EFFECT OF NITROGEN AND POTASSIUM ON THE GROWTH AND YIELD OF ONION

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CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF NITROGEN AND POTASSIUM ON THE GROWTH AND YIELD OF ONION"*** submitted to the Department of Soil Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE IN SOIL SCIENCE,*** embodies the result of a piece of bona fide research work carried out by ***Md. Shahidur Rahman,*** *Registration No.* ***00836*** under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

I, further certify that any help or sources of information as has been availed of during the course of this inquire have been duly acknowledged and the contents and style of the thesis have been approved and recommended for submission.

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Dedicated to
My Beloved Parents

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EFFECT OF NITROGEN AND POTASSIUM ON THE GROWTH AND YIELD OF ONION

ABSTRACT

A field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka-1207, during the *Rabi* season of 2007-2008 to evaluate the effect of nitrogen (N) and potassium (K) on the growth and yield of onion. The research work was carried out with four levels of nitrogen viz. 0, 80, 120 and 150 kg N ha^{-1} and four levels of potassium vi. 0, 120, 160 and 200 kg K_2O ha^{-1}. Data were recorded on yield and yield Contributing Characters. The results of the experiment revealed that most of the parameters varied significantly with different levels of nitrogen but not with potassium. Single application of N had no significant influence on bulb yield. The highest bulb yield (11.60 ton ha^{-1}) was obtained when plants were grown with nitrogen at 120 kg/ha, but higher levels of N did not show any significant increase on yield of onion. The lowest yield (9.61 ton ha^{-1}) was recorded in the control treatments. Application of potassium at 120 kg K_2O ha^{-1} produced the highest bulb yield (11.39 ton ha^{-1}) which was statistically identical with that of 0, 160 and 200 kg K_2O ha^{-1}. The interaction effect between nitrogen and potassium were statistically significant. The combination of 120 kg N and 120 kg K_2O ha^{-1} gave the highest bulb yield (12.88 ton ha^{-1}). On the considerations, 120 kg N and 120 kg K_2O ha^{-1} were considered as optimum doses for the yield of onion under the experimental conditions.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

Abbreviation		Elaborations
AEZ	=	Agro- Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centimeter
DAS	=	Days After Sowing
DAT	=	Days After Transplanting
cv.	=	Cultivar (s)
et al.	=	and others
FAO	=	Food and Agriculture Organization
G	=	Gram (s)
Hr	=	Hour(s)
K	=	Potassium
K_2O	=	Potassium Oxide
kg	=	Kilogram (s)
LSD	=	Least Significant Difference
M^2	=	Meter Square
Mm	=	Millimeter
MOP	=	Murat of Potash
N	=	Nitrogen
No.	=	Number
NS	=	Non Significant
P_2O_5	=	Phosphorus Penta Oxide
S	=	Sulfur
SAU	=	Sher-e- Bangla Agricultural University
SRDI	=	Soil Resource and Development Institute
TSP	=	Triple Superphosphate
var.	=	Variety
wt.	=	Weight
t ha^{-1}	=	Ton per hectare
^0C	=	Degree Centigrade

CHAPTER 1
INTRODUCTION

CHAPTER-I

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 belongs to the family of Alliaceae (Hamlet, 1990). And genus *Allium*. There are more than 500 species within the genus *Allium*, and most them are bulbous plants. It is most important spice as well as promising vegetable of Bangladesh. Central Asia is the primary center of origin and the mediterranean is the secondary center for large type onion (Mc. Cullum, 1976).

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 (8, 94,000 mt) in production during the year 2006-2007 (BBS, 2008).

In Bangladesh, it is mainly produced in winter season. Usually, it is sown during December to January and harvested mostly in the months from March to April. Onion cultivation during summer season is constrained due to adverse weather particularly heavy rainfall. But demand of onion is ever increasing irrespective of season. 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 tha^{-1}) (FAO, 2003). Virtually, Bangladesh is deficit in onion production. This is why; Bangladesh has to import onion every year by loosing huge currency. In 2003, Bangladesh imported 33.45 thousand MT of onion worth about 6.9 million US dollar (FAO, 2003).

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.

The deficit of onion production in our country can be overcome either by bringing more area under onion cultivation or by increasing the yield through improvement of production technology, such as optimizing the doses of chemicals fertilizers like N,P and K.

Nitrogen plays an important role for vegetative growth of the crop which ultimately helps in increasing bulb size and total yield (Steward, 1963). Nitrogen imparts greenness to plants by enhancing chlorophyll synthesis and induces more photosynthetic production per unit photosynthetic area.

The onion is a shallow rooted and potash-loving crop; hence fairly high concentration of nutrients including potassium must be maintained in the upper layer of the soil. Generally, a heavy dose of fertilizer is recommended for onion cultivation (McGillivray, 1961). Like other tuber and root crops, onion is very responsive to potash. Among the various nutrients required to produce high yield of onion, potassium is considered to be very important element due to its influence for translocation of photosynthetic, storage quality, bulb size, bulb numbers and yield per plant (Sangakkara and Piyadasa, 1993). Potassium is one of the major nutrients taken up by the plant in large quantities and the adequate level of potassium increases crop resistance to various diseases, stalk and stem breakage and at stress conditions (Razzaque *et al.*, 1990).

Considering the above discussions, the present investigation was undertaken with the following objectives:

OBJECTIVES:

1. To determine the effect of different levels of N and K on the growth and yield of onion.
2. To know the optimum dose of nitrogen and potassium on the growth and yield of onion under Bed Brown Terrace soil.
3. To know the interaction effects of N and K on the growth and yield of onion.

CHAPTER 2
REVIEW OF LITERATURE

CHAPTER - 2

REVIEW OF LITERATURE

Onion is one of the most important bulb crops in Bangladesh as well as all over the world. The yield of onion depends on many factors that are land topography, soil fertility, environmental factors (light, temperature, moisture, humidity and rainfall), cultural practices such as sowing date, mulching, methods of fertilizer application, diseases and pests control etc. Different types of chemical fertilizers play important role on the growth, yield and quality of onion. Nitrogen and potassium are the two major important macronutrients which responsible for controlling growth and yield of onion. A number of research works have been done on different levels of nitrogen and potassium on the yield of onion in various parts of the world, which have been made in this regard in Bangladesh. The present study has been taken to investigate the effect of nitrogen and potassium on the yield of onion. In this chapter an attempt has been made to research findings related to the present study have been reviewed here.

2.1 Effect of nitrogen on the growth and yield of onion

Lang (1987) clarified that N fertilizer was required to make up the crops at different growth stages. Flat rate applications of 193 kg Nha^{-1} were followed by considerable losses resulting from irrigation and cost was higher. Specific applications of N at 105 kg ha^{-1} were found to reduce N losses and costs, but the yield increased.

Srinivas and Nail (1987) observed that the bulb yield was increased from 16.51 tha^{-1} at zero N to 56.30 tha^{-1} at the highest N rate ($200kgha^{-1}$)

Dharmendra *et al.* (2001) investigated the effects of N fertilizer application (0, 65 and 130 $kgha^{-1}$) on onion cv. Pusa Red during 1992-93 and 1993-94 in Uttar Pradesh, India. In both years, the application of 130 kg $Nh^{-1}a$ resulted in the highest percentage of seedling survival, plant height, number of green leaves and pseudo stem diameter, as well as the lowest number of days to maturity. This treatment also resulted in the greatest number of roots, length of the longest root, bulb diameter, bulb fresh weight and bulb yield, compared with the other application rate.

Tiwari *et al.* (2002) studied the effects of N (0, 40, 80 and 120 $kgha^{-1}$) and plant spacing (45×30, 60×30 and 60×45) 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 $kgha^{-1}$. Spacing of 60×45 gave the highest number of leaves per plant (12.10) and 1000-seed weight (2.88 g), whereas the spacing of 60×30 and 45×30 gave the highest length of flowering stalk (93.45 cm) and seed yield (9.28 qha^{-1}), respectively. The interaction effects between applications of N at 80 or 120 $kgha^{-1}$, in combination with the closest spacing resulted in the highest yield and cost benefit ratio.

Naik and Hosamani (2003) conducted a field experiment during 1997-98 and 1998-99 to investigate the effect of spacing (15 ×10, 15×15 and 15×20 cm) and N level (0, 50, 100 and 150 kgha^{-1}) on the growth and yield of kharif onion. Narrow spacing of 15×10 cm with application of 150 kg Nha^{-1} was found optimum for enhancing yield (169.02 qha^{-1}) and other growth and quality parameters, such as plant height, leaf number per plant, bulb length, bulb diameter and total soluble solid in bulb. The maximum net return and benefit cost ratio were also recorded from this treatment combination.

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

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 (at 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 @ 150 kg ha^{-1}, potassium @ 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 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 higher bulb yield compared to lower rates of potash.

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 N K 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}).

Yamasaki and Tanaka (2005) investigated the role of N in the flower initiation of Welsh onion (*A. fistulosum*) 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.

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 @ 100 kg ha^{-1} significantly increased bulb yield and quality attributes. The treatment combination $N_4A_1S_2$ (100 kg N ha^{-1}+*Azotobacter* as seedling dipping) gave the highest bulb yield and fresh weight of bulb, followed at par by $N_3A_1S_2$ (75 kg N ha^{-1}+*Azotobacter* as seedling dipping). A higher benefit cost ratio (2.26:1) was recorded with the treatment combination of $N_3A_1S_2$ compared to $N_4A_1S_2$, with a lower benefit cost ratio (2.24:1) due to additional cost of urea and non significant difference between these 2 treatments regarding yield of bulbs. Thus, the treatment combination $N_3A_1S_2$ was the best.

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

Yadav *et al.* (2005) studied the effects of N fertilizer (50, 75 or 100% of the recommended N rate of 100 kgha^{-1}) with or without inoculation of *Azospirillum* in Durgapura, Jaipur, Rajasthan, India, during the *rabi* of 1999-2000, 2000-2001 and 2001-2002. N was applied in 3 equal splits at 30 day intervals starting at 20 days after transplanting. Before sowing, seeds were treated with *Azospirillum* @ 500 gha^{-1}. Seedlings were dipped for 15 minutes in *Azospirillum* slurry (1 kg *Azospirillum* dissolved in 50 liters of waterha^{-1}). Before transplanting, *Azospirillum* (2 kgha^{-1}) was mixed with farmyard manure and incorporated into the soil. Pooled data showed that bulb yields were highest with N @ 75 (328.4 quintalha^{-1}) and 100 kg^{-1}ha (336.5 quintalha^{-1}); 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 (323.7quintalha^{-1}) over the control (310.9 quintalha^{-1}). 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 @ 100 (32792 rupeesha^{-1}) or 75 kgha^{-1} (31 288 rupees^{-1}ha).

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 content 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 @ 200 kg K ha^{-1} produced the highest bulb yield (16.69 t 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, percentage bolters, crop growth rate and individual bulb weight. Nitrogen @ rate 150 kg ha^{-1} gave the best results, though, statistically at par with 100 kg N ha^{-1}. P 17.5 kg ha^{-1} gave statistically similar results as 35 kg P ha^{-1} and the optimum combination 100 kg N ha^{-1} and 17.5 kg P ha^{-1}.

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}.

2.2 Effect of potassium on the growth and yield of onion

The effects of FYM, ammonium sulphate, superphosphate and potassium sulphate were studied by Katyal (1977). He suggested to use 15 to 20 tons FYM, 100 kg ammonium sulphate, 175 kg supperphosphate and 130 kg potassium sulphate per hectare before transplanting and a top dressing of another 150 kg ammonium sulphate in early stage of growth of onion crop while Rashid (1983) recommended 10 tons cowdung, 175 kg urea, 125 kg TSP and 150 kg MP per hectare for successful onion cultivation in Bangladesh.

Rudolph (1986) suggested that for a single crop of onion, a base dressing providing P @ 30-40 kg and K @ 80-100 kg ha^{-1} are recommended. where crops are to be grown on a site for upto 3 successive years, the advised rates are 48-56 kg and 180-222 kg of P and K ha^{-1}, respectively.

Bruckner (1988) stated that K_2O content of the soil was lowest where onion yield was also lowest. The higher nutrient uptake from the soil was found at the site, where, higher yield was obtained. There was a positive correlation between the K content of onions and the K content of soil, but this was not the case with P. Nitrogen content of onions was less than K content; hence the high demand is for potash by this crop.

Goobkin (1989) reported that seed priming in a solution of mixed potassium salts was effective as the polyethylene glycol (PEG-6000) treatment. Germination energy and field emergence of seedlings were increased by 17-22 % using aerated solution of mixed potassium salt of 0.4-0.5 % (KNO_3 + K_3PO_4). Yield was increased by 21-28 %.

Mukhopadhyay *et al.* (1992) conducted a field experiment to study the effect of potassium doses (25, 50, 75 and 100 kg K_2O ha^{-1} applied as basal and in two equal splits along with a control) on the growth and yield of sweet potato var. IB440. It was observed that the response of potassium fertilizer was more pronounced when applied in splits. The highest LAI, CGR, tuber bulking rate, number of tubers per plant, total tuber yield (18.16 t ha^{-1}) and total vine yield (22.12 t ha^{-1}) were recorded at 75 kg K_2O ha^{-1} when applied in two equal splits.

Sharma (1992) reported that the application of K through K_2O at the rate of 40 kg ha^{-1} gave significantly higher bulb compared with control. Further increase in K level did not show any beneficial effect. He also found that the economic optimum doses were 81 kg nitrogen and 59 kg K_2O ha^{-1}. The response of optimum level of N and K was up to 43.3 t ha^{-1}.

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

Sangakkara and Piyadasa (1993) observed the effect of six levels of potassium supplied as KCI, when applied as either basal or split (basal and topdressing) on the growth and yields of shallot (onion) under uniform levels of nitrogen and phosphorus. These treatments were tested under both rainfed and irrigated conditions. Potassium increased bulb size, bulb numbers and yields per plant of shallot, along with dry weights. When potassium was applied as basal, optimum yield was obtained at 100 kg K_2O per hectare. Split applications reduce the potassium requirement for optimal yields to 75 kg K_2O per hectare. Application of irrigation did not reduce the potassium content required for optimum yield, although the response was significantly greater than under rainfed conditions.

Nagaich *et al.*(1998) obsearved a field experiment at Gwalior where S was applied @ 0, 20, 40 or 60 kg ha^{-1} and K was 0, 40, 80 or 120 kg ha^{-1} to Nasik Red onions. Bulb yield increased with the increasing of S rate and it was maximum at an intermediate K rate (80 kg 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 in 1996, onions were supplied with 0, 375, 450 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. Maximum bulb yield was found 69.4 t ha^{-1} with no fertilizer and minimum bulb yield was found with the higher rate of potassium sulphate (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, 1/2 basal+1/2 at 20 days after transplanting and 1/3 basal +1/3 at 20 DAT +1/3 at 40 DAT were used in the study. Maximum (35 kg ha^{-1}) and minimum (26 kg ha^{-1}) K accumulation were recorded in two split applications and a single basal application, respectively.

Nagaich *et al.* (1999) conducted an experiment with 4 rates of potassium (0, 40, 80 and 120 kg 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.

Yadav *et al.* (2003) conducted an experiment to determine the optimum rate of potassium to obtain maximum and good quality of onion bulb. Four cultivars (Puna Red, White Marglobe, Nasik Red and Rasidpura Local) were given three potassium rates (50, 100 and 150 kg ha^{-1}). The highest K rate was recorded the highest plant height, leaf number per plant, leaf fresh weight, leaf dry weight, neck thickness, bulb equatorial diameter, bulb polar diameter, bulb fresh weight and bulb yield. The lowest K rate was recorded the lowest neck thickness.

Singh *et al.* (2003) studied that the effects of K fertilizer (30, 60, 90 or 120 kg ha^{-1}) applied as split dressings (1/2 as basal + 1/2 as top dressing at 45 days after transplanting 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 at Dhaulakuan, Himachal Pradesh, India during the *rabi season* of 1994-95 and 1995-96. 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 K ha^{-1} in three splits was the most economical rate for onion.

From these reviews, it is observed that both nitrogen and potassium played a vital role on the growth and yield for successful onion cultivation. In most cases, urea and muriate of potash (KCl) were used as source of nitrogen and potassium. So optimum level of potassium and nitrogen along with application method might play a significant role to increase onion production. The present study was, therefore, undertaken to test the efficiency of different levels of potassium and nitrogen with different fertilizing methods.

CHAPTER 3
MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

This chapter includes a brief description of the experimental soil, onion variety, land preparation, experimental design, treatments, cultural operations, collection of soil and plant samples etc. and analytical methods followed in the experiment to study the effect of N and K on the growth and yield of onion.

3.1 Experimental site

The research work was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, during the *Rabi* season of 2007-2008. The location of the experimental site is shown in Appendix-I.

3.2 Description of soil

The soil of the experimental field belongs to the Tejgaon Series under the Agro Ecological Zone, Madhupur Tract (AEZ-28) and the General Soil Type is Deep Red Brown Terrace Soil. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground and passed through 2 mm sieve and analyzed for some important physical and chemical properties. The physical and chemical characteristics of initial soil are presented in Appendix-II.

3.3 Climate

The climate of the experimental area is characterized by sub-tropical accompanied by moderate low rainfall associated with relatively high temperature during Rabi season. The monthly temperature, total rainfall, average evaporation, relative humidity (%) and sunshine data during the cropping period are shown in Appendix -III.

3.4 Description of the cultivar

Onion cultivar Taherpuri was used for the experiment. The seeds of this variety were collected from SiddiqueBazzar, Gulistan, and Dhaka.

3.5 Land preparation

The selected land of the experimental plot was opened in the month of November 2007 with the help of a tractor. Then, the land was prepared by several ploughings and cross ploughings with a power tiller followed by laddering until the desired tilth was achieved for planting the seedlings. After removal of weeds and stubbles the land was finally brought into a good tilth by breaking larger clods into fine particles.

3.6 Treatments of the experiment

The present experiment consisted of two factors with four levels of nitrogen and four levels of potassium.

Factor A: Nitrogen levels

$N_0 = 0$ kg N ha^{-1}

$N_1 = 80$ kg N ha^{-1}

$N_2 = 120$ kg N ha^{-1}

$N_3 = 150$ kg N ha^{-1}

Factor B: Potassium levels

$K_0 = 0$ kg K ha^{-1}

$K_1 = 120$ kg K ha^{-1}

$K_2 = 160$ kg K ha^{-1}

$K_3 = 200$ kg K ha^{-1}

Treatment combinations:

$T_1 = N_0K_0$	$T_9 = N_2K_0$
$T_2 = N_0K_1$	$T_{10} = N_2K_1$
$T_3 = N_0K_2$	$T_{11} = N_2K_2$
$T_4 = N_0K_3$	$T_{12} = N_2K_3$
$T_5 = N_1K_0$	$T_9 = N_3K_0$
$T_6 = N_1K_1$	$T_{10} = N_3K_1$
$T_7 = N_1K_2$	$T_{11} = N_3K_2$
$T_8 = N_1K_3$	$T_{12} = N_3K_3$

3.7 Design and layout of the experiment

The experiment was laid out in a two factors Randomized Complete Block Design with three replications. The total number of plots was 48, each measuring 2.5 m × 2 m (5 m^2). The distance maintained between two plots was 50 cm and between blocks was 100 cm. The layout of the experiment is presented in Appendix -IV.

3.8 Doses and application of fertilizers

Besides treatment elements (N and K), other fertilizers are adding as per following rates:

Manures/fertilizers	: Dose per ha
Cow dung	: 20t ha^{-1}
Gypsum	: 20 kgha^{-1}
Triple Superphosphate (TSP)	: 250 kg ha^{-1}

The full required quantity of basal dose, one-third of each of urea and MP were applied to the plots during final land preparation. The rest of the urea and MP were top dressed in two equal installments at 30 and 60 days after transplanting. Each top dressing was followed by light irrigation with the help of water can and care was taken so that irrigated water could not pass from one plot to other.

3.9 Raising of seedlings

The onion seedlings were raised in several seed beds, which were high, well drained and sunny. The land was spaded and left for drying for 10-15 days. Bigger clods broken into small pieces and finally the soil was made loose, friable and brought into fine tilth. All weeds and stubbles were removed and the soil was mixed thoroughly with well decomposed cow dung. Onion seeds were soaked in water for 15 hours before sowing and then kept in a piece of cloth for sprouting. After sprouting the seeds were sown in the seed bed at a depth of about 5 cm on November 01, 2007. The seeds were then covered with light soil and compacted carefully. Sevin 85-WP was dusted over the seed bed to protect the germinating seeds from ants. Shades were provided to protect the seedlings from sunshine. The germination was completed within 7 DAS. Light irrigation, mulching and weeding were done whenever necessary.

3.10 Transplanting of seedlings

Healthy and disease free 35 days old seedlings were uprooted from the seedbeds and transplanted in the main field keeping line to line distance of 25 cm and plant to plant spacing of 10 cm in the afternoon on 15th December 2007. The seedbed was watered before uprooting the seedlings and watered immediately after transplanting. Some seedlings were also transplanted in the border area of the experimental field to be used for gap filling.

3.11 Intercultural operation

The crop was always kept under careful observation. After transplanting the seedlings, manifold intercultural operations were accomplished for better growth and development of the plants.

3.12 Gap filling

Gap filling was done using healthy plant within one week whenever it was required.

3.13 Weeding and mulching

Weeding was accomplished to keep the plots free from weeds and the soil was mulched by breaking the crust for easy aeration and to conserve soil moisture as and when needed.

3.14 Irrigation and drainage

Irrigation was given by water can 2 times. First irrigation was given 20 DATand second one was given 25 DAT. During this time care was taken so that irrigated water could not pass from one plot to another. Mulching was also done after each irrigation at appropriate time by breaking the soil crust. After rainfall excess water was drained out when necessary.

3.15 Plant protection

Preventive measure was taken against soil borne insects. For the prevention of Cutworm (*Agrotis ipsilon*) soil treatment was done with Furadan 3 G @ 20 kg ha^{-1}. Some plants were also attacked by purple blotch disease caused by *Alternaria pori.* It was controlled by spraying Rovral 50 WP four times at 10 days interval after transplanting.

3.16 Removal of escape

Bolting was discouraged by pinching of the flower stalks whenever they appeared during the growing period of the crop.

3.17 Harvesting

The crops were harvested on 18 March 2007 when maximum number of plant showed the sign of maturity by yellowing out most of the leaves drying of pseudo stem, thin and dried outer scale. The tops were removed by cutting off the pseudo stem keeping 2.5 cm with the bulb.

3.18 Collection of plant sample

Five plants were randomly collected from the harvested bulb of each plot, washed in distilled water and then dried in an oven at 70^0 C for 48 hours. The plant samples were ground and preserved for analysis.

3.19 Collection of onion bulb sample

Five onion bulbs were randomly collected from the harvested bulbs of each plot, the roots were removed and washed in distilled water. The collected samples were then sliced and air dried. After sun drying, they were dried in an oven at 70^0 C for 48 hours and then ground and preserved for chemical analysis.

3.20 Collection of data

Five plants were selected randomly from each plot in such a way so that the border effect could be avoided for the highest precision. The plants in outer two rows and at the extreme end of the middle rows were excluded during randomization. Data were recorded on the following parameters from the sample plants during the course of experimentation.

1. Plant height (cm)
2. Number of leaves per plant
3. Leaf length (cm)
4. Horizontal diameter of bulb (cm)
5. Vertical diameter of bulb (cm)
6. Yield of bulb (t ha^{-1})

3.20.1 Plant height (cm)

The height of the selected five plants in each plot was measured at harvest. The height was measured in centimeter (cm) from the neck of the bulb to the tip of the longest leaf and average heights of the selected five plants were taken.

3.20.2 Number of leaves per plant

The number of leaves per plant from five selected plants from each plot was counted after harvest and the average of five plants was taken as the number of leaves per plant.

3.20.3 Leaf length (cm)

The length of leaf was measured with a centimeter scale from pseudo stem to the tip of the leaf from five selected plants from each plot at harvest and their average was recorded.

3.20.4 Horizontal length of bulb per plant (cm)

The horizontal length of bulb was measured with a slide calipers from the neck to the bottom of the bulb from five randomly selected plants from each plot and their average was taken in centimeter (cm).

3.20.5 Vertical length of bulb (cm)

The vertical length of bulb was measured at the middle portion of bulb from five randomly selected plants from each plot with a slide calipers at harvest and their average was recorded.

3.20.6 Yield of bulb

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

3.21 Post harvest soil sampling

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

3.22 Analysis of soil samples

Soil samples were analyzed for both physical and chemical properties in the laboratory of the Soil Resources and Development Institute, Dhaka. The properties studied included total N, P, K and S. The soil was analyzed following standard methods:

3.22.1 Methods for soil analysis

3.22.1.1 Physical analysis of soil

3.22.1.1.1 Particle size analysis

Particle size analysis of soil sample was done by hydrometer method as outlined by Day (1965). The textural classes were ascertained using Marshell's Triangular co-ordinate as designated by USDA (1951).

3.22.2 Chemical analysis of soil

3.22.2.1 Soil pH

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

3.22.2.2 Organic carbon (%)

Soil organic carbon was determined by Walkley and Black's wet oxidation method as outlined by Jackson (1973)

3.22.2.3 Total nitrogen

Total nitrogen of soil samples were estimated by Micro-Kjeldahl method where soils were digested with 30% H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Selenium powder in the ratio 100:10:1 respectively). Nitrogen in the digests were determined by distillation with 40% NaOH followed by titration of the distillate absorbed in H_3BO_3 with 0.01N H_2SO_4 (Jackson, 1973).

3.22.2.4 Available phosphorus

Available phosphorous was extracted from the soil by Bray-1 method (Bray and Kurtz, 1945). Phosphorous in the extract was determined by ascorbic acid blue color method (Murphy and Riley, 1962) with the help of a spectrophotometer.

3.22.2.5 Exchangeable potassium

Exchangeable potassium from the soil was extracted by 1N NH_4OAC (pH 7.0) and was determined by using flame photometer (Black, 1965).

3.22.2.6 Available sulphur

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

3.23 Chemical analysis of plant samples

3.23.1 Preparation of plant samples

Five selected plants per plot were collected randomly immediately after harvest of the crop. The bulbs and leaves of the selected plants were cleaned and dried in an over at 70^0C for 48 hours. The dried samples were then ground with a grinding mill. The prepared samples were kept in a desiccator for analysis.

3.23.2 Digestion of plant samples with sulphuric acid

For N determination an amount of 0.2g plant sample was taken into a 100 ml kjeldahl flask. An amount of 1.1 g catalyst mixture (K_2SO_4: $CuSO_4 . 5H_2O$: Se = 100:10:1), 2ml 30% H_2O_2 and 3ml conc. H_2SO_4 were added into the flask. The flask was swirled and allowed to stand for about 10 minutes, followed by heating at 200^0C. After cooling, the contents were taken into a 100 ml volumetric flask and the volume was made with distilled water. A reagent blank was prepared in a similar way. This digest was used for determining the nitrogen contents in plant samples.

3.23.3 Digestion of plant samples with nitric-perchloric acid mixture

An amount of 0.5 g of sample was taken into a dry clean 100 ml. Kjeldahl flask, 10 ml of di-acid mixture (HNO_3, $HClO_4$ in the ratio of 2:1) was added and kept for few minutes. Then, the flask was heated at a temperature rising slowly to 200^0C. Heating was instantly stopped as soon as the dense white fumes of $HClO_4$ occurred and after cooling, 6 ml of 6N HCl were added to it. This digest was used for determining P, K and S.

3.23.4 Determination of elements in the digest

Nitrogen and phosphorus contents in the digests were determined by similar method as described in soil analysis. Potassium concentration in the digest was determined directly by flame photometer. Sulphur concentration in the digest was estimated turbidimeterically by a spectrophotometer using 420 ηm wave length.

3.24 Statistical analysis

The collected data on various parameters of the study were statistically analyzed using MSTAT computer package programme. The means for all the treatments were calculated and analyses of variances for all the characters were performed by F-variance test. The significance of the differences among the pairs of treatment means was evaluated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984) for the interpretation of results.

CHAPTER 4
RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the experiment. The experiment was conducted to determine the effects of four levels of nitrogen and four levels of potassium and their interaction effects on vegetative growth and yield of onion. The growth and yield contributing characters such as plant height, leaf number, leaf length, bulb diameter, bulb length, individual bulb weight and yield of bulb as influenced by nitrogen and potassium are presented in Table 1 to 2 . The results of each parameter have been adequately discussed and possible interpretations whenever necessary have been given under the following headlines:

4.1 Plant height (cm)

The effects of nitrogen on the plant height of onion are presented in (Fig. 1 & Table 1). The plant height was significantly influenced by different levels of nitrogen. Among the different doses of nitrogen, N_2 (120 kgha^{-1}) showed the highest plant height (37.62 cm). On the other hand, the lowest plant height (32.6 cm) was observed in the N_0 treatment where no nitrogen was applied. The taller plants at the highest doses received more nutrients which might have encouraged more vegetative growth. Rai (1981) and Panddey and Mundra (1971) reported that the height of plant increased with the increasing levels of nitrogen. A similar result was also found by Vachhani and Patel (1993).

Potassium showed statistically significant variation in respect of plant height when fertilizers in different doses were applied (Fig. 2 and Table 2). However, among the different doses of fertilizer, K_1 (120 $kgha^{-1}$) showed the highest plant height (38.47 cm). The lowest plant height (30.80 cm) was observed in the K_0 treatment where no potassium was applied.

Combined application of different doses of nitrogen and potassium had significant effect on the plant height of onion (Table 3). The lowest plant height (25.00 cm) was observed in the treatment combination of N_0K_0 (no nitrogen and no potassium). On the other hand, the highest plant height (43.40 cm) was recorded with N_2K_1 treatment.

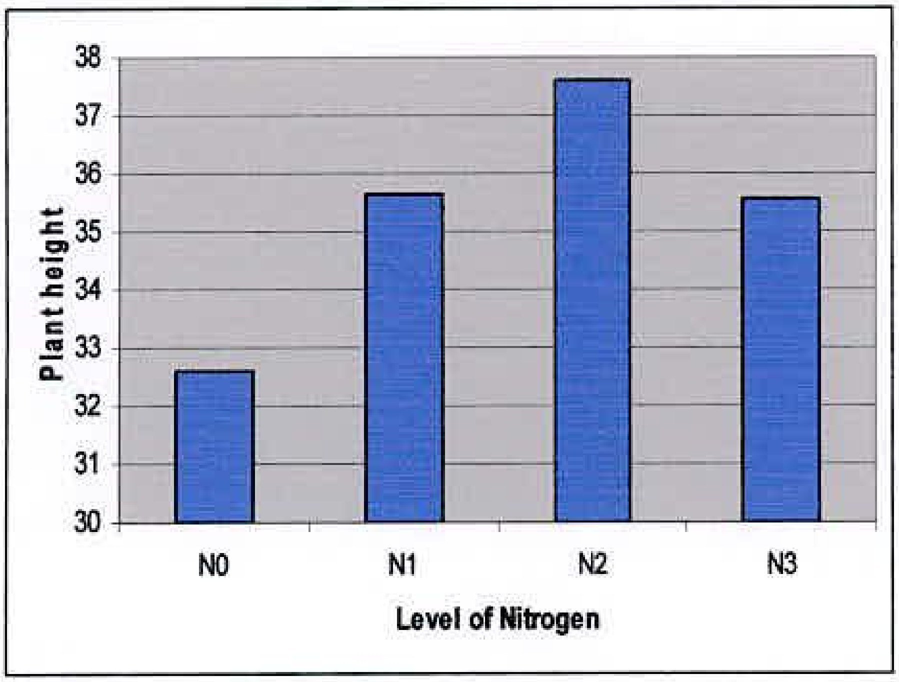

Fig.1 Effect of different levels nitrogen on the plant height of onion

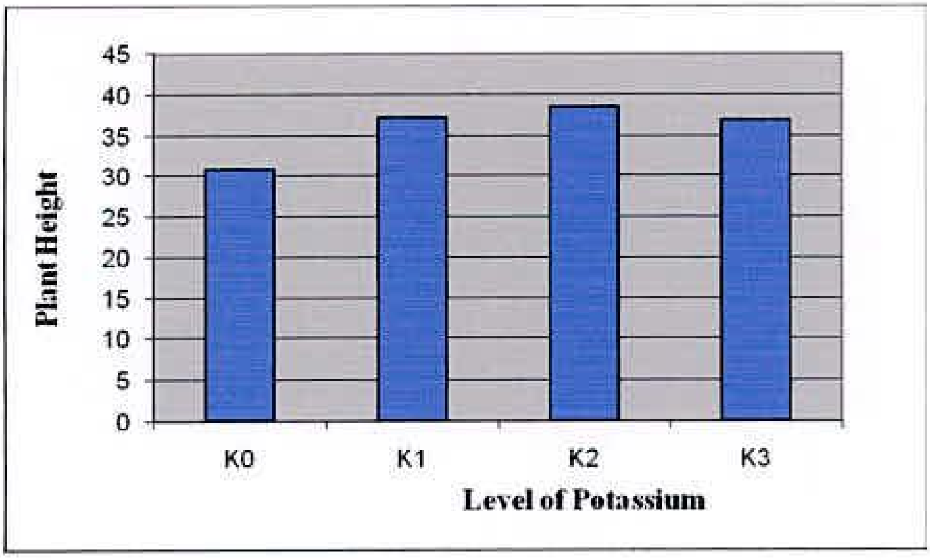

Fig.2 Effect of different levels of potassium on the plant height of onion

Table 1 Effects of nitrogen on the growth parameters of onion

Treatment	Plant height	Number of leaf	Length of Leaf
N_0	32.60b	3.80b	29.15b
N_1	35.63a	5.13ab	30.73ab
N_2	37.62a	5.20ab	34.03a
N_3	35.57a	5.28a	33.77a
$LSD_{(0.05)}$	4.34	1.44	4.12

Table 2 Effects of potassium on the growth parameters of onion

Treatment	Plant height	Number of leaf	Length of Leaf
K_0	30.8b	4.35a	28.52b
K_1	37.16a	5.61a	34.89a
K_2	38.47a	4.97a	33.13a
K_3	36.99a	4.47a	31.14ab
$LSD_{(0.05)}$	4.34	1.44	4.13

In a column figure having similar letter(s) do not differ significantly, whereas, figures with dissimilar letter(s) differ significantly as per DMRT.

Table 3 Combined effects of nitrogen and potassium on the growth parameters of onion

Treatment	Plant height (cm)	Number of leaves	Length of Leaf (cm)
N_0K_0	25h	3.43fg	23.60h
N_0K_1	34.87def	4.40def	33.07cdef
N_0K_2	39b	4.03efg	31.20efg
N_0K_3	39.53b	3.33g	28.73g
N_1K_0	35.73cde	4.83bcde	28.47g
N_1K_1	32.97efg	5.53bc	31.00efg
N_1K_2	35.7cde	5.00bcde	30.87efg
N_1K_3	38.13bc	5.16bcd	32.60def
N_2K_0	30.07g	4.66cde	31.27efg
N_2K_1	43.4a	6.73a	38.87a
N_2K_2	38.87bc	5.16bcd	35.57bc
N_2K_3	38.13bc	4.23defg	29.37g
N_3K_0	32.4fg	4.46de	30.73fg
N_3K_1	37.4bcd	5.80b	36.63ab
N_3K_2	34.4def	5.70bc	34.87bcd
N_3K_3	38.07bc	5.16bcd	33.87bcde
$LSD_{0.05}$	2.785	0.924	2.65

In a column figures having similar letter(s) do not differ significantly, whereas, figures with dissimilar letter(s) differ significantly as per DMRT

4.2 Number of leaves $plant^{-1}$

Significant variation was observed in number of leaves $plant^{-1}$ of onion when different doses of nitrogen were applied (Fig. 3 & Table 1). The highest number of leaves $plant^{-1}$ (5.28) was recorded in N_3 (150 $kgha^{-1}$). The lowest number of leaves $plant^{-1}$ (3.80) was recorded in the control treatment where no nitrogen was applied. The results clearly indicated that the number of leaves per plant gradually increased with the increasing levels of nitrogen but their variation was significant. The finding of Vachhani and Patel (1993) was in support with these results. The increased number of leaves $plant^{-1}$ might be due to favorable effects of nitrogen on the vegetative growth and accumulation of materials that helped proper growth and development of the onion bulb.

No significant variation was observed in number of leaves $plant^{-1}$ of onion when different doses of potassium were applied (Fig. 4 & Table 2). Among the different doses of K fertilizers treatment, showed the highest number of leaves $plant^{-1}$ (5.62), which was statistically similar with the different fertilizer doses. On the contrary, the lowest number of leaves $plant^{-1}$ (4.35) was observed with K_0, where no fertilizer was applied.

The combined effects of different doses of nitrogen and potassium fertilizers on number of leaves $plant^{-1}$ of onion was significant (Table 3). The highest number (6.73) was recorded with the treatment combination of N_2K_1. On the other hand, the lowest number of leaves $plant^{-1}$ (3.33) was found in N_0K_0 treatment combination (no nitrogen and no potassium) fertilizers.

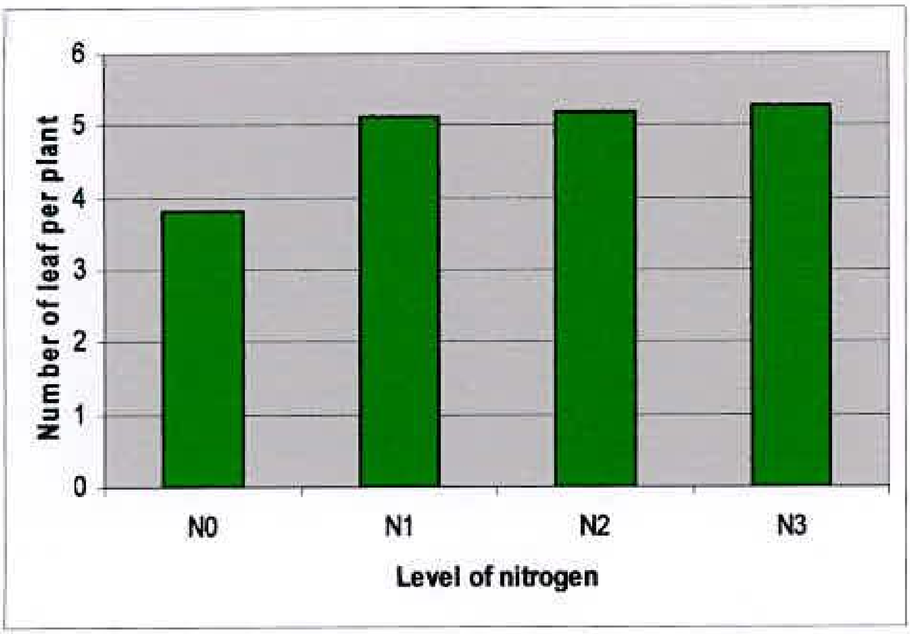

Fig. 3 Effect of nitrogen on the number of leaves per plant of onion

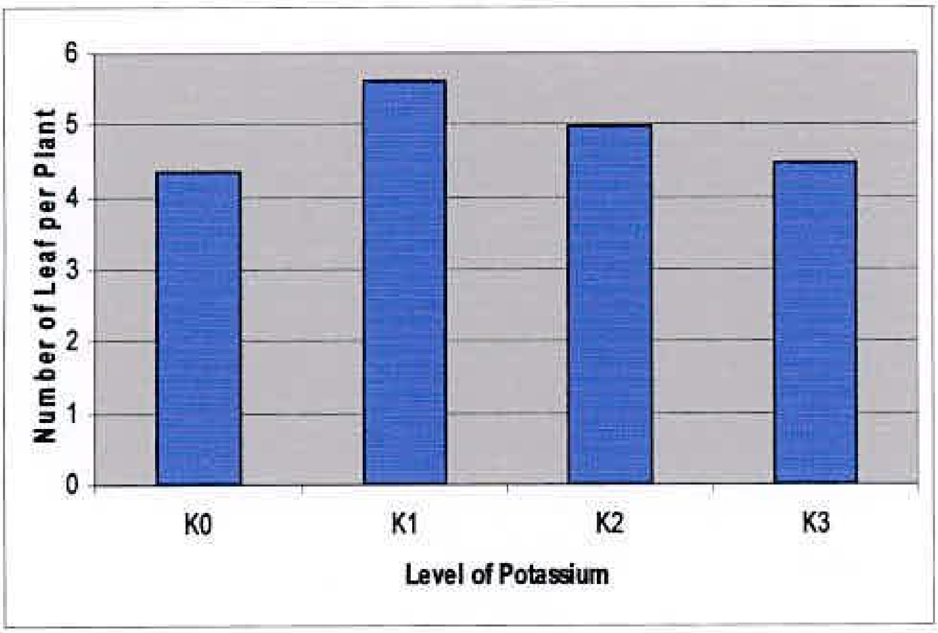

Fig. 4 Effect of different levels of potassium on the number of leaves per plant of onion

4.3 Leaf length (cm)

The leaf length as affected by different doses of nitrogen showed a statistically significant variation (Fig. 5 & Table 1). Among the different doses of nitrogen, the highest leaf length (34.03 cm) was observed in N_2 (120 $kgha^{-1}$), which was statistically identical (33.77cm) with N_3 (150 $kgha^{-1}$). The lowest leaf length (29.15 cm) was recorded in the N_0 treatment where no nitrogen was applied. Kumar *et al.* (1998) also recorded longest leaf of onion with the application of N at 150 kg ha^{-1}. Singh *et al.* (2004) found that application of the highest nitrogen rate (150 kg ha^{-1}) gave the highest leaf length (28.22 cm) of onion. Meena *et al.* (2007) stated the highest N level (150 kg ha^{-1}) gave the maximum length of the longest leaf in comparison to its lower levels, i.e. 50 and 100 kg N ha^{-1}.

Application of potassium fertilizer at different doses showed significant variation on the leaf length of onion (Fig. 6 & Table 2). Among the different fertilizer doses K_1 treatment showed the highest leaf length (34.83 cm), which was closely followed (34.35 cm) by the fertilizer dose of K_2. The lowest leaf length (33.13 cm) was recorded with K_0 treatment where no potash was applied. Optimum fertilizer doses might be increased the vegetative growth of onion that lead to the highest leaf length.

Combined effects of different doses of nitrogen and potassium fertilizers on leaf length showed a statistically significant variation (Table 3). The highest leaf length (38.87 cm) was recorded in the treatment combination of N_2K_1. The lowest leaf length (23.60 cm) was found in N_0K_0.

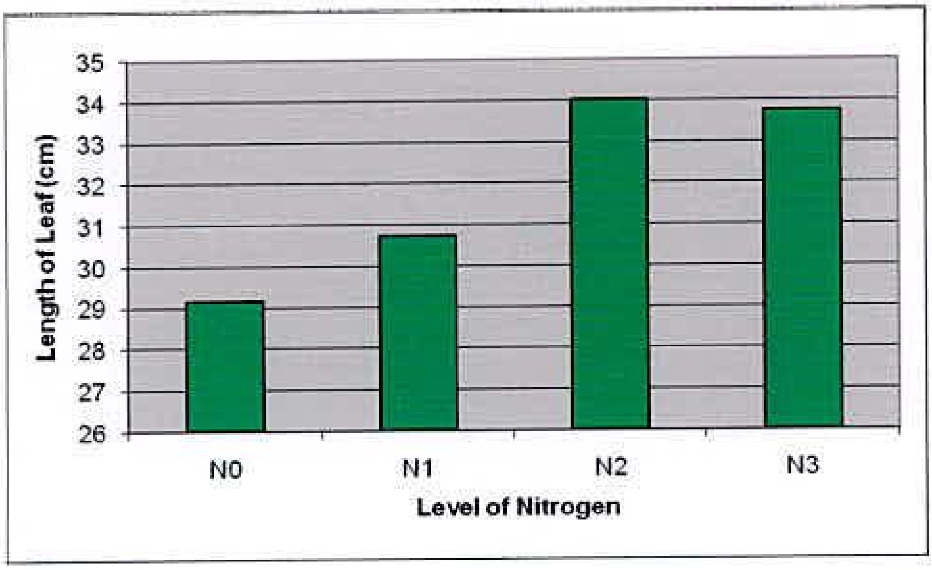

Fig. 5 Effect of nitrogen on the leaf length of onion

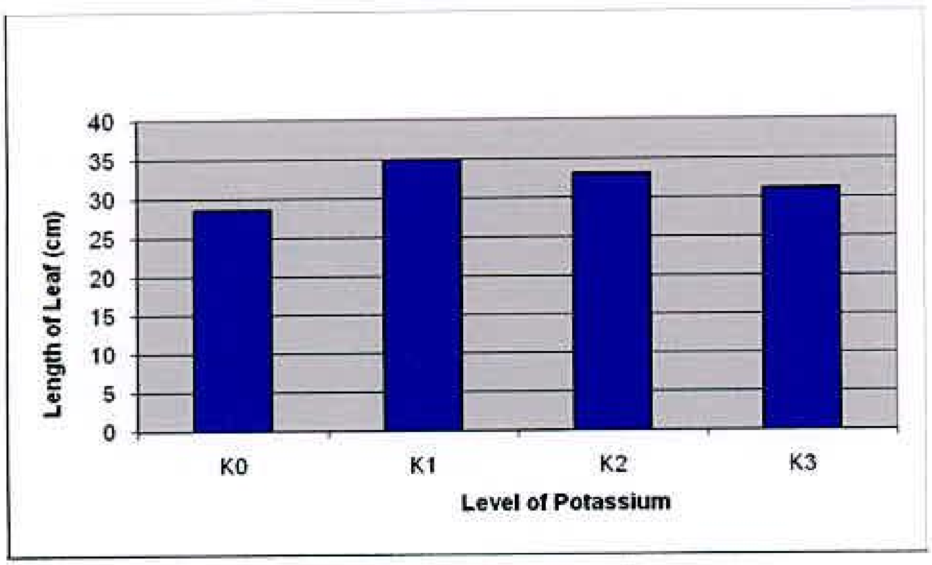

Fig. 6 Effect of different levels of potassium on the leaf length of onion

4.4 Vertical length of bulb $plant^{-1}$ (cm)

The variations in respect of vertical length of bulb due to the effects of different levels of nitrogen were found to be statistically significant (Fig.7 & Table 4). The maximum vertical length of bulb (4.38 cm) was observed from the plants grown with N_2 (120 $kgha^{-1}$) which was statistically similar with N_3 (150 $kgha^{-1}$) treatments. The treatment plants produced the minimum vertical length of bulb (3.19 cm). Verma *et al.* (1972) observed that bulb size increased in response at 200 $kgha^{-1}$.Vachhani and Patel (1993) observed the highest bulb diameter from the application of 150 kg ha^{-1}.

Vertical length of bulb per plant showed significant variation due to the effects of different levels of potassium (Fig. 8 & Table 5).The highest vertical length of bulb (4.05 cm) was obtained from the grown with the dose of K_1 (120 $kgha^{-1}$. The lowest vertical length of bulb (3.71 cm) was found when the plants were raised without potassium. Similar result was reported by Baloch *et al.* (1991). It was revealed that the treatment with the highest dose of potassium (180 kg ha^{-1}) gave the maximum diameter of bulb. Sufficient potassium nutrient supplied from K_2 treatment possibly favored plant growth along with wider bulb. Nasiruddin *et al.* (1993) found that the highest bulb yield diameter from 100 kg potash and 30 kg $sulphurha^{-1}$.

The combined effect of different doses of nitrogen and potassium fertilizer showed a statistically significant effect on vertical length of bulb per plant of onion (Table 6). The highest vertical length of bulb (4.60 cm) was recorded with the treatment combination of N_2K_1. On the other hand, the minimum vertical length of bulb (3.09 cm) was observed from N_0K_0 treatment combination (no nitrogen and no potassium) fertilization.

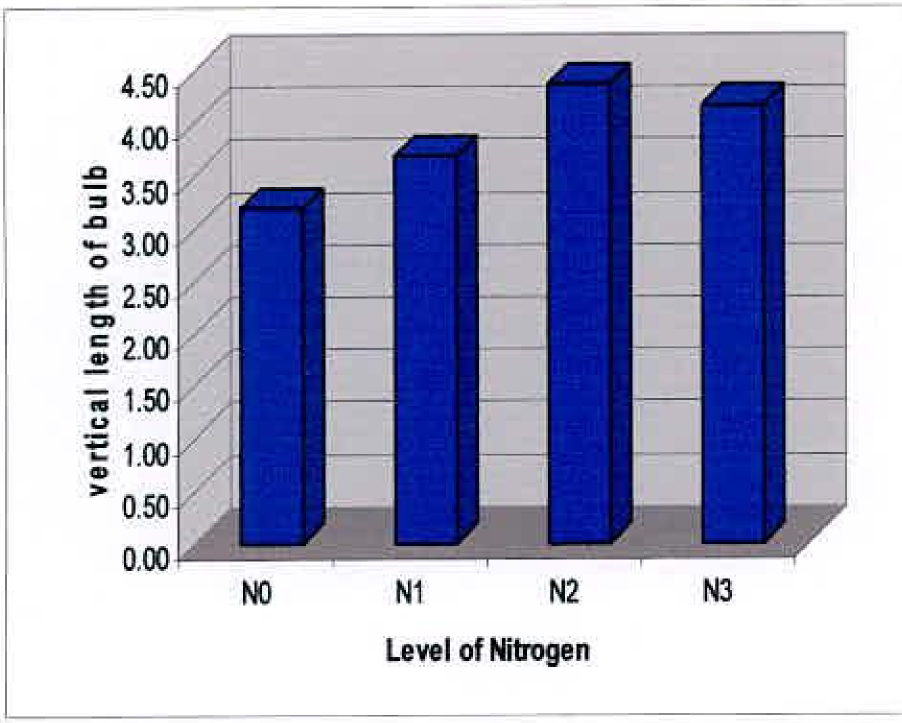

Fig. 7 Effect of nitrogen on the vertical length of bulb plant^{-1} of onion

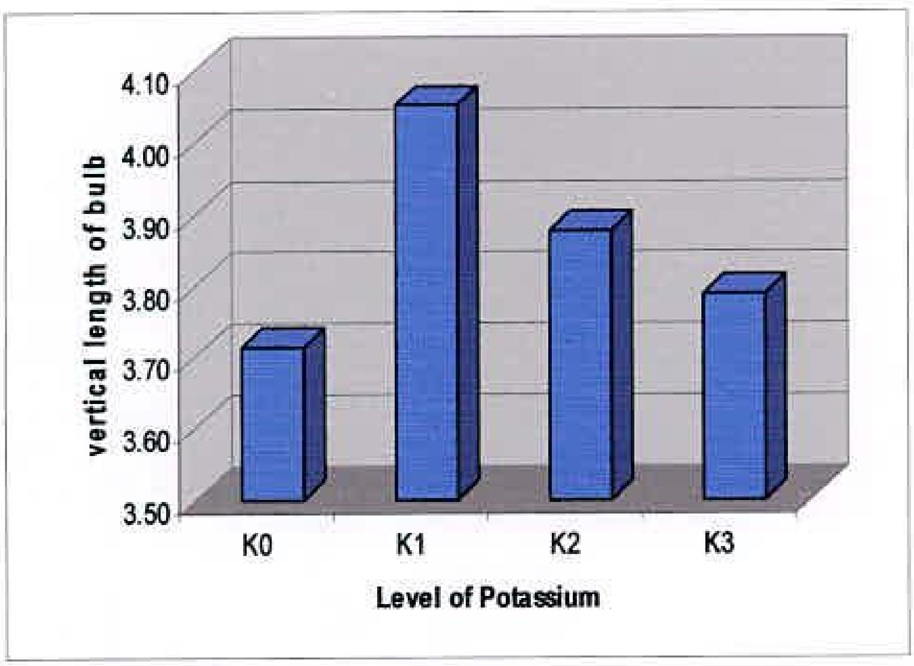

Fig. 8 Effect of different levels of potassium on the vertical length of bulb plant^{-1} of onion

Table 4 Effects of nitrogen on the yield contributing parameters of onion

Treatment	Horizontal length of bulb (cm)	Vertical length of bulb (cm)	Yield of bulb (t/ha)
N_0	4.69b	3.19c	9.61
N_1	5.19a	3.69b	10.58
N_2	5.27a	4.38a	11.60
N_3	5.06a	4.17a	11.02
$LSD_{(0.05)}$	0.35	0.29	2.44

Table 5 Effects of potassium on the yield contributing parameters of onion

Treatment	Horizontal length of bulb (cm)	Vertical length of bulb (cm)	Yield of bulb (t/ha)
K_0	4.96	3.71b	10.05
K_1	5.21	4.05a	11.39
K_2	5.07	3.88ab	10.81
K_3	4.96	3.79ab	10.57
$LSD_{(0.05)}$	0.36	0.29	2.44

Table 6 Combined effects of nitrogen and potassium on the yield contributing parameters of onion

Treatment	Vertical length of bulb (cm)	Horizontal length of bulb (cm)	Yield of bulb (t/ha)
N_0K_0	3.09j	4.68f	8.95d
N_0K_1	3.37hi	4.83ef	9.99bcd
N_0K_2	3.20ij	4.67f	9.80cd
N_0K_3	3.12j	4.58f	9.70cd
N_1K_0	3.53gh	5.04cde	10.37bcd
N_1K_1	3.85ef	5.34ab	10.94bc
N_1K_2	3.74f	5.27abc	10.57bcd
N_1K_3	3.67fg	5.10bcd	10.45bcd
N_2K_0	4.25bc	5.11bcd	10.59bcd
N_2K_1	4.60a	5.45a	12.88a
N_2K_2	4.39b	5.31ab	11.67ab
N_2K_3	4.29bc	5.18bcd	11.23abc
N_3K_0	4.00de	5.00de	10.26bcd
N_3K_1	4.40b	5.20abcd	11.75ab
N_3K_2	4.19bcd	5.04cde	11.20abc
N_3K_3	4.09cd	4.98de	10.89bc
$LSD_{0.05}$	0.19	0.23	0.16

In a column figures having similar letter(s) do not differ significantly, whereas, figures with dissimilar letter(s) differ significantly as per DMRT.

4.5 Horizontal length of bulb plant^{-1} (cm)

There was significant variation in the horizontal length of bulb plant^{-1} in onion when different doses of nitrogen fertilizer were applied (Fig. 9 and Table 4). The highest horizontal length of bulb plant^{-1} (5.27 cm) was recorded in N_2 treatment. The lowest length of bulb plant^{-1} (4.69 cm) was recorded in the N_0 treatment where no nitrogen fertilizer was applied.

Application of potassium fertilizer at different doses showed no significant variation on horizontal length of bulb (Fig. 10 and Table 5). Among the different fertilizer doses, K_1 treatment showed the highest length of bulb (5.21cm). The lowest length of bulb (4.96 cm) was recorded with K_0 treatment where no potash was applied. Optimum fertilizer doses might be increased the vegetative growth and development of onion that lead to the highest length of bulb. The highest level of potash did not show any more increase in bulb length.

The combined effects of different doses of nitrogen and potassium fertilizer on the horizontal length of bulb plant^{-1} were significant (Table 2). However, the highest length of bulb plant^{-1} (5.45 cm) was recorded with the treatment combinations of N_2K_1. On the other hand, the lowest length of bulb plant^{-1} (4.68 cm) was found in N_0K_0 treatment.

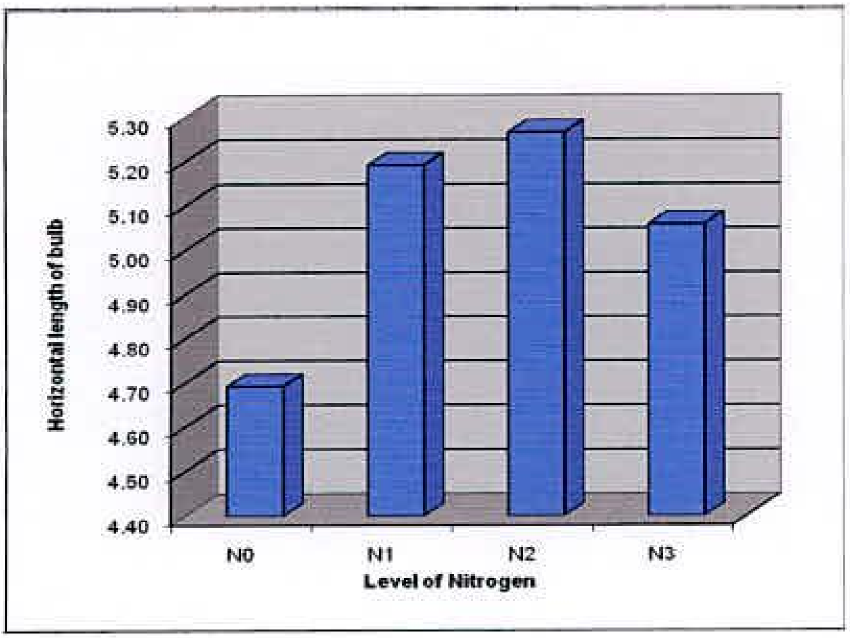

Fig. 9 Effect of nitrogen on the horizontal length of bulb plant^{-1} of onion.

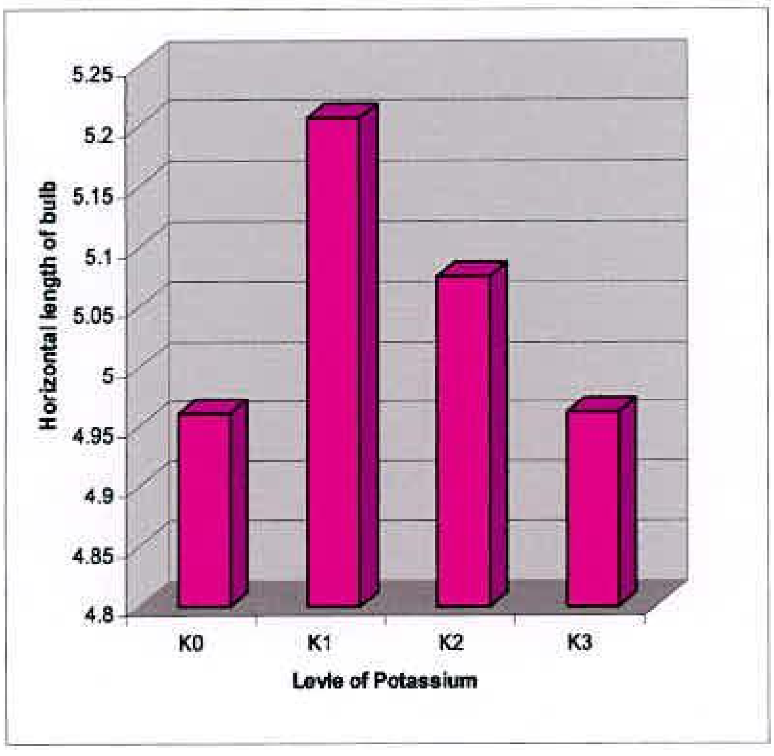

Fig. 10 Effect of different levels of potassium on the horizontal length of bulb plant^{-1} of onion

4.6 Yield of bulb (t ha^{-1})

No Significant variation was observed on the yield of bulb of onion when different doses of nitrogen fertilizer were applied (Fig. 11 and Table 4). The highest yield of bulb (11.60 tha^{-1}) was recorded in N_2 (120 $kgha^{-1}$) which was statistically dissimilar with other treatments. The lowest yield of bulb (9.61 t ha^{-1}) was recorded in the N_0 treatment where no fertilizer was applied.

The results of the single effects of different levels of potassium have been shown in (Fig. 12 and Table 5). From the table it was apparent that K_1 (120 $kgha^{-1}$) treatment gave the highest yield (11.39 t ha). On the contrary, the lowest yield of bulb (10.05 t ha^{-1}) was observed with $N_{0,}$ where no potash was applied.

The combined effects of different doses of nitrogen and potassium fertilizer on the yield of bulb of onion were significant (Table 2). The highest yield of bulb (12.88 t ha^{-1}) was recorded with the treatment combination of $N_2K_{1.}$ On the other hand, the lowest yield of bulb (8.96 t ha^{-1}) was found in N_0K_0 treatment combination (no nitrogen and no potassium). This result was in agreement with the findings of Rizk (1997) who reported that increased NPKS increased bulb yield. Pandey *et al.* (1990) and Bereniewiez and Nowosiecski (1986) also found similar results.

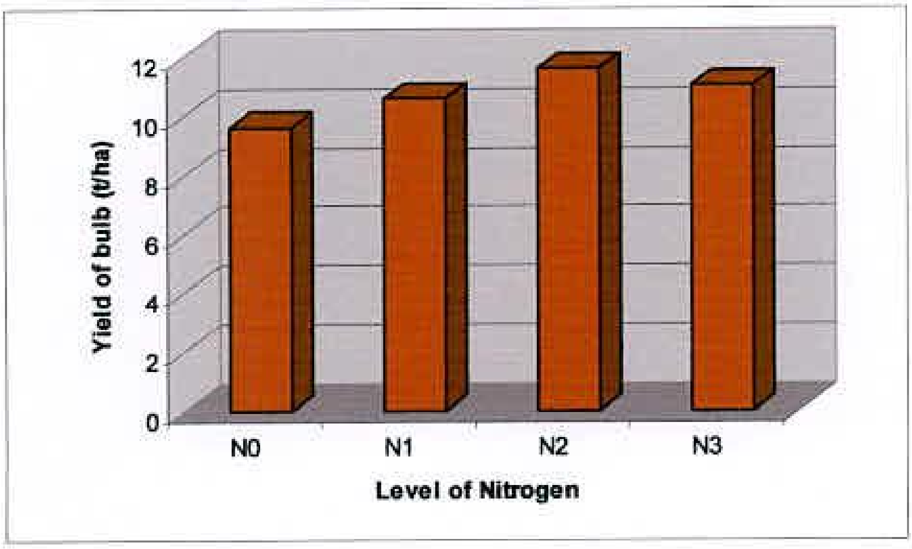

Fig. 11 Effect of nitrogen on the yield of bulb of onion

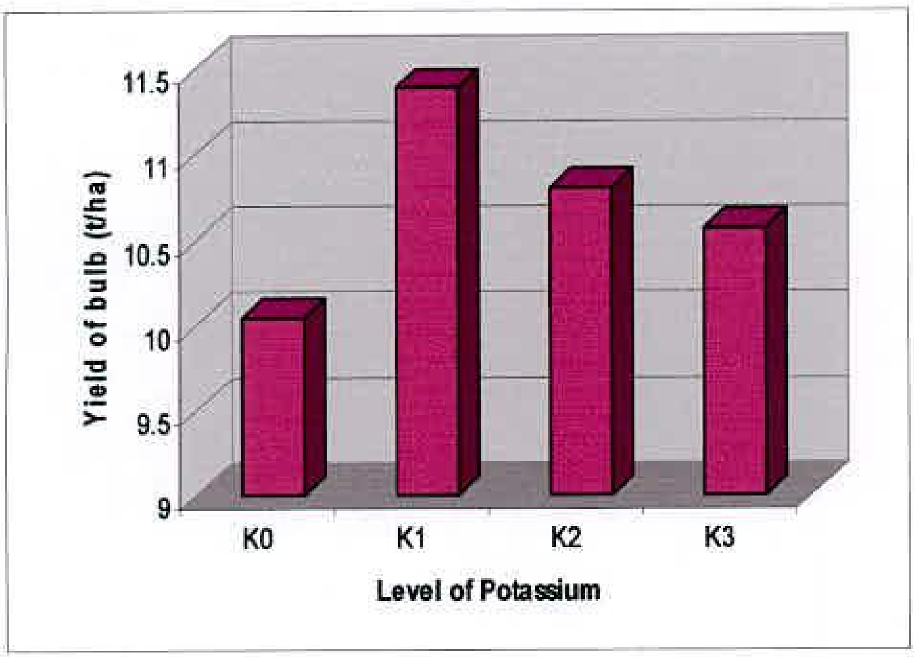

Fig. 12 Effect of different levels of potassium on the yield of bulb of onion

4.7 Effect of nitrogen on nitrogen concentrations in bulb of onion

Effect of N on N concentration of bulb was significantly influenced by the application levels of nitrogen (Table 7). The highest nitrogen concentration in onion bulb (2.7 %) was recorded in N_2 (120 kgha^{-1}), which showed similar result with N_3 (150 kgha^{-1}) treatment. Otherwise, the lowest nitrogen concentration in onion bulb (2.44 %) was recorded in N_0 treatment where no nitrogen was applied.

Effect of K on N concentration of bulb was significantly influenced by application levels of potassium (Table 8). The highest N concentration in onion bulb (2.78 %) was recorded in K_1 (120 kg ha^{-1}). The lowest N concentration in onion bulb (2.52 %) was recorded in K_0 treatment where no potassium was applied, which showed similar but not statistically similar result with K_2 and K_3 other treatments.

Significant effect was observed in combined application of different doses of nitrogen and potassium fertilizer on the nitrogen concentration in bulb of onion (Table 9). The highest concentration of nitrogen in the bulb (3.20 %) was recorded in the treatment combination of N_2K_1. The lowest nitrogen concentration (2.21 %) in bulb was found in N_0K_0.

Table 7 Effect of nitrogen fertilizer on the nitrogen and potassium concentrations in bulb and post harvest soil

Treatment	N Concentration (%)		K Concentration (%)	
	Bulb	Soil	Bulb	Soil
N_0	2.44	0.08	0.36	0.12
N_1	2.52	0.09	0.36	0.15
N_2	2.70	0.10	0.41	0.15
N_3	2.69	0.09	0.41	0.15
$LSD_{0.05}$	0.2013	0.008	0.03	0.025

Table 8. Effect of potassium fertilizer on the nitrogen and potassium concentrations in bulb and post harvest soil

Treatment	N Concentration (%)		K Concentration (%)	
	Bulb	Soil	Bulb	Soil
K_0	2.52	0.07	0.35	0.12
K_1	2.78	0.10	0.39	0.15
K_2	2.56	0.09	0.41	0.15
K_3	2.48	0.09	0.39	0.14
$LSD_{0.05}$	0.20	0.08	0.03	0.025

Table 9. Combined effect of nitrogen and potassium fertilizer on the nitrogen and potassium concentrations in bulb and post harvest soil

Treatment	N Concentration (%)		K Concentration (%)	
	Bulb	Soil	Bulb	Soil
N_0K_0	2.21h	0.02e	0.34f	0.11fgh
N_0K_1	2.59def	0.09abc	0.37def	0.13efg
N_0K_2	2.5fg	0.09bc	0.37def	0.13efg
N_0K_3	2.45fg	0.09c	0.35ef	0.12gh
N_1K_0	2.66cde	0.09c	0.35f	0.14def
N_1K_1	2.53defg	0.09bc	0.38cdef	0.15bcd
N_1K_2	2.50fg	0.09bc	0.37def	0.14cde
N_1K_3	2.40g	0.09bc	0.36ef	0.13defg
N_2K_0	2.44fg	0.09abc	0.35ef	0.12gh
N_2K_1	3.20a	0.10a	0.39bcdef	0.16abc
N_2K_2	2.58def	0.09abc	0.46a	0.17a
N_2K_3	2.56def	0.098ab	0.44abc	0.17ab
N_3K_0	2.77bc	0.07d	0.37def	0.12fgh
N_3K_1	2.81b	0.096bc	0.41abcde	0.17ab
N_3K_2	2.67cd	0.09bc	0.44ab	0.17a
N_3K_3	2.52efg	0.09bc	0.43abcd	0.17ab
$LSD_{0.05}$	0.13	0.005	0.053	0.017

4.8 Effect of nitrogen on nitrogen concentration in post harvest soil of onion field

The effect of different doses of nitrogen fertilizer showed a statistically significant variation in the nitrogen concentration in post harvest soil (Table 7) of onion field. The total N content of the post harvest soil varied from 0.08 % to 0.1 %. Among the different doses of nitrogen fertilizer, N_2 (120 $kgha^{-1}$) treatment showed the highest nitrogen concentration (0.1 %) in soil. The lowest value was 0.08 % under control treatment and N_0.

The effect of different doses of potassium fertilizer showed a statistically significant variation in the nitrogen concentration in post harvest soil (Table 8) of onion field. The total N content of the post harvest soil varied from 0.07 % to 0.1 %. The highest total N content (0.1 %) was observed in K_1 (120 $kgh^{-1}a$) treatment, which showed statistically similar result with K_2 and K_3. The lowest value of N (0.07 %) was observed under control (K_0) treatment.

Significant effect of combined application of different doses of nitrogen and potassium fertilizer on the nitrogen concentration was observed in post harvest soil of onion field (Table 9). The highest concentration of nitrogen in post harvest soil (0.103 %) was recorded in the treatment combination of N_2K_1. On the other hand, the lowest nitrogen concentration (0.02 %) in post harvest soil was found in $N_0K_{0,}$ where no nitrogen of potassium fertilizer .102 was added.

4.9 Effect of nitrogen on potassium concentration in bulb and soil of onion

K concentration of bulb was significantly influenced by application different levels of nitrogen (Table 7). The highest potassium concentration in onion bulb (0.41 %) was recorded in N_3 (150 $kgha^{-1}$), which showed similar result with N_2 (120 $kgha^{-1}$) treatment. The lowest potassium concentration in onion bulb (0.36 %) was recorded in N_0 treatment where no nitrogen was applied.

K concentration of bulb was significantly influenced by application levels of potassium (Table 8). The highest potassium concentration in onion bulb (0.4103 %) was recorded in K_3 (160 $kgha^{-1}$) treatment. The lowest potassium concentration in onion bulb (0.35 %) was recorded in K_0 treatment where no potassium was applied.
Significant effect of combined application of different doses of nitrogen and potassium fertilizer on the potassium concentration was observed in bulb of onion (Table 9). The highest concentration of potassium in the bulb (0.46 %) was recorded in the treatment combination of N_2K_2.The lowest potassium concentration (0.34 %) in bulb was found in N_0K_0.

4.10 Effect of nitrogen on potassium concentration in post harvest soil of onion field

The effect of different doses of nitrogen fertilizer showed a statistically significant variation in the potassium concentration in post harvest soil (Table 7) of onion field. The total K content of the post harvest soil varied from 0.12 % to 0.15 %. Among the different doses of nitrogen fertilizer, N_2 (120 $kgha^{-1}$) treatment showed the highest potassium concentration (0.15 %) in soil. The lowest value was 0.12 % under control treatment.

The effect of different doses of potassium fertilizer showed a statistically insignificant variation in the potassium concentration in post harvest soil (Table 8) of onion field. The total K content of the post harvest soil varied from 0.12 % to 0.15 %. The highest total K content (0.15 %) was observed in K_2 (160 kg/ha) treatment and the lowest value of 0.12 % under control (K_0) treatment.

Significant effect of combined application of different doses of nitrogen and potassium fertilizer on the nitrogen concentration was observed in post harvest soil of onion field (Table 9). The highest concentration of potassium in post harvest soil (0.17 %) was recorded in the treatment combination of N_2K_2. On the other hand, the lowest nitrogen concentration (0.11 %) in post harvest soil was found in N_0K_0.

CHAPTER 5
SUMMARY AND CONCLUSION

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The experiment was carried out at the Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during December 2007 to March 2008 to evaluate the effect of different fertilizer levels of nitrogen and potassium and their interaction effect on the yield of onion. The experiment comprised of two factors such as (a) four levels of nitrogen viz; 0, 80, 120 and 150 kg ha^{-1} and (b) four levels of potassium viz 0, 120, 160 and 200 kg ha^{-1} . The experiment was laid out in Randomized Complete Block Design with three replications. The size of each unit plot was 2.5 m × 2 m and accommodated in each plot with spacing 20 cm × 10 cm. Bulb yield per hectare was estimated on the basis of yield per plot.

Data were recorded on bulb yield and yield components namely plant height, leaf number, leaf length, vertical length of bulb, horizontal bulb length, and bulb yield per ha. The colleted data were analyzed and differences between the means were evaluated by Duncan's Multiple Range Test. The experimental results are summarized as follows:

The result of the experiment revealed that the application of nitrogen had statistically significant effect on plant height. The highest dose of nitrogen N_2 120 kg ha^{-1} gave the highest plant height (37.62 cm) and the minimum (32.60 cm) in plants receiving no nitrogenous fertilizer. The application of potassium had statistically significant effect on plant height. The different doses of fertilizer, K_1 (120 $kgha^{-1}$) showed the highest plant height (38.47 cm). The lowest plant height (30.80 cm) was observed in the K_0 treatment. The combined effect of nitrogen and potassium was found statistically significant at different doses.

The highest plant height (43.40 cm) was recorded with N_2K_1 treatment (120 kg nitrogen + 120 kg potassium ha^{-1}) and the lowest plant height (25.00 cm) was observed in the treatment combination of N_0K_0 (no nitrogen and no potassium).
Significant variation was observed in number of leaf $plant^{-1}$ of onion when different doses of nitrogen were applied. The highest number of leaf $plant^{-1}$ (5.28) was recorded in N_3 (150 kg ha^{-1}). The lowest number of leaf $plant^{-1}$ (3.80) was recorded in the control treatment. The leaf production ability was not greatly influenced by the application of nitrogen and potassium. The combined effect of different doses of nitrogen and potassium fertilizer on number of leaf $plant^{-1}$ of onion was significant. The highest number of leaf $plant^{-1}$ (6.73) was recorded with the treatment combination of N_1K_1. On the other hand, the lowest number of leaf $plant^{-1}$ (3.33) was found in N_0K_0 treatment (no nitrogen and no potassium).

The leaf length as affected by different doses of nitrogen showed a statistically significant variation. Among the different doses of nitrogen the highest leaf length (34.03 cm) was observed in N_2 (120 $kgha^{-1}$) and the lowest leaf length (29.15 cm) was recorded in the N_0 treatment where no nitrogen was applied. Increasing level of nitrogen increased the height of plant as well as the length of leaf. Application of potassium fertilizer at different doses showed significant variation on the leaf length of onion. Combined effects of different doses of nitrogen and potassium fertilizers on leaf length showed a statistically significant variation. The highest leaf length (38.87 cm) was recorded in the treatment combination of N_2K_1. On the other hand, the lowest leaf length (23.60 cm) was found in N_0K_0 treatment combination where no nitrogen and potassium where applied.

The variations in respect of vertical length of bulb due to the effects of different levels of nitrogen were found to be statistically significant. The maximum vertical length of bulb (4.38 cm) was observed from the plants grown with N_2 (180 kg ha^{-1}). The control plants produced the minimum diameter (3.19 cm) of bulb. Significant variation was observed by the application of potassium on the vertical length of bulb. Combined effect of nitrogen and potassium showed significant effects on bulb diameter. The maximum vertical length of bulb (4.60 cm) was observed from the plants grown with N_2K_1 treatment combination and the minimum diameter (3.09cm) of bulb was observed with the treatment combination of N_0K_0.

The horizontal length of bulb was influenced by the application of nitrogen and potassium as well as their combinations. Application of nitrogen showed statistically significant effects of bulb yield per hectare. Bulb yield increased progressively with the increasing level of nitrogen up to 120 kg N ha^{-1}. The maximum bulb yield (11.60 t ha^{-1}) was obtained from the plants fertilized with 120 kg N ha^{-1} and minimum (9.61 t ha^{-1}) from the plants receiving no nitrogen. Application of K had no significant effect on bulb yield. The combined effect of different doses of nitrogen and potassium fertilizer on the yield of bulb of onion was significant The highest yield of bulb (12.88 t ha^{-1}) was recorded with the treatment combination of N_2K_1 and the lowest yield of bulb (8.96 t ha^{-1}) was found in N_0K_0 treatment combination (no nitrogen and no potassium).The N contents in onion bulb and post harvest soil of onion field were significantly influenced by the application of nitrogen and potassium fertilizer alone. However, the highest N concentration in the bulb (2.7%) and in the soil (0.09%) was observed N2 treatments respectively.

In case of bulb the K concentration was significantly influenced by N fertilizer and their combined application. For every cases the highest dose showed the highest K concentration in onion bulb i.e., N_3 (0.41%), K_2 (0.41%) and N_2K_2 (0.5%), where the lowest K concentration were found in, N_0 (0.36%), K_0 (0.35%) and N_0K_0 (0.34%) treatments respectively. But in case of post harvest soil the Concentration was influenced by N fertilizer and their combination but only by K fertilizer. So highest K concentrations of the post harvest soil was found with N_2 (0.15%) and N_1K_2 (0.17%) treatments and the lowest was in N_0 (0.12%) and N_0K_0 (0.11%), treatments combination where no fertilizers were applied.

From the above discussion it can be concluded that application of N at the rate of 120 kg ha^{-1} and the K @ 120 kg ha^{-1} was favorable for maximum yield of onion. However the results are required to substantiate further with different varieties and soil management practices.

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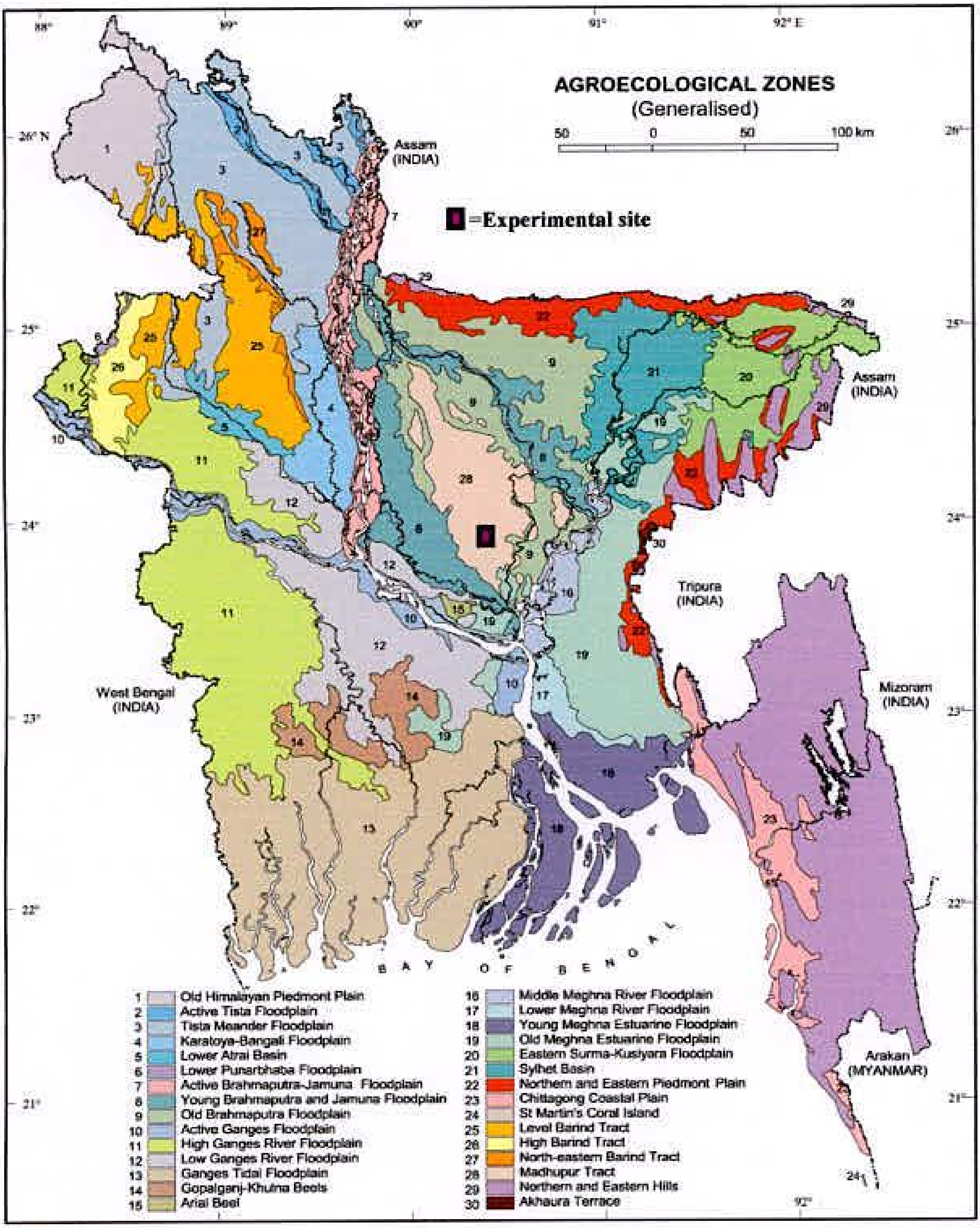
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Some Initial Characteristics of the Experimental Soil.

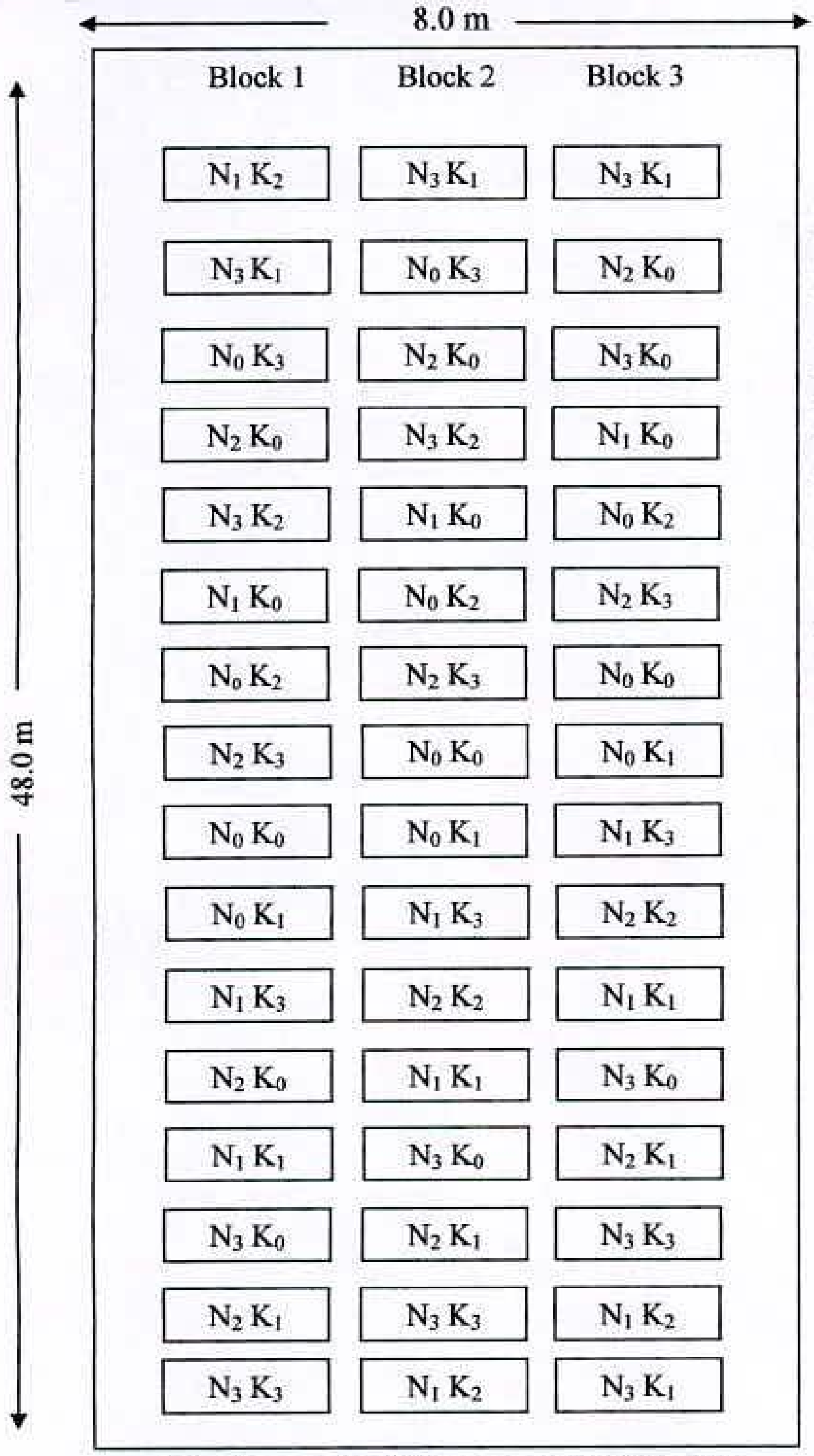
1. pH		5.8
2. Particle-size analysis of soil	Sand	29.04
	Silt	41.80
	Clay	29.16
3. Textural class		Silty clay loam
4. Total N (%)		0.08
5. Organic matter (%)		1.15
6. Available P (ppm)		22.15
7. Exchangeable K (me/100g soil)		0.18
8. Available S (ppm)		16.5

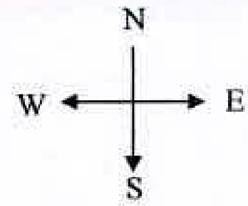
Appendix III. Monthly Average Air Temperature, Total Rainfall, Relative Humidity and Sunshine Hours of the experimental site during the period from November 2007 to April 2008

Year	Month	Average Air Temperature (^0C)			Total rainfall (mm)	Average RH (%)	Total sun shine hours
		Maximum	Minimum	Mean			
2007	November	29.7	20.1	24.9	5	65	192.20
	December	26.9	15.8	21.35	0	68	217.03
2008	January	24.6	12.5	18.7	0	66	171.01
	February	27.1	15.8	21.05	09	66	168.60
	March	30.2	18.4	24.3	12	68	165.02
	April	38.3	23.2	30.75	25	72	166.8

Source: Dhaka Metrological Centre (Climate Division)

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





Plot size =2.5 m ×2 m
Plot spacing = 0.5 m
Distance =0 .5 m

Factor A:
N_0: Control 0kg N/ha
N_1: 80 kg N/ha
N_2: 120 kg N/ha
N_3: 150 kg N/ha

Factor B:

K_0: Control 0 kg S/ha
K_1:120 kg K/ha
K_2: 160 kg K/ha
K_3: 200 kg K/ha

Fig: Lay out of the experimental plot.