EFFECT OF NITROGEN AND NUMBER OF PLANTS PER HILL ON GROWTH AND YIELD OF ONION (*Allium cepa* L.)

MD. ZIAUR RAHMAN

DEPARTMENT OF HORTICULTURE AND POSTHARVEST TECHNOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
SHER-E-BANGLA NAGAR, DHAKA-1207

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BY

MD. ZIAUR RAHMAN

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Approved by:

(Prof. M. A. Mannan Miah)
Department of Horticulture & Postharvest Technology
Sher-e-Bangla Agricultural University, Dhaka-1207
Supervisor

(Md. Hasanuzzaman Akand)
Associate professor
Department of Horticulture & Postharvest Technology
Sher-e-Bangla Agricultural University, Dhaka-1207
Co-Supervisor

(Prof. Md. Ruhul Amin)
Chairman
Examination Committee

Dedicated to

My

Beloved Parents

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

PABX: +88029144270-9
Fax: +88029112649
Web site: www.sau.edu.bd

Ref:

Date: .....

CERTIFICATE

*This is to certify that the thesis entitled, "**Effect of nitrogen and number of plants per hill on growth and yield of onion**" submitted to the Department of Horticulture and Postharvest Technology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in HORTICULTURE, embodies the result of a piece of bonafide research work carried out by MD. ZIAUR RAHMAN, Registration No. 00916 under my supervision and my 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, June, 2008
SAU, Dhaka

(Prof. M. A. Mannan Miah)
Dept. Of Horticulture & Postharvest Technology
Sher-e-Bangla Agricultural University
Supervisor

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The Author

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ABSTRACT

A field experiment was carried out at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka to study the effect of nitrogen and number of plant (s) per hill on the growth and yield of onion during the period from November 2006 to April 2007. The experiment consisted with two factors, factor A: four levels of nitrogen viz. N_0=0, N_1=60, N_2=120 and N_3=180 kg/ha respectively and factor B: three different numbers of plant(s)/hill viz. P_1=one plant, P_2=two plants and P_3= three plants/hill. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In case of nitrogen, N_3 performed maximum plant height (32.07cm) , number of leaves (7.8), diameter of bulb (3.5cm), length of bulb (2.35cm), fresh weight of foliage (7.15g), fresh weight of bulb (22.69g) and yield (20 t/ha). In case of number of plan(s)/hill P_1 performed maximum plant height (32.28cm), number of leaves (7.43), diameter of bulb (3.98cm), length of bulb (2.32cm), fresh weight of foliage (9.16g) and fresh weight of bulb/plant (27.19g), while maximum yield (22.64 t/ha) was found in case of P_3. For combined effect the maximum plant height (33.40cm), number of leaves (7.87), length of bulb (2.45cm), diameter of bulb (4.21cm), fresh weight of foliage (9.92g) and fresh weight of bulb/plant (27.55g) was obtained from P_1N_3 treatment combination, while P_3N_3 contributed the highest yield (23.53 t/ha). So, it may be suggested that three plants /hill with 180 kg N/ha can be used to obtain higher growth as well as higher yield. .

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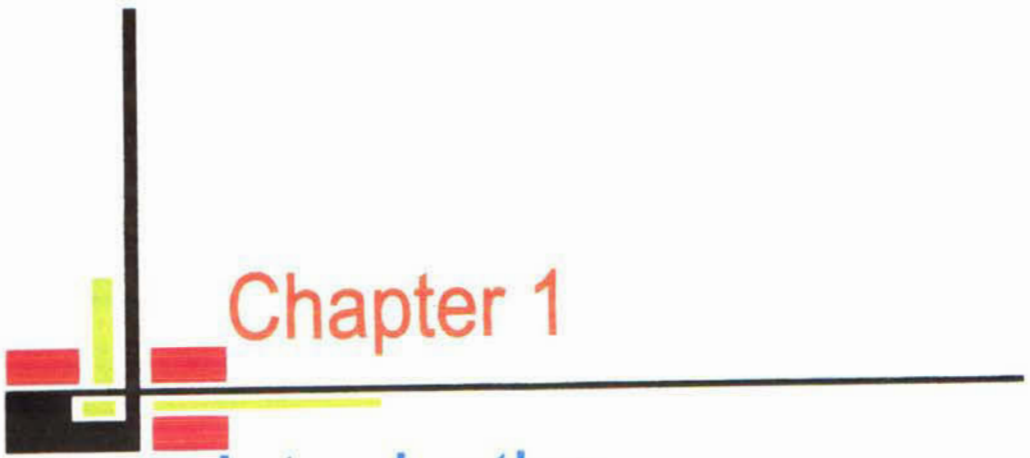
LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Non significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
BSMRAU	=	Bangabandhu Sheikh Mujibur Rahman Agricultural University
BAU	=	Bangladesh Agricultural University



Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important bulb crops and popular vegetable grown for its pungent bulbs and flavorful leaves. It is a member of Alliaceae family (Hanelt, 1990). It belongs to the genus *Allium*. There are more than 500 species within the genus *Allium*, of these most are bulbous plants. It is one of the most important spice as well as promising vegetables for Bangladesh. Central Asia is the primary center of its origin and the Mediterranean is the secondary center for large type onion (McCullum, 1976). In world production onion ranks third (46750 thousand mt) only after tomato (150259 thousand mt) and cabbage (54503 thousand mt) in terms of annual world production in the year 2001 (FAO, 2002).

The leading onion producing countries of the world are China, India, USA, Poland, Japan, Turkey and Brazil (FAO, 1997). It is photo and thermo sensitive crop (Davies and Jones. 1944). Among the spice crops grown in the country, onion ranks second (318000 Acres) next to chilli (349000 Acres) in area and first (894000 mt) in production during the year 2006-2007(BBS, 2008). It is widely cultivated throughout Bangladesh during winter season and its cultivation is concentrated in the greater districts of Faridpur, Pabna, Rajshahi, Jessore, Dhaka, Mymensing, Comilla, Rangpur (BBS, 2006). The average yield of onion in Bangladesh is very low (2.81 mt/ acre) (BBS, 2008) as compared to the world average yield (17.46 t/ha) (FAO, 2003). The yield of onion is influenced by many

factors, among which cultivars, soil, and climate, bulb weight, spacing, date of planting and seed quality are important.

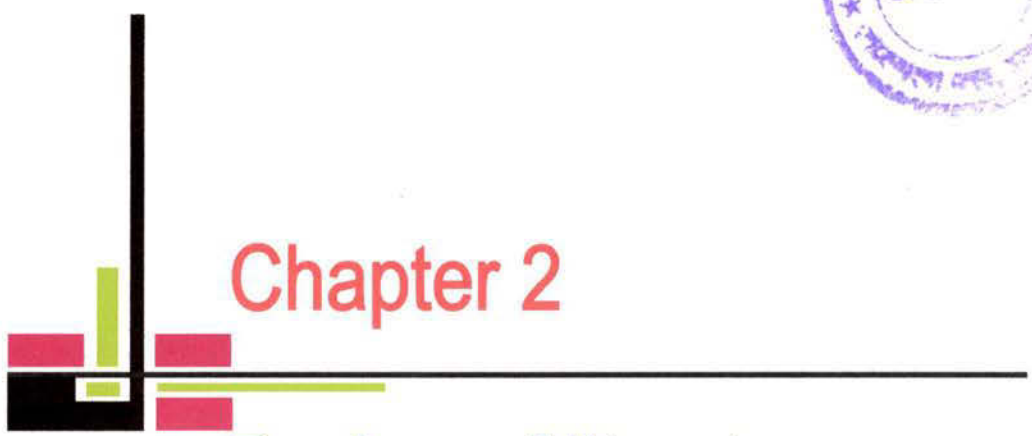
Onion is multipurpose crop. The edible portion of an onion plant is fleshy scale leaves and flower stalk. The bulb is composed of concentric, fleshy enlarged leaf bases on leafy scales. The outer leaf bases loss moisture and become scaly and the inner leaves generally thicken as bulbs develop. The green leaves above the bulb are hollow and arise sequentially from the meristem at the innermost point at the base of the bulb. The stem is very small and insignificant during vegetative growth. The onion root system is fibrous, spreading just near the soil surface to a distance of 30 to 96 cm. There are few lateral total root growth is sparse and not especially aggressive. Onion contains protein, fat, vit-A, vit-B, vit-C, iron and calcium. It is released for its pungency which is due to presence of a volatile oily substance known as allyl propyl disulphide (Yawalkar, 1985).

Bangladesh is densely populated country where cultivable lands are squeezing day by day. Total production of onion is not increasing accordingly due to limitation of land. The production per unit area of onion can be increased by adopting improved methods of cultivation. Among the improved cultivation methods, transplanting of onion seedling at proper spacing in a particular area have marked effect in increasing per unit area. On the other hand, substantial amount of nutrients also be considered for increasing production per unit area. Insignificant nitrogen will induce early maturity and reduce bulb size, high nitrogen may increase bulb size and cause large necks and soft bulb with poor storage quality.

From the beginning the farmer generally allows to grow single plant per hill. The number of plant per hill can increase the production of onion like a number of vegetables such as tomato, sweet potato and carrot (Islam, 1990, Azam, 1989, Tarafder, 1999). The horticulture division of BARI, BSMRAU and BAU has evaluated a number of cultivars of onion and conducted experiment on different agronomical aspects but little work has been done on number of plants per hill and nitrogen which is important for higher production

Considering the above situation, the present experiment was designed with the following objectives:

i. To investigate the influence of combined effect of different levels of nitrogen and number of plant (s) per hill on the growth and yield of onion.
ii. To find out the optimum level of nitrogen for highest yield and suitable bulb size.
iii. To assess the possibility of obtaining maximum yield of onion through transplanting more than single plant per hill.



Chapter 2

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

The growth and yield of onion are influenced by number of plants per hill and different levels of nitrogen. The review of literature includes reports as studied by several investigators who found pertinent in understanding the problems which may help in the explanation and interpretation of results of the present investigation. In this chapter, an attempt has been made to review the available information in home and abroad on effect of different nitrogen doses and number of plants per hill on growth and yield of onion.

2.1 Effect of nitrogen on the growth and yield of onion

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

Nagaich *et al.* (1998) observed a field experiment at Gwalior where S was applied @ 0, 20, 40 and 60 kg S ha^{-1} and K was 0, 40, 80 and 120 kg K_2O ha^{-1} to Nasik Red onions. Bulb yields increased with the increasing of S rate and it was maximum at an intermediate K rate (80 kg K_2O ha^{-1}).

Janardan and Singh (1998) conducted a field experiment to know the effect of stockosorb and potassium levels on potato and onion. They found that the higher biomass, bulb weight, bulb diameter and bulb yield were obtained with the

application of 300 kg K_2O + 150 kg stockosorbthinkg-1 plus an adequate number of irrigations. The maximum response of 11.1 kg bulbthinkg-1 stockosorb was noted at 150 kg stockosorbthinha-1. Comparatively higher concentrations of N, P and K were observed in the soils treated with stockosorb.

Jiang *et al.* (1998) studied in plot trials with onions were with 0, 375, 420 or 525 kg potassium sulfate ha^{-1}. Bulb dimensions increased with increasing rate of fertilizer application and bulb weight increased from 231 g with no fertilizer to 324 g with the highest fertilizer rate. Minimum bulb yield was found 69.4 t ha^{-1} with no fertilizer and maximum bulb yield was found with the higher rate of potassium sulfate (85.3 t ha^{-1}). Net benefit increased with increasing rate of potassium fertilizer application.

Islam (1999) conducted an experiment to find out the effects of different sources of potassium and different application methods on yield, yield attributes of onion, and potassium uptake by plants at Bangladesh Agricultural Research Institute, Gazipur during the winter of 1994-1995. Three sources of potassium (muriate of potash, potassium nitrate and potassium sulfate) and three application methods viz. basal, ½ basal + ½ at 20 days after transplanting (DAT) and 1/3 basal + 1/3 at 20 DAT + 1/3 at 40 DAT were used in study. Maximum (35 kg ha^{-1}) and minimum (26 kg ha^{-1}) K accumulation were recorded in split applications and a single basal application, respectively.

Nagaich *et al.* (1999) conducted an experiment with four rates of potassium (0, 40, 80, and 120 kg K_2O ha^{-1}) during 1995-96 and 1996-97 on growth characters,

yield attributes, yield and quality of onion on a sandy loam soil in Madhya Pradesh, India. Application of 80 kg K_2O ha^{-1} significantly increased bulb weight $plant^{-1}$ and horizontal diameter of the bulb.

Singh *et al.* (2000) conducted an experiment at Rajasthan, during summer season of 1993-95. Onion cv. N-53 was grown under factorial combinations of 3 levels each of nitrogen (50, 75 and 100 kg N), phosphate (13.2, 22.0 and 30.8 kg P) and potash (41.5, 62.2 and 83.0 kg K). It was concluded that onion productivity could be enhanced considerably by the application of 100 kg N, 30.8 kg P and 83.0 kg K ha^{-1}.

A field experiment was conducted in Rahuri, Maharashtra, India, to determine the effect of integrated nutrient management on the growth and yield of onion (cv. N-2-4-1) by Patil *et. al* (2007) seed production during the rabi season of 2004-05. Significantly higher values of all growth attribute parameters were recorded with the treatment (T2) fertilizer combination of 120:60:60 N:P2O5:K2O kg ha-1+20 t FYM ha-1 over all the other treatments, closely followed by NPK application at RDF as per soil test. The treatment (T3) 75% RDF of NPK+5 t FYM ha-1 recorded the lowest values of growth attributes. Treatment (T2) 120:60:60 NPK+20 t FYM ha-1 recorded the highest number of umbels per plant, number of seeds per umbel, weight of seeds per umbel and 1000-seed weight. The use of 100% RDF of NPK (T2) through inorganic source with 20 t FYM ha-1 was capable of gaining the highest residual N, P and K. The results indicated that the treatment (T2) combination of 100% RDF of NPK (120:60:60 kg ha-1) with FYM (20 t ha-1) gave the highest seed yield, and consequently, it can be advocated for

N-2-4-1 grown in the rabi season under irrigated conditions.

May *et al.* (2007) carried out an experiment in Sao Jose do Rio Pardo, the onion producing area in Sao Paulo State, Brazil, from 7 March to 8 August 2004 to evaluate the effects of N (at 0, 50, 100 and 150 kg/ha) and K (at 0, 75, 150 and 225 kg/ha) on the yield of 2 onion cultivars (Optima and Superex), growing in different plant populations (60, 76, 92 and 108 plants/m2). The effects of N and K levels on the yield were cultivar-dependent. Average individual bulb mass increased with decreasing plant population and N level. To reach 90% of the maximum expected crop yield of 71 t/ha for Superex and 64.8 t/ha for Optima, N levels of 125 and 105 kg/ha should be applied, respectively, without K application.

Kadam and Sonar (2006) conducted an experiment in Maharashtra, India, to develop fertilizer prescription equations for onions and these equations were tested for their validity by conducting two follow-up trials. A standard field experiment was conducted on post-monsoon onion (cv. N2-4-1) on Otur soil series (Typic Chromusterts). There were 21 selected treatment combinations out of 5 levels of N (0, 50, 100, 150, 200 kg/ha), four levels of P_2O_5 (0, 50, 100, 150 kg/ha) and three levels of K_2O (0, 50, 100 kg/ha) with 6 control treatments. Farmyard manure was also applied to all the plots at 10 Mg/ha ten days before planting of onion. The nutrient requirement of onion crop was 1.314 kg N, 1.172 kg P_2O_5 and 20.4 kg K_2O/Mg production. Efficiency of soil nutrients was 11.25, 55.35 and 7.37% of N, P_2O_5 and K_2O while that of fertilizer N, P_2O_5, K_2O were 21.01, 29.35 and 66.18%, respectively. Fertilizer rates increased with increasing

yield targets of onion and fertilizer rates decreased with increasing soil test values. Results of the two follow-up trials on onion in Otur (Typic Chromusterts) and Sawargaon series (Vertic Ustropepts) showed that yield targets of 30, 40 and 5 t/ha were achieved. The highest yield (53.5 t/ha) and profit (Rs. 90 300/ha) were observed at 50 t/ha yield target of onion followed by 40 t/ha targeted yield treatment.

Singh *et al.* (2003) studied the effect of K fertilizer (30, 60, 90 and 120 kg ha^{-1}) applied as split dressings (1/2 basal + ½ as top dressing at 45 days after transplanting or DAT or 1/3 as basal + 1/3 top dressing at 45 DAT + 1/3 top dressing at 90 DAT) on the seed yield of onion cv. N-53 Dhaulakuan, Himachal Pradesh, India during the rabi season of 1994/96 and1995/96. The application of K at 60, 90 and 120 kg ha^{-1} in three splits (1/3 as basal + 1/3 as top dressing at 45 DAT + 1/3 as top dressing at 90 DAT) induced early bolting, and resulted in the greatest height of flower stalks, 1000-seed weight and seed yield. Thus, the application of 60 kg ha^{-1} in three splits was the most economical rate for onion.

Yadav *et al.* (2003) conducted experiments in Jobner, Rajasthan, India, to determine the optimum rate of nitrogen and potassium and obtain maximum and seed quqlity of onion bulb, during the rabi seasons of 1998-99 and 1999-2000. Four cultivar (Puna red, white marglobe, Nasik Red and Rasidpura Local) were given three nitrogen (50, 100 and 150 kg/ha) and three potassium rates (50, 100 and 150 kg/ha). Among the cultivars, the higest plant height, leaf number per

plant, leaf fresh weight, leaf dry weight (g), neck length, bulb equatorial diameter, bulb polar diameter, bulb fresh weight and bulb yield were recorded in Rasidpur local. Puna red had the lowest neek thickness. The highest N rate recorded the highest plant height, leaf number per plant, leaf fresh weight, leaf dry weight (g), neck length, bulb equatorial diameter, bulb polar diameter, bulb fresh weight and bulb yield. The lowest N rate recorded the lowest neck thickness. The highest K rate recorded the highest plant height, leaf number per plant, leaf fresh weight, leaf dry weight (g), neck length, bulb equatorial diameter, bulb polar diameter, bulb fresh weight and bulb yield. The lowest K rate recorded the lowest neck thickness.

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

N, 16 kg P and 25 kg K/ha. Use of NPK fertilizers along with FYM also resulted in significant improvement in available N, P and K status of the soil.

Mandira *et al.* (2003) studied the effect on the growth, yield and yield attributes of onion cv. N-53. Different levels of nitrogen (at 0, 100, 150 and 200 kg/ha) and potassium (0, 75 and 150 kg/ha) were given as soil application recorded the best performance in terms of yield and growth. All other treatment and their combinations were superior to control.

Yadav *et al.* (2002) conducted a field experiment in Jaipur. Rajasthan, India during the *rabi* seasons of 1998-2000. Onion cultivars Puna Red, White Marglobe, Nasik Red and Rasidpur Local were supplied with 50, 100 or 150 kg N and K/ha. Yield, fresh weight of bulb, total soluble solids and allyl Propyl disulfide content increased, whereas ascorbic acid content decreased with the increase in N and K rates. Rasidpura Local recorded the highest values for the parameters measures except allyl propyl disulfide content which was highest in Nasik Red.

Anon. (2001) conducted an experiment at spices research centre. BARI, Joydebpur during 2000-2001 with four levels of nitrogen ((at 0, 100, 125 and 150 kg/ha). Influence of different levels of nitrogen was significant on different parameters of onion studied. But 125 kg/ha and 150 kg/ha of nitrogen produced 10.91 t/ha and 8.70 t/ha of bulb, respectively while it was 5.74 t/ha in control.

According to Mohanty and Das (2001) application of 90 kg N and 60 kg K_2O/ha was advocated for obtaining higher yield with larger bulbs, while 30 kg/ha each of

N and K_2O was suggested to realize medium bulbs with moderate yield and better keeping quality in long term storage.

Ramamoorthy *et al.* (1999) conducted a field experiment at Bhavanisagar, Tamil Nadu, India. Onion cv. CO4 was given 0, 30, 60, or 90 kg N/ha during the *kharif* and summer seasons of 1994 and 1995. Bulb yield increased as N rate increased.

Rodiquez *et al.* (1999) reported significant effect of N up to 150 kg/ha on yield, plant height and leaf number. Significant effects of P and K rates (applied up to 98.2 and 200 kg/ha, respectively) could not be detected non significant interactions between N and P. A statistically significant effect of P applied as normal super-phosphate was observed. Nitrogen application affected the number of leaves and plant height, and significant increase in bulb diameter observed.

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

Singh and Mohanty (1998) conducted an experiment and showed that increasing N levels resulted in increased plant height. Nitrogen and K at 160 and 80 kg/ha respectively (160:80 N:K), resulted in the tallest plants and 120:80 N:K produced

the shortest plants. Bulb girth and number of leaves/plant were greatest with 160:80 N:K followed by 120:120 N:K and 160:100 N:K; a significantly lower bulb weight was achieved with 80:80 N:K. the highest yield (29.8 t/ha) was achieved with 160:80 N:K. on the basis of these results, the recommended rates for commercial onion production in and around Bhubaneswar are 160 kg N, 80 kg K_2O and 60 kg P_2O_5/ha.

Harun-or-Rashed (1998) carried out a field experiment at the Bangladesh Agricultural University, Mymensingh on the effect of NPKS on growth and yield of onion at different plant spacing. He reported that the maximum bulb weight (40.5 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, whereas the minimum bulb yield (16.75 t/ha) was recorded from control treatment. Application of NPKS increased the plant height, leaf number, length of bulb, bulb diameter, and bulb weight as well as the bulb yield. He recommended 100-150-200-30 kg N, P_2O_5, K_2O, S/ha, respectively for the cultivation of BARI peaj-1 at BAU farm conditions. But Islam (1990) found the nitrogen at 120 kg/ha produced the maximum bulb weight and bulb yield (25.5t/h).

Dixit (1997) carried out an experiment with onion during the summer of 1994 at Lari, Himachal Pradesh, India. He used five rates of nitrogen (0, 40, 80, 120 and 150 kg/ha) and two rates of farmyard manure (10 and 20 t/ha), and reported that increasing nitrogen application rates increased bulb yield up to 120 kg N/ha. Higher yields were also obtained with the higher rate of farmyard manure used.

Application of 120 kg N/ha with 20 t/ha farmyard manure increased yields by 42.79% compared to the control.

An experiment was conducted to investigate the effects of plant density (2 or 3 lines/ridge) and NPK fertilizers (4 rates and 2 method of application on the productivity of onions by Rizk (1997). He observed that lower planting densities resulted in higher number of leaves/plant; higher fresh and dry weights, higher leaf areas. Higher average bulb weight and higher uptake of N. Total bulb yield and yield of marketable bulbs were highest with dense planting. Increasing the NPK rate increasing the vegetative growth parameters measured and increased the yield of bulbs. The best application method for NPK was 2 equal doses applied at 30 and 60 days after transplanting.

Rahim *et al.* (1997) conducted an experiment at Mymensingh, Bangladesh, from November 1991 to April 1992. Four N (0, 25, 50 and 100 kg/ha) and 4 K2O (0, 40, 80 and 160 kg/ha) rates were tested. The highest seed yield/ha were obtained from the plants receiving the highest N and K rates. The treatment combination (100 kg N + 160 kg K_2O/ha) gave the highest yield (508 kg/ha).

Hedge(1986) found that N fertilization increased the bulb yield up to 160 kg/ha although there was no significant difference between 80 kg N/ha and 160 kg N/ha.

A study with five N levels on the growth, tissue composition and yields of the 4 crops viz. potato, onion, garlic and hybrid squash was carried out by Buwalda and Freeman (1987). They found and suggested that the effect of N fertilizer on

marketable yields followed closely the effect of growth. The treatment giving the highest yield showed the highest relative growth rate (RGR).

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

Lang (1987) clarified that N fertilizer was required to make up the crops at different stages of growth. Flat rate applications of 193 kg N/ha were followed by considerable losses resulting from irrigation and costs were also higher. Specific application of N at 105 kg/ha was found to reduce N losses and costs, but the yield increased.

A field trial was conducted by Soto (1988) with critical levels for P, K and S and response to N. The rates were 100 kg/ha each of N, P_2O_5 and K_2O and 50 kg S/ha. Nitrogen was applied at 0, 50, 100 and 150 kg/ha. He observed that 50 kg N/ha gave the best yield response.

Ahmed *et al.* (1988) studied different levels of nitrogen (0, 60 and 120 kg/ha) and sulphur (0, 12, 24 and 36 kg/ha) on a local cultivar of onion Faridpuri Bhati. Both nitrogen and sulphur significantly increased the yield. However, a combined application of nitrogen and sulphur produced higher yield than nitrogen or sulphur alone. Nitrogen at 60 kg/ha together with sulphur at 36 kg/ha produced maximum yield (10.44 t/ha).

Nehra *et al.* (1988) stated that the application of 40 kg N/ha significantly increased the plant height and number of leaves compared with the control. The

difference in effect between 40 kg N were not significant except that 80 kg N which increased the number of leaves per plant over 40 kg N.

Satter and Haque (1975) Observed that an increased level of Nitrogen increased the weight of bulb; while potassium in an increased lave decreased the bulb weight. In their study, nitrogen at 67.21 kg/ha and potassium at 22.48 kg/ha were found the give a high yield of onion cv.local.

Singh and Dhankhar (1988) conducted two types of experiment on onion production. They set up two types of land, one without previously green manuring and another was cropped with green manuring by *Sesbania rostrata*. A combination of 120 kg N and 50 kg K_2O/ha gave the tallest plant and the greatest number of leaves per plant, bulb weight per plant, bulb diameter and higher bulb yield in the first experiment.

Hedge (1988) carried out an experiment with onion cv. Pusa Red and noticed that application of nitrogen fertilizer increased bulb yield but not quality. He also showed that uptake of N, P, K, Ca and Mg nutrients generally increased due to higher dry matter production.

In another trial Singh and Dhankhar (1989) stated that high N levels reduced bolting and increased plant growth, ascorbic acid content and yield. Potassium also reduced bolting and neck thickness and increased plant growth, yield and ascorbic acid, dry matter, sugar and S contents of the bulbs. The highest yield (27.4-32.7 t/ha) was obtained with the highest N rate (160 kg/ha).

Singh *et al.* (1989) conducted two experiments during the rainy seasons of 1984 and 1986 at Faizabad, onion sets C. N, 53, were planted August. Some were supplied with combinations of N at 0, 60, 90 or 120 kg/ha and K_2O at 0, 10, 20, 30, 40, or 59 kg/ha. In a second experiment they were planted on soil previously trooped with green manuring dhaincha (*Sesbania aculeate*) or were grown without previous green manurig. A combination 120 kg N and 50 kg K_2O gave the tallest plants and the greatest number of leaves/plant, plant diameter and bulb yield in the frist experiment.

An experiment was conducted by Pandey *et al.* (1990) with various levels of N and reported highest yield of marketable bulbs (34.97 ton/ha) by transplanting on 1 January and applying 100 kg N/ha.

Gaushal *et al.* (1991) reported that increasing nitrogen levels significantly increased the bulb yield. The highest yield was recorded at 150 kg N/ha which was significantly superior to the rest of the nitrogen levels. The yield at 100 kg N/ha was also significantly more than 50 kg N/ha which was at par with 100 kg N/ha and significantly lowers than two lower levels of nitrogen.

Maier *et al.* (1990) carried out an experiment and expressed that in onion crop fresh weight (FW) increase correlated with the increase in N level and the largest bulbs were 25-30 mm in diameter. Nitrogen rates in the range of 299-358 kg/ha gave 95% of maximum yield. Dry matter of bulbs was not affected by N. Bulb size was increased with increasing rate of N application.

An experiment conducted by Baloch *et al.* (1991) indicated that the highest bulb yield (22.66 t/ha) was obtained 125 kg N + 75 K_2O/ha. The highest plant height (38.5 cm), number of leaves/plant (7.0), single bulb weight (82 g), vertical bulb diameter (4.80 cm) and horizontal bulb diameter (5.78 cm) were obtained with 125 kg N + 100 kg K_2O/ha.

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

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

Pandey *et al.* (1991) studied four levels of nitrogen (0, 50, 100, and 150 kg/ha), three levels of phosphorus (0, 40, or 80 kg/ha) and two levels of potash (0 and 50 kg/ha) to determine the yield and quality of kharif onion. They found that the maximum yield and cet return were achieved with N:P:K at 105: 40: 50 kg/ha.

Kumer and Sharma (1991) conducted an experiment with two onion cultivars designated as N-53 and N-2-4-1 and grown in the kharif season. Bulb yield increased linearly as N application was increased up to 75 kg N/ha. The mean increase in the bulb/plant weight ratio was 1:2.22 with 25 kg N, compared with 1/: 1.95 for untrezted controls; higher N rates reduced this ratio.

Madan and Sandhu (1985) noticed that good plant growth, maximum bulb yield and dry matter production were obtained with N: P_2O_5,: K_2O at 120: 60: 60 kg/ha. Singh (1987) in his trial with onion cv. Push Red at different levels and combination of NPK fertilizer.

Amin *et al.* (1995) worked on sandy lam soil in Mymensingh on onion cv. Taherpuri, planted on 20 December or January and gave 0, 25, 50 or 100 kg N/ha. Yields were highest form the planting of 20 December supplied with 100 kg/ha. Individual bulb weight was also greater in this treatment.

Bhorrdwaj *et al.* (1991) stated that plant height was increased significantly with increasing levels of nitrogen. The main yield containing component were the number of seapes per plant, size of umbel, but the increase beyond 80 kg N/ha was not significant.

2.2 Effects of number of plants per hill on growth and yield of onion

Like other underground crops more than one plant per hill can increase the yield of onion. The available informations relating to plants per hill of onion are reviewed below.

Vik (1974) carried out an experiment in Norway and showed that satisfactory bulb crops were produced when groups of three to seven seedlings were raised in small pots and transplanted as a cluster. During bulbing the plants pushed each other apart and the resulting bulbs were not misshapen.

Hiron (1983) found that, the yield of bulbs greater than 40 mm diameter reaches a maximum of 45-55 ton/ha. When modules containing five to six seedlings are transplanted at ten modules per m^2. In these conditions 60-70% of the bulbs are greater than 60 mm in diameter. Using more seedlings per module, or planting modules at a higher density, reduced mean bulb size.

Herison *et al.* (1993) conducted an experiment at three onion cultivars sweet Sandwich, Vega and Yula were sown in the green house in 200-cell plastic trays and thinned to one, two or three seedlings/cell. Seedlings were transplanted in to the field 12 weeks after sowing, without separating individual plants from multi plant cells. Two and three plants/cell yielded a higher percentage of bulbs 76 mm in diameter, however one plant/cell yielded more bulbs of 102 mm in diameter

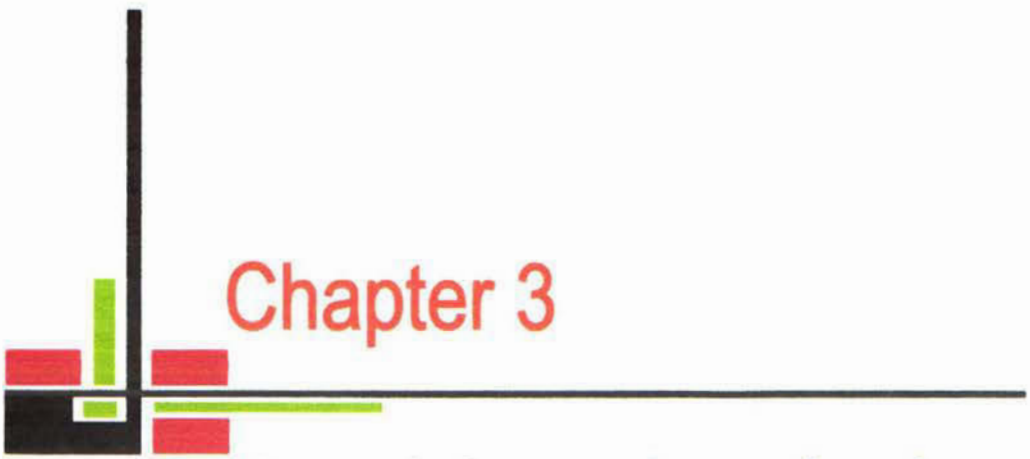
Halder (2001) conducted an experiment on the effect of plant spacing, number of plants per hill and mulching on the growth and yield of carrot under Bangladesh (BAU) condition. She found that two or three plants per hill produced significantly higher yield than one plant per hill.

Siddique and Rabbani (1987) studied the effects of length of cuttings, part of vine inserted into the soil at planting and number of vines planted per hill on the yield of sweet potato. They observed that the number of tuberous roots per hill and yield were increased when two vine cuttings were planted per hill.

Saladaga and Rodolfo (1987) stated that generally no significant differences in agronomic characters and yield components of sweet potato were observed using

either the traditional method or the recommended practice planting. Varying the number of cuttings per hill significantly influenced only the fresh vine weight of Kaimay, BNAS-51 an Samar Big Yellow sweet potato varieties. Plants that developed from one cutting per hill produced heavier herbage than other treatments per hill although the varities significantly differed in this parameter. Among the varieties Kaimay obtained the highest value in yield and nearly all yield components.

Mandal *et al*. (1973) conducted an experiment at Trivandrum in India used non branched (H-165) and branched (H-97) types of tapioca (*Manihot esculenta*) to study the effect of plant density, fertility level and shoot number on tuber yield and quality of tapipca hybrids and found that two plants per hill gave a better yield than that of one plant per hill. They recommended spacing of 75 cm×75 cm, with two plants per hill and 90 cm×90 cm with one plant per hill for types H-165 and h-97, respectively. Following a similar experiment Tarafder (1999) found that two, three or four plants per hill produced significantly higher yield than one plant per hill.



Chapter 3

Materials and methods

CHAPTER 3

MATERIALS AND METHODS

In this chapter, the details of different materials used and methodologies followed during the experiment are described.

3.1 Experimental site

The research work was carried out at the Central Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November, 2006 to April, 2007. The experimental site was located in the center of Madhupur Tract (24.09° North Latitude and $90^0$26′ East Longitude) having an elevation of 8.5 m above sea level.

3.2 Soil of the experimental field

Initial soil samples from 0-15 cm depth were collected from experimental field. The collected samples were analyzed at Soil Resources Development Institute (SRDI), Dhaka, Bangladesh. The physio-chemical properties of the soil are presented in Appendix I (a). The soil of the experimental plots belonged to the agro ecological zone of Madhupur Tract (AEZ-28) as shown in Appendix I(b).

3.3 Climate of the experimental area

The experimental area was under the subtropical climate. Usually the rainfall was heavy during Kharif season and scanty in Rabi season. The weather conditions during experimentation such as monthly mean rainfall (mm), mean temperature (^{0}C), sunshine hours and humidity (%) are presented in Appendix II.

3.4 Planting material

One onion cultivar namely Taherpuri was used for the exprment. The seeds of this variety were collected from Siddiques Bazzar, Gulistan, Dhaka.

3.5 Raising of seedlings

High, well drained and sunny place was selected for seedbed preparation. The land was ploughed finely and drying for 10 to 15 days. Weeds were removed finely and finally. The soil was made into friable, loses and brought into fine tillth, other stulbles were removed. Onion seedlings were raised in two seedbeds situated on a relatively high land adjacent to the Horticultural Farm Office. The size of each seedbed was 3 m × 1 m with height of about 10 cm was made. Seeds were soaked in water for one night and then kept in a piece of cloth for spouting. After spouting the seeds were sown in the seedbed at a depth of 0.5 cm on November 10, 2006. Curator @ 6 kg/ha was dusted over the seedbed to protect the geminating seeds from ants. To shade were given. The germination was complete within 7 days after sowing. Light irrigation with a watering can was given whenever necessary. Weeding was done as and when required.

3.6 Treatments of the experiment

The treatments were tested as follows:

A. Number of plants per hill

i) One plant per hill (P_1)

ii) Two plants per hill (P_2)

iii) Three plants per hill (P_3)

B. Levels of Nitrogen

i) Control (N_0)

ii) 60 kg N/ha (N_1) (as 130 kg urea per hectare)

iii) 120 kg N/ha (N_2) (as 260 kg urea per hectare)

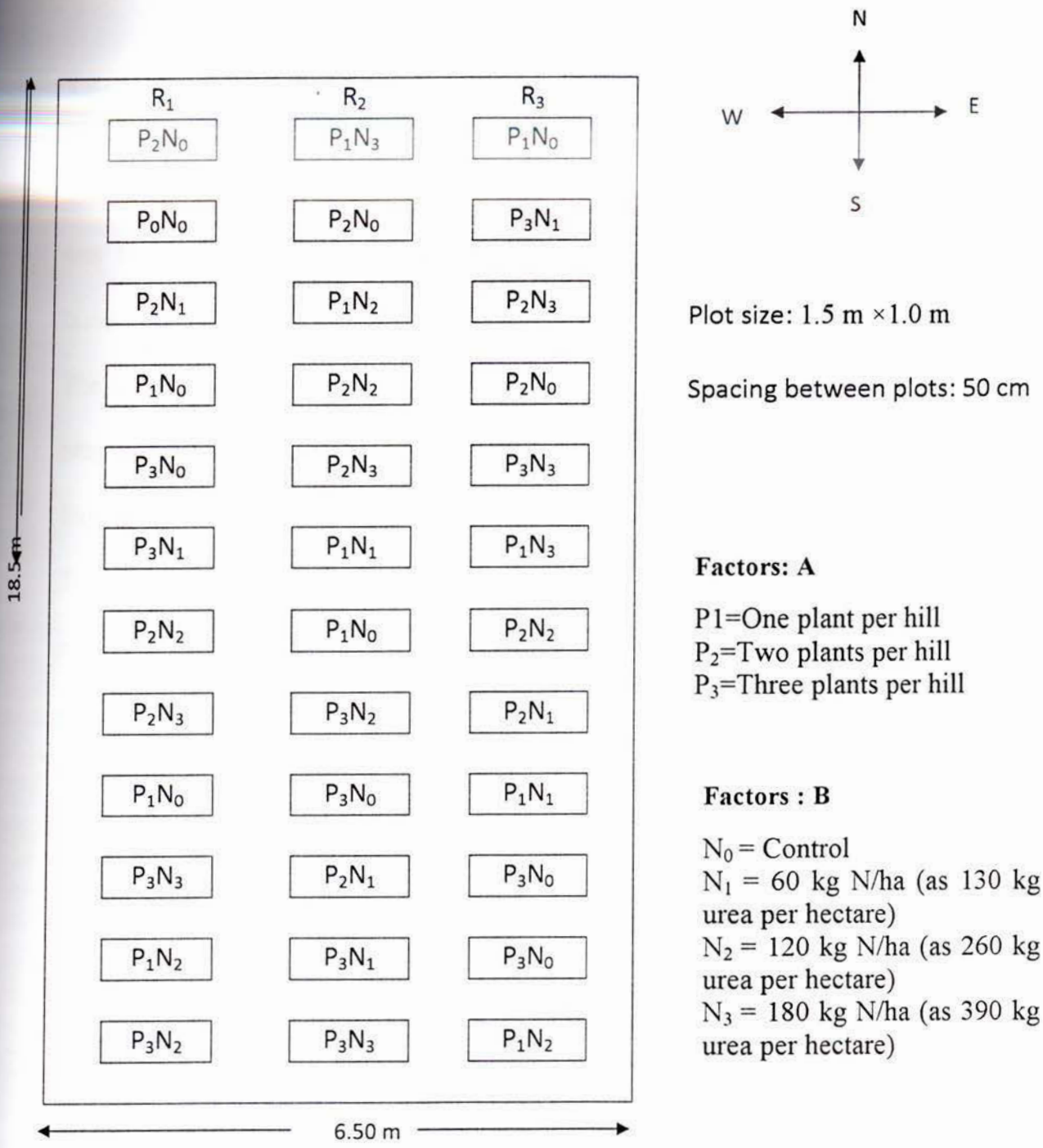
iv) 180 kg N/ha (N_3) (as 390 kg urea per hectare)

For which there were 12 treatments combination as follows

P_1N_0	P_2N_0	P_3N_0
P_1N_1	P_2N_1	P_3N_1
P_1N_2	P_2N_2	P_3N_2
P_1N_3	P_2N_3	P_3N_3

3.7 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD). Each treatment was replicated for three times. The total field was divided into three equals blocks each containing 12 unit plots. The treatments combination was randomly assigned to each unit plot as to all of one treatment combination only once in each block. The size of each unit plot was 1.5 m ×1.0 m. The distance between two adjacent replications (block) was 0.5 meter and plot to plot distance was 0.5 meter, number of row per plot was 10 and plant (hill) to plant (hill) 15 and row to row 10 cm distance so number of hill per plot was 100. The intra block and plot spaces were used as irrigation and drainage channels. A layout of the experiment has been shown in Fig 1.



Plot size: 1.5 m ×1.0 m

Spacing between plots: 50 cm

Factors: A

P1=One plant per hill
P_2=Two plants per hill
P_3=Three plants per hill

Factors : B

N_0 = Control
N_1 = 60 kg N/ha (as 130 kg urea per hectare)
N_2 = 120 kg N/ha (as 260 kg urea per hectare)
N_3 = 180 kg N/ha (as 390 kg urea per hectare)

Fig 1: Field layout of the two factors experiment in the Randomized complete Block

3.8 Cultivation procedure

3.8.1 Land preparation

The land was irrigated before ploughing. After having "zoe" condition the land was first opened with the tractor drawn disc plough. Ploughed soil was then brought into desirable tilth by 6 operations of ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 28 November and 5 December 2006, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were made about 10 cm high from the soil surface. Ridges were made around each plot to restrict the lateral run off of irrigation water. The plots were spaded one day before planting and the basal dose of fertilizers were incorporated thoroughly.

3.8.2 Manuring and Fertilization

Farmyard manure (FYM) and fertilizers TSP, MP, and Gypsum were applied @ 10 tons, 200, 160 and 20 kg/ha, respectively according to BARI krishi projukti hatboi, 2005). The farmyard manure (FYM) was applied after opening the land. Triple Super Phosphate (TSP) and gypsum were applied at the time of final land preparation. Muriate of Potash (MP) was applied in two equal installments at the time of final land preparation and 40 days after transplanting. Urea was used as top dressed in three equal splits at 35, 55, and 75 days after transplanting. Top dressing of fertilizers was done followed by irrigation

3.8.3 Transplantation and after care

Healthy and uniform sized seedling of 60 days were taken separately from the seedbed and were transplanted in the experimental plots in the afternoon of January 08, 2006 maintaining a spacing of 15 cm × 10 cm between the rows and plants and number of plant per hill as per treatments. The seed bed was watered before uprooting the seedlings from the seedbed so as to minimize damage to the roots. The seedlings were light watered after transplanting. Seedlings were also transplanted around the border of the experimental plots for gap filling.

3.8.4 Intercultural operations

After transplanting the seedlings, different intercultural operations were accomplished for better growth and development of the plants.

a. Gap filling

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gap filling was done whenever it was required using healthy, diseased free, injured free plants.

b. Weeding and mulching

Weeding and mulching were done to keep the crop free from weeds and to pulverize the soil crust for better aeration and to conserve soil moisture. Mulching was done after each irrigation at appropriate time by breaking the soil crust.

c. Irrigation

Two irrigations were given throughout the growing period. The first irrigation was given 30 days after planting followed by irrigation 20 days after the first irrigation.

Initially the crop was irrigated by watering cane during early stage of plant growth. At the latter stage irrigation was done by flood method.

d. Plant Protection

Insect pests: Cutwarm (*Agrotis ypsilon*) attact plants at early stage and vegetative stage. Severe infestation result in undersized bulb which were controlled mechanically and by the use of Dursban 20 EC @7 l/ha.

Disease: Purple blotch *(Alternaria porri*) and stemphylium leaf blight attacks onion. Initially, small white sunken spot develop on the leaves. These most conditions turn purple. This fungus is borne. Both the fungus controlled by spraying the crop with Ridomil @ 2g/L of water.

Removal of scape

The flower stalk was removed whenever appeared in plants. This was done daily by keen inspection.

3.9 Harvest

When the leaves become collapse and leaf become dry 18 April, 2007, the crop was harvested. The tops were removed by cutting of the pseudostem keeping 2.5 cm with the bulb.

3.10 Data collection

The following data were recorded

3.10.1 Plant height (cm)

The heights of pre-selected ten plants were measured with a meter scale from the ground level to the top of the tallest leaf after 50 days of transplanting and then at

10 days interval up to 70 days of transplanting and the mean height was expressed in cm.

3.10.2 Number of leaves per plant

Total number of leaves per 10 plants was counted after 50 days of transplanting and then 10 days interval up to 70 days of transplanting. The average number of leaves per plant was recorded.

3.10.3 Diameter of bulb (cm)

Diameter of bulb was measured at the middle portion of 10 selected bulb from each plot with a slide calipers and there average was taken in cm as the diameter of bulb.

3.10.4 Length of bulb (cm)

The length of bulb was measured with a scale from the neck of the bulb to the bottom of 10 selected bulbs from each plot and there average was taken in cm as the length bulb.

3.10.5 Diameter of pseudostem (cm)

Diameter of pseudostem was measured at the middle portion of 10 selected pseudostem from each plot with a slide calipers and there average was taken in cm as the diameter of pseudostem.

3.10.6 Fresh foliage weight per plant (g)

Determined from harvested fresh foliage of 10 selected plants were weighted and their average as the fresh foliage weight per plant

3.10.7 Fresh bulb weight per plant (g)

Ten bulbs were weighted by simple balance after removing pseudostem and their average as the fresh bulb weight per plant

3.10.8 Dry matter content of folliage (%)

Ten pseudostems 100 g foliage was collected from randomly in each unit plot and weights of dry matter of foliage were measured in gram after keeping in an oven at 70° C for drying. It took 72 hrs to reach the constant weight. The weight of dry matter was converted into percentage of dry matter content of foliage per plant using the following formula:

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of the sample}}{\text{Fresh weight of the sample}} \times 100$$

3.10.9 Dry matter content of bulb (%)

Hundred gram foliages were collected from ten plants randomly in each unit plot sliced finely. Then sliced onion was dried in the sun kept in an oven at 70° C for drying. It took 72 hrs. The weight of dry matter was converted into percentage of dry matter content of bulb per plant using the following formula:

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of the sample}}{\text{Fresh weight of the sample}} \times 100$$

3.10.10 Yield of bulb per plot (kg)

An Electric balance was used to take the weight of bulb per plot. It was measured by totaling the bulb yield of each unit plot separately harvest and was recorded in kilogram (kg).

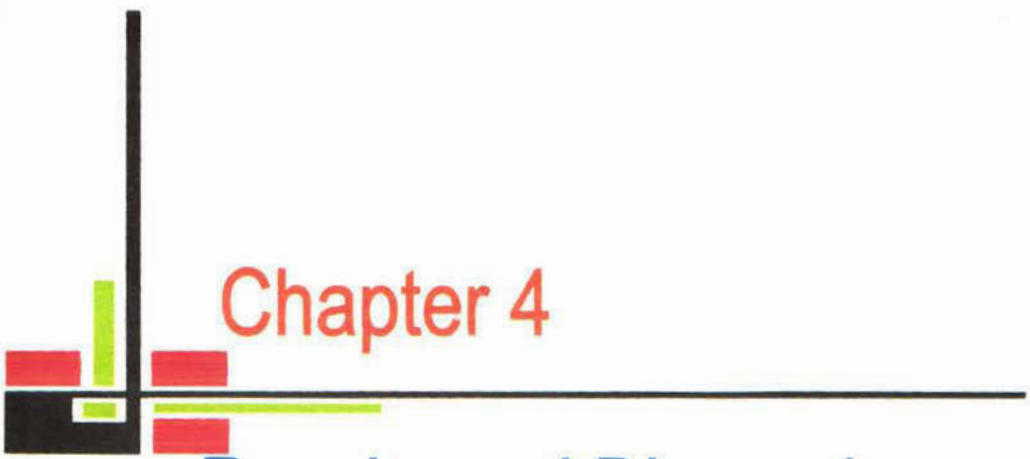
3.10.11 Yield of bulb per hectare (ton)

It was measured by the following formula

$$\text{Bulb yield per hectare (ton)} = \frac{\text{Bulb yield per plot (Kg)} \times 10000}{\text{Area of plot in square meter} \times 1000}$$

3.12 Statistical analysis

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT-computer package program developed by Russell (1986). The means were separated following Duncan's Multiple Range Test (DMRT) test at 0.05 level of significance.



Chapter 4

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the effects of number of plants per hill and different levels of nitrogen on the growth and yield of onion. Data on different parameters were analyzed statistically and results have been presented in tables 1 to 4 and figures 2 to 8 . The result of the present study have been presented and discussed in this chapter under the following heading.

4.1 Plant height

The number of plants (1, 2, and 3) per hill had significantly influenced on the plant height at 50, 60 and 70 DAT (days after transplanting) of observation. The plant height increased gradually with the advancement of time and continued up to 70 days after transplanting (DAT). The tallest plant height (28.93 cm) was obtained when one plant was grown per hill and the shortest plant height (25.58cm) was obtained when three plants was grown per hill (Fig. 2) at 50 DAT. At 60 DAT, The tallest plant height (30.55 cm) was obtained when one plant was grown per hill and the shortest plant height (27.3 cm) was obtained when three plants was grown per hill. At 70 DAT, The tallest plant height (32.28cm) was obtained when one plant was grown per hill and the shortest plant height (29.72 cm) was obtained when three plants was grown per hill. The shortest plant heights at all date of observations was found when three plants were grown per hill. The increased plant at one plant per hill was probably due to more plant nutrients, air and water. This result is agreed with the findings of Rahman (2004).

Plant height was significantly varied due to the application of different levels of nitrogen treatment. The plant height increased gradually with the advancement of time and continued up to 70 days after transplanting (DAT). At 50 DAT, the tallest plant (28.56 cm) was produced by N_3 (180 kg N/ha) and the shortest plant (25.71cm) was produced by N_0 (0 kg N/ha) (Fig. 3). At 60 DAT, the tallest plant (30.2 cm) was produced by N_3 (180 kg N/ha) and the shortest plant (27.38 cm) was produced by N_0 (0 kg N/ha). At 70 DAT, the tallest plant (32.07 cm) was produced by N_3 (180 kg N/ha) and the shortest plant (29.29 cm) was produced by N_0 (0 kg N/ha). Bhordwaj *et al.* (1991) and Hoque and Mamun (2000) also found taller plants with increasing levels of nitrogen.

Different number of plants per hill and nitrogen treatment showed significantly interaction on the plant height on different dates. At 50 DAT, the tallest plant height (30.07cm) was obtained from N_3P_1 (one plant per hill and 180 kg N/ha) treatment while the shortest plant height (23.27cm) was obtained from N_0P_3 (three plant per hill and control nitrogen) treatment. At 60 DAT, The tallest plant height (31.67 cm) was obtained from N_3P_1 (one plant per hill and 180 kg N/ha) treatment while the shortest plant height (25.27 cm) was obtained from N_0P_3 (three plant per hill and control nitrogen) treatment. At 70 DAT, the tallest plant height (33.4 cm) was obtained from N_3P_1 (one plant per hill and 180 kg N/ha) treatment while the shortest plant height (27.87 cm) was obtained from N_0P_3 (three plant per hill and control nitrogen) treatment. The plant height increased at different days with different combined treatments (table 1)

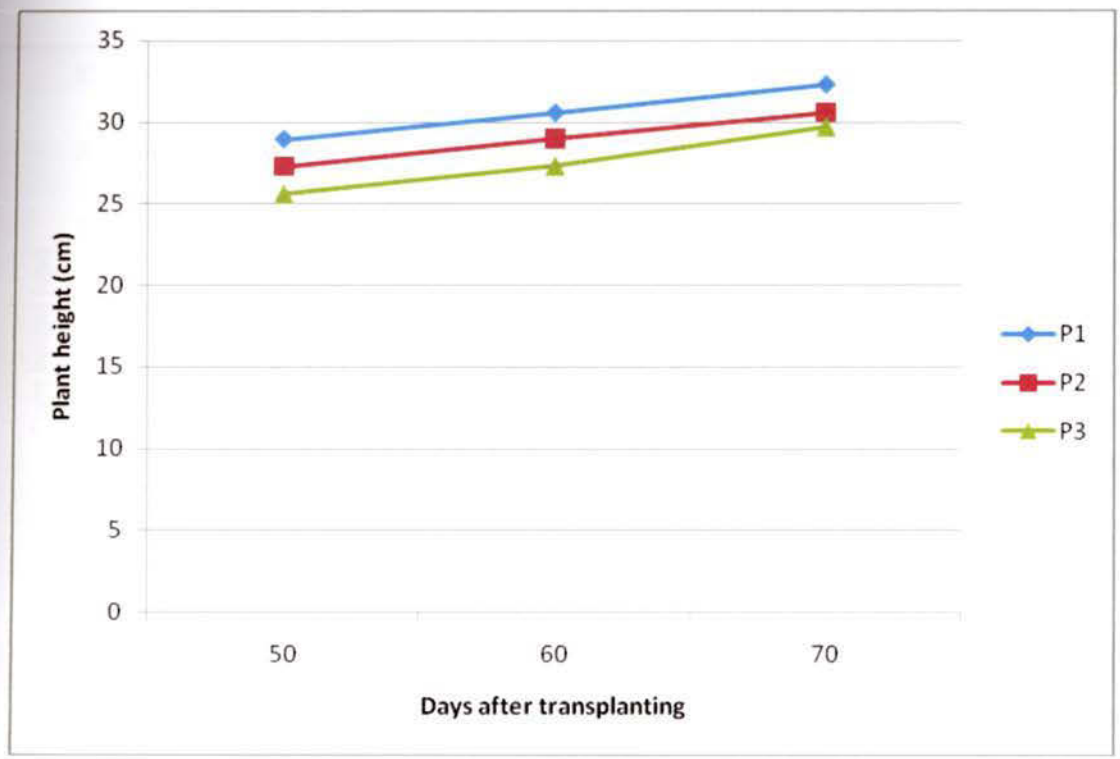


Figure 2 Effects of number of plants per hill on the plant height of onion at different days after transplanting.

P_1=One plant/hill

P_2=two plants/hill

P_3=three plants/hill.

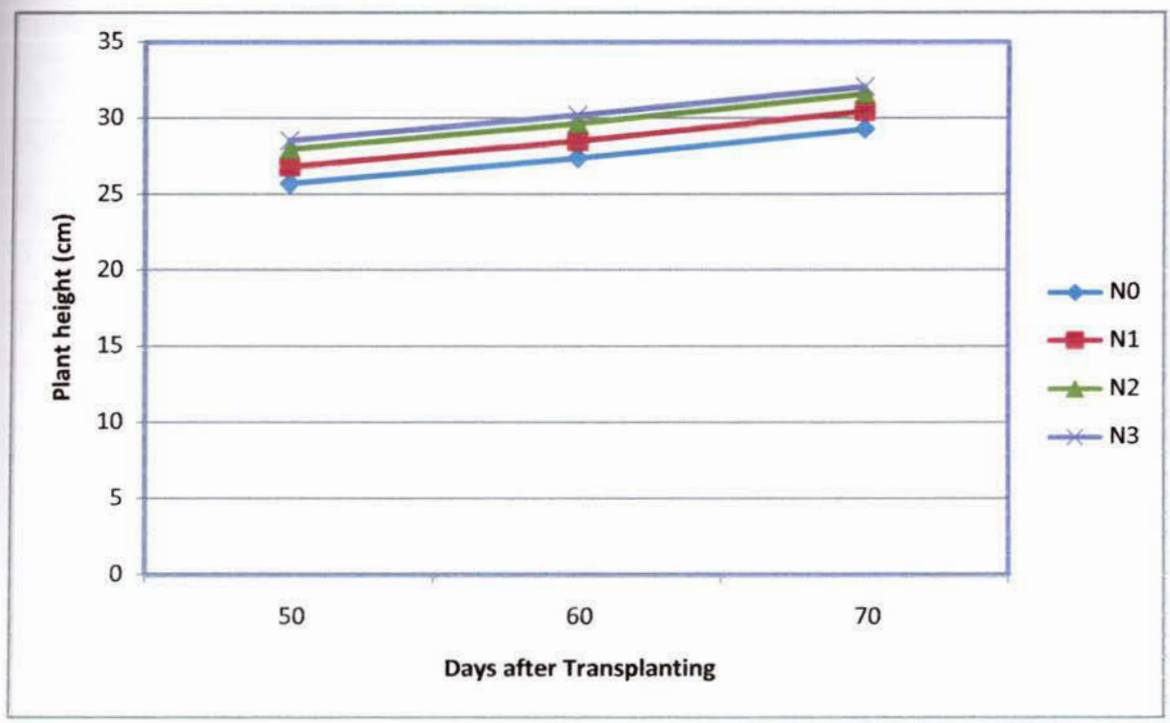


Figure 3 Effect of nitrogen on the plant height of onion at different days after transplanting

N_0 = Control

N_1 = 60 kg N/ha

N_2 = 120 kg N/ha

N_3 = 180 kg N/ha

Table 1. Combined effect of number of plans per hill and level of nitrogen on the growth and yield of onion

treatment	Plant height			Number of leaves per plant		
	50DAT	60 DAT	70 DAT	50 DAT	60DAT	70DAT
$P_1 N_0$	28.07c	29.33de	31.07de	4.57ab	5.93c	7.13bc
$P_2 N_0$	25.82e	27.53h	28.93g	4.47b	5.47d	6.61cd
$P_3 N_0$	23.27f	25.27j	27.87h	3.40c	5.15d	6.43d
$P_1 N_1$	28.44c	30.53bc	32.07bc	4.67ab	6.13bc	7.27ab
$P_2 N_1$	26.67d	28.42fg	30.07f	4.73ab	6.07bc	7.13bc
$P_3 N_1$	25.43e	26.61i	29.27g	4.87ab	6.33bc	7.33ab
$P_1 N_2$	29.20b	30.67b	32.60b	4.87ab	6.23bc	7.47ab
$P_2 N_2$	28.13c	30.07bcd	31.73cd	4.73ab	6.27bc	7.33ab
$P_3 N_2$	26.63d	28.27g	30.47ef	4.52ab	6.47bc	7.53ab
$P_1 N_3$	30.07a	31.67a	33.40a	5.10a	6.83a	7.87a
$P_2 N_3$	28.53c	29.87cd	31.53cd	5.06a	6.47ab	7.82a
$P_3 N_3$	27.07d	29.07ef	31.27cde	5.00a	6.80a	7.81a
$LSD_{(0.05)}$	0.127	0.182	0.210	0.4544	0.3935	0.5487
Level of significance	*	*	*	*	*	*
CV (%)	4.5	3.5	3.8	5.78	3.76	4.4

Means bearing the common letter (s) in a column do not differ significantly at 5% level

*significant at 5% level of probability

NS- non significant

P_1=One plant/hill

P_2=two plants/hill

P_3=three plants/hill.

N_0 = Control

N_1 = 60 kg N/ha

N_2 = 120 kg N/ha

N_3 = 180 kg N/ha

4.2 Number of leaves per plant

The number of plants (1, 2, and 3) per hill had significantly influenced on the number of leaves per plant at 50, 60 and 70 DAT (Appendix III). The number of leaves per plant increased gradually with the period of time and continued up to 70 DAT (Fig. 4). The number of leaves per plant was the highest (4.77) when one plant was grown per hill and the lowest number of leaves per plant (4.44) was obtained when three plants were grown per hill at 50 DAT. At 60 DAT, the number of leaves per plant was the highest (6.28) when one plant was grown per hill and the lowest number of leaves per plant (6.18) was obtained when three plants were grown per hill. At 70 DAT, the number of leaves per plant was the highest (7.43) when one plant was grown per hill and the lowest number of leaves per plant (7.22) was obtained when three plants were grown per hill. In case of more than one plant per hill there might have competition among the plants for nutrients, water, light and air and thereby produced less number of leaves per plant. This result is agreed with the findings of Mondal and Islam (1987). They found that, increase in plant density resulted in reduction of plant size and number of leaves.

Application of nitrogen also significantly influenced on the number of leaves per plant at 50, 60 and 70 DAT of observation (Appendix III). The number of leaves per plant increased gradually with the period of time and continued up to 70 DAT (Fig. 5). At 50 DAT, the number of leaves per plant was the highest (4.99) by N_3 treatment and the lowest number of leaves per plant (6.72) was obtained by N_0 treatment. At 60 DAT, The number of leaves per plant was the highest (6.7) by N_3

treatment and the lowest number of leaves per plant (5.5) was obtained by N_0 treatment. At 70 DAT, the number of leaves per plant was the highest (7.822) at 90 DAS by N_3 treatment and the lowest number of leaves per plant (6.72) was obtained by N_0 treatment. It was possible that the application of nitrogen increased the height of plants and ultimately the leaf number was also increased due to the influence of this nutrient. This finding agrees with the results of Bhuiyan (1979) who obtained higher number of onion leaves with application of nitrogen.

The combined effects of number of plants per hill and nitrogen had significantly influenced on number of leaves per plant at different DAT of observation (Appendix III). The highest number of leaves per plant (5.1) was counted with N_3P_1 (one plant per hill and 180 kg N/ha) treatment combination at 50 DAS, whereas the lowest number of leaves per plant (3.4) was obtained from N_0P_3 (three plant per hill and 0 kg N/ha) treatment. At 60 DAT, the highest number of leaves per plant (6.83) was counted with N_3P_1 (one plant per hill and 180 kg N/ha) treatment combination, whereas the lowest number of leaves per plant (5.1) was obtained from N_0P_3 (three plant per hill and 0 kg N/ha) treatment. At 70 DAT, the highest number of leaves per plant (7.87) was counted with N_3P_1 (one plant per hill and 180 kg N/ha) treatment combination, whereas the lowest number of leaves per plant (6.43) was obtained from N_0P_3 (three plant per hill and 0 kg N/ha) treatment. The number of leaf increased with different combined treatment at different days (Table 1).

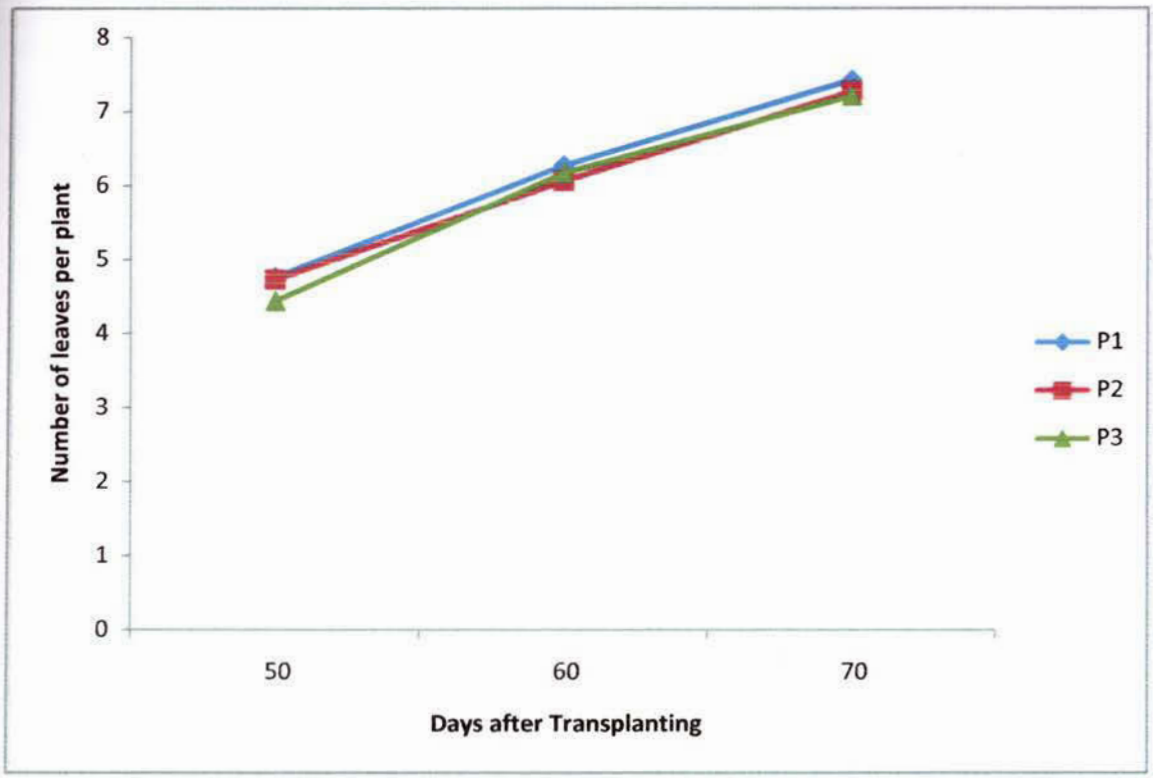


Figure 4 Effects of number of plants per hill on the plant height of onion at different days after transplanting.

P_1=One plant/hill

P_2=two plants/hill

P_3=three plants/hill.

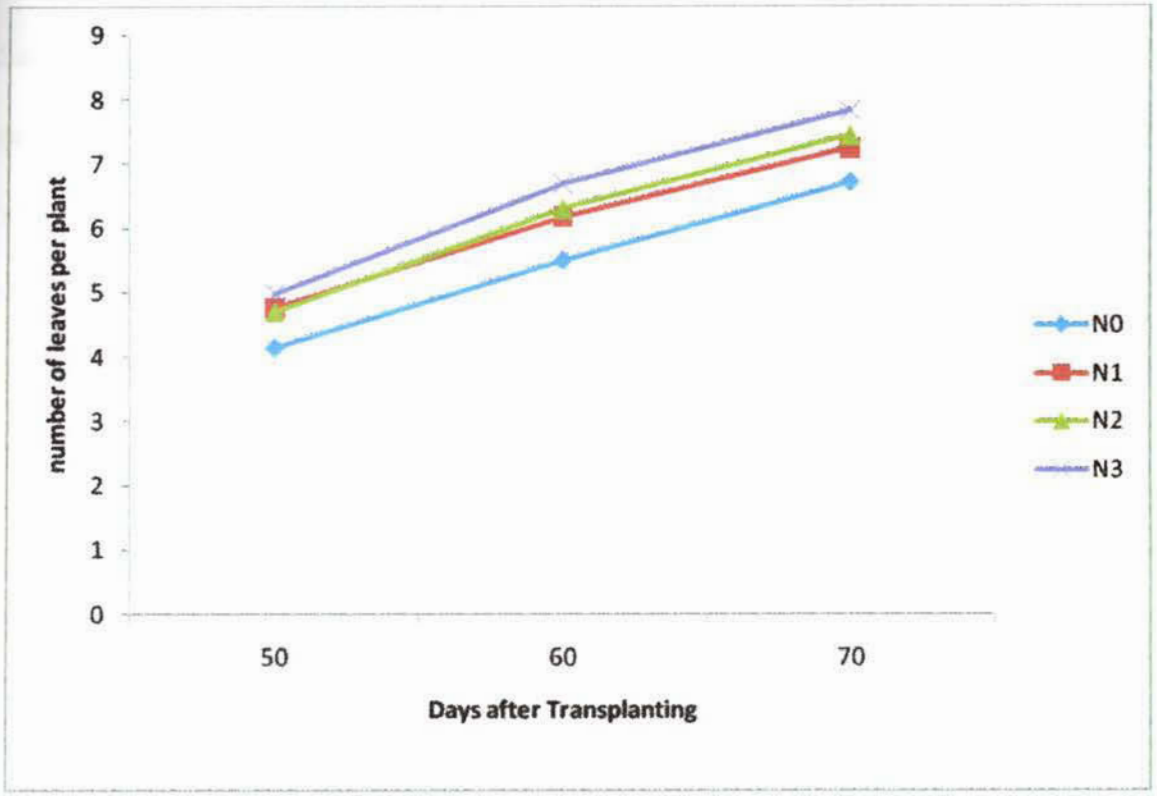


Figure 5 Effect of nitrogen on the number of leaves per plant of onion at different days after transplanting.

N_0 = Control

N_1 = 60 kg N/ha

N_2 = 120 kg N/ha

N_3 = 180 kg N/ha

4.3 Diameter of bulb

The number of plants per hill had significantly influenced on the diameter of bulb (Appendix IV). The highest diameter of bulb (3.98 cm) was recorded from P_1 (single plant/hill) that significantly higher than others. The minimum (2.8 cm) diameter of bulb was found in the treatment of three plants per hill (P_3), which was statistically identical with two plants per hill (Table 2). The decreased diameter of bulb incase of more than one plant per hill was due to more competition for nutrients, air and water. These results are in conformity with the results of Herison *et al.* (1993). Who obtained larger diameter of bulbs when one seeding was transplanted per hill.

Significant variation was found on diameter of bulb of onion due to the application of different levels of nitrogen (Appendix IV). The highest diameter of bulb (3.5 cm) was recorded by the plants having received 180 kg N/ha, which was statistically similar (3.48cm) to N_3 and the lowest (9.19 cm) was obtained from control (N_0) treatment (Table 3). The diameter of bulb increased with the increase level of nitrogen. Verma *et al.* (1972) observed that bulb increased in response of N at 200 kg/ha .The higher rate of nitrogen was not found economic.

The combined effect between number of plants per hill and levels of nitrogen showed significant variation in respect diameter of bulb was observed. The bulb diameter ranged from 2.32 to 4.21cm. The highest diameter of bulb (4.21 cm) was recorded from the treatment combination of one plant per hill with 180 kg N/ha

Table 2. Main effect of number of plant per hill on the growth and yield of onion

Treatment	Diameter of bulb (cm)	length of bulb (cm)	Pseudostem diameter (cm)	Fresh weight of foliage per plant (g)	Fresh weight of bulb per plant (g)	Dry mater content of foliage (%)	Dry mater content of bulb (%)	yield (kg/plot)
P_1	3.98a	2.32	0.92a	9.16a	27.19a	7.46a	10.16a	2.30c
P_2	3.17b	2.21	0.81a	5.79b	22.72b	6.39b	8.25b	3.05b
P_3	2.79b	2.19	0.55b	4.83c	16.47c	5.16c	7.20c	3.39a
$LSD_{(0.05)}$	0.628	1.377	0.111	0.248	1.677	1.031	1.012	0.272
Level of significance	*	NS	*	*	*	*	*	*
CV (%)	5.36	3.05	3.19	3.5	2.16	6.26	4.95	2.75

Means bearing the common letter (s) in a column do not differ significantly at 5% level
*significant at 5% level of probability
NS- non significant

P_1=One plant/hill
P_2=two plants/hill
P_3=three plants/hill.

Table 3. Main effect of nitrogen on the growth and yield of onion

Treatment	Diameter of bulb (cm)	length of bulb (cm)	Pseudostem diameter (cm)	Fresh weight of foliage per plant (g)	Fresh weight of bulb per plant (g)	Dry mater content of foliage (%)	Dry mater content of bulb (%)	yield (kg/plot)
N_0	2.96b	2.11b	0.70b	6.03d	21.44b	8.02	8.31	2.79b
N_1	3.33ab	2.20ab	0.76ab	6.38c	22.04ab	8.69	8.46	2.90ab
N_2	3.48a	2.31a	0.78ab	6.81b	22.32ab	8.81	8.60	2.94ab
N_3	3.49a	2.35a	0.80a	7.15a	22.69a	9.03	8.67	3.02a
$LSD_{(0.05)}$	0.465	0.184	0.082	0.184	1.241	1.629	0.693	0.201
Level of significance	*	*	*	*	*	NS	NS	*
CV (%)	5.36	3.05	3.19	3.1	3.6	6.26	4.95	2.75

Means bearing the common letter (s) in a column do not differ significantly at 5% level

*significant at 5% level of probability

NS- non significant

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

Table 4 Combined effects of number of plans per hill and level of nitrogen on the growth and yield of onion

Treatment	Diameter of bulb (cm)	length of bulb (cm)	Pseudostem diameter (cm)	Fresh weight of foliage per plant (g)	Fresh weight of bulb per plant (g)	Dry mater content of foliage (%)	Dry mater content of bulb (%)	yield (kg/plot)
$P_1 N_0$	3.62b	2.15de	0.84b	8.54d	26.71a	8.30b	9.18b	2.21f
$P_2 N_0$	2.96de	2.09e	0.74c	5.26h	22.26c	8.66c	7.13c	2.89d
$P_3 N_0$	2.32f	2.08e	0.52e	4.29k	15.36f	8.29e	6.10e	3.28b
$P_1 N_1$	3.99a	2.27bcd	0.94a	8.87c	27.21a	9.32b	9.39ab	2.25ef
$P_2 N_1$	3.18cd	2.18cde	0.81b	5.58g	22.71bc	8.80c	8.15c	3.06c
$P_3 N_1$	2.83e	2.15de	0.53e	4.69j	16.22e	8.38d	7.30de	3.39b
$P_1 N_2$	4.11a	2.41ab	0.94a	9.29b	27.313a	9.35b	9.52a	2.34ef
$P_2 N_2$	3.33c	2.27bcd	0.83b	6.06f	22.67bc	8.67c	7.32c	3.09c
$P_3 N_2$	3.03cde	2.25cd	0.56de	5.07i	16.99de	8.42d	6.45d	3.38b
$P_1 N_3$	4.21a	2.45a	0.95a	9.92a	27.55a	9.50a	9.62a	2.39e
$P_2 N_3$	3.24cd	2.29bc	0.87b	6.28e	23.23b	8.67c	7.26c	3.14c
$P_3 N_3$	3.04cde	2.31bc	0.59d	5.27h	17.29d	8.37d	6.44d	3.53a
CV (%)	5.36	3.05	3.1	3.6	2.16	6.26	4.95	2.75
$LSD_{(0.05)}$	0.303	0.119	0.054	0.119	0.809	0.076	0.299	0.301
Level of significance	*	*	*	*	*	*	*	*

Means bearing the common letter (s) in a column do not differ significantly at 5% level
*significant at 5% level of probability

P_1=One plant/hill
P_2=two plants/hill
P_3=three plants/hill.

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

(P_1N_3), whereas the lowest bulb diameter (2.32 cm) was observed from three plant per hill with 0 kg N/ha (Table 4)

4.4 Length of bulb

The length of bulb of onion was no significantly influenced on number of plants per hill (Appendix IV). The bulb of onion was observed to be gradually decreased with increasing number of plants per hill. The bulb of onion per plant was produced the highest (2.32 cm) when single plant was grown per hill which was followed by two plants per hill (2.21 cm). However, the three plants per hill showed the lowest (2.19 cm) length of bulb of onion (Table 2). These finding are in agreement with the result of Hiron (1983). They noted that bulb of onion is decreased with the increasing plant population.

The variation in length of bulb among different levels of nitrogen was found to be statistically significant (Appendix IV). The maximum (2.35 cm) length of bulb was found from the treatment of 180 kg N/ha, which was statistically similar with N_2 and the minimum (2.11 cm) was observed from control (Table 2). Rodriquez *et al.* (1999) reported significant effect N application on the number of leaves and plant height, and significant increase in bulb diameter with N applications.

The combined effect of length of bulb of onion was significantly influenced on number of plants per hill and different levels of nitrogen (Appendix IV). The length of bulb per plant ranged from 2.08 to 2.45 cm. The length of bulb was produced the highest (2.45 cm) from the treatment combination of P_1N_3 (one plant

per hill and 180 kg N/ha), whereas,the lowest length of bulb (2.08 cm) was observed from P_3N_0 (three plant per hill with 0 kg N/ha) treatment (Table 4).

4.5 Pseudostem diameter

The number of plants per hill had significantly influenced on diameter of pseudostem(Appendix IV). The highest (0.92 cm) diameter of pseudostem was recorded from P_1 (single plant/hill) that significantly higher than P_3. The minimum (0.55 cm) in this regard was found in the treatment of three plants per hill (Table 2). One plant per hill produced larger bulb as well as larger diameter of pseudistem. These finding are in agreement with the result of Rahman (2004).

The different levels of nitrogen had significantly influenced on the diameter of pseudostem (Appendix IV). The highest (0.80 cm) diameter of pseudostem was recorded from N_3 (180 kg/ha) and the minimum (0.70 cm) was found from control treatment (Table 3).

The combined effect between number of plants per hill and levels of nitrogen showed significant variation on diameter of pseudostem (Appendix IV). The highest diameter of pseudostem (0.95 cm) was recorded from the treatment combination of N_3P_1 (one plant per hill with 180 kg N/ha), whereas the lowest diameter of pseudostem (0.50 cm) was observed from N_0P_3 (three plant per hill with 0 kg N/ha) treatment (Table 4)

4.6 Fresh weight of foliage per plant

A significantly variation was found due to number of plants per hill on fresh weight of foliage per plant (Appendix IV). The maximum (9.16 g) fresh weight of foliage per plant was recorded when P_1 (single plant/hill) and the minimum (4.83 g) was found from the treatment of three plants per hill (Table 2). The decreasing trend of fresh weight of foliage with the increase in number of plants per hill might be due to overcrowding of plants per hill, facing high inter plant competitions for light, nutrients, water and air. These finding are in agreement with the result of Rahman (2004).

There was significantly influenced among different levels of nitrogen on the fresh weight of foliage per plant (Appendix). The maximum (7.15 g) fresh weight of foliage per plant was obtained from N_3 (180 kg N/ha), while the minimum (6.03 g) fresh weight of foliage per plant was recorded from in control treatment (Table 3).

The significant combined effect between number of plants per hill and levels of nitrogen treatment was observed on fresh weight of foliage per plant. The highest fresh weight of foliage per plant (9.92 g) was recorded from the treatment combination of P_1 N_3 (one plant per hill with 180 kg N/ha), while the lowest (4.29 g) fresh weight of foliage per plant was obtained from (three plant per hill with 0 kg N/ha) (Table 4)

4.7 Fresh weight of bulb per plant

The fresh weight of bulb per plant was observed to be significantly influenced by the number of plants per hill. The maximum (27.19 g) fresh weight of blub per

plant was recorded when P_1 (single plant/hill) and the minimum (16.47 g) was found from three plants per hill (Table 2). The decreasing trend of fresh weight of foliage with the increase in number of plants per hill might be due to overcrowding of plants per hill, facing high inter plant competitions for light, nutrients, water and air. This result is in agreement with the results of Vik (1974) who found that bulb weight was decreased when three to seven seedlings were raised in small pots.

The fresh weight of blub per plant also varied significantly due to different levels of nitrogen (Appendix IV). The maximum (22.69 g) fresh weight of blub per plant was obtained from N_3 (180 kg N/ha), while the minimum (21.44 g) fresh weight of blub per plant was obtain in control treatment (Table 3). The fresh weight of bulb per plant was increased gradually with the incresing level of nitrogen.

The combined effect between number of plants per hill and levels of nitrogen showed significant variation on fresh weight of bulb per plant. The highest (27.55 g) fresh weight of bulb per plant was recorded from the treatment combination of P_1N_3 (one plant per hill with 180 kg N/ha), while the lowest (15.36 g) fresh weight of blub per plant was observed from (three plant per hill with 0 kg N/ha) (Table 4).

4.8 Dry matter content of foliage

The number of plants per hill had significantly influenced on the dry matter content of foliage (Appendix IV). The highest dry matter content of foliage (7.46%) was recorded from P_1 (single plant/hill) that significantly higher than others. The minimum (5.16%) was noted from the treatment of three plants per hill (Table 2). These finding are in agreement with the result of Rahman (2004).

There was no significantly influenced among different doses of nitrogen on the dry matter content of foliage (Appendix IV). The maximum dry matter content of foliage (9.03%) was obtain at N_3 (180 kg N/ha), while the minimum (8.02%) dry matter content of foliage was obtained from control treatment (Table 3).

The significant variation was found due to combined effect of number of plants per hill and levels of nitrogen treatment were observed on dry matter content of foliage. The highest dry matter content of foliage (9.50%) was recorded from the treatment combination of P_1N_3 (one plant per hill with 180 kg N/ha), while the lowest (8.10%) dry matter content of foliage was observed from P_2N_1 (two plant per hill with 60 kg N/ha) (Table 4)

4.9 Dry matter content of bulb

The dry matter content of bulb was observed to be significantly influenced by the different number of plants per hill. The highest (10.16%) dry matter content of bulb was recorded from P_1 (single plant/hill) that significantly higher than others. The minimum (7.20%) was found from the treatment of three plants per hill (Table 2). These finding are in agreement with the result of Rahman (2004).

There was no significant variation on dry matter content of bulb due to the application of the different levels of nitrogen (Appendix IV). The maximum (8.67%) dry matter content of bulb was obtained from N_3 (180 kg N/ha), while the minimum (8.31%) dry matter content of bulb was found from control treatment (Table 3).

The significant variation was found due to combined effect of number of plants per hill and levels of nitrogen on dry matter content of bulb (Appendix IV). The highest (9.62%) dry matter content of bulb was recorded from the treatment combination of P_1N_3 (one plant per hill with 180 kg N/ha), while the lowest (6.10%) fresh dry matter content of bulb was observed from P_3N_0 (three plant per hill with 0 kg N/ha) (Table 3)

4.1.10 yield of bulbs

The total yield of bulb was significantly influenced due to the number of plants per hill (Appendix IV). The yield was found to increase with increasing number of plants per hill. The highest (22.64 t/ha) yield of bulb was obtained when three plants were grown per hill and the lowest yield (15.78 t/ha) was found when one plant was grown per hill (Fig. 6 &Table 2). The above result clearly indicated that the increase in yield from more number of plants per hill was due to the increase in number of plants per unit area. The results of the present experiment were in full agreement with Mondal and Brewster (1989). They found that, the higher population per hill performed the higher yield.

The total yield of bulb was significantly varied due to different levels of nitrogen doses applied in onion (Appendix IV). The highest yield of onion (20.00 t/ha) was recorded from N_3 (180 kg N/ha) treatment while the control treatment (N_0) was produced the lowest (19.22 t/ha) in this respect. It was clearly observed that the yield increased with increasing level of nitrogen (N) (Table 4 and Fig.7). Different

doses of nitrogen produced significantly different yields. The present results was also supported the findings of Ramamoorthy *et al.* (1999).

The combined effect of number of plants per hill and different levels of nitrogen performed significant variation on yield per plot (Appendix IV). The highest bulb yield (23.53 t/ha) was recorded from the treatment combination of P_3N_3 (three plant per hill with 180 kg N/ha), while the lowest yield of bulb (15.03 t/ha) was observed from P_1 N_0 (one plant per hill with 0 kg N/ha) (Fig 8 and Table 4).

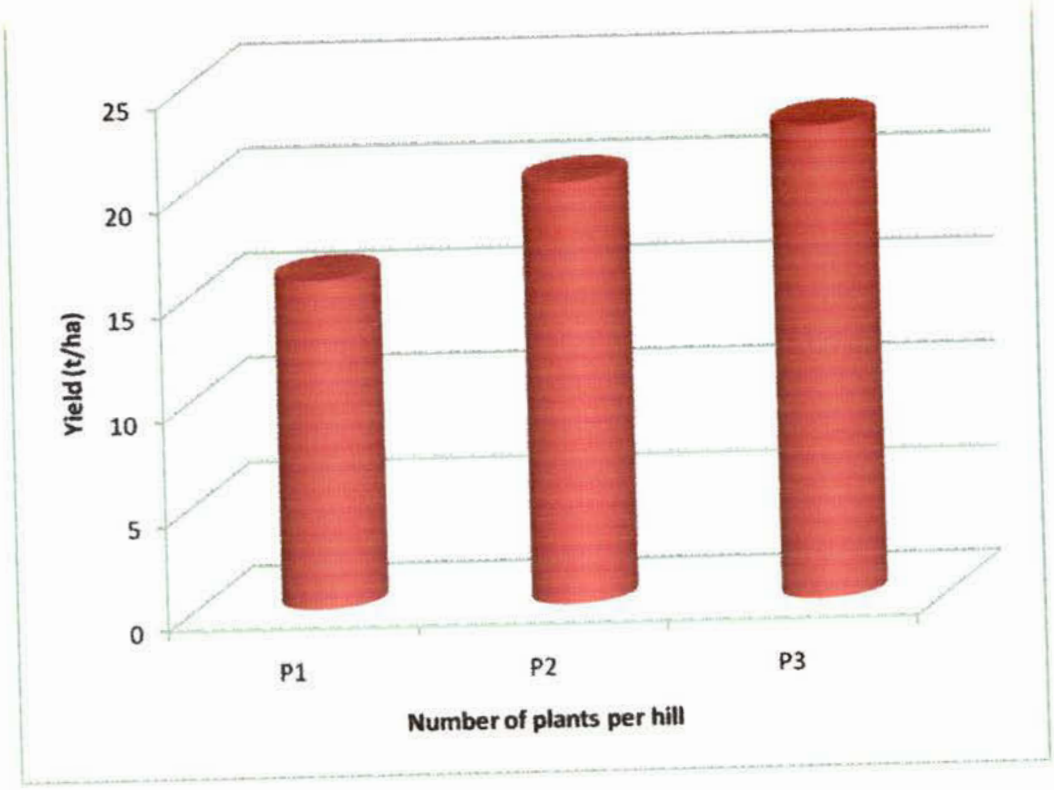


Figure 6 Effect of number of plants per hill on the yield of onion.

P_1=One plant/hill

P_2=two plants/hill

P_3=three plants/hill

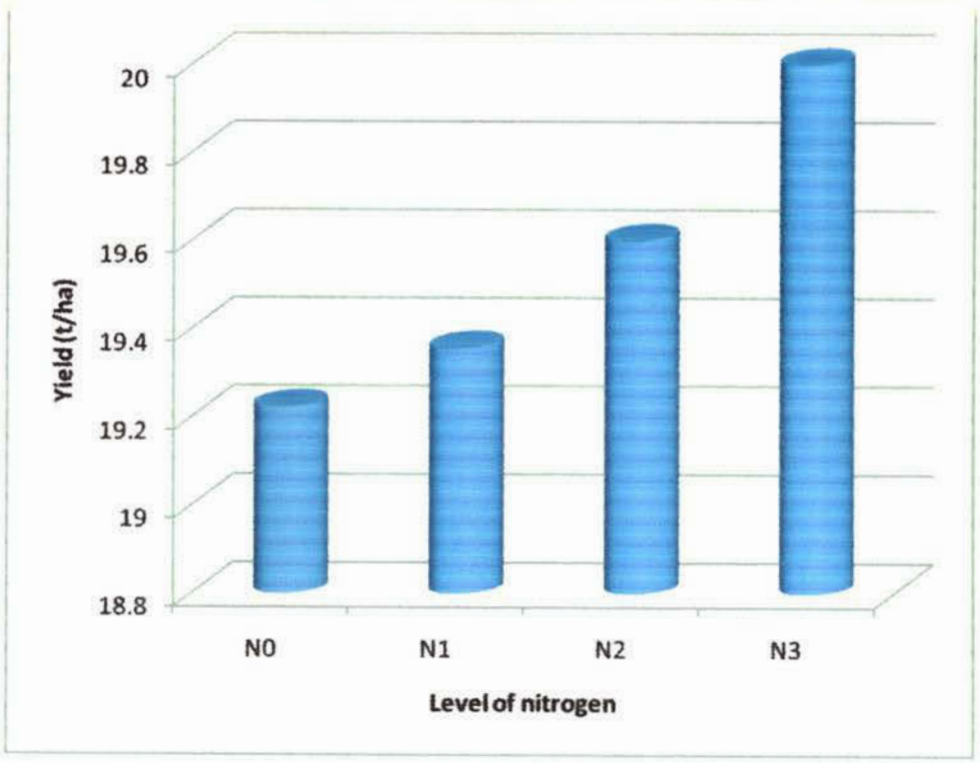


Figure 7 Effect of Nitrogen on the yield of onion.

N_0 = Control

N_1 = 60 kg N/ha

N_2 = 120 kg N/ha

N_3 = 180 kg N/ha

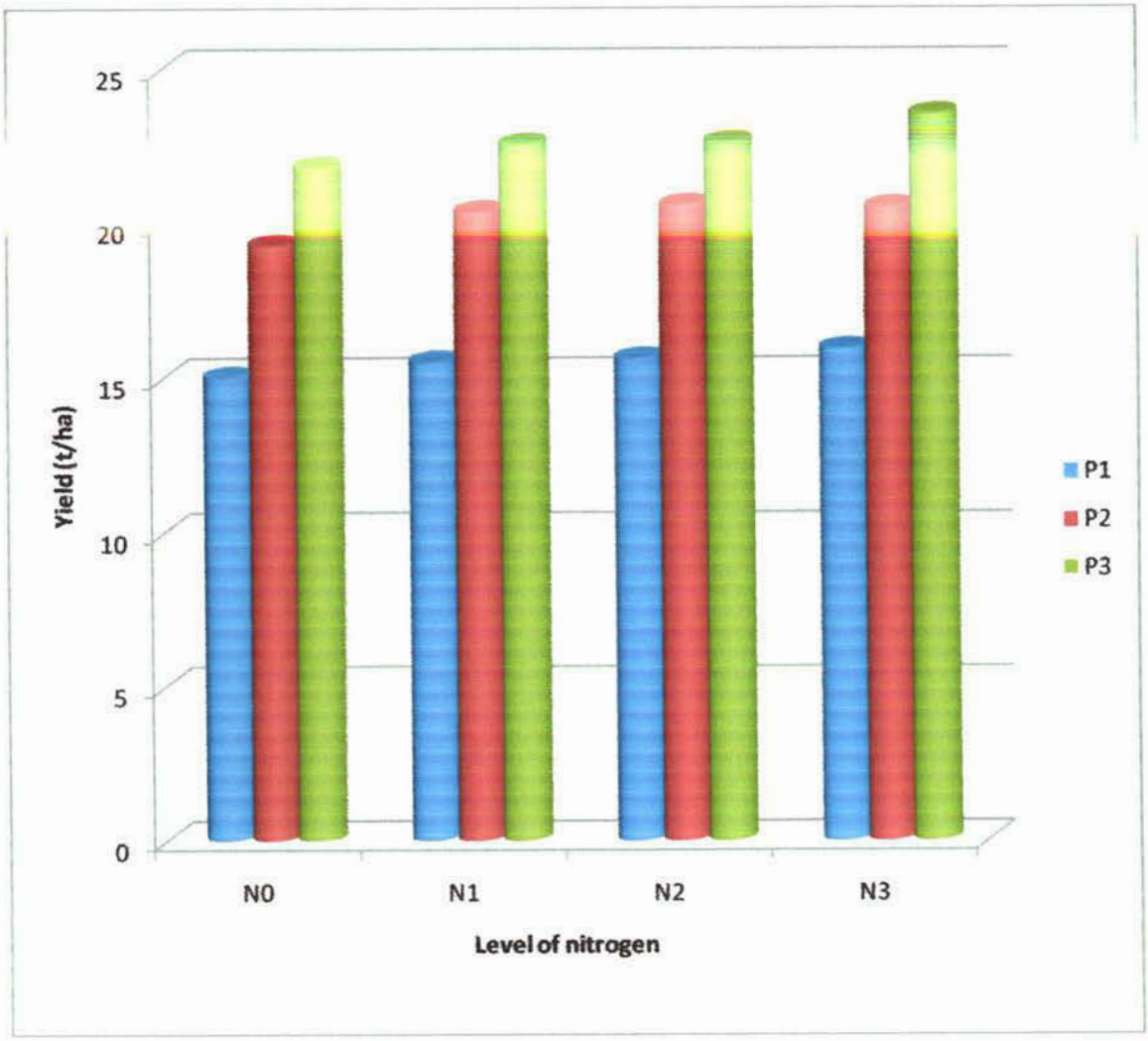


Figure 8 yield of onion bulbs as influenced by number of plants per hill and level of nitrogen.

N_0 = Control

N_1 = 60 kg N/ha

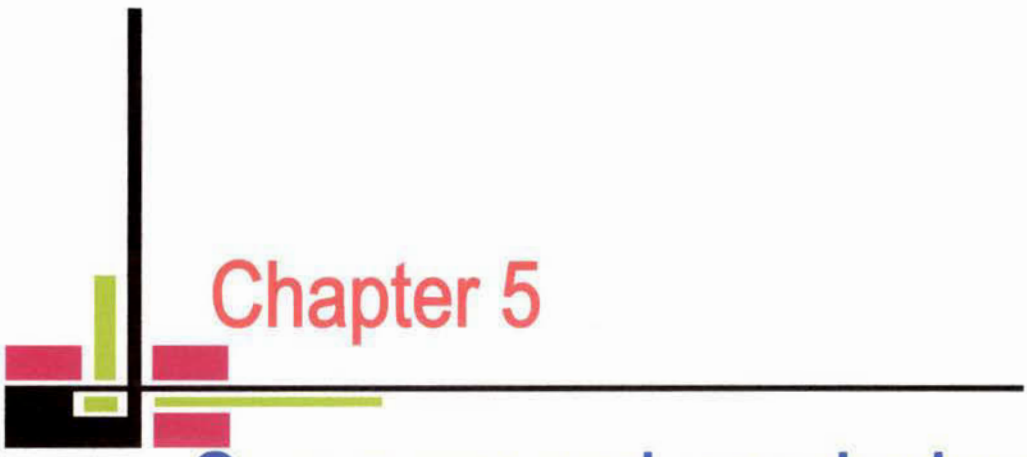
N_2 = 120 kg N/ha

N_3 = 180 kg N/ha

P_1=One plant/hill

P_2=two plants/hill

P_3=three plants/hill



Chapter 5

Summary and conclusion

CHAPTER 5

SUMMERY AND CONCLUSION

The present experiment was carried out at the Horticulture Farm Sher-e-Bangla Agricultural University, Dhaka-1207 to evaluate the effect of nitrogen and number of plants per hill on the growth and yield of onion during the period from November, 2006 to April, 2007. The experiment consisted of three levels of number of plants per hill (viz. 1, 2 and 3 plants per hill) and four levels of nitrogen (viz. 0, 60, 120, 180 kg N/ha).

The two-factor experiment was set up in Randomized Complete Block Design (RCBD) with three replications. In total there were 12 treatments combination in this study. A unit plot was 1.5 m×1 m and the treatments were distributed randomly in each block. There were 100 hills in single plot maintaining a spacing of 15 cm × 10 cm. The experimental plot was fertilized at the rate of 10 tons Farmyard manure (FYM), 200 kg TSP and 160 kg MP and 20 kg Gypsum per hectare along with the nitrogen as per treatment. The onion seed were sown on January 08, 2006. The crop was harvested on 18 April, 2007. Ten hills were randomly selected for data collection from each plot. Data on growth and yield parameters were recorded and analyzed statistically. The differences were evaluated by Least Significant Difference (LSD) test.

The result showed that number of plants per hill had significant influence on all the parameters, except length of bulb. The highest plant height (32.28 cm), number of

leaves (7.43), diameter of bulb (3.98 cm), length of bulb (2.32 cm), diameter of pseudostem (0.92 cm), fresh weight of foliage per plant (9.16 g), fresh weight of blub per plant (27.19 g), dry matter content of foliage (7.46%), and dry matter content (10.16%) were obtained when one plant per hill. On the other hand, highest yield per hectare (22.64 t/ha) were recorded when grown three plants per hill and the lowest was from one plant per hill.

Nitrogen had significant influence on the growth and yield contributing characters of tomato. The highest plant height (32.07 cm), number of leaves (7.8), diameter of bulb (3.49 cm), length of bulb (2.35 cm), diameter of pseudostem (0.81 cm), fresh weight of foliage per plant (7.15 g), fresh weight of blub per plant (22.69 g), dry matter content of foliage (9.03%), dry matter content of bulb (8.67%) and yield per hectare (20.00 t/ha) were obtained from the application of 180 kg N/ha (N_3).

Combined effect of number of plants per hill and different nitrogen levels produced significant variation in respect of yield and yield contributing characters. The highest plant height (33.40 cm), number of leaves (7.87), diameter of bulb (4.21 cm), length of bulb (2.45 cm), diameter of pseudostem (0.95 cm), fresh weight of foliage per plant (9.2 g), fresh weight of blub per plant (27.19 g), dry matter content of foliage (9.50%), dry matter content of bulb (9.62%) were obtained from the treatment combination of one plant per hill with 180 kg N/ha. The yield per plot and yield per hectare were highly interacted with the number of plants per hill and different levels of nitrogen.

The highest yield per hectare (23.53 t/ha) were recorded when three plants per hill with 180 kg N/ha and the lowest was from one plant per hill with 0 kg N/ha.

Conclusion:

Therefore, it may be suggested that three plants per hill with 180 kg N/ha can be used to obtain higher growth as well as higher yield. The present study was conducted under AEZ No 28. However, further studies in this relation should be carried out in other agro-ecological zone of the country before final recommendation.

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Appendices

APPENDICES

Appendix I: Results of Physical and chemical properties of soil of the experimental plot

Physical properties (a)

Constituents	Percent
Sand,	32.45
Silt,	61.35
Clay,	6.10
Textural class	Sandy loam

Chemical analysis (b)

Soil properties	Amount
Soil pH	5.6
Organic carbon (%)	1.32
Total nitrogen (%)	0.075
Available P (ppm)	19.5
Exchangeable K (%)	0.2

Source: SRDI, Dhaka

Appendix II: Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from November 2006 to February 2007

Month	Air temperature (^{0}C)			Average RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
November 06	28.18	16.26	22.72	72.52	25
December 06	24.82	14.04	20.53	70.61	16
January 07	24.6	11.5	17.6	65	0
February 07	27.1	15.8	21.05	66	09
March 07	28.79	17.37	23.8	72.19	68.20
April 07	30.28	20.18	25.23	78	170.51

Source: Dhaka Metrological Centre (Climate Division)

Appendix III. Analysis of variance of the data on the growth and yield components of onion as influenced by number of plants per hill and level of nitrogen

Sources of variation	Degrees of freedom	Mean sum of Square					
		Plant height			number of leaf		
		50	60	70	50	60	70
Replication	2	0.213	0.134	0.141	0.044	0.148	0.201
Factor A	3	14.353*	14.22*	13.88*	1.152*	2.249*	1.891*
Factor B	2	33.67*	31.694*	20.514*	0.384*	0.13*	0.151*
A×B	6	0.769*	0.798*	0.399*	0.335*	0.211*	0.106*
Error	22	0.127	0.182	0.21	0.072	0.054	0.105

*Significant at 5% level of probability

NS Non Significant

AppendixIV. Analysis of variance of the data on the growth, yield components and yield of onion as influenced by number of plants per hill and level of nitrogen

Sources of variation	Degrees of freedom	Mean sum of Square							
		Diameter of bulb	Length of bulb	pseudostem diameter	Fresh foliage weight	Fresh blul weight	dry mater content of foliage (%)	dry mater content of bulb (%)	yield
Replication	2	0.01	0.008	0.002	0.009	0.345	0.949	0.659	0.007
Factor A	3	0.557*	0.111^{NS}	0.016*	2.177*	2.492*	1.857*	0.871*	0.078*
Factor B	2	4.389*	0.054*	0.429*	61.898*	348.266*	4.613^{NS}	18.224^{NS}	3.773*
A×B	6	0.033*	0.002*	0.001*	0.044*	0.301*	8.541*	6.547*	0.004*
Error	22	0.032	0.005	0.001	0.005	0.228	1.062	0.882	0.006

*Significant at 5% level of probability

NS Non Significant