EFFECT OF N AND K ON THE YIELD OF ONION

BY

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

MASTER OF SCIENCE

IN

SOIL SCIENCE

SEMESTER: JANUARY-JUNE, 2008

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CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF N AND K ON THE YIELD OF ONOIN"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***SOIL SCIENCE,*** *embodies the result of a piece of bonafide research work carried out by* ***MD. MIZANUR RAHAMAN****, Registration No.* ***00782*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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DEDICATED TO
MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are due to Omnipotent"Allah Rabbul Al-Amin" Who enabled me to pursue higher study and to complete the research work as well as to submit the thesis for the degree of Master of Science (M.S.) in Soil Science, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

I would like to express my heartfelt respect, deepest sense of gratitude, profound appreciation and ever indebtedness to my supervisor, Associate Professor A.T.M. Shamsuddoha, Chairman, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism, extending generous help and constant inspiration throughout the course and in preparation of the manuscript of thesis.

I express my sincere respect to my Co-supervisor, Professor Dr. Alok Kumer Paul, Department of Soil Science, Sher-e-Bangla Agricultural University, (SAU), Dhaka for his utmost co-operation, constructive suggestion to conduct the research work as well as preparation of the manuscript of thesis.

I feel to express my sincere appreciation and indebtedness to my esteemed teachers Professor Dr. Md. Nurul Islam, Professor Dr. Gopi Nath Chandra Sutradhar, Associate Professor Asaduzzaman Khan, Associate Professor Mst. Afrose Jahan, Assistant Professor Md. Mosharraf Hossain, Lecturer Issak, Saiful, Saikat, Jarna, Dept. of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for their valuable teaching, direct and indirect advice, encouragement and cooperation during the whole study period.

I express my unfathomable tributes, sincere gratitude and heartfelt indebtedness from my core of heart to my father late Md. Abdul Kader Bapari, mother Mrs. Nurjahan Begum, and also pleasant to my brother Md. Nurul Haque and sisters, whose blessing, inspiration, sacrifice, and moral support opened the gate and paved to way of my higher study.

I feel much pleasure to convey the profound thanks to my friends, well wishers for their active encouragement and inspiration; personal acknowledgement are made to Arif, Ripon, Sumon, Sankar, Enamul, Zilani and Kamal.

Mizan

Place: Dhaka *Md.Mizanur Rahman*

Dated:The June 2008

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LIST OF ABBREVIATIONS

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 Squares
mm	Millimeter
MP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Non significant
P_2O_5	Phosphorus Penta Oxide
S	Sulphur
SAU	Sher-e- Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
var.	Variety
Wt.	Weight
t ha^{-1}	Ton per hectare
^{0} C	Degree Centigrade

ABSTRACT

A field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during the *Rabi* season of 2006-2007 to evaluate the effect of nitrogen (N) and potassium (K) fertilizers levels on the yield of onion. The research was carried out with four levels of nitrogen viz; 0, 60, 120 and 180 kg N ha^{-1} and three levels of potassium viz; 0, 60 and 120 kg K_2O ha^{-1}. Data were recorded on yield and yield components. 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 significant influence on bulb yield. The highest bulb yield (8.53 ton ha^{-1}) was obtained when plants were grown with nitrogen at 120 kg ha^{-1}, but higher levels of N did not show any significant increase in yield of onion. The lowest yield (6.70 ton ha^{-1}) was recorded in the control treatments. Application of potassium at 60 kg K_2O ha^{-1} produced the highest bulb yield (7.77 ton ha^{-1}) which was statistically identical with that of 0 or 120 kg K_2O ha^{-1} The effect of interaction between nitrogen and potassium was statistically significant. The combination of 120 kg N and 60 kg K_2O ha^{-1} gave the highest bulb yield (9.40 ton ha^{-1}). On overall considerations, 120 kg N and 60 kg K_2O ha^{-1} were considered as optimum dose for the yield of onion under the experimental conditions.

Chapter 1

Introduction

Chapter 1

INTRODUCTION

Onion (*Allium cepa*) variety (Taherpuri) is one of the most important spices in Bangladesh as well as in the world, which belongs to the family Alliaceae (Jones and Mann, 1963). The crop is appreciated as condimflavoring foods and also it is used in the preparation of different kinds of food of our daily diet. Onion contains high medicinal properties having adequate vitamin B, vitamin C, iron and calcium (Vohora *et al.*, 1974). Recently it is known that onion reduces the blood sugar by 25 percent as diabetic drugs in Arabian folk medicine (Mossa, 1985 and Yawalkar, 1985).

The crop is being cultivated all over the world. Western China deserts lying in the east of the Caspian Sea are considered as the place of origin of onion (Jones and Mann, 1963). The leading onion growing countries of the world are the Netherlands, Korea, Israel, Japan, Turkey, Syria, Iran, Egypt, USA, Lebanon, Austria and India (FAO, 2003a). In Bangladesh, its cultivation in commercial scale is found to be concentrated in the greater districts of Faridpur, Rajshahi, Dhaka, Comilla, Mymensingh, Jessore, Rangpur and Pabna (BBS, 2004).

Onion is a thermophotosensitive crop. In Bangladesh, it is mainly produced in winter season. The optimum temperature for onion cultivation is 13-24°c (Rashid, 1983). Usually, it is sown during December to January and harvested mostly in the months from March to April. Onion cultivation during winter season is profitable due to prevailing favourable weather condition.

There is a shortage production of onion in Bangladesh. The statistical information revealed that Bangladesh produced only 153 thousand metric tons of onion on an area of 37637 hectares of land as against the total requirement of 450 thousand MT per year (BBS, 2004). The average yield of onion in Bangladesh is far below being 4 t/ha (BBS, 2004) as compared to world average yield of 17.45 t/ha (FAO, 2003b).This is why Bangladesh have to import onion every year by loosing huge foreign currency. In 2003, Bangladesh had to import 33.452 thousand MT of onion worth about 6.9 million US dollar (FAO, 2003c).

The deficit situation 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 dose of N, P and K fertilizers.

Nitrogen plays an important role for the 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. Onion is also known to be potash loving crop (Rai, 1981). Potassium helps in root development and increase photosynthetic efficiency of leaves. Potassium exerts a balancing role on the effect of both nitrogen and phosphorous, consequently it is especially important in a multi-nutrient fertilizer application. Among the yield promoting factor, application of proper doses of nitrogen and potassium is of great importance.

A detailed and systematic study is needed to find out the requirements and effect of N and K for maximizing the yield of onion in Bangladesh. Considering the above facts the present investigation was under taken with the following objectives:

i. to study the yield and yield contributing characters of onion under different levels of nitrogen and potassium fertilizers.
ii. to find out the best combination of N and K for maximizing the production of onion bulbs.

Chapter 2
Review of Literature

Chapter 2

REVIEW OF LITERATURE

Onion is one of the most important bulb crops in the world. The yield of onion depends on many factors are land topography, soil fertility, soil productivity, environment (light, temperature, moisture, humidity and rainfall), cultural practices such as sowing date, mulching, methods of fertilizer application, disease and pest control etc. Nitrogen and potassium are the two major important macro nutrients responsible for controlling growth and yield of onion. In shallow rooted crop like onion, split application of nitrogen as well as potash could be more useful for better utilization by the plant. A good 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 as well as in Bangladesh. However, literatures available in this respect at home and abroad are summarized below:

Application of half nitrogen and potash after one week of transplantation of onion and the rest half after one week of first application was reported to produce higher yield than the application of full amount of nitrogen and potash after one week of transplantation.Tseng (1972)

Satter and Hague (1975) observed that an increased level of nitrogen increased the weight of bulb; while potassium in an increased level decreased the bulb weight. In their study, nitrogen 67.21kg ha^{-1} and potassium 22.48kg ha^{-1} were found to give the highest yield of local variety of onion.

The effects of FYM, ammonium sulphate, super phosphate and potassium sulphate were studied by Katyal (1977). He suggested to use 15 to 20 tons FYM, 100 kg ammonium sulphate, 175 kg supper phosphate 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 cow dung, 175 kg urea, 125 kg TSP and 150 kg MP per hectare for successful onion cultivation in Bangladesh.

Agarwal *et al.* (1981) studied the yield of onion with N, P_2O_5 and/ or K_2O at 80-160: 40-80: 40-80 kg ha^{-1}. The highest yield was obtained from plots receiving 160:40:40 or 80:40:80 kg ha^{-1}.

Gupta and Gaffar (1981) studied the effect of different row spacing under different combinations of nitrogen, phosphorus and potassium on the growth and yield of onion. Application of NPK exerted a significant effect on the yield and yield contributing characters of onion. Economic yield was obtained from NPK application @46:36:36 kg ha^{-1}.

Satyanarayana and Arora (1984) reported that onion bulb yield increased with direct application of nitrogen up to 60 kg ha^{-1}, and potash up to 40 kg as K_2O ha^{-1}. Deshmukh *et al.* 1984 also reported beneficial effect of K on bulb yield of onion up to 40 kg K_2O ha^{-1}.

Madan and Sandhu (1985) noticed that effective plant growth and maximum bulb yield and dry matter yield were obtained with the application of N: P_2O_5: K_2O at 120: 60: 60 kg ha^{-1}.

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

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

Duque *et al.* (1989) studied the growth and nitrogen, phosphorus and potassium uptake of onion. The results indicated that the plantsdemand for N and K was higher during early growth stages, whereas demand for P was continuous through out the development.

Uptake levels were 38.8, 38.6 and 71.3 kg N, P_2O_5 and K_2O, respectively, for the yield of 2.5 t ha^{-1}.

Singh *et al.* (1989) observed the effect of green manuring on the yield. They set up two types of lands, one without previous green manuring and another with green manuring by *Sesbania aculata*. A combination of 120 kg N and 50 kg K_2O gave the taller plants and the higher number of leaves per plant, maximum bulb weight and diameter per plant and higher bulb yield in the first experiment; green manuring also greatly enhanced plant growth and bulb yield.

Pandey *et al.* (1990) studied the effect of four levels of nitrogen (0, 50, 100, and 150 kg ha^{-1}), three levels of phosphorus (0, 40, or 80 kg ha^{-1}) and two levels of potash (0 and 50 kg ha^{-1}), on the yield and quality of *kharif* onion. They found maximum yield and net return with N: P: K @ 130:40:50 kg ha^{-1}.

Baloch *et al.* (1991) obtained maximum bulb yield (22.66 t ha^{-1}) with the application of 125 kg N+75 kg K_2O ha^{-1}. The highest plant height (38.5 cm), number of leaves $plant^{-1}$ (17.0), single bulb weight (82 g), vertical bulb diameter (4.80 cm) and horizontal bulb diameter (5.78) were obtained with 125 kg N + 100 kg K_2O ha^{-1}.

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

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

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 the individual and combined effect of potassium and sulphur on growth and yield of onion and found an increase in plant height, leaf production ability, bulb diameter and weight as well as the bulb yield. They recommended 100 kg potash and 30 kg sulphur per hectare for cultivation of onion.

Sangakkara and Piyadasa (1993) observed the effect of six levels of potassium supplied as KCl, 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.

Vachhani and Patel (1993) studied the effect of different levels of nitrogen (50, 100 or 150 kg ha^{-1}), phosphorus (25, 50 or 75 kg P_2O_5 ha^{-1}) and potash (50, 100 or 150 kg K_2O ha^{-1}) on the growth and yield of onion. They found that plant height, number of leaves $plant^{-1}$, bulb weight and yield were the highest with 150 kg N ha^{-1}, although bulb weight and yield with 100 kg N ha^{-1} were not significantly different. Increasing phosphorus application increased the number of leaves per plant and weight, size and yield of bulbs. Application of K increased only the number of leaves per plants.

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

Rizk (1997) carried out an experiment to investigate the effect of plant density and NPK fertilizers on the productivity of onion. Lower planting density resulted in higher number of leaves per plant, higher fresh and dry weight; higher leaf areas, higher average bulb weights and higher uptake of N. Total bulb yield and yield of marketable bulbs were highest with dense planting. Increasing the NPK rate increased all vegetative growth parameters measured and increased the yield of bulbs. The best application method for NPK was two equal doses applied at 30 and 60 days after transplanting.

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

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

Harun-or-Rashid (1998) carried out a field experiment at the Bangladesh Agricultural University, Mymensingh on the effect of NPKS on growth and yield of onion at different plant spacing. He reported that the maximum bulb weight (40.50 g) and bulb yield (20.75 t ha^{-1}) were found from the combination of 125-150-150-30 kg N, P_2O_5, K_2O, S ha^{-1}, whereas the minimum bulb yield (16.75 t ha^{-1}) was recorded from the control treatment. Application of NPKS increased the plant height, leaf number, length of bulb, bulb diameter, and bulb weight as well as the bulb yield. He recommended 100-150-200-30 kg N, P_2O_5, K_2O, S ha^{-1} for the cultivation of BARI peaj-1 at BAU Farm conditions. Islam (1998) found that nitrogen at 120 kg ha^{-1} produced the maximum bulb weight and bulb yield (25.5 t ha^{-1}).

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 (DAT) 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.

Rodriguez *et al.* (1999) carried out an experiments during 1993-94 and 1994-95 on onion to find out the effect of nitrogen, phosphorus and potassium rates, sources and forms upon onion (*Allium cepa*) bulb yield and quality. Yield, plant height, leaf number, and polar and equatorial diameters were measured in treatments with different rates, sources and forms of N, P and K. Significant effects of P and K rates (applied up to 98.2 and 200 kg ha^{-1}, respectively) could not be detected, nor significant interactions between N and P.

Geetha *et al.* (1999) studied the effects of application of farm yard manure and K fertilizer on K nutrition and dry matter yields of onion grown on an Alfisol. Combined application of farmyard manure and muriate of potash at 25 t ha^{-1} and 200 kg K_2O ha^{-1}, respectively, resulted in higher dry matter yields and K uptake at various stages of growth. The interaction between the organic and inorganic sources also showed significant effect on these parameters. The uptake of K increased with progressing plant development.

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.

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

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

Dharmendra *et al.* (2001) investigated the effects of N fertilizer application (0, 65 and 130 kg/ha) on onion cv. Pusa Red during 1992-93 and 1993-94 in Uttar Pradesh, India. In both years, the application of 130 kg N/ha resulted in the highest percentage of seedling survival, plant height, number of green leaves and 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.

Mohanty and Das (2001) observed that the application of 90 kg N and 60 kg K_2O ha^{-1} was better for obtaining higher yield with larger bulbs, while 30 kg ha^{-1} each of N and

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

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

Yadav *et al.* (2002) conducted an experiment on onion cultivars Pusa Red, White Marglobe, Nasik Red and Rasidpura Local which were supplied with 50, 100 or 150 kg N and K ha^{-1} in Jaipur, Rajasthan, India during the rabi seasons of 1998-2000. Yield, fresh weight of bulb, total soluble solids and allyl propyl disulfide content increased, whereas ascorbic acid content decreased with the increase in N and K rates. Rasidpura Local recorded the highest values for the parameters measured except allyl propyl disulfide content which was the highest in Nasik Red.

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

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

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 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 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 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 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.

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 yield of onion.

3.1 Experimental site

The research work was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka- 1207 during the *Rabi* season of 2006-2007. The location of the experimental site is shown in Figure 3.1.

3.2 Description of soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28) and the General soil type is Shallow Red Brown Terrace Soils. 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 parameters. The physical and chemical characteristics of initial soil are presented in Table 1.

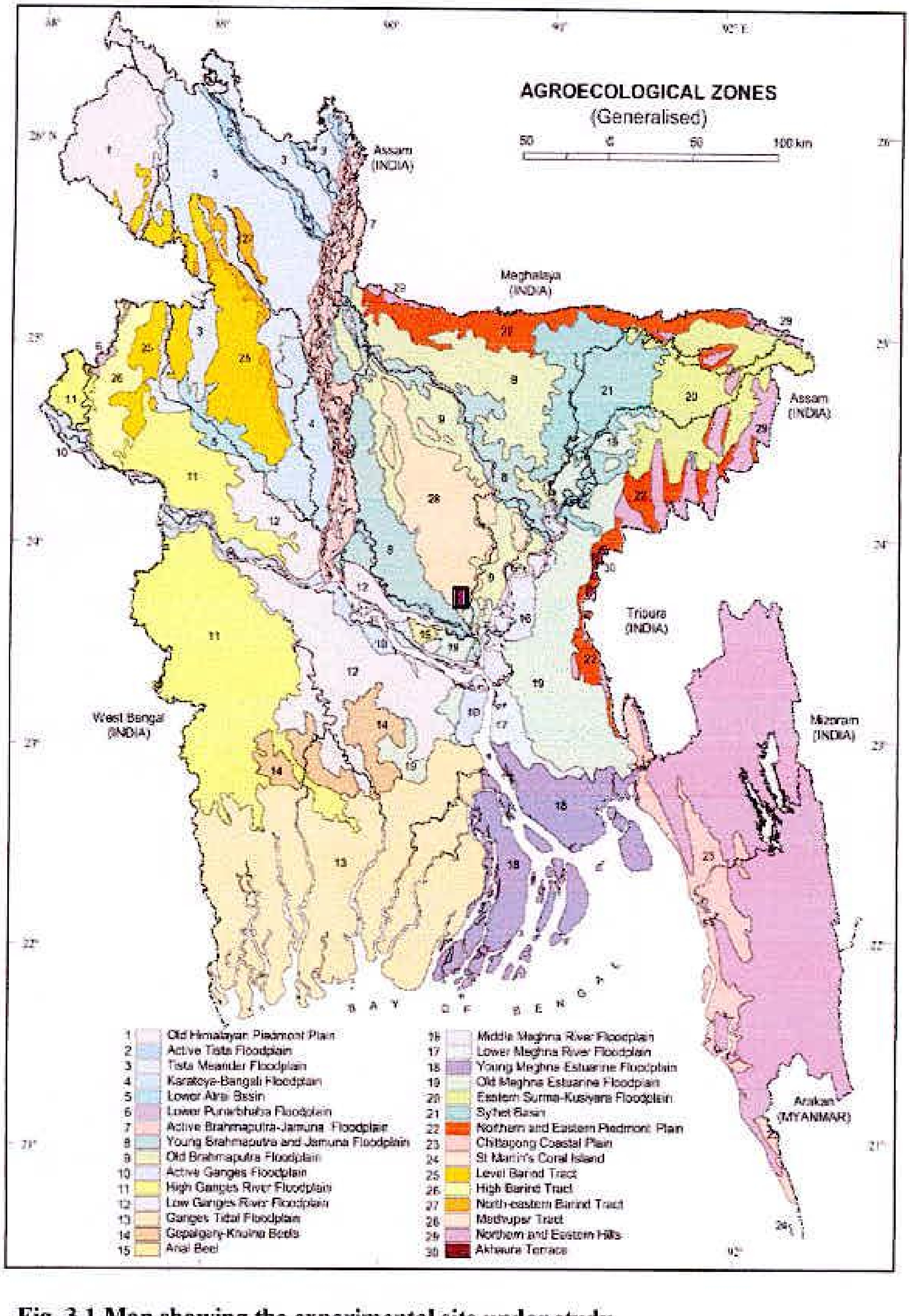

Fig. 3.1 Map showing the experimental site under study

Table 3.1 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 (%)		1.34
6. Available P (ppm)		31.15
7. Exchangeable K (me/100g soil)		0.18
8. Available S (ppm)		34.55

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 Fig. 3.2 to 3.6.

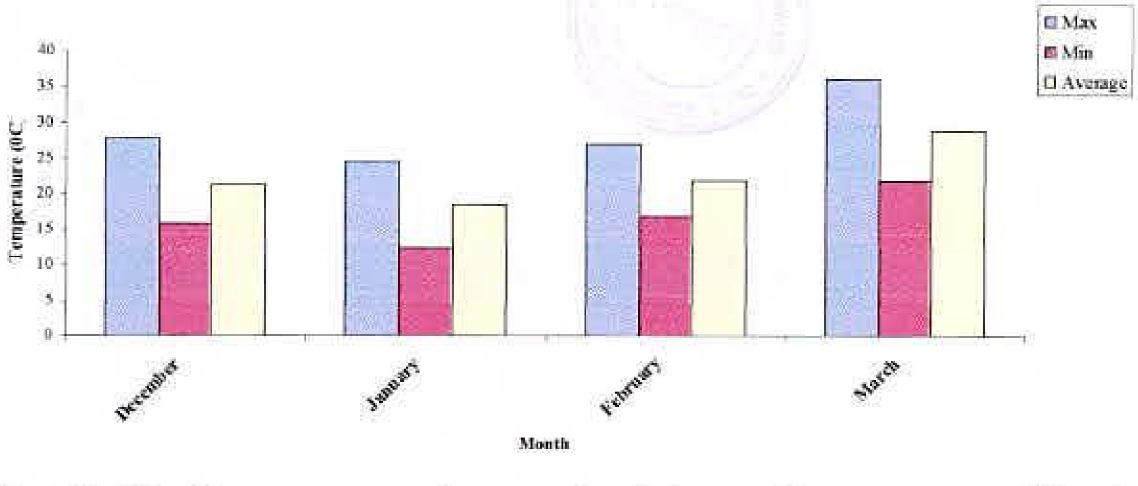

Fig. 3.2 Monthly average maximum and minimum air temperature (^{0}C) of the experimental site during the growing period (December 2006 to March 2007)

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207

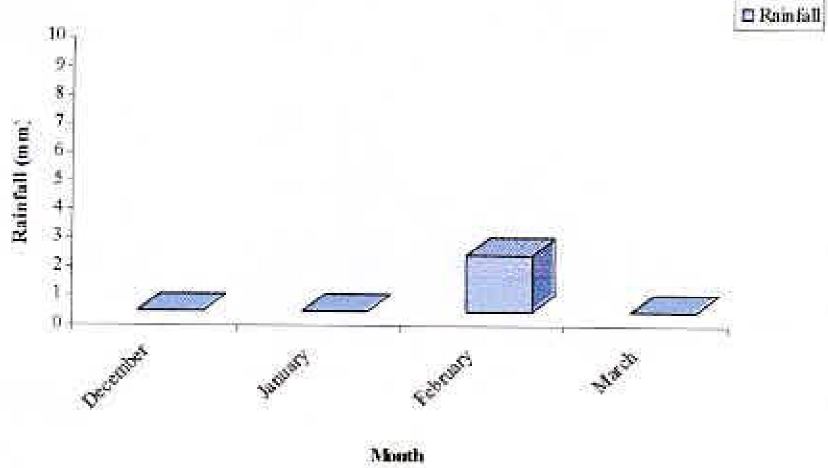

Fig. 3.3 Monthly total rainfall (mm) of the experimental site during the growing period (December 2006 to March 2007). Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207.

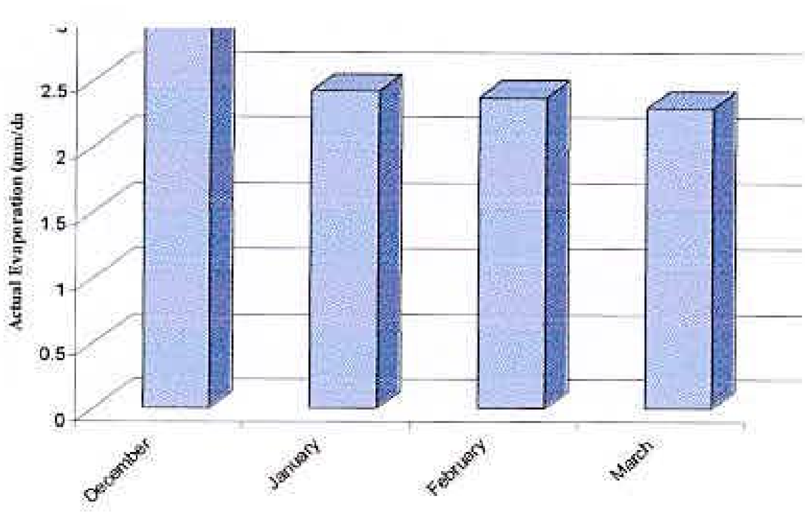

Fig. 3.4 Monthly average actual Evaporation (mm) of the experimental site during the growing period (December 2006 to March 2007). Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207.

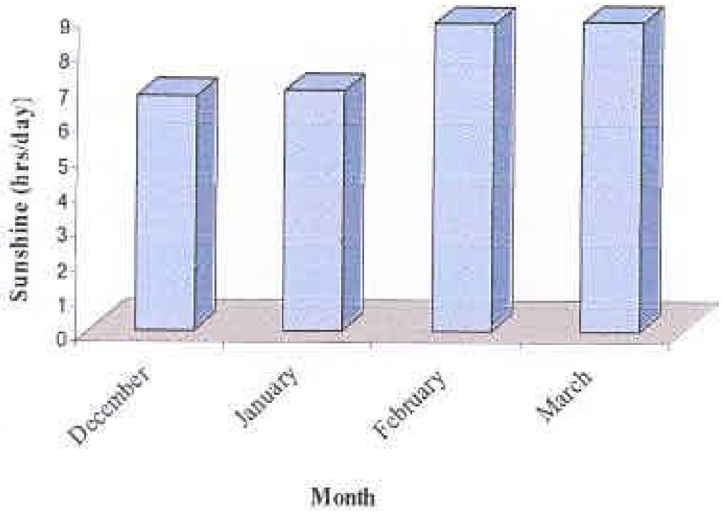

Fig. 3.5 Monthly average sunshine hrs of the experimental site during the growing period (December 2006 to March 2007) Source: Bangladesh Metrological Department (Climate division), Agargaon, Dhaka-1207.

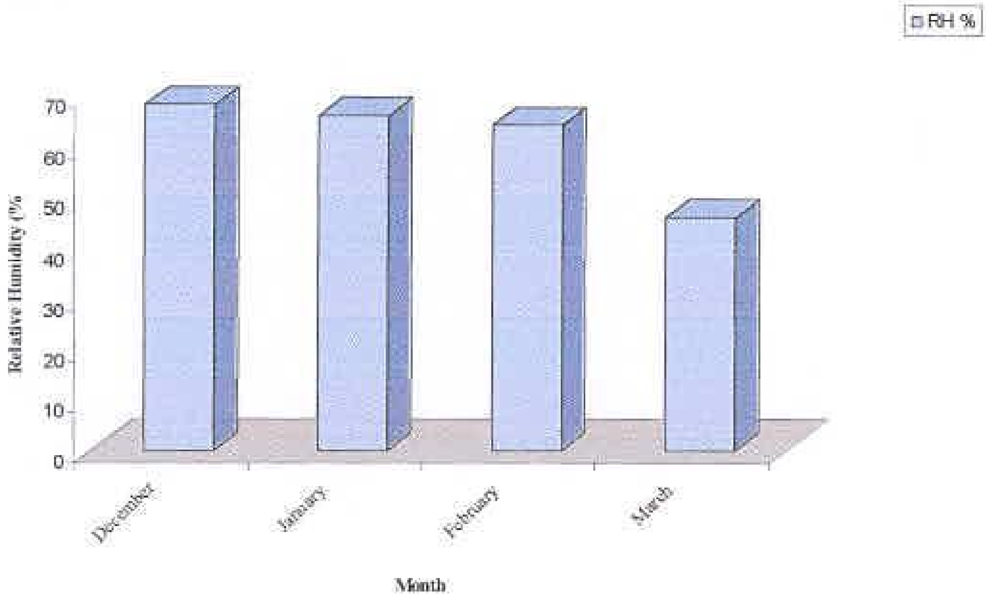

Fig. 3.6 Monthly average maximum and minimum relative humidity (%) of the experimental site during the growing period (December 2006 to March 2007) Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207.

3.4 Description of the cultivar

An improved local onion variety (Taherpuri) was used in this experiment. The characteristics of this variety, the bulbs are flat round, medium sized, resistant to *Alternaria*. The bulbs are rhombic and highly pungent with pinkish-red skin. Nearly 50-60% bulbs are single type, matures within 130-140 days and the yield ranged from 12-16 t/ha.

3.5 Land preparation

The selected land of the experimental plot was opened in the month of December 2006 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 Rates of fertilizer

N (Urea): 0, 60, 120 and 180 kg N ha^{-1}

K (M P): 0, 60 and 120 kg K ha^{-1}

3.7 Application of fertilizers

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 watering can and care was taken so that irrigated water could not pass from one plot to other.

3.8 Design and layout of the experiment

The experiment was laid out in a two factor Randomized Complete Block Design with three replications. The total number of plots was 36, each measuring 2.5 m × 1.8 m (4.5m). The distance maintained between two plots was 50 cm and between blocks was 100 cm. The layout of the experiment is presented in Figure 3.7.

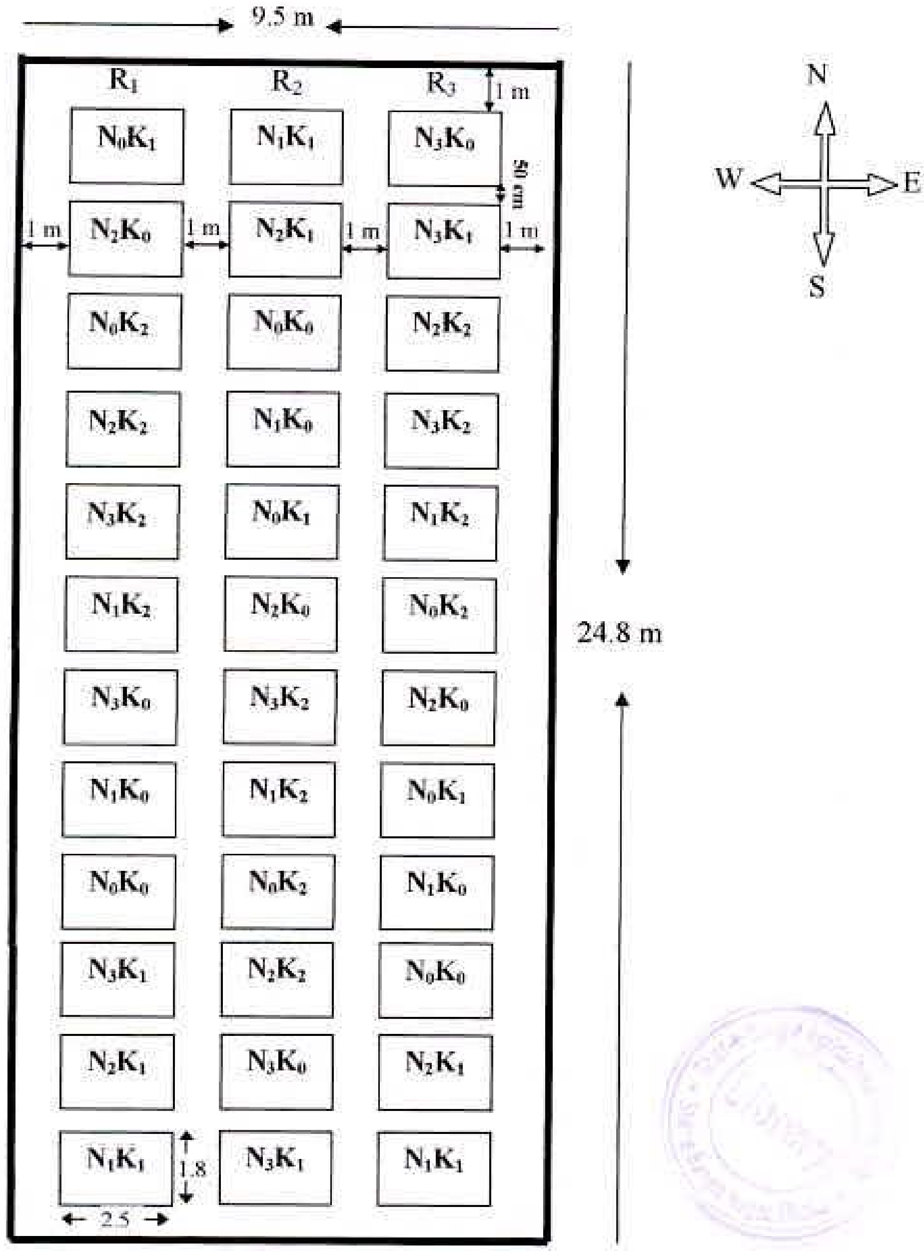

Fig. 3.7 Lay out of the experiment

3.9 Treatments of the experiment

The present experiment consisted of 2 factors, namely nitrogen and potassium. Nitrogen has four levels and potassium has three levels.

Factor A: Nitrogen levels

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

$N_1 = 60$ kg N ha^{-1}

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

$N_3 = 180$ kg N ha^{-1}

Factor B: Potassium levels

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

$K_1 = 60$ kg K ha^{-1}

$K_2 = 120$ kg K ha^{-1}

Treatment combinations:

$T_1 = N_0K_0$ Control (No Nitrogen +No Potassium)

$T_2 = N_0K_1$

$T_3 = N_0K_2$

$T_4 = N_1K_0$

$T_5 = N_1K_1$

$T_6 = N_1K_2$

$T_7 = N_2K_0$

$T_8 = N_2K_1$

$T_9 = N_2K_2$

$T_{10} = N_3K_0$

$T_{11} = N_3K_1$

$T_{12} = N_3K_2$

3.10 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 (Lipe and Skinner, 1979) 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, 2006. 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 strong sunshine. The germination was completed within 7 DAS days after sowing. Light irrigation, mulching and weeding was done whenever necessary.

3.11 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 25 cm and plant to plant spacing of 10 cm in the afternoon on 8th December 2006. 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.

3.12 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.

3.13 Gap filling

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

3.14 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.

3.15 Irrigation and drainage

Irrigation was given by watering can 2 times. First irrigation was given 20DATand 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.

3.16 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.

3.17 Removal of escape

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

3.18 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.

3.19 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.

3.20 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 were preserved for chemical analysis.

3.21 Collection of data

Five plants were selected randomly from each plot in such a way 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. Length of bulb per plant (cm)
5. Weight of single bulb (g)
6. Diameter of bulb per plant (cm)
7. Yield of bulb (t ha^{-1})

3.21.1 Plant height (cm)

The height of the selected five plants in each plot was measured after 30 days of transplanting (DAT) and then 10 days interval up to 85 days of transplanting. The height was measured in centimeters (cm) from the neck of the bulb to the tip of the longest leaf and average heights of the selected five plants were taken.

3.21.2 Number of leaves per plant

The number of leaves per plant from five selected plants from each plot was counted after 30 DAT and the average of five plants was taken as the number of leaves per plant. The number of leaves per plant was also recorded at an interval of 10 days up to 85 days of transplanting.

3.21.3 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 60 DAT and their average was recorded.

3.21.4 Length of bulb per plant (cm)

The 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).

3.21.5 Weight of single bulb (g)

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

3.21.6 Diameter of bulb (cm)

The diameter 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.

3.21.7 Yield of bulb

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

3.22 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.

3.23 Analysis of soil samples

Soil samples were analyzed for both physical and chemical properties in the laboratory of the Soil Resource Development Institute, Dhaka. The properties studied included texture, pH, and organic carbon, total N, P, K and S. The initial physical and chemical properties of the soil have been presented in Table 2. The soil was analyzed following standard methods:

3.23.1 Methods for Soil Analysis

3.23.1.1 Physical analysis of soil

3.23.1.1.1 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).

3.23.2 Chemical analysis of soil

3.23.2.1 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).

3.23.2.2 Organic carbon (%)

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

3.23.2.3 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).

3.23.2.4 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 (LKB Nova spec, 1949).

3.23.2.5 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).

3.23.2.6 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 (LKB Nova spec, 4049).

3.24 Chemical analysis of plant samples

3.24.1 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 72 hours. The dried samples were then ground with a grinding mill. The prepared samples were kept in a desiccator for analysis.

3.24.2 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.

3.24.3 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, 6ml of 6N HCl were added to it. . This digest was used for determining P, K and S.

3.24.4 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 lengths.

3.25 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 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 three levels of potassium and their interaction effects on vegetative growth and yield of onion. The growth and yield components 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 4.1 to 4.6 and Appendix Figures 1 to 34. The results of each parameter have been discussed and possible interpretations whenever necessary have been given under the following headlines:

4.1 Plant height (cm)

4.1.1 Effect of nitrogen on the plant height of onion

The effects of nitrogen on the plant height of onion are presented in (Table 4.1 and Appendix Fig. 1). The plant height was significantly influenced by different levels of nitrogen. Among the different doses of nitrogen, N_3 (180 kg ha$^{-1)}$ showed the highest plant height (134.98 cm) and it was not significantly different from N_2 (120 kg ha^{-1}) (133.16cm) treatment. On the other hand, the lowest plant height (110.21cm) 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 Pandey 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).

Table 4.1 Effect of nitrogen on the growth parameters of onion.

N fertilizers	Plant height (cm)	Leaf plant^{-1}	Leaf length (cm)
N_0	110.21c	8.78a	30.28b
N_1	126.03b	9.31a	33.95ab
N_2	133.16a	9.94a	35.61a
N_3	134.98a	10.56a	36.61a
$LSD_{0.05}$	**6.034**	**1.84**	**4.125**

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

4.1.2 Effect of Potassium on the plant height of onion.

Potassium showed statistically non-significant variation in respect of plant height when fertilizers in different doses were applied (Table 4.2 and Appendix Fig. 8).However among the different doses of fertilizer, K_2 (120 kg ha^{-1}) showed the highest plant height (127.78 cm).

Table 4.2 Effect of Potassium fertilizer on the growth parameters of onion

K Fertilizers	Plant height (cm)	leaf $plant^{-1}$ (cm)	Leaf length (cm)
K_0	124.51a	9.54a	33.15a
K_1	125.99a	9.81a	34.35a
K_2	127.78a	9.58a	34.83a
$LSD_{0.05}$	**10.02**	**2.08**	**4.68**

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

4.1.3 Combined effect of nitrogen and potassium on the growth parameters of plant height of onion

Combined application of different doses of nitrogen and potassium had significant effect on the plant height of onion (Table 4.3 and Appendix Fig. 15). The lowest plant height (107.30 cm) was observed in the treatment combination of N_0K_0 (no nitrogen and no potassium). On the other hand, the highest plant height (138.43 cm) was recorded with N_3K_2 treatment.

Table 4.3 Combined effects of nitrogen and potassium on the growth parameters of onion

N × K Fertilizers	Plant height (cm)	Leaf plant^{-1} (cm)	Leaf length (cm)
N_0K_0	107.30e	8.50c	28.17b
N_0K_1	107.86e	9.16bc	31.17cb
N_0K_2	115.45b	8.67bc	31.50cd
N_1K_0	125.00c	10.33ab	34.17bc
N_1K_1	124.73c	11.00a	34.50bc
N_1K_2	128.37bc	10.33ab	33.17bc
N_2K_0	135.00ab	9.16bc	35.10abc
N_2K_1	135.60ab	9.60abc	33.23bc
N_2K_2	128.87bc	9.16bc	38.50a
N_3K_0	130.77abc	10.00abc	35.17abc
N_3K_1	135.73ab	9.50abc	38.50a
N_3K_2	138.43a	10.33ab	36.17ab
$LSD_{0.05}$	**4.78**	**1.56**	**3.496**

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 Leaf plant^{-1}

4.2.1 Effect of nitrogen on the leaf plant^{-1} of onion

No significant variation was observed in leaf plant^{-1} of onion when different doses of nitrogen were applied (Table 4.1 and Appendix Fig. 2). The highest leaf plant^{-1} (10.56) was recorded in N_3 (180 kg ha^{-1}), which was statistically similar with the other doses of nitrogen application. The lowest leaf plant^{-1} (8.78) 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 not significant. The finding of Vachhani and Patel (1993) was in support with these results. The increased leaf 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.

4.2.2 Effect of potassium on the leaf plant^{-1} of onion.

No significant variation was observed in leaf plant^{-1} of onion when different doses of potassium were applied (Table 4.2 and Appendix Fig. 9). Among the different doses of fertilizers K_1 treatment, showed the highest leaf plant^{-1} (9.81cm), which was statistically similar with the different fertilizer doses. On the contrary, the lowest leaf plant^{-1} (9.54cm) was observed with K_0, where no fertilizer was applied.

4.2.3 Combined effects of nitrogen and potassium on the growth parameters of onion

The combined effect of different doses of nitrogen and potassium fertilizer on leaf plant^{-1} of onion was significant (Table 4.3 and Appendix Fig. 16). The highest leaf plant^{-1} (11) was recorded with the treatment combination of N_1K_1. On the other hand, the lowest leaf plant^{-1} (8.50) was found in N_0K_0 treatment (no nitrogen and no potassium).

4.3 Leaf length (cm)

4.3.1 Effect of nitrogen on the leaf length of onion

The leaf length as affected by different doses of nitrogen showed a statistically significant variation (Table 4.1 and Appendix Fig. 3). Among the different doses of nitrogen the highest leaf length (36.61 cm) was observed in N_3 (180 kg ha^{-1}), which was statistically identical (35.61cm) with N_2 (120kg ha^{-1}) and N_1 (60kg ha^{-1}) the lowest leaf length (30.28 cm) was recorded in the N_0 treatment where no nitrogen was applied. Increasing level of nitrogen increased the height of plant.

4.3.2 Effect of potassium fertilizer on the leaf length of onion.

Application of potassium fertilizer at different doses showed no significant variation on the leaf length of onion (Table 4.2 and Appendix Figure. 10). Among the different fertilizer doses K_2 treatment, showed the highest leaf length (34.83 cm), which was closely followed (34.35 cm) by the fertilizer dose of K_1. On the other hand, the lowest leaf length (33.15 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.

4.3.3. Combined effects of nitrogen and potassium on the growth parameters of onion

Combined effects of different doses of nitrogen and potassium fertilizers on leaf length showed a statistically significant variation (Table 4.3 and Appendix Fig. 17). The highest leaf length (38.50 cm) was recorded in the treatment combination of both N_2K_2 and N_3K_1. On the other hand, the lowest leaf length (28.17cm) was found in N_0K_0.

4.4 Yield and yield contributing characters

4.4.1 Diameter of bulb per plant (cm)

4.4.1.1 Effect of nitrogen on the diameter of onion bulb per plant

The variations in respect of bulb diameter due to the effects of different levels of nitrogen were found to be statistically significant. The maximum diameter of bulb (4.39 cm) was observed from the plants grown with N_3 (180 kg ha^{-1}) which was statistically similar with N_2 (120 kg ha^{-1}) treatments. The control plants produced the minimum diameter (3.20cm) of bulb. The diameter of bulb increased with the increase level of nitrogen. Verma *et al* (1972) observed that bulb size increased in response at 200 kg ha^{-1}. Vachhani and Patel (1993) observed the highest bulb diameter from the application of 150 kg ha^{-1}.

Table 4.4 Effect of nitrogen on the yield contributing characters and the yield of onion

N fertilizers	Diameter of bulb plant^{-1} (cm)	Length of bulb plant^{-1} (cm)	Weight of single bulb (gm)	Yield of bulb (t/ha^{-1})
N_0	3.20c	4.74a	29.51b	6.70c
N_1	3.72bc	5.17a	33.67ab	7.62b
N_2	3.96ab	5.13a	37.67a	8.53a
N_3	4.39a	4.95a	31.48b	7.02bc
$LSD_{0.05}$	**0.6254**	**0.6863**	**4.233**	**0.8213**

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

4.4.1.2 Effect of potassium on the diameter of onion bulb per plant

Diameter of bulb per plant showed no significant variation due to the effects of different levels of potassium (Table 4.4 and Appendix Fig. 11).The highest bulb diameter (3.95 cm) was obtained from the grown with the dose of K_2 (120 kg ha^{-1}) which was statistically similar with those of plants under K_0 and K_1 treatment. The lowest diameter (3.69 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 sulphur ha^{-1}.

Table 4.5 Effect of Potassium fertilizer on the yield contributing characters and the yield of onion.

K Fertilizer	Diameter of bulb $plant^{-1}$ (cm)	Length of bulb $plant^{-1}$ (cm)	Weight of single bulb (gm)	Yield of bulb (t ha^{-1})
K_0	3.69a	4.94a	30.98a	7.03a
K_1	3.81a	5.10a	34.35a	7.77a
K_2	3.95a	4.95a	33.91a	7.60a
$LSD_{0.05}$	**0.7097**	**0.7787**	**4.803**	**0.9319**

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

4.4.1.3 Combined effect of nitrogen and potassium fertilizer on the diameter of onion bulb per plant

The combined effect of different doses of nitrogen and potassium fertilizer showed a statistically significant effect on the diameter of bulb per plant of onion (Table 4.6 and Appendix Fig. 18).The highest diameter of onion bulb (4.58cm) was recorded with the treatment combination of N_3K_2 which was statistically identical with N_3K_1 and N_3K_0 On the other hand, the minimum diameter of onion bulb (3.07 cm) was observed from N_0K_0 treatment (no nitrogen and no potassium).

Table 4.6 Combined effect of nitrogen and potassium fertilizer on the yield contributing characters of onion

N × K Fertilizers	Diameter of bulb plant^{-1} (cm)	Length of bulb plant^{-1} (cm)	Weight of single bulb (g)	Yield of bulb (t ha^{-1})
N_0K_0	3.07g	4.70a	27.47e	6.29e
N_0K_1	3.18fg	4.70a	30.21de	6.85de
N_0K_2	3.35efg	4.83a	30.87de	6.99de
N_1K_0	3.61defg	5.10a	32.57cd	7.37cd
N_1K_1	3.72cdef	5.36a	33.43cd	7.57cd
N_1K_2	3.83bcde	5.06a	35.00bc	7.94c
N_2K_0	3.85bcde	5.33a	33.37cd	7.56cd
N_2K_1	3.980bcd	5.03a	41.45a	9.40a
N_2K_2	4.05abcd	4.70a	38.17ab	8.64b
N_3K_0	4.23abc	5.00a	30.50de	6.92de
N_3K_1	4.37ab	5.00a	32.30cd	7.32cd
N_3K_2	4.58a	4.85a	31.63cd	6.84de
$LSD_{0.05}$	**0.5301**	**0.5817**	**3.588**	**0.6961**

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

4.4.2 Length of bulb plant^{-1} (cm)

4.4.2.1 Effect of nitrogen on the length of onion bulb plant^{-1}

There was no significant variation in the length of bulb plant^{-1} (cm) in onion when different doses of nitrogen fertilizer were applied (Table 4.4 and Appendix Fig. 5). The highest length of bulb plant^{-1} (5.17 cm) was recorded in N_1 treatment. The lowest length of bulb plant^{-1} (4.74 cm) was recorded in the N_0 treatment where no nitrogen fertilizer was applied.

4.4.2.2 Effect of potassium fertilizer on the length of onion bulb plant^{-1}

Application of potassium fertilizer at different doses showed no significant variation on length of bulb (Table 4.5 and Appendix Fig. 12). Among the different fertilizer doses K_1 treatment, showed the highest length of bulb (5.10 cm), which was statistically similar with those of plants under K_0 and K_2 treatment. The lowest length of bulb (4.94 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.

4.4.2.3 Combined effect of nitrogen and potassium fertilizers on the length of onion bulb plant^{-1}

The combined effect of different doses of nitrogen and potassium fertilizer on the length of bulb plant^{-1} was not significant (Table 4.6 and Appendix Fig. 19). However, the highest length of bulb plant^{-1} (5.36 cm) was recorded with the treatment combination of N_1K_1. On the other hand, the lowest length of bulb plant^{-1} (4.70 cm) was found in N_0K_0, N_0K_1 and N_2K_2 treatments.

4.4.3 Weight of single bulb (g)

4.4.3. Effect of nitrogen on the weight of single bulb of onion.

Different levels of nitrogen gave significant results on the weight of onion bulb. The weight of bulb varied from 29.51 to 37.67(g). (Table 4.4 and Appendix Fig.6). The highest weight of single bulb (37.67 g) was recorded in N_2 treatment (120kg ha^{-1}). The lowest weight of single bulb (29.51 g) was recorded in the N_0 treatment where no nitrogen was applied, which was statistically similar with N_3 treatment (180 kg ha^{-1}).

4.4.3.2 Effect of potassium fertilizer on the weight of single bulb of onion

The effect of different doses of potassium fertilizer on the weight of single bulb of onion was not significant (Table 4.5 and Appendix Fig.13). However, the highest weight of single bulb of onion (34.35 g) was recorded with the treatment of K_1. On the other hand, the lowest weight of single bulb of onion (30.98 g) was found in K_0 treatment, where no fertilizer was applied.

4.4.3.3 Combined effect of nitrogen and potassium fertilizer on the weight of single bulb of onion

The data on the average weight of bulb per plant were analyzed and shown in (Table 4.6 and Appendix Fig. 20). The maximum weight of single onion bulb (41.45 g) was recorded with the treatment combination of N_2K_1. On the other hand, the minimum weight of single onion bulb (27.47 g) was observed from N_0K_0 treatment (no nitrogen and no potassium). The findings of Jitendra *et al.* (1989) were in agreement with the present results. They stated that 160 kg N and 100 kg K/ha produced better bulb quality.

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

4.4.4.1 Effect of nitrogen on the yield of onion bulb

Significant variation was observed on the yield of bulb of onion when different doses of nitrogen fertilizer were applied (Table 4.4 and Appendix Fig. 7). The highest yield of bulb (8.53 t ha^{-1}) was recorded in N_2 (180 kg ha^{-1}) which was statistically dissimilar with other treatments. The lowest yield of bulb (6.70 t ha^{-1}) was recorded in the N_0 treatment where no fertilizer was applied.

4.4.4.2 Effect of potassium fertilizers on the yield of onion bulb.

The results of the single effects of different levels of potassium have been shown in (Table 4.5 and Appendix Fig. 14).From the table it was apparent that K_1 (60 kg ha^{-1}) treatment gave the highest yield (7.77 t ha^{-1}). On the contrary, the lowest yield of bulb (7.03 t ha^{-1}) was observed with N_0, where no potash was applied.

4.4.4.3 Combined effect of nitrogen and potassium fertilizers on the yield of onion bulb.

The combined effect of different doses of nitrogen and potassium fertilizer on the yield of bulb of onion was significant (Table 4.6 and Appendix Fig. 21). The highest yield of bulb (9.40 t ha^{-1}) was recorded with the treatment combination of N_2K_1. On the other hand, the lowest yield of bulb (6.29 t ha^{-1}) was found in N_0K_0 treatment (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.

4.5 Effect of nitrogen on nitrogen concentrations in bulb and post harvest soil of onion

4.5.1 Effect of nitrogen on nitrogen concentrations in bulb of onion

N concentration of bulb was not significantly influenced by the application levels of nitrogen (Table 4.7 Appendix Fig. 22). The highest nitrogen concentration in onion bulb (2.65 %) was recorded in N_2 (120 kg ha^{-1}), which showed similar result with N_3 (180 kg/ha) treatment. On the other hand, the lowest nitrogen concentration in onion bulb (2.33 %) was recorded in N_0 treatment where no nitrogen was applied.

Table 4.7 Effect of nitrogen fertilizer on the nitrogen concentrations in bulb and post harvest soil

Nitrogen fertilizers	N concentration (%)	
	Bulb	Soil
N_0	2.33a	0.082a
N_1	2.45a	0.082a
N_2	2.65a	0.087a
N_3	2.61a	0.088a
$LSD_{0.05}$	**0.3996**	**0.1998**

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

4.5.2 Effect of nitrogen on nitrogen concentrations in post harvest soil of onion field

The effect of different doses of nitrogen fertilizer showed a statistically insignificant variation in the nitrogen concentration in post harvest soil (Table 4.7 and Appendix Fig. 23) of onion field. The total N content of the post harvest soil varied from 0.082 % to 0.088 %. Among the different doses of nitrogen fertilizer, N_3 (180 kg ha^{-1}) treatment showed the highest nitrogen concentration (0.088 %) in soil, which was similar to N_2 (120 kg ha^{-1}) treatment. The lowest value was 0.082 % under control treatment and N_1.

4.5.3 Effect of potassium on nitrogen concentrations in bulb of onion

K concentration of bulb was not significantly influenced by application levels of potassium (Table 4.8 Appendix Fig. 24). The highest potassium concentration in onion bulb (2.62 %) was recorded in K_2 (120 kg/ha), which showed statistically similar result with other treatments. On the other hand, the lowest potassium concentration in onion bulb (2.45 %) was recorded in K_0 treatment where no potassium was applied.

Table 4.8 Effect of potassium fertilizer on the nitrogen concentrations in bulb and post harvest soil

K fertilizers	N concentration (%)	
	Bulb	**Soil**
K_0	2.45a	0.082a
K_1	2.62a	0.088a
K_2	2.47a	0.085a
$LSD_{0.05}$	**0.4534**	**0.02267**

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

4.5.4 Effect of potassium on nitrogen concentrations in post harvest soil of onion field

The effect of different doses of potassium fertilizer showed a statistically insignificant variation in the nitrogen concentration in post harvest soil (Table 4.8 and Appendix Fig .25) of onion field. The total N content of the post harvest soil varied from 0.082 % to 0.088 %. The highest total N content (0.088 %) was observed in K_1 (60 kg/ha) treatment and the lowest value of 0.082 % under control (K_0) treatment.

4.5.5 Combined effect of nitrogen and potassium fertilizers on the nitrogen content in bulb of onion plant

Significant effect of combined application of different doses of nitrogen and potassium fertilizer on the nitrogen concentration was observed in bulb of onion (Table 4.9 and Appendix Fig. 26). The highest concentration of nitrogen in the bulb

(3.13 %) was recorded in the treatment combination of N_2K_1. On the other hand, the lowest nitrogen concentration (2.11 %) in bulb was found in N_0K_0.

Table 4.9 Combined effects of N and K fertilizer on the nitrogen concentrations in bulb and post harvest soil

N × K Fertilizer	N concentration (%)	
	Bulb	Soil
N_0K_0	2.11c	0.010e
N_0K_1	2.40bc	0.087abc
N_0K_2	2.49bc	0.083abc
N_1K_0	2.56b	0.080bc
N_1K_1	2.35bc	0.083abc
N_1K_2	2.43bc	0.083abc
N_2K_0	2.34bc	0.080bc
N_2K_1	3.13a	0.073c
N_2K_2	2.48bc	0.093a
N_3K_0	2.67b	0.090abc
N_3K_1	2.71b	0.083abc
N_3K_2	2.47bc	0.080bc
$LSD_{0.05}$	**0.3387**	**0.01693**

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

4.5.6 Combined effect of nitrogen and potassium fertilizers on the nitrogen content in post harvest soil of onion field

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 4.9 and Appendix Fig. 28). The highest concentration of nitrogen in post harvest soil (0.093 %) was recorded in the treatment combination of N_2K_2. On the other hand, the lowest nitrogen concentration (0.01 %) in post harvest soil was found in N_0K_0.

4.6 Effect of nitrogen on potassium concentrations in bulb and soil of onion

4.6.1 Effect of nitrogen on potassium concentrations in bulb of onion

K concentration of bulb was significantly influenced by application levels of nitrogen (Table 4.10 Appendix Fig. 29). The highest potassium concentration in onion bulb (0.406 %) was recorded in N_3 (180 kg ha^{-1}), which showed similar result with N_2 (120 kg ha^{-1}) treatment. On the other hand, the lowest potassium concentration in onion bulb (0.347 %) was recorded in N_0 treatment where no nitrogen was applied.

Table 4.10 Effect of nitrogen on the potassium concentration in the bulb and post harvest soil

Fertilizers	K concentration (%)	
	Bulb	Soil
N_0	0.347b	0.118b
N_1	0.358b	0.143a
N_2	0.393a	0.133ab
N_3	0.406a	0.132ab
$LSD_{0.05}$	**0.01998**	**0.01998**

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

4.6.2 Effect of nitrogen on potassium concentrations 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 4.7 and Appendix Fig. 30) of onion field. The total K content of the post harvest soil varied from 0.118 % to 0.143 %. Among the different doses of nitrogen fertilizer, N_1 (60 kg ha^{-1}) treatment showed the highest potassium concentration (0.143 %) in soil. The lowest value was 0.118 % under control treatment.

4.6.3 Effect of potassium on potassium concentrations in bulb of onion

K concentration of bulb was significantly influenced by application levels of potassium (Table 4.11 Appendix Fig. 31). The highest potassium concentration in onion bulb (0.410 %) was recorded in K_2 (120 kg ha^{-1}) treatment. On the other hand, the lowest potassium concentration in onion bulb (0.334 %) was recorded in K_0 treatment where no potassium was applied.

Table 4.11 Effect of potassium fertilizer on the potassium concentrations in bulb and post harvest soil

K Fertilizer	K concentration (%)	
	Bulb	**Soil**
K_0	0.334c	0.125a
K_1	0.383b	0.170a
K_2	0.410a	0.143a
$LSD_{0.05}$	**0.2267**	**0.2267**
CV		

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

4.6.4 Effect of potassium on potassium concentrations in post harvest soil of onion field

The effect of different doses of potassium fertilizer showed a statistically insignificant variation in the potassium concentration in post harvest soil (Table 4.11 and Appendix Fig. 32) of onion field. The total K content of the post harvest soil varied from 0.125 % to 0.170 %. The highest total K content (0.170 %) was observed in K_1 (60 kg ha^{-1}) treatment and the lowest value of 0.125 % under control (K_0) treatment.

4.5.5 Combined effect of nitrogen and potassium fertilizers on the potassium content in bulb of onion

Significant effect of combined application of different doses of nitrogen and potassium fertilizer on the potassium concentration was observed in bulb of onion (Table 4.12 and Appendix Fig. 33). The highest concentration of potassium in the bulb (0.447 %) was recorded in the treatment combination of N_3K_2. On the other hand, the lowest potassium concentration (0.300 %) in bulb was found in N_0K_0.

Table 4.12 Combined effect of nitrogen (N) and potassium (K) fertilizers on the potassium concentrations in the bulb and post harvest soil

N × K Fertilizer	K concentration (%)	
	Bulb	Soil
N_0K_0	0.300e	0.113e
N_0K_1	0.350d	0.120de
N_0K_2	0.390c	0.120de
N_1K_0	0.337d	0.130bcde
N_1K_1	0.353d	0.133bcd
N_1K_2	0.383c	0.167a
N_2K_0	0.347d	0.123cde
N_2K_1	0.413b	0.137bcd
N_2K_2	0.420b	0.140bc
N_3K_0	0.353d	0.127cde
N_3K_1	0.4317b	0.143cde
N_3K_2	0.447a	0.147be
$LSD_{0.05}$	**0.01693**	**0.01693**

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

4.6.6 Combined effect of nitrogen and potassium fertilizers on the potassium content in post harvest soil of onion field

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 4.12 and Appendix Fig. 27). The highest concentration of potassium in post harvest soil (0.167 %) was recorded in the treatment combination of N_1K_2. On the other hand, the lowest nitrogen concentration (0.113 %) in post harvest soil was found in N_0K_0.

Chapter 5
Summary and Conclusion

Chapter 5

SUMMARY AND CONCLUSION

The experiment was carried out at the Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during December 2006 to March 2007 to evaluate the effect of different fertilizer levels nitrogen and potassium and their interaction on the yield of onion. The soil was silty clay loam in texture having pH 5.80, and organic matter content 1.34 %. The experiment comprised of two factors such as (a) four levels of nitrogen viz; 0, 60, 120 and 180 kg ha^{-1} and (b) three levels of potassium viz 0, 60 and 120 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 × 1.8m and 102 plants were accommodated in each plot with spacing 20cm × 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, bulb diameter, bulb length, single bulb wt. and single bulb yield per plot. The colleted data were analyzed and the 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_3 (180 kg ha^{-1}) gave the highest plant height (134.98cm) and the minimum (110.21cm) in plants receiving no nitrogenous fertilizer. The application of potassium had statistically non- significant effect on plant height. The combined effect of nitrogen and potassium was found statistically significant at different doses. The highest plant height (138.43 cm) was recorded with N_3K_2 treatment (180 kg nitrogen + 120 kg potassium ha^{-1})and the lowest plant height (107.30 cm) was observed in the treatment combination of N_0K_0 (no nitrogen and no potassium).

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 leaf plant^{-1} of onion was significant. The highest leaf plant^{-1} (11cm) was recorded with the treatment combination of N_1K_1. On the other hand, the lowest leaf plant^{-1} (8.50cm) 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 (36.61 cm) was observed in N_3 (180 kg/ha) and the lowest leaf length (30.28 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 no significant variation on the leaf length of onion.

The variations in respect of bulb diameter due to the effects of different levels of nitrogen were found to be statistically significant. The maximum diameter of bulb (4.39 cm) was observed from the plants grown with N_3 (180 kg ha^{-}). The control plants produced the minimum diameter (3.20cm) of bulb. No significant variation was observed by the application of potassium on the diameter of bulb. Combined effect of nitrogen and potassium showed significant effects on bulb diameter. The maximum diameter of bulb (4.58 cm) was observed from the plants grown with N_3K_2 treatment and the minimum diameter (3.07cm) of bulb was observed with the treatment combination of N_0K_0.

The length of bulb was not greatly influenced by the application of nitrogen and potassium as well as their combinations. Significant variation on single bulb weight was observed by different levels of nitrogen applied. The maximum bulb weight was recorded from the dose of 120 kg N and 60 kg K ha^{-}). The minimum individual bulb weight (27.47 g) was found when the plants were raised without any nitrogen and potassium (absolute control).The combined effect of nitrogen and potassium was also significant. The maximum weight of single onion bulb (41.45 g) was recorded with the treatment combination of N_2K_1. On the other hand, the minimum weight of single onion bulb (27.47 g) was observed from N_0K_0 treatment.

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 (8.53 t ha^{-1}) was obtained from the plants fertilized with 120 kg N ha^{-1} and minimum (6.70 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 (9.40 t ha^{-1}) was recorded with the treatment combination of N_2K_1 and the lowest yield of bulb (6.2940 t ha^{-1}) was found in N_0K_0 treatment (no nitrogen and no potassium).

The N contents in onion bulb and post harvest soil of onion field were not significantly influenced by the application of nitrogen and potassium fertilizer alone. However, the highest N concentration in the bulb (3.13%) and in the soil (0.093%) was N_2K_1 and N_2K_2 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 (0.40%), K_2 (0.41%) and N_3K_2 (0.447%), where the lowest K concentration were found in, N_0 (0.347%), K_0 (0.334%) and N_0K_0 (0.300%) 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_1 (0.143) and N_1K_2 (0.167%) treatments and the lowest was in N_0 (0.118%) and N_0K_0 (0.113%), treatments where no fertilizers were applied.

From the above discussion it can be concluded that application of N at the rate of 120kg/ha and the Kat the rate of 60kg 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

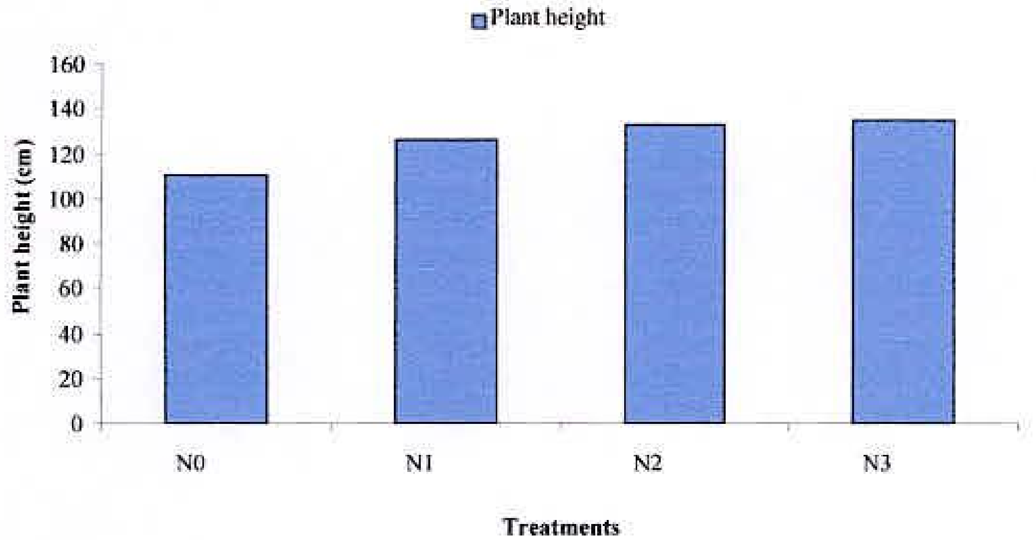

Fig.1 Effect of nitrogen on the plant height (cm) of onion

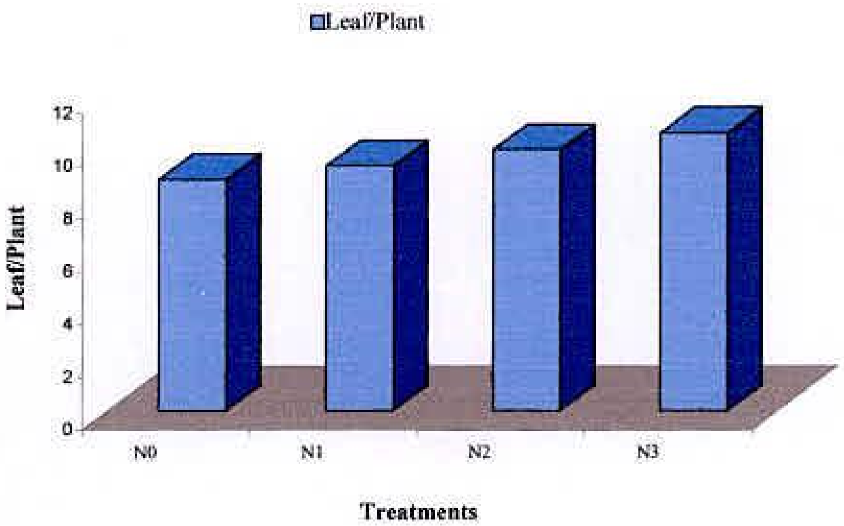

Fig.2 Effect of nitrogen on the leaf plant^{-1} of onion.

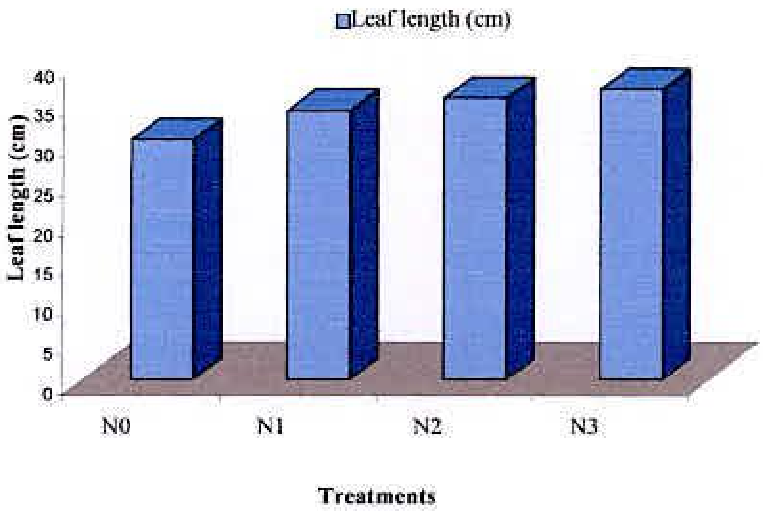

Fig. 3 Effect of nitrogen on the leaf length (cm) of onion

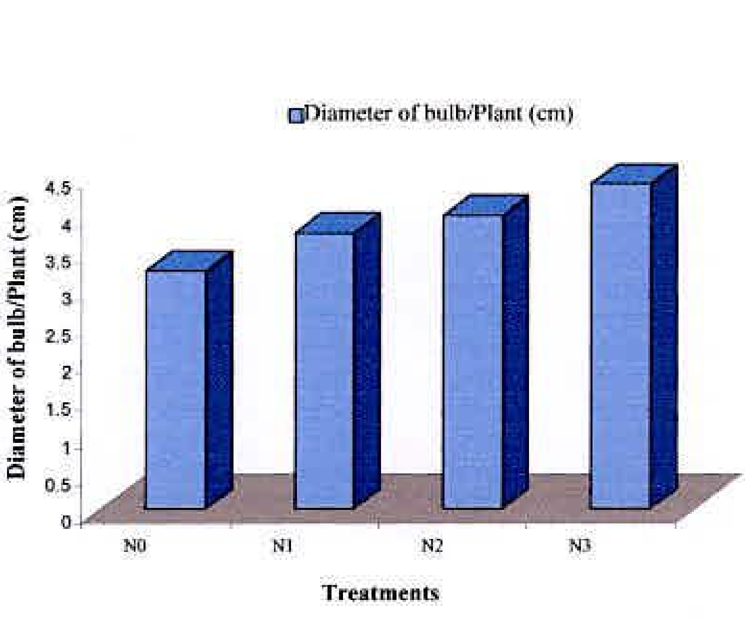

Fig. 4 Effect of nitrogen on the diameter of bulb (cm) of onion

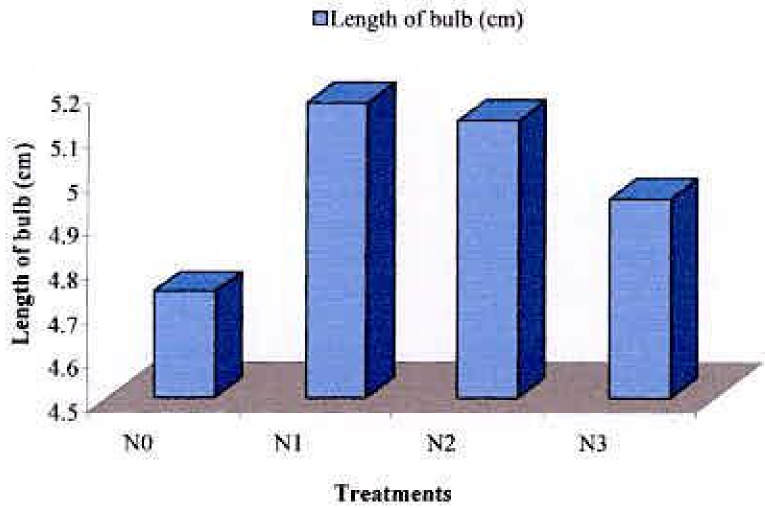

Fig. 5 Effect of nitrogen on the length of bulb (cm) of onion

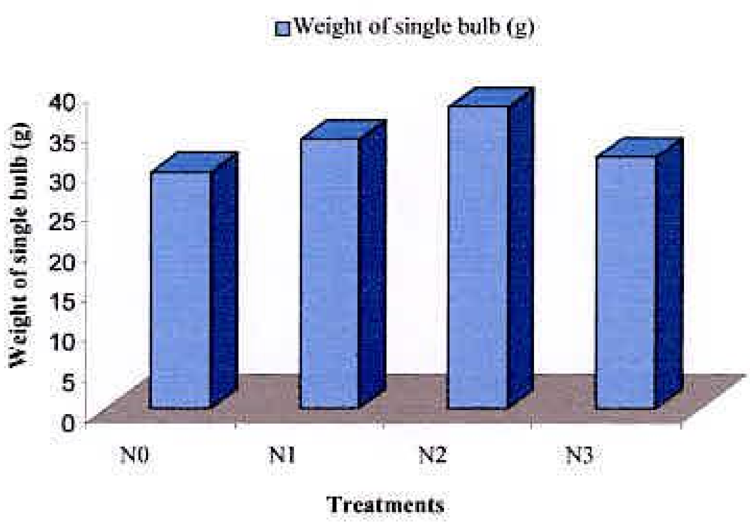

Fig. 6 Effect of nitrogen on the weight of single bulb (g) of onion

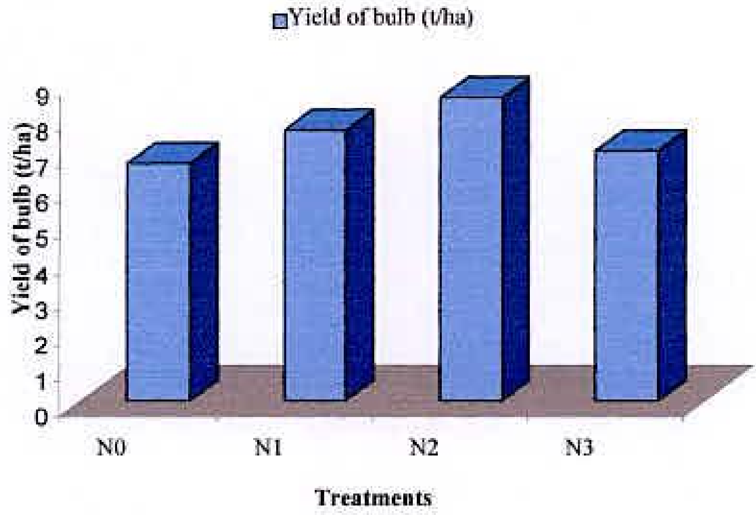

Fig. 7 Effect of nitrogen on the yield of bulb (t ha^{-1}) of onion

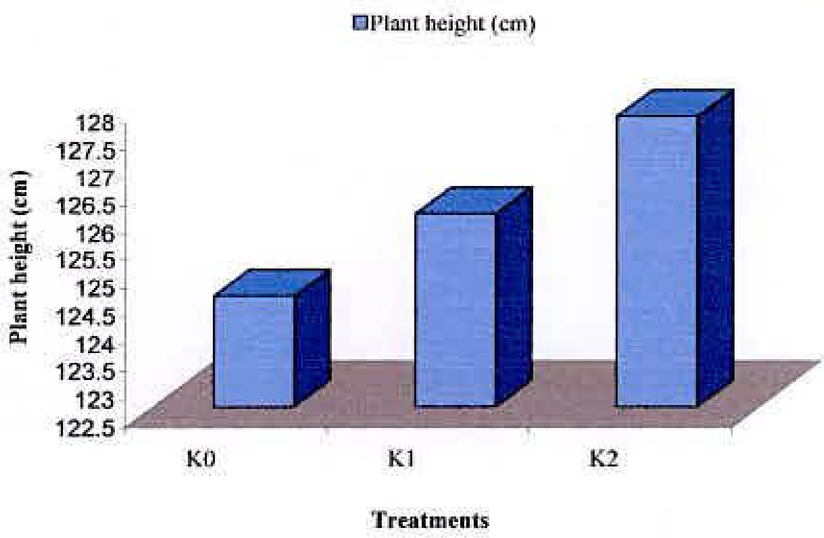

Fig. 8 Effect of potassium on the plant height (cm) of onion

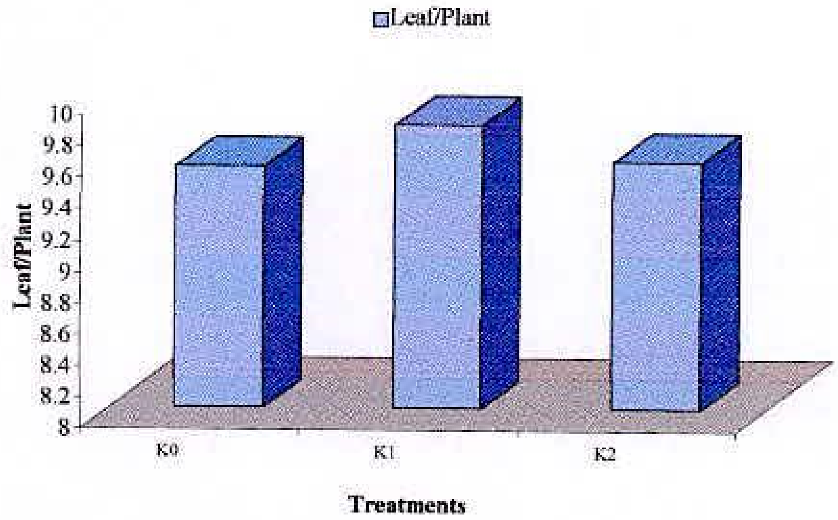

Fig. 9 Effect of potassium on the leaf plant^{-1} of onion

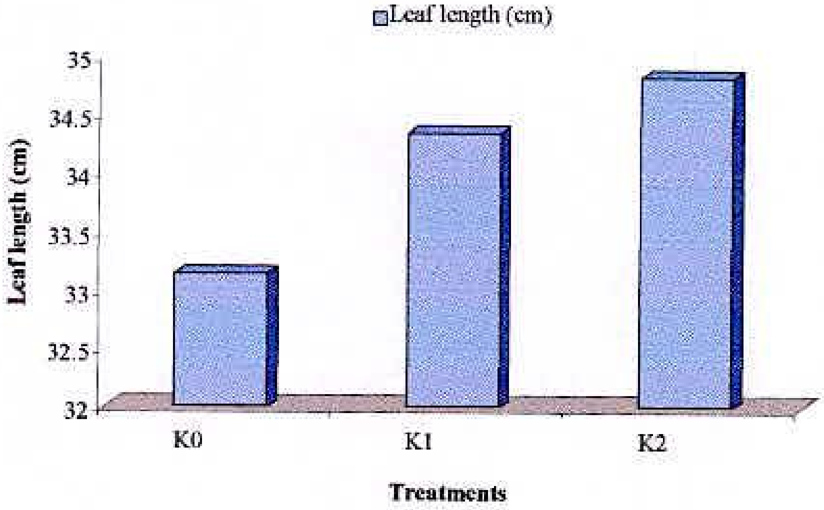

Fig. 10 Effect of potassium on the leaf length (cm) of onion

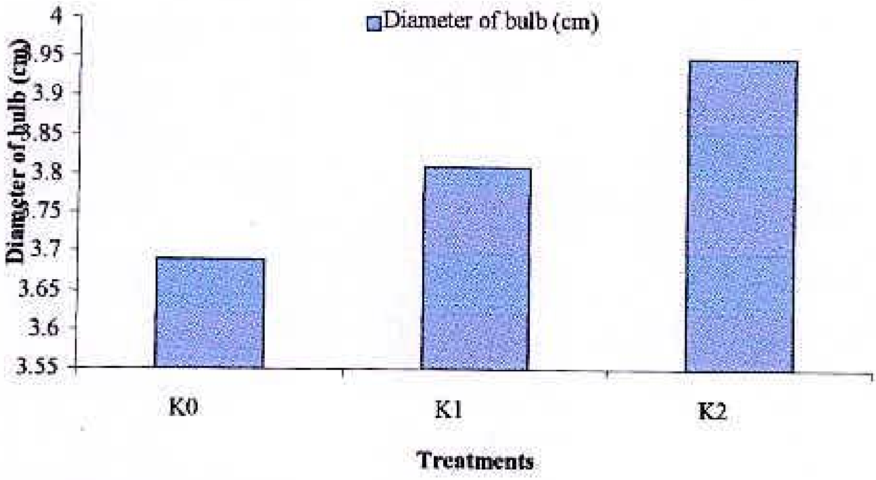

Fig. 11 Effect of potassium on the diameter of bulb (cm) of onion

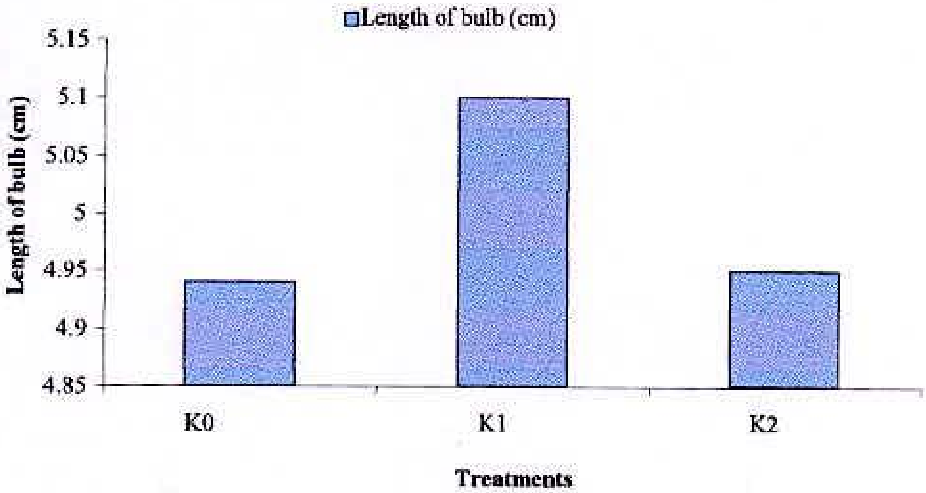

Fig. 12 Effect of potassium on the length of bulb (cm) of onion

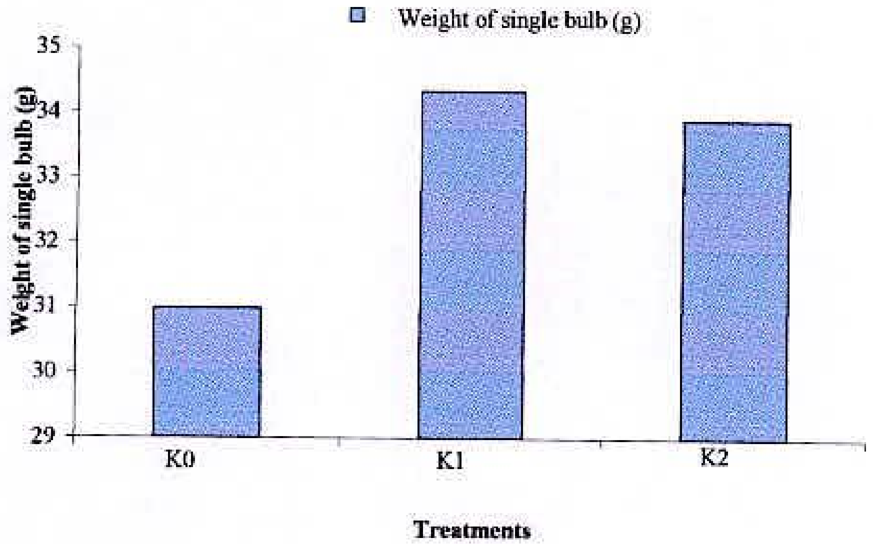

Fig. 13 Effect of potassium on the weight of single bulb (gm) of onion

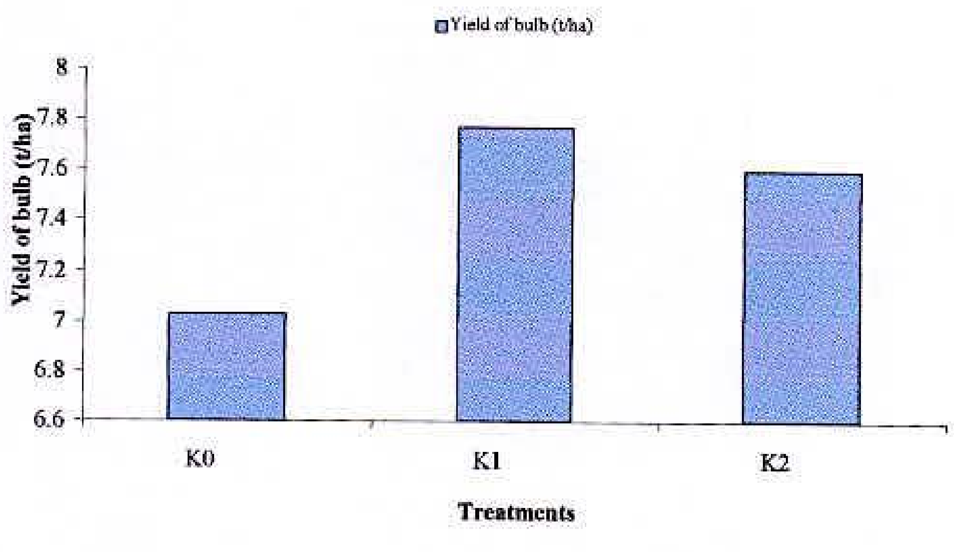

Fig. 14 Effect of potassium on the yield of bulb ($t\ ha^{-1}$) of onion

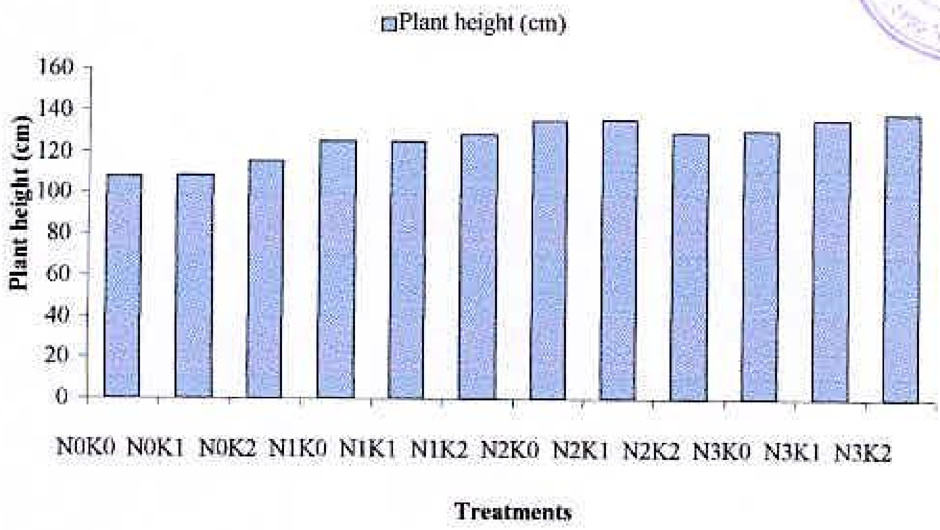

Fig. 15 Combined effect of nitrogen and potassium on the plant height of onion

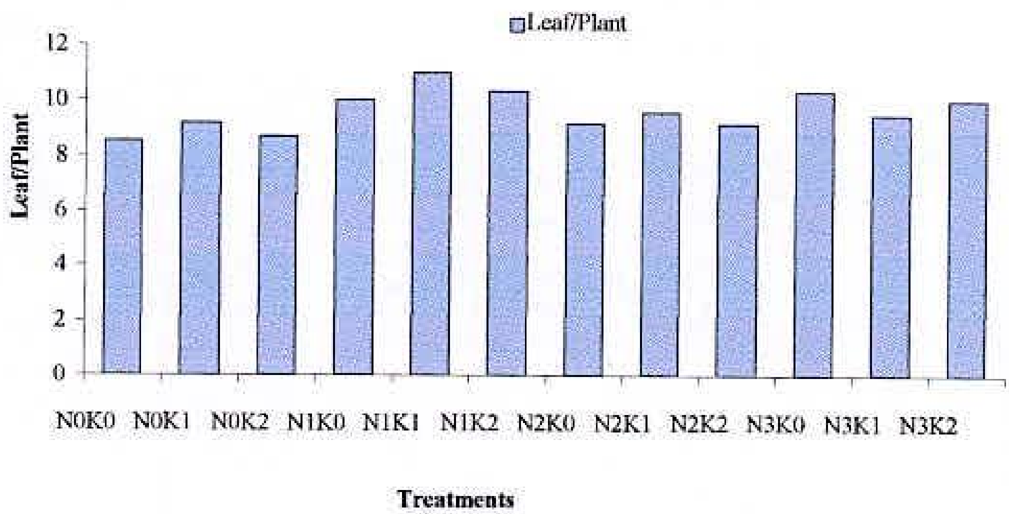

Fig. 16 Combined effect of nitrogen and potassium on the leaf plant^{-1} of onion

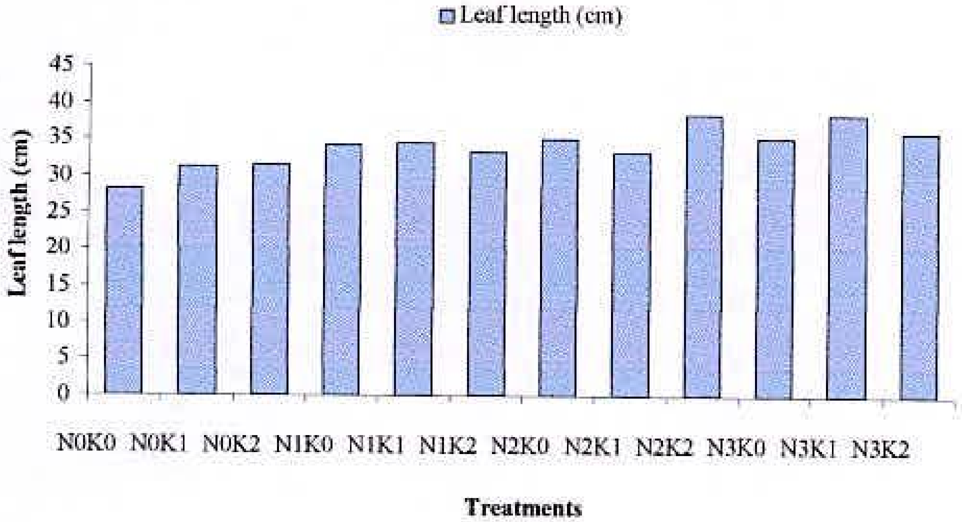

Fig.17 Combined effect of nitrogen and potassium fertilizers on the leaf length (cm) of onion

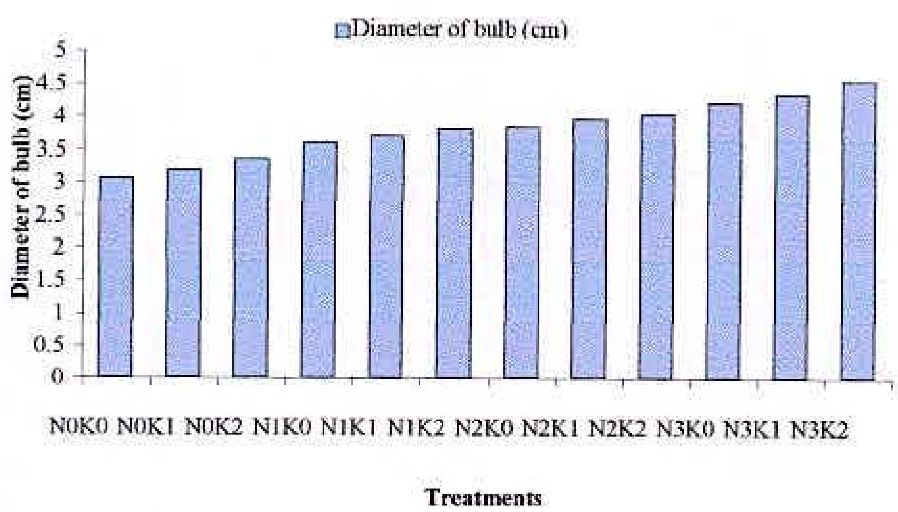

Fig.18 Combined effect of nitrogen and potassium fertilizers on the diameter of bulb (cm) of onion

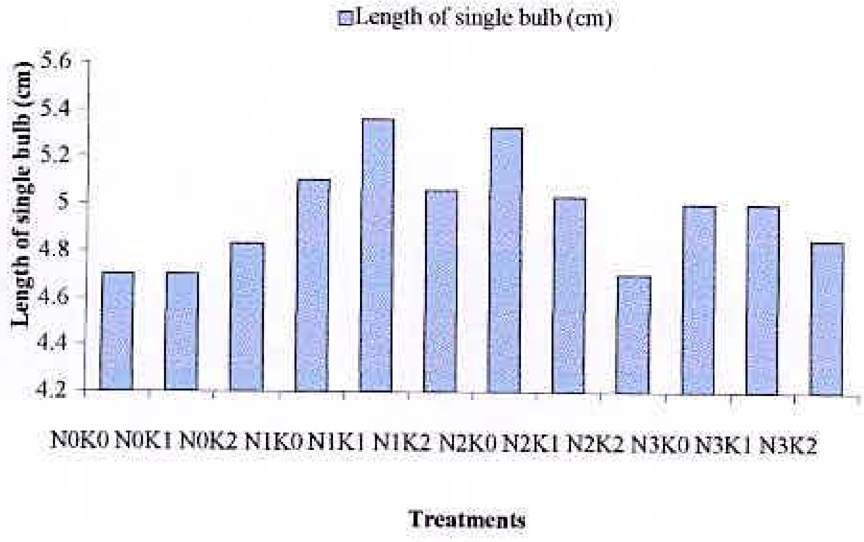

Fig. 19 Combined effects of different doses of nitrogen and potassium fertilizers on the Length of bulb plant^{-1} (cm) of onion

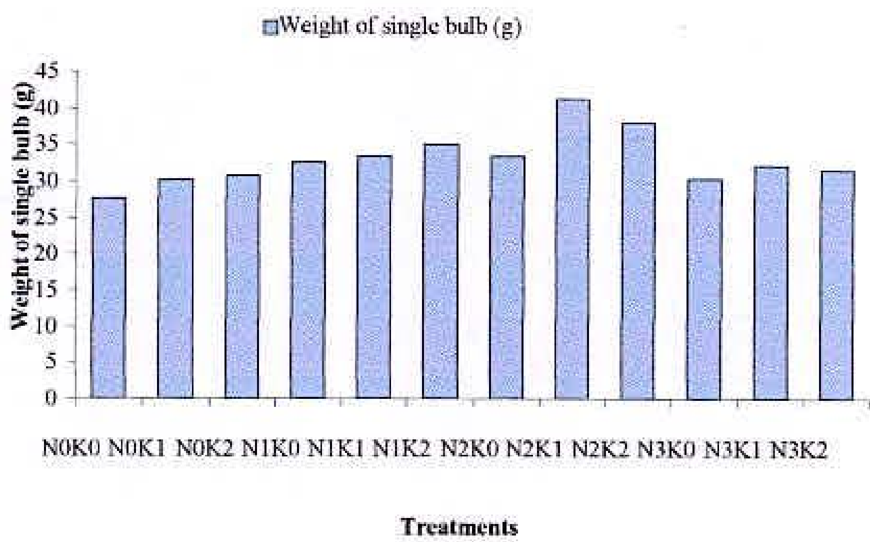

Fig.20 Combined effect of different doses of nitrogen and potassium fertilizers on the weight of single bulb (g) of onion

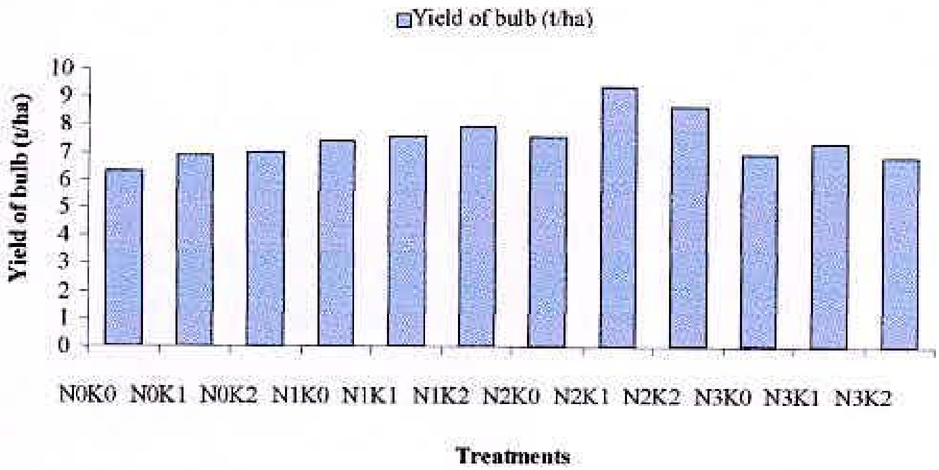

Fig. 21 Combined effect of different doses of nitrogen and potassium fertilizers on the yield ($t\ ha^{-1}$) of onion

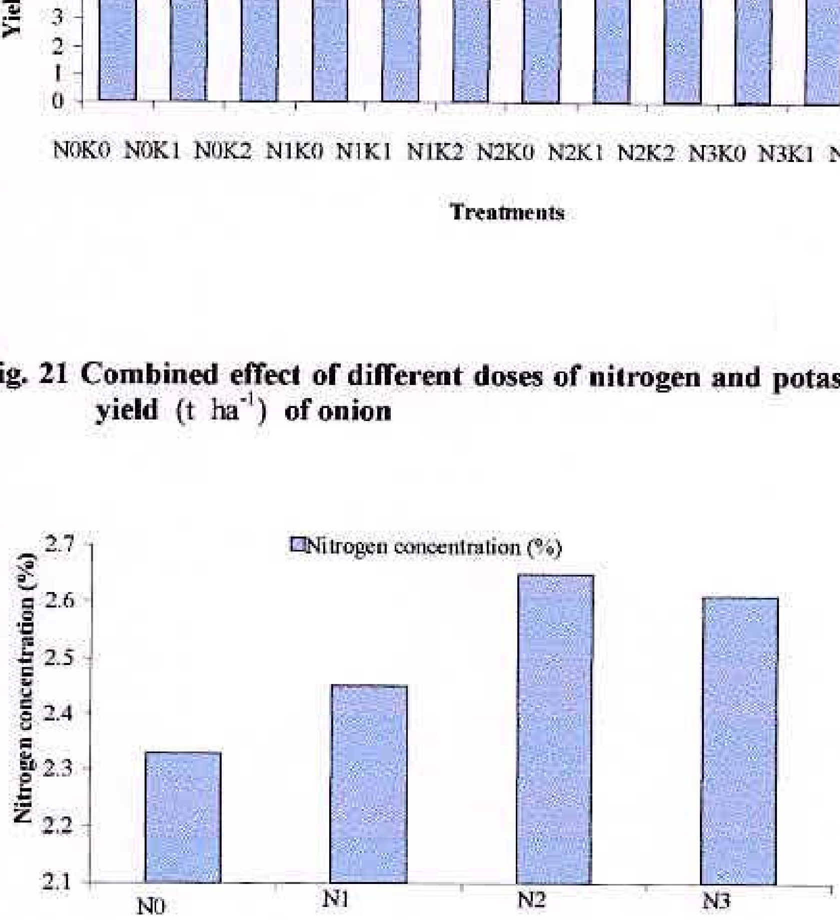

Fig. 22 Effect of N fertilizer on the nitrogen concentrations in bulb of onion

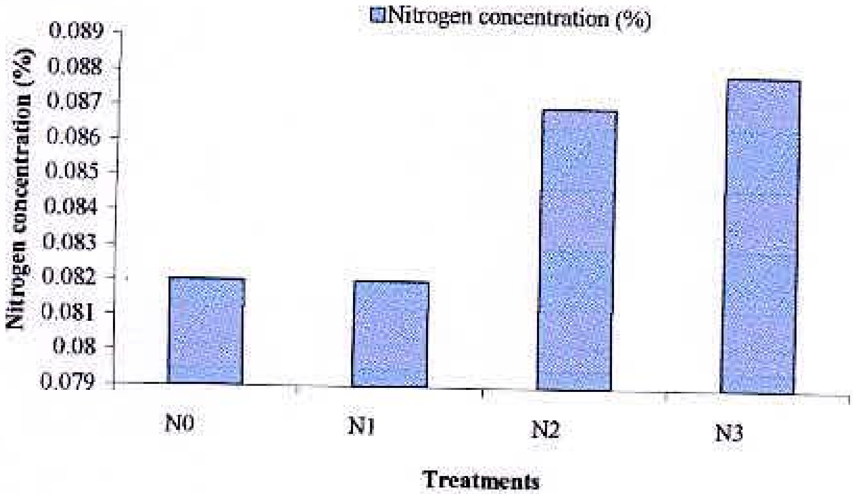

Fig.23 Effect of N fertilizer on the nitrogen concentrations in post harvest soil of onion

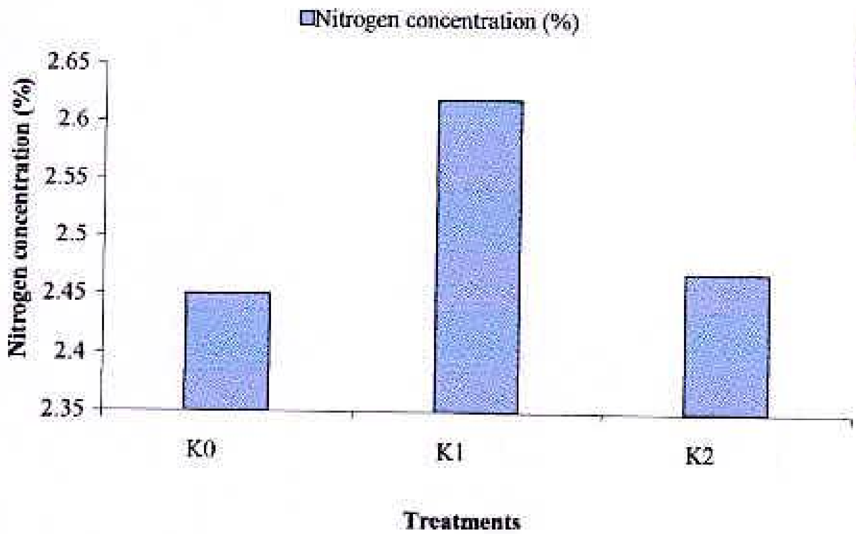

Fig. 24 Effect of K fertilizer on the nitrogen concentrations in bulb of onion

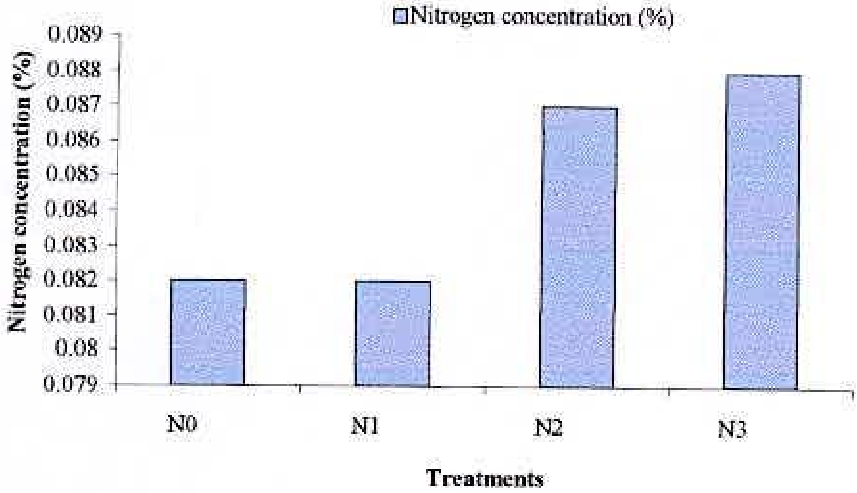

Fig. 25 Effect of K fertilizer on the nitrogen concentrations in post harvest soil

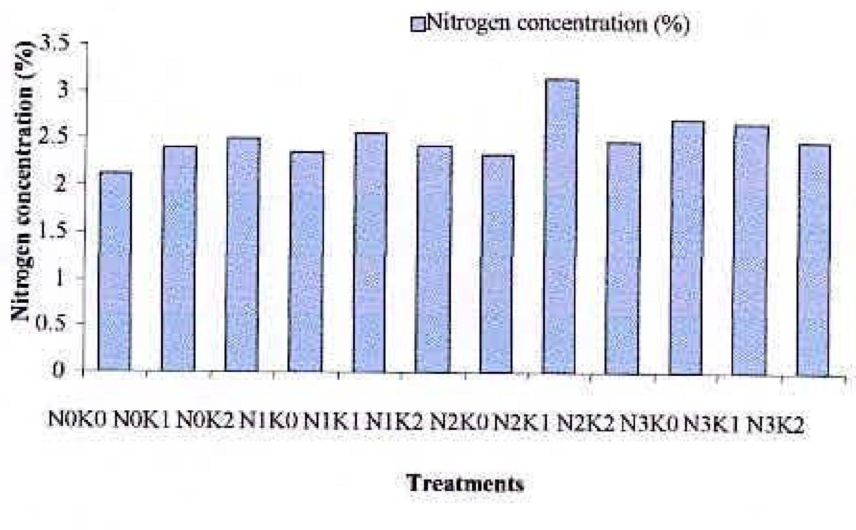

Fig. 26 Combined effects of nitrogen and potassium fertilizers on the nitrogen concentrations in bulb of onion.

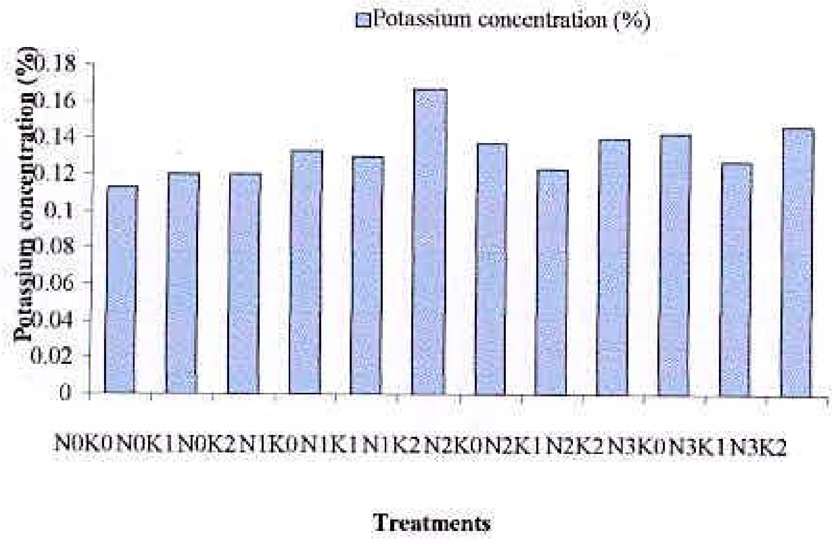

Fig. 27 Combined effect of nitrogen (N) and potassium (K) fertilizers on the potassium concentrations in the post harvest soil

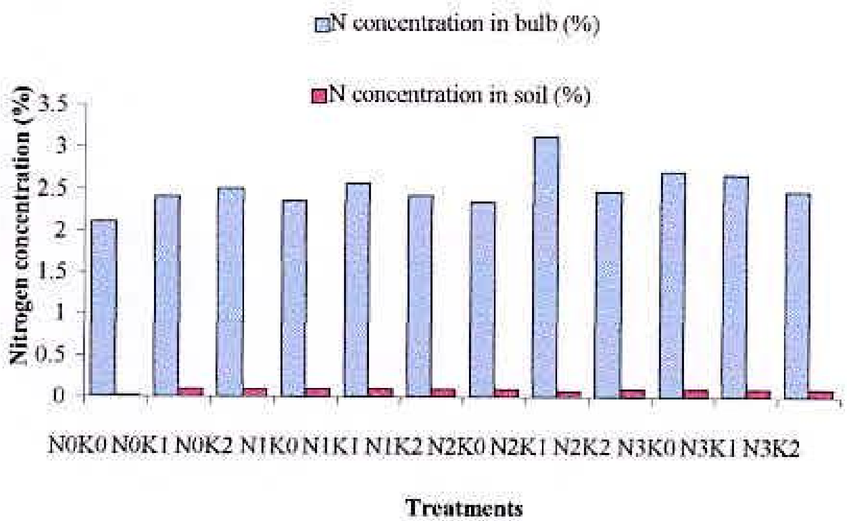

Fig.28 Combined effect of different doses of nitrogen and potassium fertilizers on the nitrogen concentration in bulb and post harvest soil

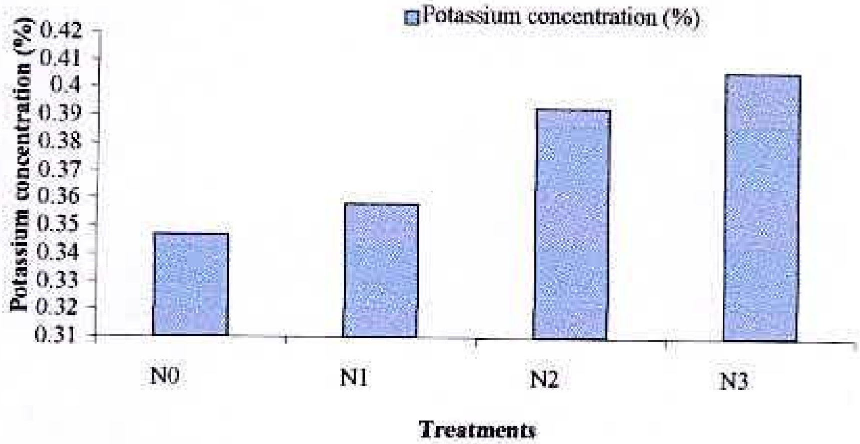

Fig.29 Effect of nitrogen on the potassium concentration in the bulb of onion.

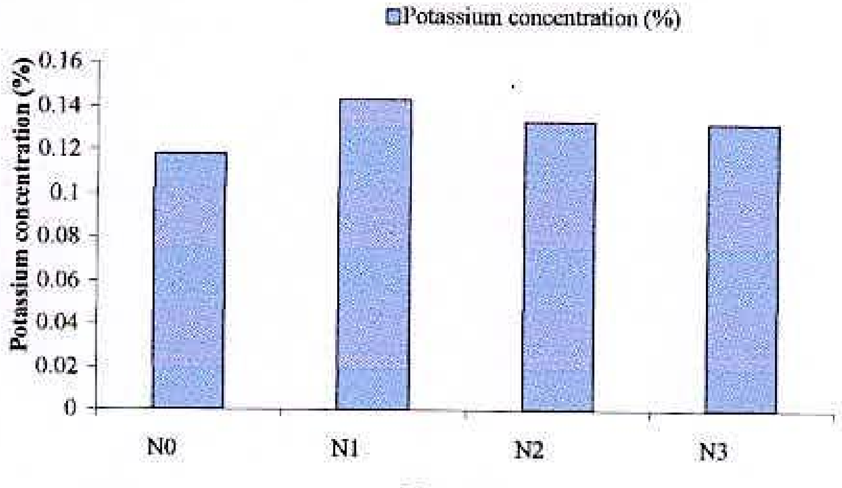

Fig. 30 Effect of nitrogen on the potassium concentration in the post harvest soil of onion

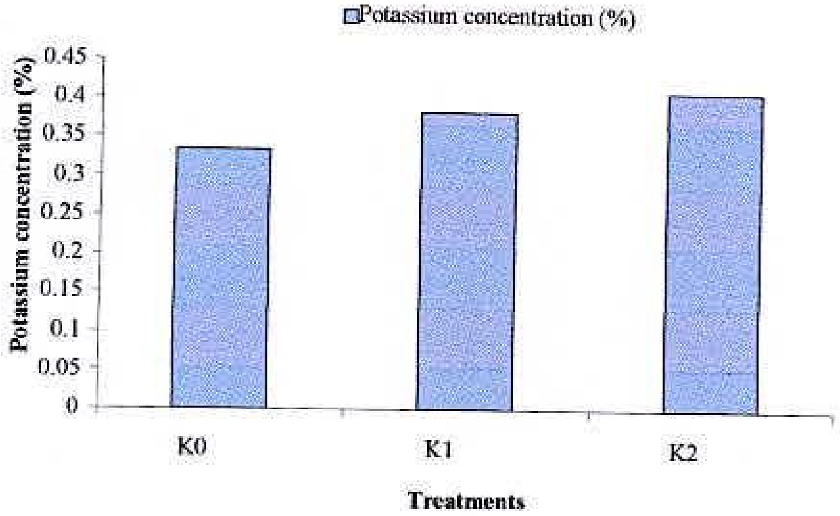

Fig.31 Effect of potassium on the potassium concentration in the bulb of onion.

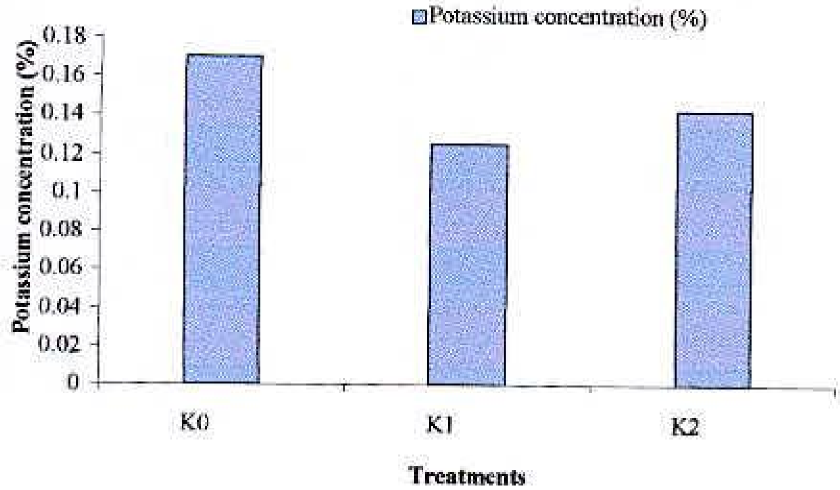

Fig. 32 Effect of potassium on the potassium concentration in the post harvest soil of onion

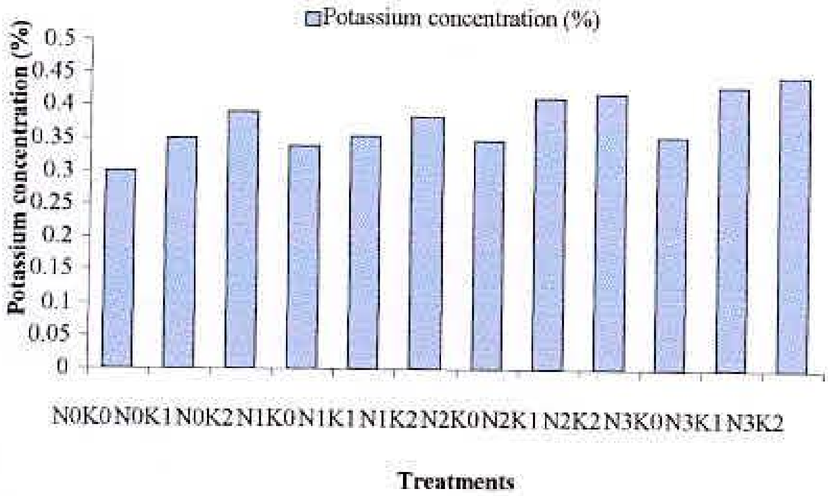

Fig. 33 Combined effect of nitrogen (N) and potassium (K) fertilizers on the potassium concentrations in the bulb of onion.

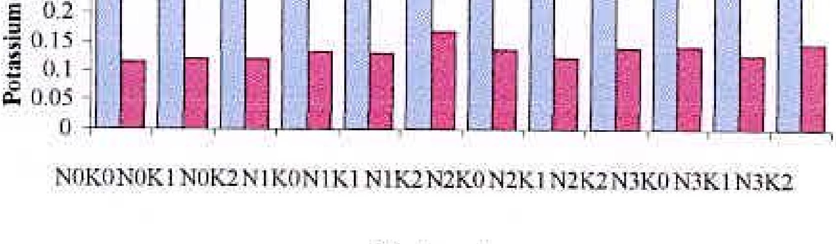

Fig. 34 Combined effect of nitrogen (N) and potassium (K) fertilizers on the potassium concentrations in the bulb and post harvest soil.