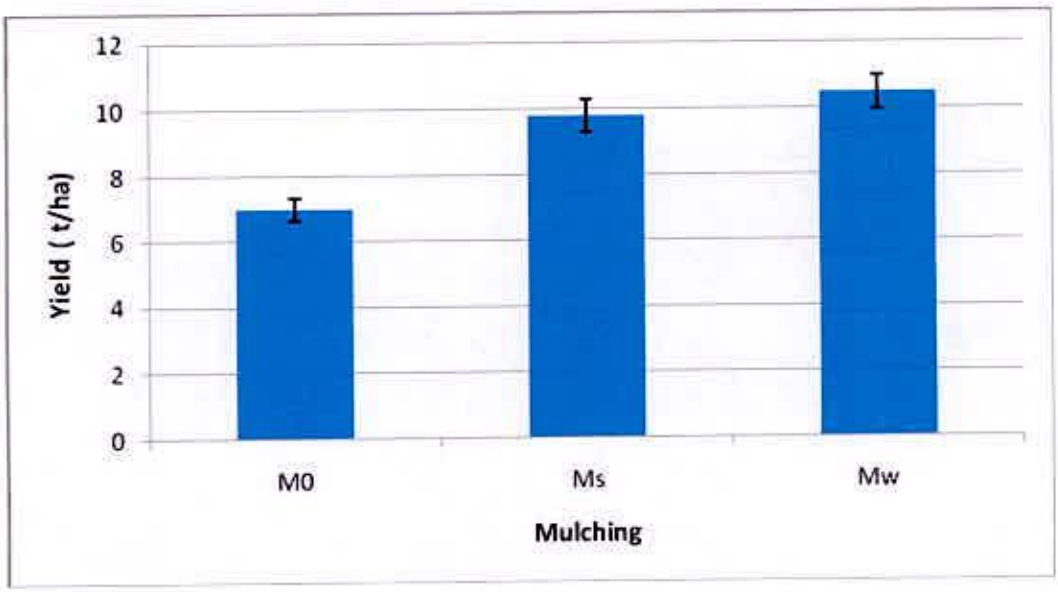
Appendix VII) These results were agreed with the findings of Adetunji, (1994), Mia, (1996) and Hossain, (1996), they reported that M gave higher bulb yield compare to un-mulched condition. Soil moisture is essential for proper growth and development of onion bulb. All together it is suggested that onion bulb yield per plot as well as per hector is increased with M.

Nitrogen (N) is essential for proper growth and development of plant. On the other hand M conserve soil moisture as a result physical activities of onion plant done properly and bulb development occurred. N and M both are separately increased the bulb yield of onion. In this study, interaction effects of N and M also varied significantly on onion bulb yield (Table 6, Figure 7 and Appendix VII) and the highest bulb yield (3.66 kg $plot^{-1}$ and 12.20 t/ha) was recorded from $N_{120}M_w$ treatment. Meanwhile $N_{120}M_s$, $N_{180}M_s$ $N_{60}M_w$ and $N_{180}M_w$ treatment also gave statistically similar bulb yield whereas the lowest yield (1.79 kg/plot and 5.99 t/ha) was found from N_0M_0. This result is consistant with values of bulb diameter, bulb fresh weight and bulb dry weight rather than bulb length with N and M of this study (Table 6 and Appendix VII). This higher onion bulb yield might be due to more soil moisture, favorable temperature and available form of nutrient.



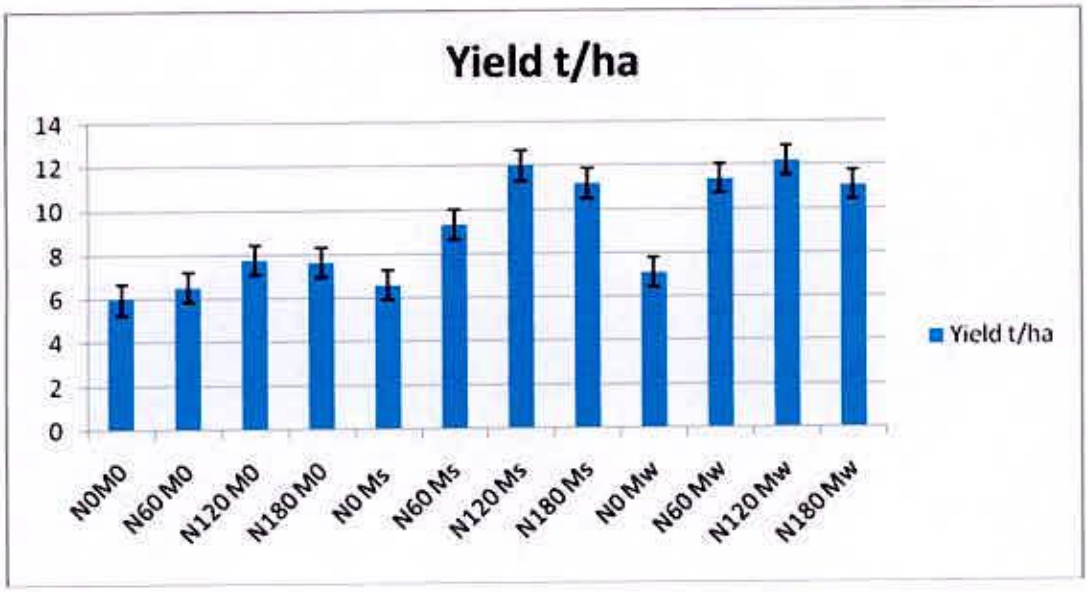
N_0 = without nitrogen, N_{60} = 60 kg N/ha , N_{120} = 120 kg N/ha , N_{180} = 180 kg N/ha

Figure 5: Effect of nitrogen on bulb yield of onion (Error bars represent standard deviation)



M_0 = Without mulching, M_s = Mulching with straw, M_w = Mulching with water hyacinth

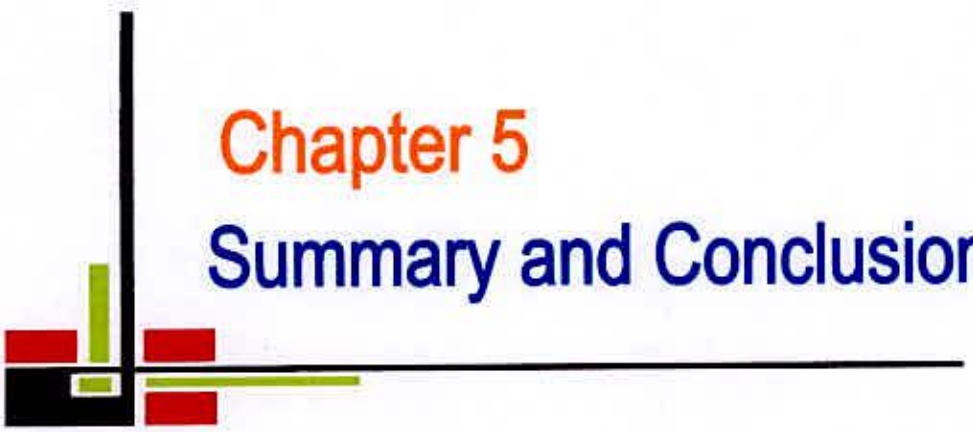
Figure 6: Effect of mulching on bulb yield of onion (Error bars represent standard deviation)



N_0 = without nitrogen, N_{60} = 60 kg N/ha , N_{120} = 120 kg N/ha , N_{180} = 180 kg N/ha

M_0 = Without mulching, M_s = Mulching with straw, M_w = Mulching with water hyacinth

Figure 7: Combined effect of nitrogen and mulching on bulb yield of onion (Error bars represents standard deviation)



Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

A field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during the rabi season from October 2010 to April 2011 to evaluate the influence of nitrogen (N) and mulching (M) on the growth and yield of onion (*Allium cepa*) cv. Taherpuri. The experiment was carried out with four levels of nitrogen *viz*: 0 (N_0) , 60 (N_{60}), 120 (N_{120}) and 180 (N_{180}) kg ha^{-1} and three types of mulching such as control (M_0), rice straw (M_s) and water hyacinth (M_w). The experiment consisted of 12 treatment combinations and was laid out Randomized Complete Block Design (RCBD) with 3 replications. An area of 245 m^2 was divided into 36 plots. The size of each plot was 2 m × 1.5 m = 3 m^2. The distance between block to block is 1 m and distance between plot to plot is 0.5 m and 20 cm spacing between line to line 10 cm between plant to plant. Bulb yield per hectare was calculated on the basis of yield per plot.

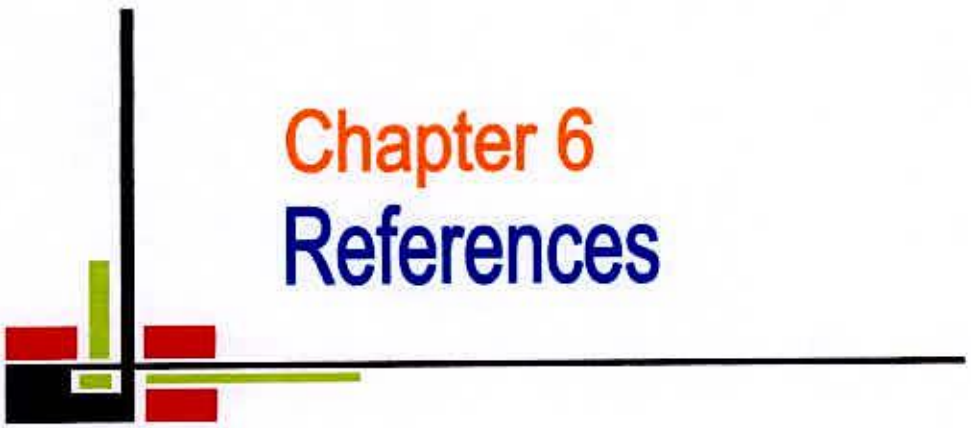
Data were recorded on growth and yield parameter such as plant height, leaves number, leaves dry weight, pseudosteam dry weight, roots dry weight, length and diameter of bulb, fresh weight of bulb, dry weight of bulb, bulb yield per plot and hectare. The collected data were analyzed and the differences between the means were evaluated by Duncan's Multiple Range Test. The experimental results are summarized that the highest plant height as 31.93, 34.95, 35.34 cm respectively at 40, 50, 60 DAT, maximum number of leaves per plants as 6.28, 7.8, 7.97 respectively at 40, 50, 60 DAT, higher leaf dry weight (1.73 g), more pseudostem dry weight (0.59 g), maximum root dry weight (0.018 g) was observed with N_{180} treatment which was statistically similar with N_{120} treatment. Highest bulb length (3.53 cm), maximum bulb diameter (3.60 cm), highest bulb fresh weight (22.83 g), more bulb dry weight (2.41 g) and highest bulb yield (10.65 t ha^{-1}) was obtained from N_{120} treatment. This result was statistically similar with N_{180} treatment whereas lowest value of all above mentioned parameter was noted from control (N_0).

All the parameter separately showed statistically significant effect with M. Tallest plant as 30.72, 33.69, 34.89 cm respectively at 40, 50, 60 DAT, more number of leaves as 5.65, 7.10, 7.28 respectively at 40, 50, 60 DAT, maximum leaves dry weight (1.59 g), higher root dry weight (0.017 g), maximum bulb length (3.40 cm), highest bulb diameter (3.47 cm), maximum

bulb fresh weight (22.41 g), highest bulb dry weight (2.25 gm) was obtained with M_w treatment which was statistically similar with M_s, whereas lowest value of all this parameter was obtained from M_0. Finally maximum bulb yield 3.13 kg /plot as well as 10.46 t /ha was noted from M_w treatment which was statistically similar with Ms treatment and lowest yield of onion bulb 2.09 kg/ plot as well as 6.99 t/ ha was found from M_0 treatment.

Interaction effect of N and M on plant height at different DAT, number of leaves per plant at different DAT, root dry weight, bulb diameter, bulb fresh weight, bulb dry weight and bulb yield showed statistically significant. The highest root dry weight (0.020 g), highest bulb diameter (3.75 cm), highest bulb fresh weight (26.13 g) and highest bulb dry weight (2.77 g) was obtained from $N_{120}M_w$ treatment. Finally, the treatment combination $N_{120}M_w$ was found to be give the best bulb yield (12.20 t ha^{-1}) whereas control, N_0M_0 showed the lowest yield (5.99 t ha^{-1}). In this study, 103 % bulb yield of onion was increased by $N_{120}M_w$ compare to N_0M_0.

Among the various factors affecting on growth and yield of onion, nutrient management plays a vital role. Based on the above results it can be suggested that the combined use of 120 kg N ha^{-1} along with water hyacinth mulch, ($N_{120}M_w$) may increase onion bulb yield under this locality. Researchers may conduct further experiment to verify present results for increasing the accuracy of the experiment at different locations of Bangladesh.



Chapter 6
References

CHAPTER 6

REFERENCES

Abdel, C.G. 1990. The influence of mulching on irrigated and non-irrigated onion cultivations. Mesoptamia J. Agric., 22(4): 25-33.

Abdissa, Y., Tekalign, T., and Pant, L.M. 2011. Growth, bulb yield and quality of onion (Allium cepa L.) as influenced by nitrogen and phosphorus fertilization on vertisol I. growth attributes, biomass production and bulb yield. African. J. of Agril. Res. Vol. 6(14), pp. 3252-3258.

Abu-Awad, A.M. 1999. Irrigation water management for efficient water use in mulched onion. J. Agron. Crop Sci., 183(1): 1-7.

Adetunji, I.A. 1990. Response of onion to solarization and organic mulching in semi-arid tropics. Sci. Hortic., 60: 161-166.

Al-Fraihat, H.A. 2009. Effect of different nitrogen and sulphur fertilizer levels on growth, yield and quality of Onion (Allium cepa, L.). Jordan J. of Agril. Sci., 5(2): 155-165.

Aliyu, A.U. Dikko, M.D. Magaji and Singh,A. 2008. Nitrogen and Intra-row Spacing Effects on Growth and Yield of Onion (Allium cepa L.). J. of Plant Sci., 3: 188-193.

Aliyu, U., Magaji, M.D., Singh, A. and Mohammed, S.G. 2007. . Growth and yield Of onion (Allium cepa L.) as influenced by nitrogen and phosphorus levels. Int. J. of Agril. Res. 2(11): 937-944.

Amal, K.R., Muhsi, A.A.A. and Khan, M.A.H. 1990. Effect of different mulches on the growth of potato (Solanum tuberosum L.). Bangladesh J. Bot., 19: 56-60.

Amans, E.B., Ahmed, M.K. and Yayock, J.Y. 1996. Effect of plant spacing nitrogen rates on early and late-sown dry season onion (Allium cepa) in the Sudan Savanna of Nigeria Growth, maturity and bulb yield. Ph.D. Thesis. Ahmadu Bello University, Zaria.

Amin, M.R, 1995. Effect of potash and nitrogen on the growth and yield of onion (Allium cepa L.). M.Sc. (Ag) thesis. Dept. of Hort. BAU.

Anisuzzaman, M., Ashrafuzzaman, M., Ismail, M. K., Uddin and Rahim M.A. 2009. Planting time and mulching effect on onion development and seed production. African J. of Biot. Vol. 8 (3), pp. 412-416.

Anonymous. 2001. Effect of nitrogen and irrigation on the growth and yield of onion Research Report of Spices Research Centre, Bangladesh Agricultural Research Institute, Bogra. pp. 51-53.

Anonymous. 2007. Effect of nitrogen, phosphorus, potassium and sulphur on the growth and yield of kharif onion. Annual Report, Bangladesh Agricultural Research Institute, Gazipur. pp. 142-143.

Anower, M.N., Huq, M.S., Sarker, M.J.U., Hoque, A.K.M.S. and Islam, M.S. 1998. Influence of nitrogen, phosphorus, potassium, sulphur and zinc on onion. Bangladesh J. Agril. Res. 16(2): 181-186.

Arboleya, J. and Garcia, C. 1993. Adjustment of. fertilization in relation to different planting densities. With or Without Irrigation Mendoza Argentina.

Baten, M.A., Nahar, B.S., Sarker, S.C. and Khan, M.A.H. 1995. Effect of different mulches on the growth and yield of late planted garlic (Allium sativum L.). Pakistan Journal of Scientific and Industrial research. 38 (3-4), 138-141.

BBS. 2010. Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division. Ministry of Planning, Govt. of the Peoples Republic of Bangladesh. Dhaka. P. 119.

Castila, N., Hernandez, J., Quesada, F.M., Morales, M.I. and Gallardo. 1994. Soil mulching in garlic crop using clear polythene. Proceeding of a conference held in Verona, Italy, March 1994.(Cited from Hort. Abst. 66(10):41, 1996)

Devlin, R.M. 1979. Plant physiology. Third Ed., Affiliated East West Press, New Delhi, Madras.

Dharmendra, K., Sanjay, K. and Ajay, K. 2001. Effect of different levels of nitrogen on growth and yield of onion (Allium cepa L).Department of Horticulture, Institute of Advanced Studies, C.C.S. University, Meerut 250 001, India J. Agric. Sci. Digest. 21 (2): 121-123.

Duranti, A. and Gucolo, L. 1989. Chemical weed control and mulching in onion and garlic. Advance Hort. Sci., 1:7-12.

Eck, H.V. 1988. Winter wheat response to nitrogen and irrigation. Agronomy J. 80: 902-908.

El-Oksh, I.I., El-Gizawy, A.M., Abdallah, M.M.F., Mohamed, A.R.A.G. and Abdallah, A.A.G. 1993. Effect of soil moisture and nitrogen fertilizer levels on onion grown in mixture in tafla and seed. Bull, Cairo. Agric. Univ. 44(1): 145-156.

FAO, 1988. Production Year Book. Food and Agriculture Organization of United Nations. Rome, Italy. 51: 125-27.

FAO, 2003. FAO Production Yearbook, Food and Agriculture Organization of the United Nations. Rome, Italy: 155-156.

Graham, H.A.H., Decoteau, D.R., Linvill, D.E. 1995. Development of polyethylene mulch system the change color in field. Hort. Sci. 30:265-9.

Grajri, P.R., Arora, V.K. and Chaudhary, M.R. 1994. Mize growth response to deep tillage, straw mulching and farmyard manure in coarse texture soil of N. W. India. Soil Use Manage. 10: 15-19.

Greenwood, D.J., D.A. Stones and A. Barnes, 2001. Root development of vegetable crops. Plant Soil, 68: 75-96.

Gunjan, A., Paliwal, R. and Sarolia, D.K. 2005. Effect of nitrogen and bio-fertilizer on yield and quality of rabi onion (Allium cepa L) cv. Puna Red. Indian. J. Agric. Sci. Digest. 25 (2): 124-126

Gupta, J. P. and Gupta, G. K., 1986, Effect of soil tillage and mulching on soil environment and cowpea seedling growth under arid conditions. Soil Till. Res., 7 : 233-240.

Gupta, J. P., 1985, Mulch is mulch. Intensive Agri., 22 : 16-18.

Halvorson, A.D., Follet, R.F., Bortolo, M.E. and Schowessing, F.C. 2002. Nitrogen fertilizer efficiency of furrow-irrigated onion and corn. Agron. J., 94: 442-449.

Haque, I. and Jutzi, S. 1984. Potentials and limitations to the biological nitrogen contribution from forage legumes in Sub-saharan Africa. In: Proceedings of the First Conference of the African Association for Biological Nitrogen Fixation (AABNF), Nairobi, Kenya.

Haque, M.I., Zaman, M. M., Hasan, M.K., Begum, M. and Pervin, F. 2004. Growth and Yield of Onion as Influnced by Nitrogen and Irrigation J. Agril. and Rural Dev. 2(1): 151-153.

Haque, M.I., Zaman, M.M., Hasan, M.K., Begum, M. and Pervin, F. 2004. Growth and yield of onion as influenced by nitrogen and irrigation. J. Agril. And Rural Dev. 2(1): 151-153.

Haque, M.S., Islam, R., Karim, M.A. and Khan, A.H. 2003. Effects of Natural and Synthetic Mulches on Garlic (Allium sativum L.). Asian Journal of Plant Sciences, 2: 83-89.

Harper, J.L. 1977. Population Biology of Plants. Academic Press, London.

Harun-or-Rashid, A.R.M. 1998. Effect of NPKS on the growth and yield of onion at different plant spacing. M.S. thesis, Dept. of Hort., Bangladesh Agril. Univ., Mymensingh.

Hassan, M.J., 1999. Effect of soil moisture management and nitrogen levels on growth and yield of garlic. M.Sc. Thesis, Dept. of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Hossain, M.I., 1996. Effect of mulches and different manuria practices involving equal cost on the growth, yield and storability of garlic. M.Sc. Thesis, Dept. of Horticulture, Bangladesh AgriculturalUniversity,Mymensingh,Bangladesh

Hussaini, M.A. and Amans, E.B. 2000. Yield, bulb size distribution, and storability of onion (Allium cepa L.) under different levels of N fertilization and irrigation regime. Trop. Agril. 77: 3, 145-149.

Hwang, H., Suh, J., Ha, I. and Roy, Y. 1996. Effect of planting time and mulching material growth and seed yield production culture in onion. RDA J. Agril. Sci. Hort., 38(1):640-647

Islam, M. J., A. K. M. M. Hossain, F. Khanam, U.K. Majumder, M. M. Rahman and Rahman, M. 2000. Effect of Mulching and Fertilization on Growth and Yield of Garlic at Dinajpur in Bangladesh. Asian J. Plant sci., 6:98-101.

Islam, M.K., Awal, M.A. Ahmed, S.U and Baten, M.A. 1999. Effect of different set sizes, spacing and nitrogen levels on the growth and bulb yield of onion. Pak. J. Biol. Sci. 2: 1143-1146.

Islam, M.N., Ahmed, S.U., Hossain, M.M. and Chowdhury, S. 2002. Effect of mulch and bulb size on growth of onion. Pakistan Journal of Biological Science 5(6): 648-650.

Islam, M.T., Mondol, M.F., Siddique, M.A., Rahman, M.A. and Rahman, M.N. 2006. Effect of different levels of nitrogen and potassium on the growth and yield of onion. J. of Sub-trop. Agril. Res. and Dev. 4(1): 32-38.

Jamil, M., Munir, M., Quasim, M., Jalal. And Rehman, K. 2005. Effect of different types of Mulches and their duration on the growth and yield of garlic. Int. Jur. Of agi.and bio. p.p:1560-853

Jilani, M.S., Ghaffoor, A., Waseem, K. and Farooqi, J.I. 2004. Effect of different levels of nitrogen on growth and yield of three onion varieties. Int. J. Agri. and Biology. 6(3): 507-510.

Jitendra, S., Nasreen, D., Haque, M.M., Hossain, M.A. and Farid, A.T.M., 2007. Nutrient uptake and yield of onion as influenced by nitrogen and sulpher fertilization. Bangladesh J. Agril. Res. 32(3) : 413-420

Juan, C.,William, M., George, B., Ronald, W., David, G. and Hunt, F. 2004. Effect of mulch and Irrigation system on sweet onion : Bolting, plant growth and bulb yield and quality. J. Amer. Soc. HORT. Sci. 129(2) :218-224.

Kashi, A. and B.R. Frodi. 1998. Effect of nitrogen on the yield, quality and storability of edible onion cultivars (Allium cepa L.) Iran. J. Agric. Sci., 29: 589-597

Katwale, T.R. and Saraf, R.K. 1994. Studies on response of onion to varying levels of fertilizer doses during Monsoon season in Satpura Plateau. Orissa J. Hort., 22 (1-2): 13-18.

Kebede, W., Gertsson, U. and John, A. 2003. Response of shallots to mulching and nitrogen fertilization. J. HORT. Sci. 38(2): 217-221.

Kesik T., Konopinski M., Blazewicz-Wozniak M., 2006 . Wplyw uprawy przedzimowej mulczuz roslin okrywajacych na retencje wody, zageszczenie i porowatosc dyferencyjna gleby poprzezimowaniu. Acta Agrophysica 7(4), 135, 915–926.

Khan, H.M. Igbal, A. Ghaffoor and K. Waseem. 2002. Effect of various plant spacing and different levels of nitrogen on the growth and yield of onion (Allium cepa L.). J.

Biological Sci., 2: 545-547.

Kumar, D., Kumar, S. and Kumar, A. 2001. Effect of different levels of nitrogen on growth and yield of onion (Allium cepa L.). Agril. Sci. Digest. 21(2): 121-123.

Kumar, H., Singh, J.V., Kumar, Ajay, Singh, Mahak, Kumar, A., and Singh, M. 1998. Studies on the influence of nitrogen on growth and yield of onion (Allium cepa L.) cv. Patna Red. Ind. J. Agril. Res. 32: 2, 88-92.

Kumar, J.C. and Shama, J.R. 1991. Studies on nitrogen requirement of kharif onion. Haryana J. Hort. Sci. 20(1-2): 95-97.

Kumar, S., Kumar, A. and Mandal, G. 2006. Effect of irrigation scheduling and fertigation on storability of onion (Allium cepa) under microsprinkler irrigation regime. New Delhi, India: Indian Council of Agricultural Research. Indian J. of Agril. Sci. 2006; 76(7): 401-404.

Lang, C. 1987. Specific nitrogen provision of summer onions. Gemuse Munchen, 24 (3):140-144.

MacGillivary, J.H. 1961. Vegetable Production. Mc.Graw. Hill Book Co. Inc. Newyork P.P 169-273.

Mahajan, G., Sharda, R., Kumar, A., Singh, K.G. 2007. Effect of plastic mulch on economizing irrigation water and weed control in baby corn sown by different methods. African Journal of Agricultural Research. 2 (1), 19-26.

Mandira, C. and Khan, A.H. 2003. Effect of nitrogen and potassium on growth, yield and yield attributes of onion. New- Agriculturist. ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura- 799 210, India. 14(1/2): 9-11.

Mccullum, G.D. 1976. Evaluation of Crop Plants . Ed. N,W. Simmonds, Longman,London and NewYork.P.P.186-190.

Meena, P.M., Umrao, V.K., Kumar, A. and Kumar, R. 2007. Effect of nitrogen doses on growth and yield of onion (Allium cepa L.) cv. 'Nasik Red'. Agril. Sci. Digest. 27(2): 144-145.

Melek, H. and Dursun, C.M. 2009. Effect of different mulch materials on plant growth, some quality parameters and yield in melon cultivars in high altitude environmental condition. Pak. J. Bot., 41(4): 1891-1901.

Mia, M.H. 1996. Effect of mulch and different levels of N and K on the growth, bulb yield and seed yield of onion. M.S. thesis, Dept. Hort. BAU, Mymenshing. Pp.75-76.

Miah, M.D. 2008. Effect of irrigation and nitrogenon the growth and yield and nutrient content of onion. M.Sc (Ag) thesis. Dept. of Soil Science. SAU.

Mishra, M.K. and Gupta, R.B. 2011. Effect of nitrogen and irrigation on bulb yield and quality of onion (Allium cepa). Indian J.Agro., 3: 333-334.

Mohanty, B.K. and Das, J.N. 2001. Response of rabi onion cv. Nasic Red to nitrogen and potassium fertilization. Vegetable-Science. University of Agril. and Technology, Regional Research Station, Bhawanipatna- 766 001, Orissa, India. 28: 1, 40-42.

Morsy, M.G., Marey, R.A., Karam, S.S. and Abo- Dahab, A.M.A. 2012. Productivity and storability of onion as influenced by the different levels of NPK fertilization J. Agric. Res. Kafer El-Sheikh Univ., 38(1): 1 7 1

Muoneke, C.O., Umar, M. and Magaji, M.D. 2003. Growth, yield and keeping quality of onion as influenced by N and P fertilization in a semi-arid agroecology. ASSET Series A: Agri. and Environment. 3(2): 73-80.

Naik, B.H. and Hosamani, R.M. 2003. Effect of spacing and nitrogen levels on growth and yield of kharif onion. Karnataka J. Agril. Sci., 16(1): 98-102.

Najafabadi, M.B., Peyvast, G.H., Hassanpour, H., Olfati, J.A., and Rabiee, M. 2012. Mulching effects on the yield and quality of garlic as second crop in rice fields. International Journal of Plant Production ISSN: 1735-6814 (Print), 1735-8043 (Online)

Nason, A. and Mc-Elrox, W.D. 1963. Modes of action of the essential minerals elements in plant physiology, ed. F.C. Steward Academic Press. Newyork . p.p. 138-139.

Nasreen, S., Haque, M.M., Hossain, M.A., and Farid, A.T.M., 2007. Nutrient uptake and yield of onion as influenced by nitrogen and sulpher fertilization. Bangladesh J. Agril. Res. 32(3) : 413-420.

Neeraja, G. and Reddy, K.M . 2000. Crop coefficients for onion (Allium cepa L.) as influenced by different levels of irrigation based on IW/CPE ratio. Hyderabad, India: Acharya N G Ranga Agricultural University. J. Res. ANGRAU. 2003; 31(2): 40-47.

Nicholls, P. B., and May, L. H. (1963).-Studies on the growth of the barley apex. I.Interrelationships between primordium formation, apex length, and spikelet development. Aust. J. bioi. Sci. 16,561-71.

Pala, M., Matar, A., and Mazid, A. 1996. Assessment of the effect of environmental factors on the response of wheat to fertilizer in on-farm trials in a Mediterranean type environment. Exp. Agric. 32: 339-349.

Pandey, R. C. and Ekpo, R.S. 1991. Note on response of onion(Allium cepa) L. to varying levels of N. P and K. Indian j. Agril. Sci., 41(2): 107-108

Pandey, U.B., Panwar, D.S. and Sharma, V.P. 1992. Effect of spacings and levels of nitrogen on growth and seed yield of kharif onion. Seed Res. 20: 2, 147-148.

Patel, I. J. and A. T. Patel (1990). Effect of nitrogen and phosphorus levels on growth and yield of onion. (Allium cepa L.) cultivar Pusa Red Res. Gujarat Agric. Univ., 15: 1-5.

Patel, Z. G. and M. U. Vachhani (1994). Effect of N P K fertilization on the yield and quality of onion. Hort. J., 7(1): 75-77.

Perilas, J.M. and Nicor, F.P. 1994. Nitrogen uptake and growth response of bulb onion (Allium cepa L.) to varying rates of nitrogen application on kobacan sandy loam. USM-CA-Res. J. 5(1): 51-56.

Qiao, H., Wang, X., Ai Feng, Z. and Zhong Lan, G. 2005. Effects of decreasing chemical fertilizer application and applying organic fertilizer on yield and quality of welsh onion. China. Agril. Scie. Acta-Agriculturae. 21 (2): 49-52.

Qureshi, A.A., Sankar, V., Lawande, K.E. And Tripathi, P.C. 2003. Effects of granulated ammonium sulphate on the yield and quality of rabi onion. National Research Centre for Onion & Garlic, Rajgurunagar, Pune 410 505 (MS), India. Indian J. Hort. 60 (3): 273-276.

Rahim, M.A., Hakim, M.A., Begum, A. and Islam, M.S. 1992. Scope for increasing the total yield and fulfilling the demand for onions during the period of shortage in Bangladesh through the bulb-to-bulb (set) method of production. Onion Newsletter for the tropics, BAU, Mymensingh. Bangladesh

Rahman, M.S., Khan, M.A.H. and Rahman, M.M. 1996. Variation of microclimate parameters and yield component in onion due to mulching. Prog. Agrc., 7(2): 5-10.

Ramamoorthy, K.K., Selvaraj, V. and Velayutham, A. 1999. Effect of irrigation and nitrogen levels on bulb yield of small onion (Allium cepa L.). Madras Agril. J. 86(1-3): 140-141.

Rashid, M.M. 1976. Bangladesher Sabji. First edition Bangla Academy, Dhaka, Bangladesh. P. 459

Rekowska. E. 1997. The effect of soil mulching on the yield and quality of garlic developing inflorescence stalks. Folia Horticulture, 9(1): 59-65.

Rhee, K.M., Yoon, J.H. and Park, J.K. 1990. Effect of polythene film mulching on the changes of soil chemical properties during the sesame cropping season. Res. Rep. Rur. Adm.,soil Fert. Abstr., 54(9); 116-27

Rodriguez, S.N., Belmar, N.C. and Valenzuela, P.A. 1999. Effect of nitrogen, phosphorus and Potassium rates, sources and forms upon onion (Allium cepa) bulb yield and quality. Agri. Tech. Santiago. 59(2): 122-132.

Samaila, A., 2000. Effect of planting patern and fertilizer rates in onion (Allium cepa L.) and pepper (Capsicum annum L.) mixed crop. Seminar Paper Presented to the Ahmadu Bello University, Zaria.

Shankhar, B.S. and Singh, J. 1989. Effect of nitrogen, potash and zinc on storage loss of onion bulbs (Allium cepa L.). Vegetable Science, 18(1): 16-23.

Singh, D. and Sharma, R.P. 1991. Effect of soil moisture regimes and nitrogen fertilization on onion. Ind. J. Agron. 36(1): 125-126.

Singh, D.K., Lal, G., Rai, P.N. and Shukla, G.S. 1994. Response to nitrogen on yield and keeping quality of onion bulb (Allium cepa L.). Ann. of Agril. Res. 15: 4, 407-409.

Singh, H., Singh, S. and Singh, V. 1996. Response of onion to nitrogen and sulphur. Ann. Agric. Res. 17: 441-444.

Singh, J. and Chaure, N.K. 1999. Effect of age of seedlings and nitrogen levels on growth and yield of onion (Allium cepa L.). Adv. Hort. Fores. India. 6: 73-77.

Singh, R.P., Jain, N.K. and Poonia, B.L. 2000. Response of kharif onion to nitrogen, phosphorus and potash in eastern plains of Rajasthan. Ind. J. Agril. Sci. 70(12): 871-872

Singh, S., Yadav, P.K. and Singh, B. 2004. Effect of nitrogen and potassium on growth and yield of onion (Allium cepa L.) cv. Pusa Red. Haryana J. of Hort. Sci. 33(3/4): 308-309.

Singh, S.P. and Mohanty, C.R. 1998. A note on the effect of nitrogen and potassium on the growth and yield of onion. Orissa J. Hort. 26(20): 70-71.

Srinivas, K. and Nail, L.B. 1987. Growth and yield of onion (Allium cepa L) cultivars in relation to nitrogen fertilization. Progr. Hort., 19 (1-2): 22-26

Stowell, B., 2000. Organic kiwifruit production–maintaining soil fertility and yields. Kiwifruit, 139: 18–21

Sumi, S., Castellane, P., Bellingieri, P. and Churatamasca, M.G.C. 1986. Mulching and rate of simple super phosphate in garlic crop. Hort. Brasileira, 4(1): 32-34.

Sur, H.S., P.S. Mastana and M.S. Hadda, 1992. Effect of rates and modes of mulch application on runoff, sediment and nitrogen loss on cropped and uncropped fields. Trop. Agric., 69: 319-322.

Suresh, C.H. 2007. Studies on effect of organics on seed yield and quality in onion. MS thesis. Dept. of seed science and technology. Dharwad University of Agricultural Science. Dharwad.

Thakur, P. S., Anju Thakur and Kanaujia, S. P., 2000, Reversal of water stress effects, mulching impact on the performance of Capsicum annuum under water deficit. India. J. Hortic., 57(3) : 250-254.

Tiwari, R.S., Sengar, S.C. and Agarwal, A. 2002. Effect of nitrogen doses and spacing on seed yield of onion (Allium cepa L.) cv. Pusa Red. Indian Seed Res., 30(2):230-233.

Umar, M., Magaji, M.D. and Muoneke, C.O. 2003. Growth, yield and keeping quality of onion

as influenced by N and P fertilization in semi-arid agroecology. Agric. Environ., 3: 73-80.

UNDP, 1988. Land Resource Appriseal of Bangladesh for Agricultural Development Report 2: Agro- ecological Regions of Bangladesh, FAO, Rome, Italy, pp.577.

Vachhani, M.U. and Patel, Z.G. 1993. Growth and yield of onion (Allium cepa L.) as influenced by nitrogen, potash and phosphorus under South Gujrat Condition. Prog. Hort. 25 (3-4): 166-167

Vander Zaag, Demagante, A., Acasia, R., Domingo, A. and Hagerman, H., 1986, Response of solanum potatoes to mulching during different seasons in an isohyperthemic environment in the Philippines. Trop. Agric. (Trinidad), 63 : 229-239.

Vanderwerken, J.E. and Wilcox-Lee, D. 1988. Influence of plastic mulch and type and frequency of irrigation on growth and yield of bell pepper. HortScience, 23: 985-988.

Vavrina, C.S., Roka, F.M., 2000. Comparison of plastic mulch and bare ground production and economics for short-day onion in a semitropical environment. Horticultural. Technol. 10, 326-333.

Vohora, S.B., Rizman, M. and Khan, J.A. 1974. Medicinal Uses of Common IndianVegetables. Plant Medico. 23(4) : 381-394

Woldetsadik , K., Gertsson, U. and Ascard , J. 2003. Response of shallots to mulching and nitrogen fertilization. Hort. Science 38 (2): 217-221.

Yadav, B.D., Khandelwal, R.B. and Sharma, Y.K. 2005. Use of biofertilizer (Azospirillum) in onion. Indian. J. Hort. 62 (2): 168-170.

Yadav, R. L., Sen, N. L. and Yadav, B. L. 2003. Response of onion to nitrogen and potassium fertilization under semi-arid condition of Rajasthan. Indian J. Hort. 60(2): 176-178.

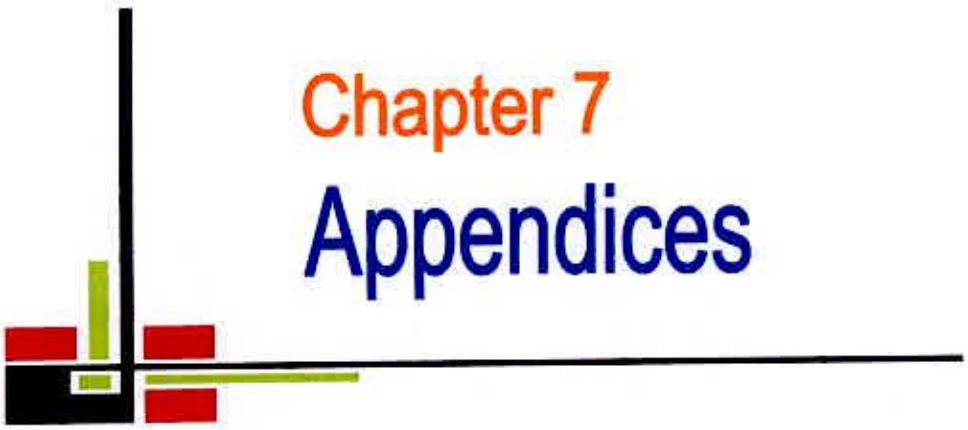
Yadav, R. L., Sen, N. L. and Yadav, B. L. 2003. Response of onion to nitrogen and potassium fertilization under semi-arid condition of Rajasthan. Indian J. Hort. 60(2): 176-178.

Yamasaki, A and Tanaka, K. 2005. Effect of nitrogen on bolting of bunching onion (Allium fistulosum L.). Hort. Res. Japan. 4(1): 51-54.

Zaman, A. and Mallick, S. 1991. Water use and seed yield of horse-gram under different

moisture regimes and mulches in Semi-arid region of Eastern India. Agron

Zaongo C.G.L., Wendt C.W., Lascano R.J. Juo A.S.R., 1997. Interactions of water, mulch and nitrogen on sorghum in Niger. Plant Soil 197, 119–126.

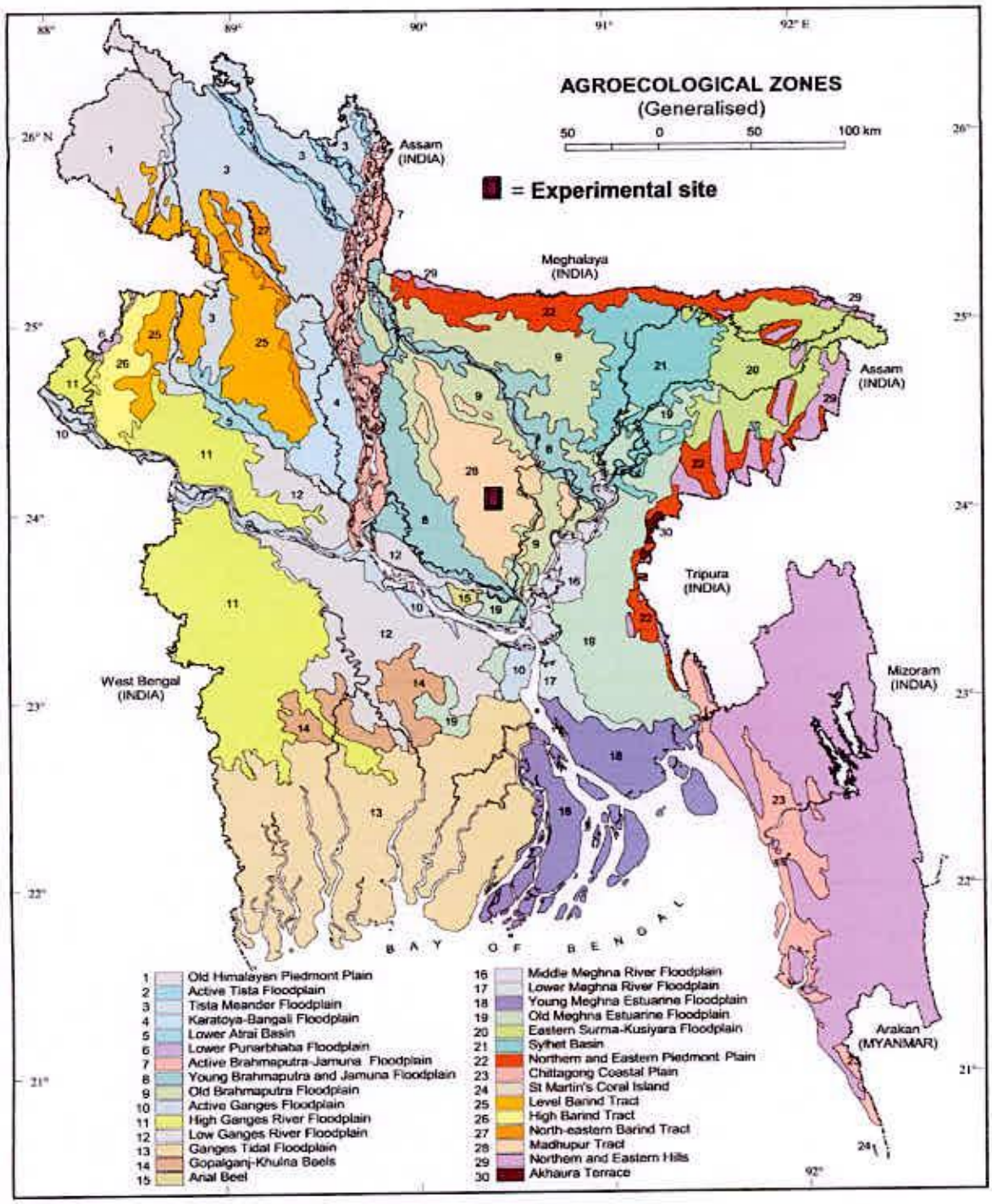


Chapter 7
Appendices

CHAPTER 7

APPENDICES

Appendix I: Experimental location on the map of agro-ecological zones of Bangladesh



Appendix II. Monthly average air temperature, total rainfall, relative humidity and sunshine hours of the experimental site during the period from October 2010 to April 2011

Year	Month	Average Air temperature (^{0}C)		Total rainfall (mm)	Average RH (%)	Average Sun shine hours
		Maximum	Minimum			
2010	October	31.6	23.8	172.3	74	5.2
	November	29.6	19.2	34.4	68	5.7
	December	26.4	14.1	26.4	66	5.5
2011	January	23.4	12.2	0	69	5.3
	February	28.7	16.9	0	54	5.4
	March	32.1	21.5	20	57	5.6
	April	33.5	23.2	123	64	5.8

Source: Dhaka metrological centre (Climate Division)

Appendix VI : Mean square values of leaves dry weight, pseudostem dry weight and root dry weight

Sources of variation	DF	Means square values		
		Leaf dry weight (g)	Pseudostem dry weight (g)	Root dry weight (g)
Replication	2	0.174 *	0.011 NS	0.001 NS
Nitrogen (N)	3	0.454 **	0.042 **	0.001 **
Mulching (M)	2	0.269 *	0.046 **	0.001 **
N x M	6	0.019 NS	0.002 NS	0.001 **
Error	22	0.032	0.006	0.001

Appendix VII : Mean square values of bulb length, bulb diameter, bulb fresh weight, bulb dry weight, bulb yield (kg/plot) and bulb yield (t/ha)

Sources of variation	DF	Means square values					
		Bulb length (cm)	Bulb diameter (cm)	Bulb fresh weight (g)	Bulb dry weight (g)	Bulb yield (kg/plot)	Bulb yield (t/ha)
Replication	2	0.022 NS	0.22 *	0.96 NS	0.60 NS	0.019 NS	0.21 NS
Nitrogen (N)	3	1.042 **	1.673 **	131.49 **	1.16 **	2.58 **	28.65**
Mulching (M)	2	0.662 **	0.946 **	185.71 **	1.29 **	3.64 **	40.45**
N x M	6	0.245 NS	0.45 **	13.91 **	0.097 **	0.27 **	3.03**
Error	22	0.469	0.010	2.19	0.024	0.042	0.47

NS = Non significant

** = significant at 1% level

* = Significant at 5% level