RESPONSE OF SUMMER ONION TO POTASH AND ITS APPLICATION METHODS

BY

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CERTIFICATE

This is to certify that thesis entitled, "*RESPONSE OF SUMMER ONION TO POTASH AND ITS APPLICATION METHODS*" Submitted to the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE (M.S.) in SOIL SCIENCE* embodies the result of a piece of *bona fide* research work carried out by *MD. ANOWARUL ISLAM* Roll No. **72** Registration No. **23931/00252** 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 by him.

Dated: 8/2/09

Place: **Gazipur, Bangladesh**

Dr. Md. Mohabbat Ullah

Senior Scientific Officer

Supervisor

Dedicated To My

Beloved Parents

LIST OF ABBRIVIATIONS

ABBREVIATION	FULL WORD
AEZ	Agro-Ecological Zone
@	At the rate
Cm	Centimeter
$CuSO_4.5H_2O$	Green vitriol
cv.	Cultivar(s)
CV%	Percentage of Coefficient of Variance
DMRT	Duncan's Multiple Range Test
et al	and others
FYM	Farm Yard Manure
G	Gram
$HClO_4$	Percholoric acid
HNO_3	Nitric acid
H_2O_2	Hydrogen per oxide
H_2SO_4	Sulfuric acid
K	Potassium
kg	Kilogram
ha	Hectare
K_2SO_4	Potassium Sulfate
LSD	Least Significant Difference
S	Sulphur
TSP	Triple Super Phosphate
M	Meter
ml	Milliliter
mm	Millimeter
MP	Muriate of Potash
N	Nitrogen
NaOH	Sodium Hydroxide
NPKS	Nitrogen, Phosphorus, Potassium and Sulphur
NS	Non Significant
OM	Organic matter
pH	Hydrogen ion concentration
^0C	Degree Centigrade
%	Percent
RCBD	Randomized Complete Block Design
BARI	Bangladesh Agricultural Research Institute
t ha^{-1}	Tone per hectare
cc	Cubic centimeter
WP	Wetable powder
DAT	Days after transplanting
$NaHCO_3$	Sodium bicarbonate

LIST OF ABBRIVIATIONS (Contd)

ABBREVIATION	FULL WORD
$SnCl_2$	Staneum chloride
$CaCl_2$	Calcium chloride
ηm	Nanometer
Se	Selenium
conc.	Concentrated
HCl	Hydrochloric acid
KCl	Potassium chloride
K_3PO_4	Potassium phosphate
q	Quintal
viz.	Namely

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LIST OF CONTENTS

LIST OF CONTENTS (Contd.)

LIST OF CONTENTS (Contd.)

LIST OF CONTENTS (Contd.)

LIST OF TABLES

LIST OF TABLES (Contd.)

LIST OF FIGURES

LIST OF APPENDICES

RESPONSE OF SUMMER ONION TO POTASH AND ITS APPLICATION METHODS

BY

MD. ANOWARUL ISLAM

ABSTRACT

A field experiment was conducted at On Farm Research Division of Bangladesh Agricultural Research Institute, Gazipur during March 2005 to July 2005 to evaluate the effects of different levels of potash and their application methods on growth, yield and yield attributes of onion .Six different levels of potash viz. 0, 30, 60, 90, 120 and 150 kg ha^{-1} and three application methods viz. basal , ½ basal + ½ at 20 DAT and ⅓ basal + ⅓ at 20 DAT + ⅓ at 40 DAT were included in the present study .A significant improved in different growth parameters , yield attributes , bulb yield as well as potassium uptake was observed in response to different application methods and levels of potassium . Among the methods highest bulb yield (11.85 t ha^{-1}) was obtained from three split application of potassium and the lowest (11.49 t ha^{-1}) was obtained from application of basal doses of potassium. Yield contributing characters shows the similar trend of response of K like bulb yield. Application of potassium at 120 kg ha^{-1} produced highest bulb yield (14.76 t ha^{-1}), but higher level of potassium did not show any more increase in yield of summer onion. The lowest bulb yield (7.94 t ha^{-1}) was obtained from control plants (0 kg ha^{-1} potassium). The combined effect of different levels of potassium and its application methods was statistically significant. The combination of three split application of 120 kg ha^{-1} potassium (K_5B_2) gave the highest bulb yield (15.27 t ha^{-1}) and the lowest bulb yield (7.94 t ha^{-1}) was obtained from control (K_0B_0). Three split application of 120 kg ha^{-1} potassium (K_5B_2) may be considered to be optimum for getting higher yield as well as higher net profit (Tk. 1,46,100.00 ha^{-1}) for summer onion production at Chhiata series of Grey Terrace soils (AEZ 28), Gazipur, Bangladesh.

Chapter 1

Introduction

INTRODUCTION

Onion (*Allium cepa*) is one of the most important spices of the world, which belongs to the family Alliaceae (Jones and Mann, 1963). It is thought that onion has been first domesticated in the mountainous region of Turkmenia, Uzbekistan, Tajikistan, North Iran, Afghanistan and Pakistan (Brewster, 1994). It is used in the preparation of different kinds of food of our daily diet. It is also used as condiments for flavoring foods. 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. The leading onion growing countries of the world are the Netherlands, Korea, Israel, Japan, Turkey, Syria, Iran, Egypt, USA, Lebanon, Austria and India (FAO, 2003[a]). In Bangladesh it is commercially cultivated in the greater districts of Faridpur, Rajshahi, Dhaka, Comilla, Mymensingh, Jessore, Rangpur and Pabna (BBS, 2004).

Onion is a thermal and photosensitive crop. 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 along with absence of summer tolerant varieties and proper cultural practices. But demand for its use is ever increasing irrespective of season. The statistical information revealed that Bangladesh produced only 153 thousand metric tons of onion as against the total requirement of 450 thousand MT per year on an area of 37637 hectares of land (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). Virtually, Bangladesh is deficit in onion production. This is why Bangladesh have to import onion every year by loosing huge foreign currency. In 2003, Bangladesh has to import 33.452 thousand MT of onion worth about 6.9 million US dollar (FAO, 2003c). It may be mentioned here that remaining portion of requirement comes through unauthorized channel.

Introducing hot and rain tolerant onion variety in production or manipulation of prevailing summer climatic condition and cultural management might help solving shortage of onion production in the country. Formerly, summer onion was not successfully cultivated in Bangladesh. Recently BARI has released two summer onion varieties for growing in kharif season as its genetic potentiality proved to be suitable for this climate. There is a significant response of onion to both inorganic and organic fertilizer (Nasreen and Hossain, 2000; Ullah, 2003). The importance of nitrogen, phosphorus, potassium and sulphur, zinc and boron for the growth and yield of vegetable crops is well established. Among the nutrients, potassium plays an important role on onion production.

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

(MacGillibray, 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 photosynthates, storage quality, bulb size, bulb numbers and yield per plant (Sangakkara and Piyadasa, 1993). Potassium is one of the three 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). Methods of application of potassium fertilizers have great influence on their utilization by the crop. Time of application of potash during the growing period of onion is important in bulb formation. Satter and Haque (1975) reported that split application of nitrogen and potash gave higher weight of winter onion bulb than single application of same dose. In Bangladesh, very limited works have been carried out to evaluate the effect of different methods of application of potash on summer onion crop. There are also several evidences of fixation and leaching loss of potassium from the soil (Huq *et al.*, 1990). So proper doses of potash and their application method of fertilizer might help increasing the potash fertilizer use efficiency. Considering the above facts the present investigation was under taken with the following objectives:

i. To determine the appropriate doses of potassic fertilizer for maximizing the yield of summer onion.
ii. To determine the suitable application method of potassic fertilizer for summer onion cultivation.
iii. To evaluate the economic returns of summer onion cultivation.

Chapter 2

Review of Literature

REVIEW OF LITERATURE

A number of studies on split application of potash and a limited study with various level of potash on the performance of various crops in many areas of the world were done. The results of split application of potash were proved to be satisfactory in comparison with the results of single application of the same. This may be due to loss of potash in various forms when the entire dose is applied at a time. In shallow rooted crop like onion, split application of nitrogen as well as potash could be more useful for better utilization by the plant. In Bangladesh, some research works have been done on the influence of split application of potash on some vegetable crops while most of the works were concentrated with the source of muriate of potash (KCl). Research reports regarding application method and different level of potash for onion production under varying soil and climatic situations of Bangladesh are very scanty. However, some of the related research findings on onion from various sources of home and abroad have been reviewed in this chapter which may be important and useful for the present study.

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 cowdung, 175 kg urea, 125 kg TSP and 150 kg MP per hectare for successful onion cultivation in Bangladesh.

Green *et al.* (1980) observed that on a nutrient depleted sandy loam soil, optimal level of N, P and K fertilizer were 206,105 and 119 kg ha^{-1}, respectively for spring sown bulb crops and 209 and 138 kg ha^{-1} of P and K, respectively for autumn-sown bulb crops.

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

Agarwal *et al.* (1981) observed that the plant received N, P_2O_5 and/ or K_2O at 80-160: 40-80: 40-80 kg ha^{-1} respectively gave the highest yield from plots receiving 160:40:40 or 80:40:80 kg ha^{-1}.

Patil *et al.* (1983) had a trial of NPK with the onion cv. White Local. In their experiment, N, P_2O_5 and K_2O were applied at the rate of 75, 150, 75 or 150 and 50 or 100 kg ha^{-1}, respectively. In case of 75 kg N, yield was 222.9 q ha^{-1}. With the increase of phosphorus the yield was also increased but application of K had little effect on the yield.

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

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}).

In a fertilizer trial on onion conducted by Beresniewiez and Nowosiecski (1986), it was reported that 200 kg K_2O along with 200 kg N, 200 kg P_2O_5, 20 kg Mg, 5 kg Mn, 5 kg Zn, 10 kg Cu and 1.5 kg Mo per hectare gave the highest yield .Yield was further increased when organic fertilizer (lignite or peat) at 100 M^3/ha was applied at the same time.

Rudolph (1986) suggested that for a single crop of onion a base dressing providing P at 30-40 kg and K at 80-100 kg ha^{-1} is 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.

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

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

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

Bruckner (1988) stated that where K_2O content of the soil was lowest the 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.

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

Duque *et al.* (1989) studied the growth and nitrogen, phosphorus and potassium uptake of onion. The results indicated that the plant demand for N and K was higher during early growth stages, whereas demand for P was continuous through out the development. Uptake levels were 38.8, 38.6 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 of onion. They set up two types of lands, one without previously 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.

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

Jayabharathi (1989) reported that the higher yield of onion was be obtained by using the highest dose of NPK (75 kg of each nutrient). It was 55-75 % greater than the control. With the application of higher dose of fertilizer the production of big size bulbs in comparison with medium and small size bulbs were produced significantly greater than the lower dose supplied bulbs.

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

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}.

Amado and Teixeira (1991) studied in a fallow area with or without N and all the treatments received 120 kg P_2O_5 ha^{-1} and 66 kg K_2O ha^{-1}. Combined application of NPK gave the highest dry matter and bulb yield of onion. They also reported that increase in bulb yield was related to the amount of dry matter of the cover crop residues.

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

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.

Rahim *et al.* (1992) conducted fertilizer trial on onion production. Onion sets were planted on 6th November at a spacing of 25 × 15 cm and supplied with 0-160 kg ha^{-1} N and potassium 0-100 kg ha^{-1}, while half fertilizers were applied before planting and half 30 days after planting. The combined application of higher rates 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 as 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 applied either individually or combined increased plant height, leaf production ability, bulb diameter and weight as well as the bulb yield. They recommended 100 kg potash and 30 kg sulphur per hectare for cultivation of onion.

Sangakkara and Piyadasa (1993) observed the effect of six levels of potassium supplied as KCl, when applied as either basal or split (basal and top dressing) 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 reduced 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 and 150 kg N ha^{-1}), phosphorus (25, 50 and 75 kg P_2O_5 ha^{-1}) and potash (50, 100 and 150 kg K_2O ha^{-1}) on the growth and yield of onion. They found that plant height, number of leaves $plant^{-1}$, bulb weight and yield were highest with 150 kg N ha^{-1}, although bulb weight and yield with 100 kg N ha^{-1} were not significantly different. Increasing phosphorus application increased the number of leaves per plant and weight, size and yield of bulbs. Application of K increased only the number of leaves per plants.

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

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 the number of leaves/plant along with higher bulb yield of onion with the increasing rates up to 150 kg N ha^{-1}, 120 kg P_2O_5 ha^{-1}, 120 kg K_2O ha^{-1}, 20 kg S ha^{-1} and 5 kg Zn ha^{-1} at Jessore area.

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

Janardan and Singh (1998) conducted a field experiment to know the effect of stockosorb and potassium levels on potato and onion. They found that the higher biomass, bulb weight, bulb diameter and bulb yield were obtained with the application of 300 kg K_2O + 150 kg stockosorbthinkg-1 plus an adequate number of irrigations. The maximum response of 11.1 kg bulbthinkg-1 stockosorb was noted at 150 kg stockosorbthinha-1. Comparatively higher concentrations of N, P and K were observed in the soils treated with stockosorb.

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

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

Jiang *et al.* (1998) studied in plot trials with onions were 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. Minimum bulb yield was found 69.4 t ha^{-1} with no fertilizer and maximum bulb yield was found with the higher rate of potassium 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 (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 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.

Nagaich *et al.* (1999) conducted an experiment with four rates of potassium (0, 40, 80 and 120 kg K_2O ha^{-1}) during 1995-96 and 1996-97 on growth characters, yield attributes, yield and quality of onion on a sandy loam soil in Madhya Pradesh, India. Application of 80 kg K_2O ha^{-1} significantly increased bulb weight $plant^{-1}$ and horizontal diameter of the bulb.

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

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.

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

Mandira and Khan (2003) carried out an experiment with different levels of nitrogen (at 0, 100, 150 and 200 kg ha^{-1}) and potassium (0, 75 and 150 kg ha^{-1}) given as soil application, to study their effect on the growth, yield and yield attributes of onion cv. N-53 in a study conducted in Tripura, India during *rabi* season of 2001. Nitrogen at 150 kg ha^{-1}, potassium at 75 kg ha^{-1} and their combination recorded the best performance in terms of yield and growth. 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, 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 the effects of K fertilizer (30, 60, 90 and 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.

From these reviews, it is observed that both potassium and its fertilizing method played a vital role on the growth and yield for successful onion cultivation. In most cases, muriate of potash (KCl) was used as source of potash. So optimum level of potassium 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 potash with different fertilizing methods.

Chapter 3

Materials and Methods

MATERIALS AND METHODS

This chapter deals with the materials and methods including a brief description of the experimental site, soil, climate and materials used for the experiment. The details of research procedure are described here.

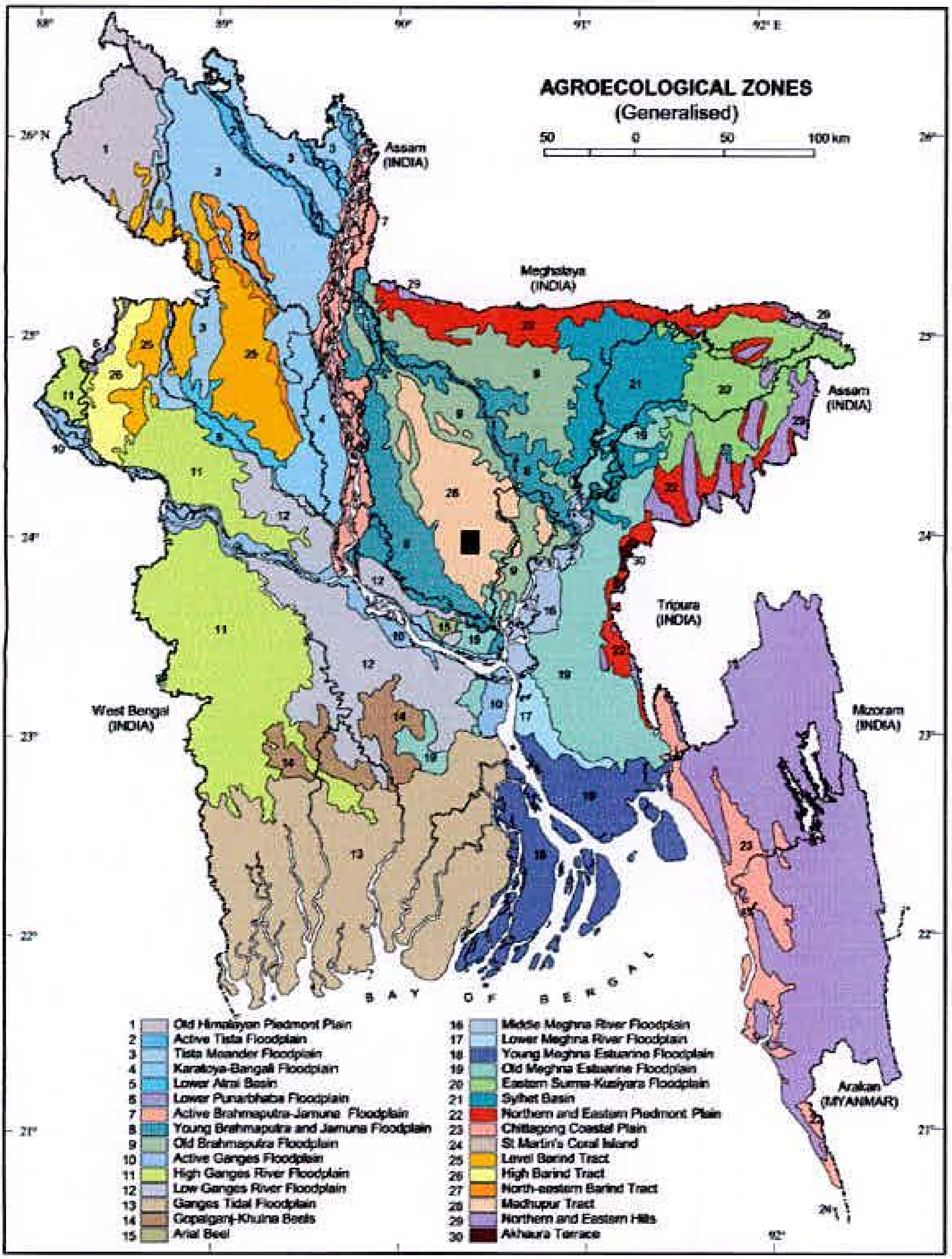
3.1 Description of the experimental site

3.1.1 Location

The research work was conducted in the Grey Terrace soil of On Farm Division of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur to investigate the potash and its application method on the growth and yield of summer onion. The location of the farm is situated at 24°23′ N latitude and 90°08′ E longitude at an elevation of 8.4 m from the sea level.

3.1.2 Soil

The soil of the experimental site belongs to Chhiata series and has been classified as Grey Terrace Soil in Bangladesh soil classification system, which falls under Inceptisol in soil taxonomy (Brammer, 1978). This soil of Modhupur tract (AEZ No.28) is characterized by heavy clays within 50 cm from the surface and is acidic in nature. The soil has poor physical and chemical properties. The morphological, physical and chemical characteristics of the soil are presented in Tables 1 and 2.



■ Location of the experimental sites

Fig. 1 Map showing the experimental sites under study

Table 1. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Bangladesh Agricultural Research Institute (BARI)
AEZ	Madhupur Tract
General Soil Type	Grey Terrace Soil
Land type	Medium High Land
Soil series	Chhiata
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Table 2. Physical and chemical properties of the the soil.

Characteristics	Analytical result
A. Physical	
% Sand	8.00
% Silt	41.00
% Clay	51.00
Textural class	Silty clay
Bulk density (g/cc)	1.42
Particle density (g/cc)	2.50
B. Chemical	
Soil pH	6.10
Organic carbon (%)	0.63
Organic matter (%)	1.09
Total nitrogen (%)	0.07
Available Phosphorus (ppm)	20.00
Exchangeable potassium (Cmol kg^{-1})	0.098
Available sulphur (ppm)	18.00

3.1.3 Climate

The climate of the experimental area is characterized by sub tropical accompanied by moderate high rainfall associated with relatively high temperature during *kharif* season. The monthly temperature, total rainfall, average evaporation, relative humidity(%) and sunshine data during the cropping period are shown in fig. 2-6 and Appendix I.

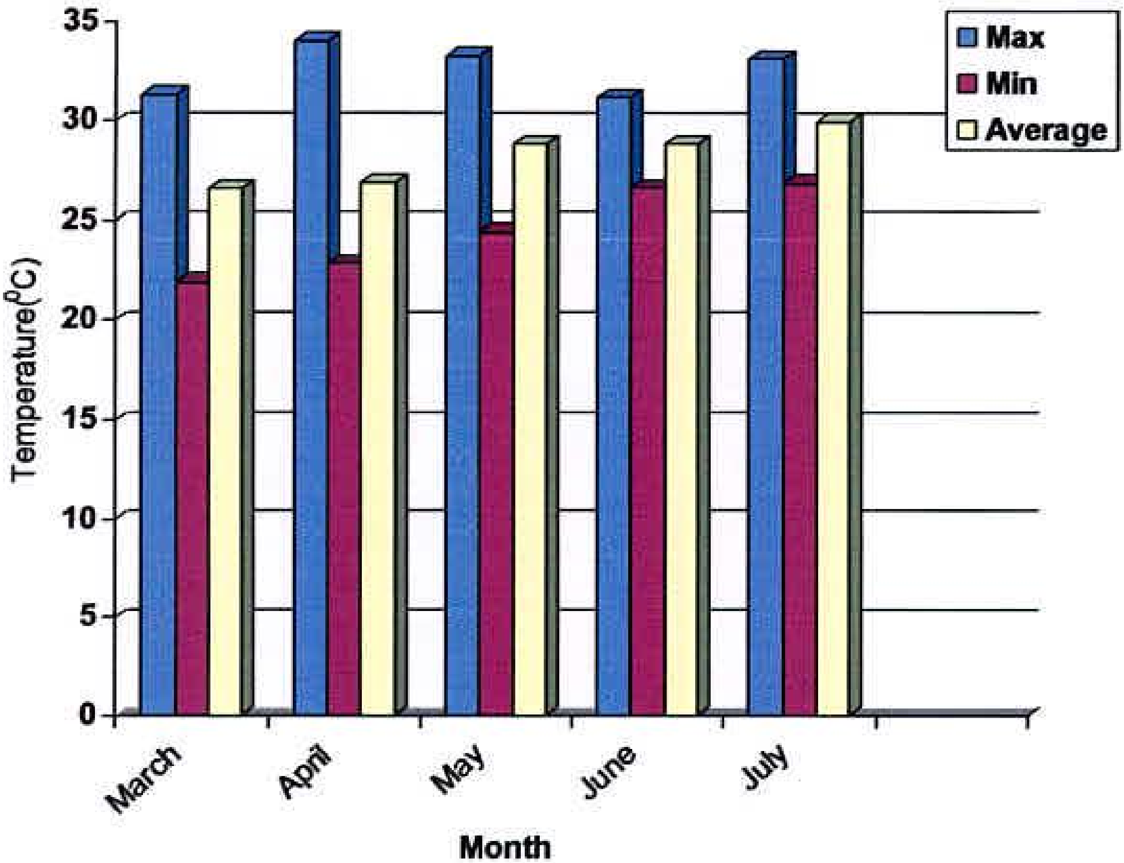


Fig.2 Monthly average maximum and minimum air temperature (°C) of the experimental site, Gazipur during the growing period (March to July, 2005).

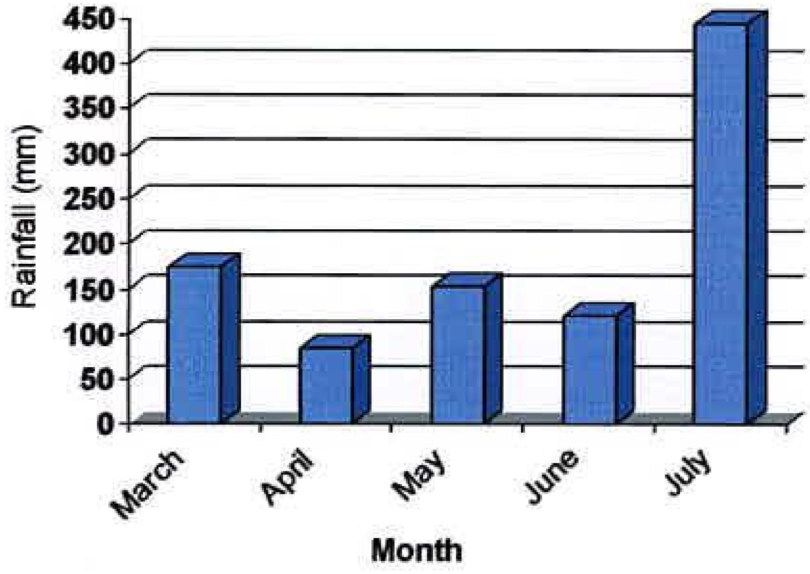


Fig.3 Monthly total rainfall (mm) of the experimental site, Gazipur during the growing period (March to July, 2005).

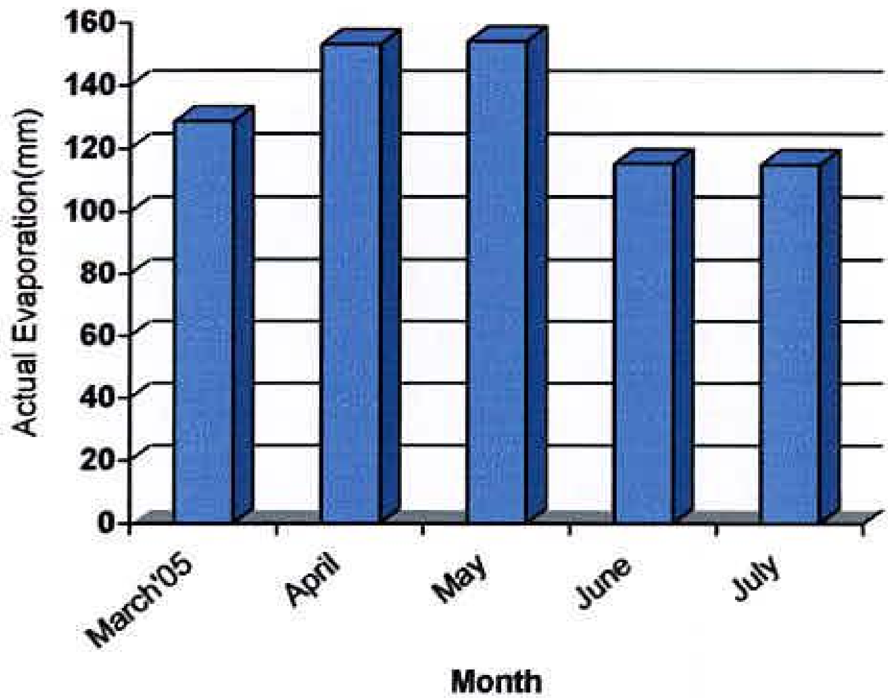


Fig. 4 Monthly average actual Evaporation (mm) of the experimental site, Gazipur during the growing period (March to July, 2005).

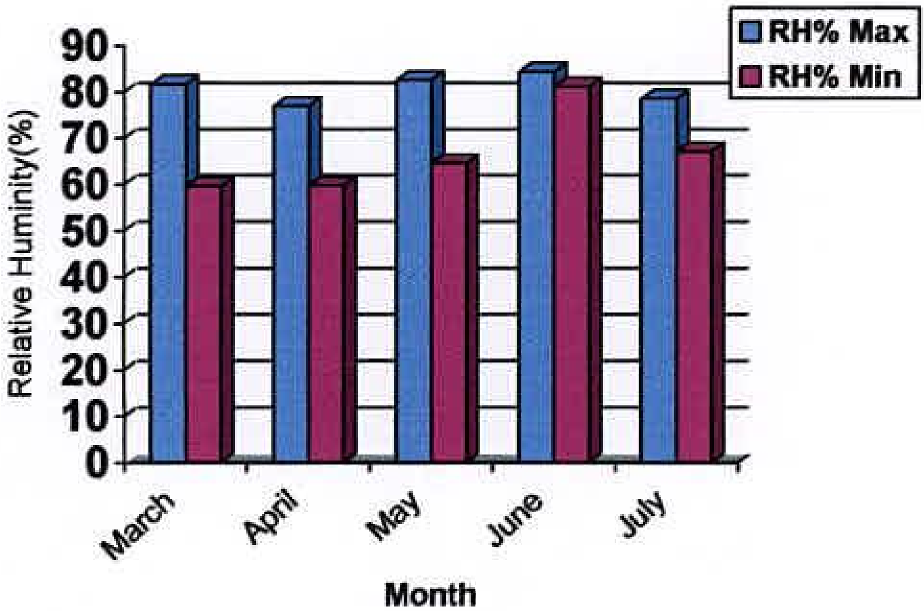


Fig.5 Monthly average maximum and minimum relative humidity (%) of the experimental site, Gazipur during the growing period (March to July, 2005).

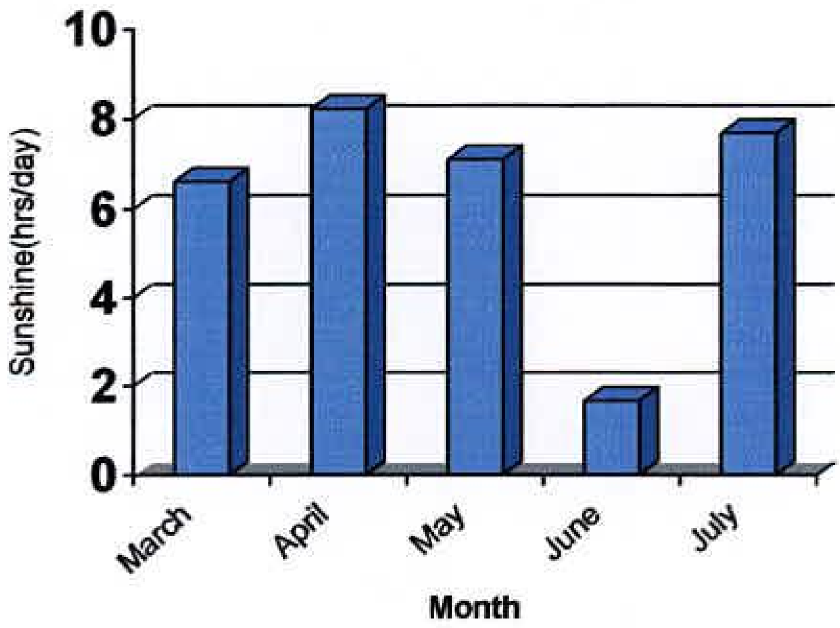


Fig.6 Monthly average sunshine (hrs/day) of the experimental site, Gazipur during the growing period (March to July, 2005).

3.2 Planting materials

An approved summer onion variety released by National Seed Board as BARI Peaj-2 was selected for the present study. This variety was released in 2000. The variety produces plants 50-55 cm tall with 9-10 leaves plant^{-1}. The diameter of bulb is 4-5 cm, the bulbs are highly pungent with pinkish red skin. Nearly 50-60 % bulbs are of single type, mature within 120-130 days, and yield of bulb is about 10 to 12 t ha^{-1} (Anonymous, 2000). The germination percentage of the seed was 85.

3.3 Collection and preparation of initial soil sample

Before initiation of the experiment, initial soil samples at 0-15 cm depth were collected from different plots of experimental field. The composite soil sample was air dried, ground to pass through 2 mm sieve and used for analysis of physical and chemical properties of soil.

3.4 Treatment of the experiment

The experiment consisted of two factors viz. Potassium and its application methods.

The levels of two factors were as follows:

Factor A: Six levels of potash

K_0: Control (0 kg ha^{-1} potassium)

K_1: 30 kg ha^{-1} potassium

K_2: 60 kg ha^{-1} potassium

K_3: 90 kg ha^{-1} potassium

K_4: 120 kg ha^{-1} potassium

K_5: 150 kg ha^{-1} potassium

Factor B: Three methods of application of potassium.

B_0: Basal

B_1: $^1/_2$ Basal + $^1/_2$ top dressing at 20 DAT

B_2: $^1/_3$ Basal + $^1/_3$ top dressing at 20 DAT + $^1/_3$top dressing at 40 DAT

Thus, the combinations were as follows:

$K_0 B_0$	$K_2 B_0$	$K_4 B_0$
$K_0 B_1$	$K_2 B_1$	$K_4 B_1$
$K_0 B_2$	$K_2 B_2$	$K_4 B_2$
$K_1 B_0$	$K_3 B_0$	$K_5 B_0$
$K_1 B_1$	$K_3 B_1$	$K_5 B_1$
$K_1 B_2$	$K_3 B_2$	$K_5 B_2$

3.5 Design and layout of the experiment

The two-factor experiment consisting of 18 treatment combinations was laid out in Randomized Complete Block design (RCBD) with three replications. An area of 604.5 m^2 of more or less uniform fertility with good irrigation and drainage channels was divided into three equal blocks, representing the replications, each containing 18 plots. Thus, there were in total 54 unit plots. Each unit plot was of 3m x 2m in size. Treatments were assigned at random to 18 plots of each block. The space kept between blocks was 1.0 m and between the plots was 50 cm and border was 1.0 m.

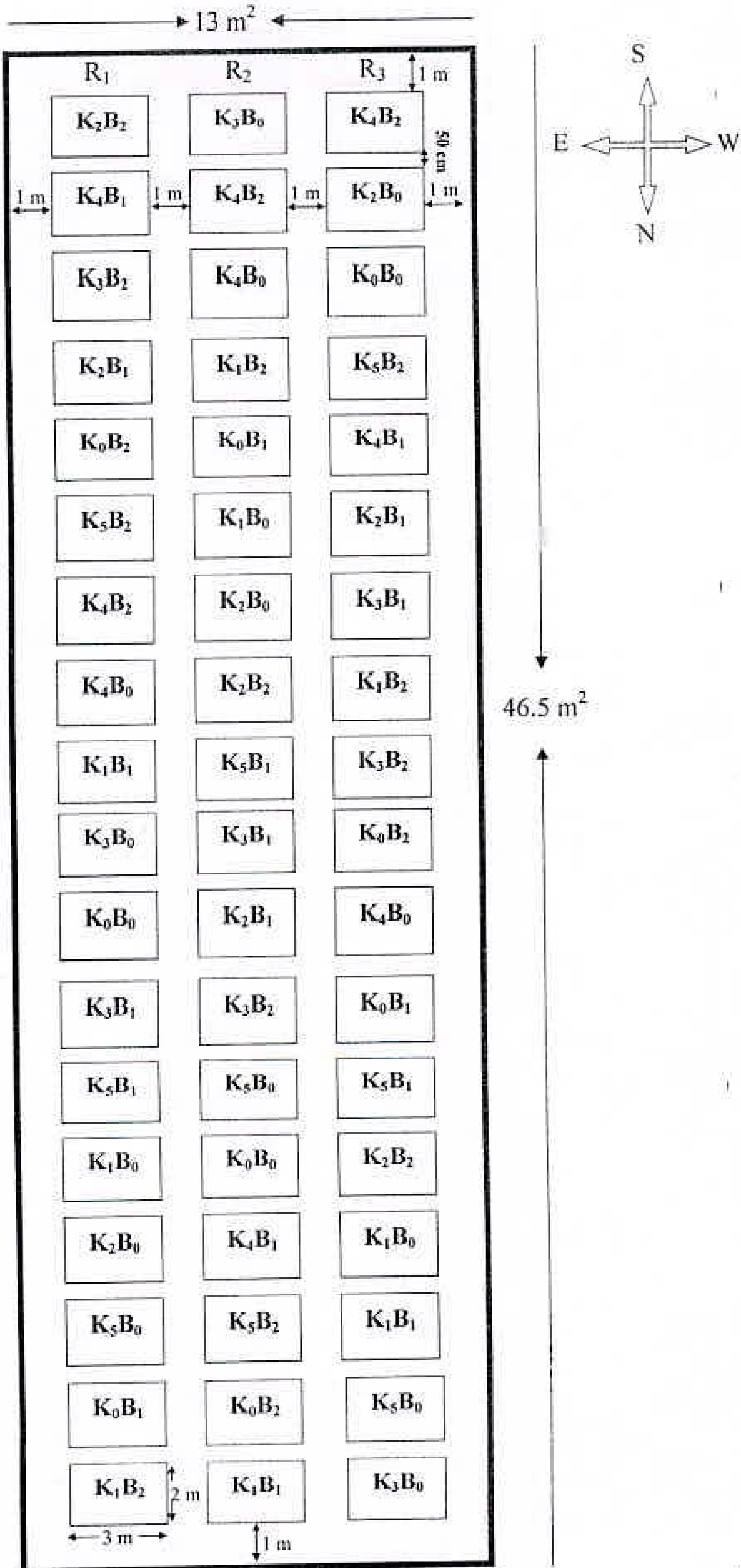


Fig.7. Lay out of the experiment

3.6 Cultivation of summer onion

3.6.1 Crop rising

The land selected for raising seedling was light in texture and well drained. The land was opened and left for drying for 10 days. Bigger clods were broken into pieces and finally the soil was made loose, friable and brought to fine tilth. All weeds and stubbles were removed and the soil was mixed with well-decomposed cow dung; applying Furadan 3 G @ 20 kg ha^{-1} was covered by polythene for two days. The seedbed was 3m x 1m in size with a height of about 20 cm. Onion seeds were soaked overnight (twelve hours) in water and allowed to sprout in a piece of moist cloth keeping in the sunshade for one day.

3.6.2 Seed sowing

The first date of seed sowing was 13^{th} March 2005. The sprouted seeds (3-4 in number) were sown directly in the raised seedbed for raising seedlings to be transplanted. The young seedlings were exposed to dew by night and mild sunshine in the morning and evening. Shades were given over the seedbeds to retain soil moisture and to save the seedlings from direct sun and rain. When the seedlings of the seedbeds attained a height of about 10 cm, thinning operation was done keeping only one healthy seedling in right place.

3.6.3 Land preparation

The experimental plot was opened in the month on April 2005 with the help of a tractor. Thereafter, the land was prepared by several ploughings and cross ploughings with a power tiller followed by laddering. Weeds and stubbles were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of friable soils for transplanting the seedlings.

3.6.4 Rate of manures and fertilizers

Manures and fertilizers were used in the experiment according to the recommendation of BARI as follows:

Manures/ fertilizer	Dose ha^{-1}	Dose/ plot
Cow dung	5 t ha^{-1}	3 kg
Urea	260 kg ha^{-1}	156 g
Triple super phosphate (TSP)	220 kg ha^{-1}	132 g
Gypsum	180 kg ha^{-1}	108 g

3.6.5 Application of fertilizers

The whole amount of well decomposed cow dung and all the fertilizers, except nitrogen and potassium were added to the soil during final land preparation. Urea was applied in three equal splits. The first split was applied during final land preparation, the second split after 20 days of transplanting and the third split after 40 days of transplanting. The fertilizer was thoroughly mixed with the soil.

3.6.6 Transplanting of seedlings

Healthy and disease free uniform sized 50 days old seedlings were uprooted from the seedbeds and transplanted in the main field with the spacing of line to line15 cm and plant to plant 10 cm in the afternoon on 28th April 2005. The seedbed was watered before uprooting the seedlings so as to minimize the damage of roots. The seedlings were watered immediately after transplanting. Some seedlings were also transplanted adjacent to the experimental area to be used for gap fillings.

3.6.7 Intercultural operation

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

3.6.7.1 Gap fillings

Damaged seedlings were replaced using healthy plants from the excess plants within one week.

3.6.7.2 Weeding and mulching

Weeding was done three times after transplanting to keep the crop free from weeds and mulching was done by breaking the crust of the soil for easy aeration and to conserve soil moisture, when needed especially after irrigation.

3.6.7.3 Irrigation and drainage

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

3.6.7.4 Plant protection

Preventive measure was taken against soil borne insects. For the prevention of Cutworm, Furadan 3 G @ 20 kg ha^{-1} was applied. No insect pest infestation was found in the field after pesticide application. Few days after transplanting some plants were attacked by purple blotch disease caused by *Alternaria puri*. It was controlled by spraying Ruvral 50 WP four times at 10 days interval after transplanting.

3.7 Field data collection

Data of the five selected plants were recorded from each plot on the following parameters during the course of experiment, i.e. Plant height (cm), Leaf length (cm) and Number of leaves per plant.

3.8 Harvesting

The crop was harvested on 30th July 2005 according to their attainment of maturity showing the sign of drying out of most of the leaves and collapsing at the neck of the bulbs.

3.9 Sampling at harvest

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

3.10 Collection of data

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

Data were collected on the following parameters:

1. Plant height (cm)
2. Leaf length (cm)
3. Number of leaves per plant
4. Diameter of bulb per plant (cm)
5. Length of bulb per plant (cm)
6. Weight of single bulb (g)

7. Number of bulbs per plot
8. Yield of bulb per plot (kg)
9. Yield of bulb per hectare (t)

3.10.1 Plant height (cm)

The height of the selected five plants in each plot was measured after 30, 50, 70, and 90 days after transplanting (DAT). The height was measured in centimeters (cm) from the neck of the bulb to the tip of the longest leaf and average heights of the selected five plants were taken to observe the rate of growth.

3.10.2 Leaf length (cm)

The length of leaf was measured in centimeter from pseudo stem to the tip of the leaf from five selected plants at 30, 50, 70, and 90 DAT and their average was recorded.

3.10.3 Number of leaves per plant

The numbers of leaves per plant from selected plants were counted after 30 DAT and the average of five plants was taken as the number of leaves per plant. The number of leaves $plant^{-1}$ was also recorded at 50, 70, and 90 DAT.

3.10.4 Diameter of bulb (cm)

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

3.10.5 Length of bulb (cm)

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

3.10.6 Weight of single bulb

Five randomly selected plants from each unit plot were harvested. The top was removed by cutting pseudostem 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.

3.10.7 Number of bulbs per plot

The whole bulbs of summer onion were harvested from each unit plot. The number of bulbs were counted and recorded individually from each unit plot.

3.10.8 Yield of bulb per plot

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

3.10.9 Yield of bulb per hectare

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

3.11 Analysis of soil samples

The initially collected soil samples were analyzed for both physical and chemical properties in the laboratory of the Department of Soil Science, Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur. The properties studied included texture, pH, organic matter, total N, available P, exchangeable K and available S. The physical and chemical properties of the initial soil have been presented in table 2. The soil was analyzed following standard methods:

3.12 Post harvest soil sampling

The soil samples were collected after harvest from a 0-15 cm soil depth. The samples were by means of an auger from each plot to make a plot wise individual composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up and removed. Then the samples were air-dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

3.13 Physico-chemical analysis of soil

3.13.1 Physical Analysis of Soil

3.13.1.1 Particle size analysis

Particle size analysis of soil sample was done by hydrometer method as outlined by Day (1965) and the textural class was ascertained using USDA textural triangle.

3.13.1.2 Bulk density

Bulk density was determined by obtaining a known volume of undisturbed soil cores by using core sampler. It was determined by dividing the oven-dried (at 105°C) mass of the soil core with the inner volume of the sampler (Black, 1965).

3.13.1.3 Particle density

Particle density of soil was determined by Pycnometer method as described by Black (1965).

3.13.1.4 Porosity

Porosity of the soil was calculated by the relation between bulk density and particle density as outlined below:

$$\% \text{ Porosity} = \left(1 - \frac{\text{Bulk density}}{\text{Particle density}}\right) \times 100$$

3.13.2 Chemical Analysis of Soil

3.13.2.1 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).

3.13.2.2 Organic carbon (%)

Organic carbon in soil was estimated by wet oxidation method described by Walkley and Black (1935).

3.13.2.3 Total nitrogen

Total nitrogen was determined by micro-Kjeldahl method following concentrated sulphuric acid digestion and distillation with 40% NaOH. The ammonia evolved was collected in boric acid indicator and was titrated against 0.02 N H_2SO_4 (Black, 1965).

3.13.2.4 Available phosphorus

Available phosphorus was extracted from soil by shaking with 0.5 M $NaHCO_3$ solution of pH 8.5 (Olsen *et al.* 1954). The phosphorus in the extract was then determined by developing blue colour using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue colour was measured at 660 nm wave length by spectrophotometer and available P was calculated with the help of a standard curve.

3.13.2.5 Exchangeable potassium

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

3.13.2.6 Available sulphur

Available sulphur in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Page *et al.*, 1982). The S content in the extract was determined turbidimetrically and the intensity of turbidity was measured by spectrophotometer at 420 nm wavelength.

3.14 Chemical analysis of plant samples

3.14.1 Preparation of plant samples

Five selected plants per plot were collected immediately after harvest of the crop. The selected plants were cleaned and dried in an over at 65^0C for 48 hours. The dried samples were then ground with a grinding mill. The prepared samples were put into small paper bags and kept in a dessicator for future use.

3.14.2 Digestion of plant samples with sulphuric acid

For N determination an amount of 0.1g 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. Heating was continued until the digest was clear and colourless. 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.

3.14.3 Digestion of plant samples with nitric-perchloric acid mixture

An amount of 0.5 g of sub-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 raising slowly to 200^{0}C. 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. The content of the flask was boiled until they became clear and colourless. This digest was used for determining P, K and S.

3.14.4 Determination of elements in the digest

Nitrogen content in the digest was determined by similar method as described in soil analysis.

Phosphorus content was determined following the procedure as described in the soil analysis section.

Potassium concentration of the digest was determined directly by flame photometer.

Sulphur concentration in the digest was estimated turbidimeterically by a spectrophotometer using 420 ηm wave length.

3.15 Economic evaluation

The analysis was done in order to find out the most profitable treatment based on cost and benefit of various treatments. Net benefit was calculated by subtracting the total input cost from the gross income. Gross income was calculated as the total market value of onion bulb. The input cost was calculated as the total market value of fertilizers, and other material and non-material cost which was indicating highest net benefit.

3.16 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

RESULT AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the investigation. Data on plant morphological characters were gathered periodically. Plant height, leaf length, number of leaves per plant and other related characters of summer onion were monitored. Yield and yield attributes of summer onion plants were also recorded. The results and the analysis of variance of data on different plant growth characteristics obtained from the present investigations have been presented in Tables 3-9, Figures 8-11 and Appendices II-III for interpretation and understanding. The results have been presented under the following headings.

4.1 Plant height (cm)

4.1.1 Effect of different methods of potassium application

The height of onion plants was significantly influenced by the methods of application and levels of potassium at different days after transplanting (DAT) [Fig. 8 and Appendix II (a)]. There was a gradual increase in plant height upto 70 DAT and then a decreasing trend was observed. At all DAT, the tallest plant was found in the plots receiving three-splits of potash (B_2) while the shortest plant was noted from the plots receiving single application of potash as basal dose (B_0). These results revealed that the application of split doses of potash gave higher plant height over basal application. This finding agrees with the results of Bhuyan (1979) and Yadav *et al.* (2003). They obtained taller summer onion plants with split application of potash.

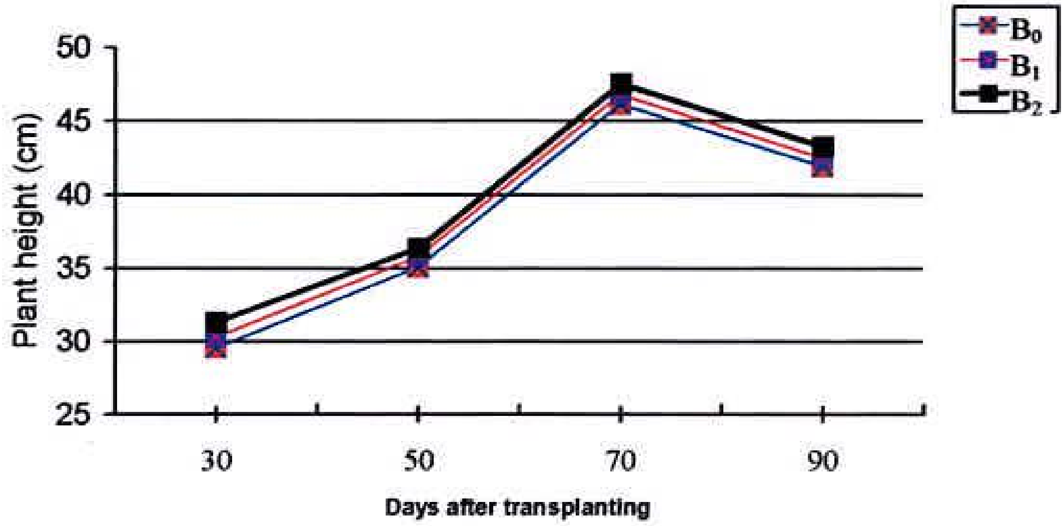
4.1.2 Effect of different levels of potassium

Similar to application method, plant height of summer onion was also significantly influenced by different levels of potash [Fig. 8 and Appendix II (b)]. At 70 DAT, the tallest plant was recorded from the plots, which received 120 kg ha^{-1} (K_4) potassium and the shortest plant also recorded from 0 kg ha^{-1} (K_0) potassium. Similar effect was also recorded at 30, 50, 70, and 90 DAT. The rate of 120 kg ha^{-1} potassium showed the best performance which might be due to the availability of optimum level of potassium than other levels.

4.1.3 Interaction effect of different levels of potassium and its application methods

The combined application methods and levels of potash was significantly influenced on plant height at all DAT (Table 3). However, the highest plant height (53.34 cm) and the lowest plant height (40.84 cm) were recorded from the treatment combination of three-splits with potassium 120 kg ha^{-1} (K_4B_2) and potassium 0 kg ha^{-1} (K_0B_0), respectively at 70 DAT. It was clearly found that the treatment combinations showed higher plant height from K_4B_2 at every stage of growth.

A) Different application methods of potassium



B) Different levels of potassium

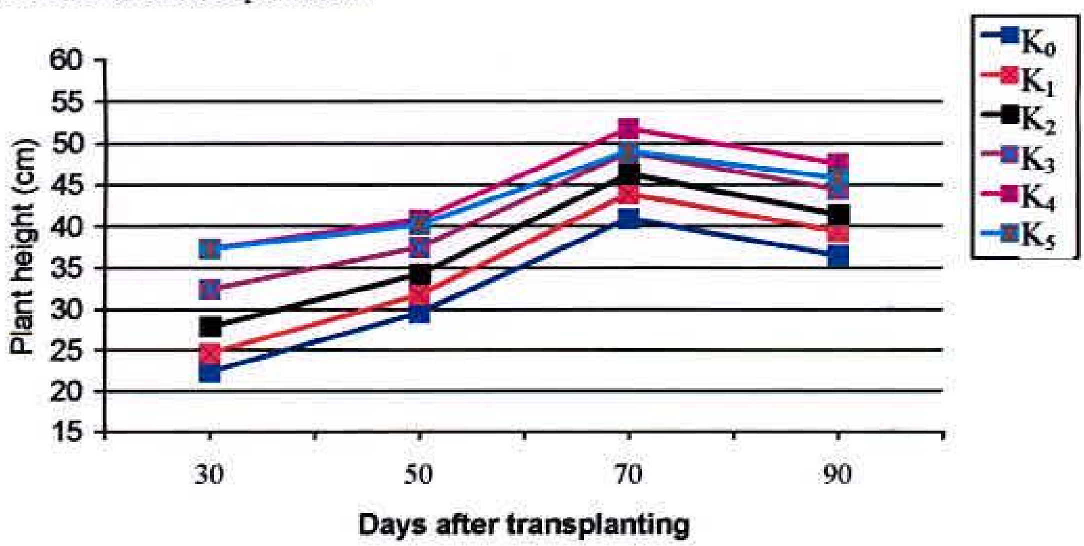


Fig. 8 Plant height of onion as influenced by different application methods and levels of potash at various growth stages.

K_0: 0 kg ha^{-1} potassium (Control)	B_0 Basal:
K_1: 30 kg ha^{-1} potassium	B_1: $^1/_2$ Basal + $^1/_2$ top dressing at 20 DAT
K_2: 60 kg ha^{-1} potassium	B_2: $^1/_3$ Basal + $^1/_3$ top dressing at 20 DAT + $^1/_3$top dressing at 40 DAT
K_3: 90 kg ha^{-1} potassium	
K_4: 120 kg ha^{-1} potassium	
K_5: 150 kg ha^{-1} potassium	

Table 3. Plant height of onion as influenced by interaction effect of different methods of application and levels of potash at various growth stages.

Treatment	Plant height (cm)			
	30 DAT	50 DAT	70 DAT	90 DAT
$K_0 B_0$	22.34 n	29.71 l	40.84 l	36.56 k
$K_0 B_1$	22.43 n	29.78 l	40.91 l	36.59 k
$K_0 B_2$	22.47 n	29.81 l	40.98 l	36.62 k
$K_1 B_0$	23.72 m	31.59 kl	43.29 k	38.51 j
$K_1 B_1$	24.74 l	31.70 jkl	43.88 jk	39.49 i
$K_1 B_2$	25.72 k	32.31 ijk	44.68 ij	40.38 h
$K_2 B_0$	26.57 j	33.69 hij	45.45 i	40.88 h
$K_2 B_1$	27.78 i	34.23 hi	46.32 h	41.30 gh
$K_2 B_2$	29.35 h	34.90 gh	47.16 g	41.97 g
$K_3 B_0$	31.21 g	36.56 fg	48.13 f	43.83 f
$K_3 B_1$	32.50 f	37.66 ef	49.09 de	44.77 e
$K_3 B_2$	33.84 e	38.46 def	49.61 d	44.98 de
$K_4 B_0$	36.49 d	39.89 cde	50.53 c	46.48 bc
$K_4 B_1$	36.84 cd	41.36 ab	51.59 b	47.29 b
$K_4 B_2$	38.75 a	42.16 a	53.34 a	49.21 a
$K_5 B_0$	37.03 bcd	39.89 bcd	48.65 ef	45.43 de
$K_5 B_1$	37.55 bc	40.25 abcd	49.12 de	45.82 cd
$K_5 B_2$	37.77 b	40.63 abc	49.49 de	46.44 bc
LSD	0.8095	1.899	0.8196	0.8874
Level of significance	**	**	**	*
CV %	6.6	3.2	4.05	2.26

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

**	= Significant at 1% level of significance	$K_0 B_0$	Basal doses of 0 kg ha^{-1} potassium
		$K_0 B_1$:	Two split application of 0 kg ha^{-1} potassium
		$K_0 B_2$:	Three split application of 0 kg ha^{-1} potassium
		$K_1 B_0$:	Basal doses of 30 kg ha^{-1} potassium
*	= Significant at 5% level of significance	$K_1 B_1$:	Two split application of 30 kg ha^{-1} potassium
		$K_1 B_2$:	Three split application of 30 kg ha^{-1} potassium
		$K_2 B_0$:	Basal doses of 60 kg ha^{-1} potassium
		$K_2 B_1$:	Two split application of 60 kg ha^{-1} potassium
		$K_2 B_2$:	Three split application of 60 kg ha^{-1} potassium
		$K_3 B_0$:	Basal doses of 90 kg ha^{-1} potassium
		$K_3 B_1$:	Two split application of 90 kg ha^{-1} potassium
		$K_3 B_2$:	Three split application of 90 kg ha^{-1} potassium
		$K_4 B_0$:	Basal doses of 120 kg ha^{-1} potassium
		$K_4 B_1$:	Two split application of 120 kg ha^{-1} potassium
		$K_4 B_2$:	Three split application of 120 kg ha^{-1} potassium
		$K_5 B_0$:	Basal doses of 150 kg ha^{-1} potassium
		$K_5 B_1$:	Two split application of 150 kg ha^{-1} potassium
		$K_5 B_2$:	Three split application of 150 kg ha^{-1} potassium

4.2 Leaf length (cm)

4.2.1 Effect of different methods of potassium application

Like plant height, leaf length of onion increased continuously upto 70 DAT and decreased thereafter [Fig. 9(A) and Appendix III (a)]. Leaf length varied significantly due to both application methods and levels of potash almost at all DAT. Generally split application produced longer leaf than basal. At all DAT, the highest leaf length was found in the plots receiving three-splits of potash (B_2) while the shortest from the plots receiving single application of potash as basal (B_0). These results obtained might be due to non availability of potash from the loss in various form into soil when the entire dose was applied during planting. These results also revealed that the application of split doses of potash gave longer leaf length over basal application.

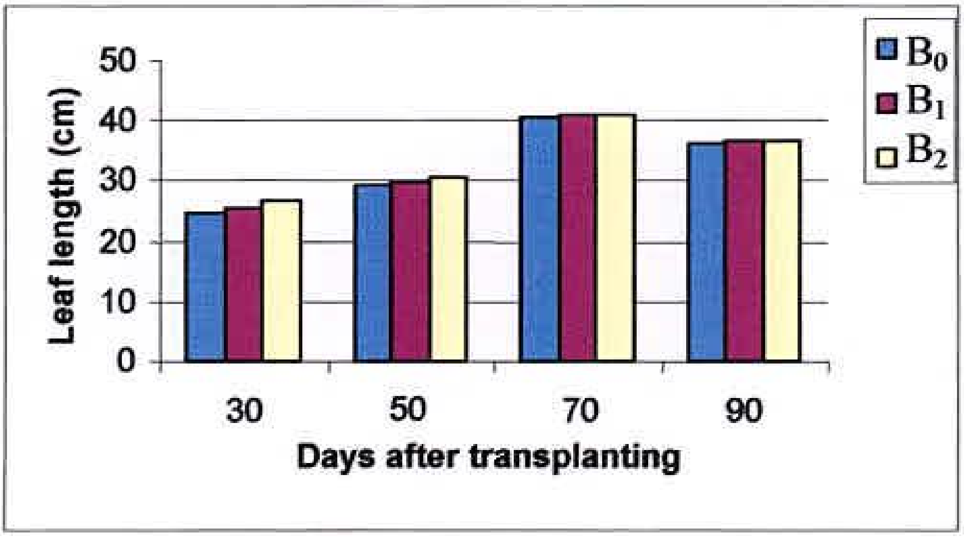
4.2.2 Effect of different levels of potassium

Significant variation in leaf length among levels of potash was observed at all the assigned DAT [Fig. 9(B) and Appendix III (b)]. At all DAT, 120 kg ha^{-1} potassium (K_4) produced longer leaf length and 0 kg ha^{-1} potassium (K_0) had lower leaf length.

4.2.3 Interaction effect of different levels of potassium and its application methods

The interaction effect of methods and levels of potassium on leaf length showed significant variation at 30, 50, 70 and 90 DAT. The longest leaf length was (46.60 cm) observed when 120 kg ha^{-1} potassium was applied in three-splits (K_4B_2) at 70 DAT and the shortest leaf length was (35.13 cm) was found from control treatment (K_0B_0) at 70 DAT (Table 4). Leaf length decreased slowly when potassium was applied in two-splits or as basal. This happened possibly due to unavailability and inadequate amount of uptake of potassium at the later stages of crop growth.

A) Different application methods of potassium



B) Different levels of potassium

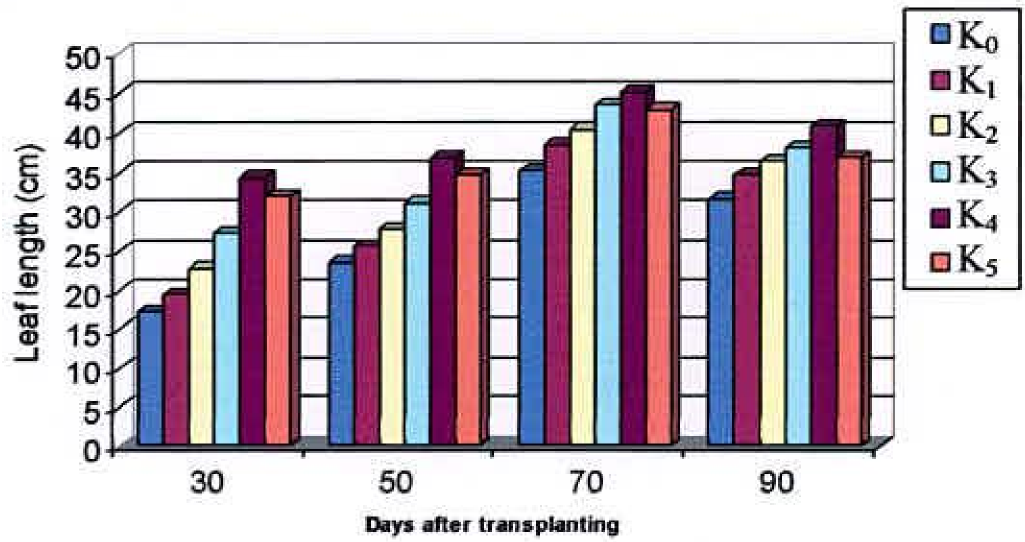


Fig. 9 Leaf length of onion as influenced by different application methods and levels of potash at various growth stages.

K_0:	0 kg ha^{-1} potassium (Control)	B_0:	Basal
K_1:	30 kg ha^{-1} potassium	B_1:	$^1/_2$ Basal + $^1/_2$ top dressing at 20 DAT
K_2:	60 kg ha^{-1} potassium	B_2:	$^1/_3$ Basal + $^1/_3$ top dressing at 20 DAT + $^1/_3$ top dressing at 40 DAT
K_3:	90 kg ha^{-1} potassium		
K_4:	120 kg ha^{-1} potassium		
K_5:	150 kg ha^{-1} potassium		

Table 4. Leaf length of summer onion as influenced by interaction effect of different methods of application and levels of potash at various growth stages.

Treatment	Leaf length (cm)			
	30 DAT	50 DAT	70 DAT	90 DAT
$K_0 B_0$	17.23 n	23.57 k	35.13 k	31.53 i
$K_0 B_1$	17.29 n	23.63 k	35.17 k	31.54 i
$K_0 B_2$	17.24 n	23.68 k	35.23 k	31.60 i
$K_1 B_0$	18.53 m	25.47 j	38.17 j	34.33 h
$K_1 B_1$	19.40 l	25.33 j	38.17 j	34.40 h
$K_1 B_2$	20.47 k	25.90 i	39.14 i	35.27 g
$K_2 B_0$	21.30 j	27.60 h	40.33 h	36.33 f
$K_2 B_1$	22.60 i	27.60 h	40.20 h	36.60 f
$K_2 B_2$	24.37 h	28.13 g	40.80 g	36.47 f
$K_3 B_0$	25.93 g	30.20 f	42.20 f	37.07 e
$K_3 B_1$	27.27 f	31.57 e	44.07 c	38.83 d
$K_3 B_2$	28.73 e	31.56 e	43.53 d	35.50 g
$K_4 B_0$	31.10 d	33.57 d	44.20 c	38.47 d
$K_4 B_1$	31.40 d	34.47 c	45.30 b	39.60 c
$K_4 B_2$	34.80 a	37.37 a	46.60 a	42.03 a
$K_5 B_0$	33.63 c	36.50 b	42.20 f	36.50 f
$K_5 B_1$	34.10 b	36.10 b	43.27 e	38.73 d
$K_5 B_2$	34.20 b	36.47 b	43.20 e	41.13 b
LSD	0.4514	0.4030	0.2624	0.3784
Level of significance	**	**	**	**
CV %	5.06	4.81	3.38	4.62

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

** = Significant at 1% level of significance	$K_0 B_0$	Basal doses of 0 kg ha^{-1} potassium
	$K_0 B_1$:	Two split application of 0 kg ha^{-1} potassium
	$K_0 B_2$:	Three split application of 0 kg ha^{-1} potassium
	$K_1 B_0$:	Basal doses of 30 kg ha^{-1} potassium
	$K_1 B_1$:	Two split application of 30 kg ha^{-1} potassium
	$K_1 B_2$:	Three split application of 30 kg ha^{-1} potassium
	$K_2 B_0$:	Basal doses of 60 kg ha^{-1} potassium
	$K_2 B_1$:	Two split application of 60 kg ha^{-1} potassium
	$K_2 B_2$:	Three split application of 60 kg ha^{-1} potassium
	$K_3 B_0$:	Basal doses of 90 kg ha^{-1} potassium
	$K_3 B_1$:	Two split application of 90 kg ha^{-1} potassium
	$K_3 B_2$:	Three split application of 90 kg ha^{-1} potassium
	$K_4 B_0$:	Basal doses of 120 kg ha^{-1} potassium
	$K_4 B_1$:	Two split application of 120 kg ha^{-1} potassium
	$K_4 B_2$:	Three split application of 120 kg ha^{-1} potassium
	$K_5 B_0$:	Basal doses of 150 kg ha^{-1} potassium
	$K_5 B_1$:	Two split application of 150 kg ha^{-1} potassium
	$K_5 B_2$:	Three split application of 150 kg ha^{-1} potassium

4.3 Number of leaves per plant

4.3.1 Effect of different methods of potassium application

The number of leaves per plant was significantly influenced by the methods of application and levels of potassium at different days after transplanting (DAT) [Table 5 (a)]. There was a gradual increase in number of leaves per plants upto 70 DAT and then a decreasing trend was observed. At all DAT, the highest number of leaves were found in the plots receiving three-splits of potash (B_2) while the lowest from the plots receiving single application of potash as basal (B_0). These results were possibly due to non availability of potash from the loss in various form into soil when the entire dose was applied during planting. These results also revealed that the application of split doses of potash gave higher number of leaves over basal application.

4.3.2 Effect of different levels of potassium

Effect of different levels of potassium on the number of leaves per plant at different stages of growth was also significant [Table 5 (b)]. The number of leaves per plant increased with the increase of potassium level and at 70 DAT the highest number of leaves (7.78) was obtained from 120 kg ha^{-1} (K_4) whereas the control (K_0) produced the lowest (5.63). Probably, the application of potassium increased the height of plants and ultimately the leaf number was also increased due to the influence of this nutrient. Nasiruddin *et al.* (1993) found the highest number of leaves from the plants receiving 100 kg muriate of potash. Vachhani and Patel (1993) and Yavdav *et al.* (2003) also observed that number of leaves per plant increased with the increased levels of potassium application. In all the potassium treatments a decreasing trend was also observed in case of number of leaves per plant after 70 DAT.

4.3.3 Interaction effect of different levels of potassium and its application methods

The combined effect of application methods and levels of potash significantly influenced this parameter at all DAT [Table 5 (c)]. However, the highest (8.10 cm) and the lowest number of leaves (5.63 cm) were recorded from the treatment combination of three-splits application of potassium 120 kg ha^{-1} (K_4B_2) and single application as basal with potassium 0kg ha^{-1} (K_0B_0), respectively at 70 DAT. It was clearly found from the treatment combinations that there was a tendency to produce higher number of leaves from the K_4B_2 combination at every stage of growth.

Table 5 (a). Number of leaves per plant influenced by different methods of application at various growth stages of summer onion.

Treatment	Number of leaves per plant			
	30 DAT	50 DAT	70 DAT	90 DAT
B_0	4.16 c	5.35 c	6.53 c	5.01 c
B_1	4.33 b	5.52 b	6.72 b	5.15 b
B_2	4.53 a	5.73 a	6.83 a	5.29 a
LSD	0.04790	0.06059	0.08832	0.06774
Level of significance	**	**	**	**
CV %	2.69	4.56	2.94	3.98

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

** = Significant at 1% level of significance

B_0 Basal:
B_1: $^1/_2$ Basal + $^1/_2$ top dressing at 20 DAT
B_2: $^1/_3$ Basal + $^1/_3$ top dressing at 20 DAT + $^1/_3$top dressing at 40 DAT

Table 5 (b). Number of leaves per plant influenced by different levels of potash at various growth stages of summer onion.

Treatment	Number of leaves per plant			
	30 DAT	50 DAT	70 DAT	90 DAT
K_0	3.03 f	4.20 f	5.63 f	4.40 f
K_1	3.35 e	4.75 e	6.08 e	4.67 e
K_2	3.95 d	5.33 d	6.54 d	5.00 d
K_3	4.50 c	5.73 c	6.98 c	5.37 c
K_4	5.80 a	6.80 a	7.78 a	5.96 a
K_5	5.42 b	6.41 b	7.24 b	5.50 b
LSD	0.06774	0.08569	0.1249	0.09580
Level of significance	**	**	**	**
CV %	2.69	4.56	2.94	3.98

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

** = Significant at 1% level of significance

K_0: 0 kg ha^{-1} potassium (Control)
K_1: 30 kg ha^{-1} potassium
K_2: 60 kg ha^{-1} potassium
K_3: 90 kg ha^{-1} potassium
K_4: 120 kg ha^{-1} potassium
K_5: 150 kg ha^{-1} potassium

Table 5 (c). Number of leaves per plant as influenced by interaction effect of different methods of application and levels of potash at various growth stages of summer onion.

Treatment	Number of leaves per plant			
	30 DAT	50 DAT	70 DAT	90 DAT
K_0B_0	3.03 m	4.20 l	5.63 m	4.40 i
K_0B_1	3.08 m	4.22 l	5.64 m	4.43 i
K_0B_2	3.09 m	4.24 l	5.67 m	4.47 i
K_1B_0	3.16 l	4.63 k	5.90 l	4.53 i
K_1B_1	3.33 k	4.76 jk	6.10 kl	4.70 h
K_1B_2	3.56 j	4.86 j	6.26 jk	4.80 gh
K_2B_0	3.76 i	5.16 i	6.40 ij	4.90 fg
K_2B_1	4.00 h	5.33 h	6.56 hi	5.03 f
K_2B_2	4.10 h	5.46 gh	6.66 gh	5.06 f
K_3B_0	4.26 g	5.50 g	6.80 fg	5.23 e
K_3B_1	4.43 f	5.70 f	6.96 ef	5.36 de
K_3B_2	4.80 e	6.00 e	7.20 cd	5.53 d
K_4B_0	5.46 c	6.40 c	7.43 c	5.73 c
K_4B_1	5.73 b	6.73 b	7.83 b	5.96 b
K_4B_2	6.20 a	7.26 a	8.10 a	6.20 a
K_5B_0	5.30 d	6.20 d	7.03 de	5.26 e
K_5B_1	5.46 c	6.40 c	7.26 c	5.46 d
K_5B_2	5.50 c	6.63 b	7.43 c	5.76 c
LSD	0.1173	0.1484	0.2163	0.1659
Level of significance	**	*	*	*
CV	2.69	4.56	2.94	3.98

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

**	= Significant at 1% level of significance	K_0B_0	Basal doses of 0 kg ha^{-1} potassium
		K_0B_1:	Two split application of 0 kg ha^{-1} potassium
		K_0B_2:	Three split application of 0 kg ha^{-1} potassium
		K_1B_0:	Basal doses of 30 kg ha^{-1} potassium
*	= Significant at 5% level of significance	K_1B_1:	Two split application of 30 kg ha^{-1} potassium
		K_1B_2:	Three split application of 30 kg ha^{-1} potassium
		K_2B_0:	Basal doses of 60 kg ha^{-1} potassium
		K_2B_1:	Two split application of 60 kg ha^{-1} potassium
		K_2B_2:	Three split application of 60 kg ha^{-1} potassium
		K_3B_0:	Basal doses of 90 kg ha^{-1} potassium
		K_3B_1:	Two split application of 90 kg ha^{-1} potassium
		K_3B_2:	Three split application of 90 kg ha^{-1} potassium
		K_4B_0:	Basal doses of 120 kg ha^{-1} potassium
		K_4B_1:	Two split application of 120 kg ha^{-1} potassium
		K_4B_2:	Three split application of 120 kg ha^{-1} potassium
		K_5B_0:	Basal doses of 150 kg ha^{-1} potassium
		K_5B_1:	Two split application of 150 kg ha^{-1} potassium
		K_5B_2:	Three split application of 150 kg ha^{-1} potassium

4.4 Bulb diameter (cm)

4.4.1 Effect of different methods of potassium application

Marked variation in bulb diameter was observed due to various application methods of potassium [Table 6 (a)]. Among the methods, three splits (B_2) produced significantly bigger bulb than others. The highest diameter of bulb (3.71 cm) was obtained from B_2 and the lowest diameter of bulb (3.58 cm) was recorded from B_0. The results indicated that the diameter of bulb increased with the split application of potash at different stages of growth. It is known that application methods of potash helps in root development and increases the efficiency of leaf in synthesizing photosynthates. The present result agrees with the findings of Islam (1999), Nagaich *et al.* (1999), and Bhuyan (1979) because they also obtained bigger bulbs using potash with split application.

4.4.2 Effect of different levels of potassium

Different levels of potassium also influenced the bulb diameter significantly. Potassium @ 120 kg ha^{-1} (K_4) produced significantly higher bulb diameter while Potassium @ 0 kg ha^{-1} (K_0) had significantly lower bulb diameter [Table 6 (b)]. The largest bulb diameter (4.22 cm) was obtained from K_4 and the lowest bulb diameter (2.84 cm) obtained from K_0. Like application methods, levels of K also influenced bulb diameter. Potassium is essential for photosynthesis, which ultimately increased starch formation. Yadav *et al.* (2003) and Choboczek (1936) reported that bulb size increased with increased levels of potassium.

4.4.3 Interaction effect of different levels of potassium and its application methods

The interaction effect of application methods and levels of potash on bulb diameter was found significant due to different treatment of combinations [Table 6 (c)]. The highest diameter of bulb (4.32 cm) was produced from the treatment combination of three-splits with K 120 kg ha^{-1} (K_4B_2) and the lowest diameter of bulb (2.84 cm) was produced from the control.

4.5 Length of bulb (cm)

4.5.1 Effect of different methods of potassium application

Bulb length was also significantly influenced by the application methods [Table 6 (a)]. The maximum length of bulb (3.64 cm) was found from three-split application of potash and the minimum length of bulb (3.49 cm) from basal doses of application.

4.5.2 Effect of different levels of potassium

The variation in length of bulb among different levels of potash was found to be statistically significant [Table 6 (b)]. Maximum length of bulb (4.28 cm) was found from 120 kg ha^{-1} potassium and the minimum length (2.46 cm) from 0 kg ha^{-1} potassium. Yadav *et al.* (2003) reported that bulb size increased with increased levels of potassium.

4.5.3 Interaction effect of different levels of potassium and its application methods

Result presented in Table 6 (c) showed that the interaction effect was statistically significant on bulb length. The highest length of bulb (4.33 cm) was observed from the treatment combination K_4B_2. The lowest length of bulb (2.46 cm) was produced by unfertilized control treatment (K_0B_0). This result indicated that the production of larger bulb in respect of length needs a good supply of potash.

4.6 Weight of single bulb (g)

4.6.1 Effect of different methods of potassium application

The bulb weight significantly influenced by the application methods on summer onion [Table 6 (a)]. The maximum bulb weight (35.78 g) was recorded in B_2. The minimum bulb weight (31.40 g) was recorded in B_0. It is known that split application of potassium helps root development and increases synthesis of photosynthates which ultimately helps to form higher weight of bulb. The result indicated that three-split application of potash (B_2) produced that heavier bulb than two-splits (B_1) or basal (B_0) application, which was possibly due to better utilization of potash over time. Significant improvement in bulb weight of summer onion in response to split application of potassium was also reported from a number of investigators at home and abroad (Islam,1999; Nagaich *et al.*, 1999; Sangakkara and Piyadas, 1993; Bhuyan, 1979; Satter and Haque, 1975).

4.6.2 Effect of different levels of potassium

In case of different levels of potash, significant difference of bulb weight was recorded on summer onion in different plots [Table 6 (b)]. The highest bulb weight (51.96 g) was recorded from 120 kg ha^{-1} potassium (K_4) and the minimum bulb weight (14.13 g) from 0 kg ha^{-1} potassium (K_0). This result indicated better performance of 120 kg ha^{-1} potassium (K_4) for production of higher bulb weight.

4.6.3 Interaction effect of different levels of potassium and its application methods

Interaction of methods and levels of potash showed significant influence on bulb weight. The highest bulb weight (52.67 g) was recorded from the treatment combination of three-split with 120 kg ha^{-1} potassium (K_4B_2) and the lower bulb weight (14.13 g) was recorded from the treatment combination of zero application of potassium (K_0B_0) [Table 6 (c)]. The result indicated that the bulb weight was consistently increased with the increase of potassium levels except K_5B_2 and K_4B_2 combination those always produced the heaviest bulb. This result also supported the growth of plant height, leaf length and number of leaves per plant at these combinations.

4.7 Number of bulbs m^{-2}

4.7.1 Effect of different methods of potassium application

The number of bulb m^{-2} was found identical in different application methods but there was some numerical difference among themselves [Table 6 (a)]. The maximum number of bulbs (47.61) was recorded at three-split application of potassium (B_2) and minimum number of bulbs per square meter (46.89) was recorded at basal application of potassium (B_0). It is known that split application of potassium helps plant development. It is clear from the results that three-split application of potassium produced the highest number of bulbs than two split (B_1) or basal application of potassium (B_0), which was possibly due to better utilization of potassium over growing period of summer onion.

4.7.2 Effect of different levels of potassium

In case of different levels of potassium, significant difference in number of bulbs per square meter was recorded on summer onion [Table 6 (b)]. The highest number of bulbs per square meter (51.11) was recorded from 120 kg ha^{-1} potassium (K_4). The minimum number of bulbs m^{-2} (42.00) was recorded from 0 kg ha^{-1} potassium (K_0) application. This result indicated better performance of 120 kg ha^{-1} potassium (K_4) towards plant development.

4.7.3 Interaction effect of different levels of potassium and its application methods

Interaction effect of methods and levels of potassium was statistically significant on number of bulbs m^{-2}. The highest number of bulbs m^{-2} (53.33) was recorded from the treatment combination of three-split application of 120 kg ha^{-1} potassium (K_4B_2) and the lowest number of bulbs m^{-2} (42.00) was recorded from the treatment combination of basal application of 0 kg ha^{-1} potassium (K_0B_0) [Table 6 (c)]. The result indicated that the bulb weight was consistently increased with the increase of potassium levels except 150 kg ha^{-1} and K_4B_2 combination those always produced higher number of bulbs m^{-2}. This result was possibly may be due to better physiological growth of summer onion caused by three-split application of 120 kg ha^{-1} potassium.

4.8 Yield and yield attributes

4.8.1 Effect of different methods of potassium application

The observed number of harvested bulbs, bulb diameter, bulb length, single bulb weight and bulb yield of summer onion were influenced by method or levels of potassium and their combined effect are presented in Table 6 (a). The number of harvested bulbs in one m^2 area, bulb diameter, average bulb weight and bulb yield of summer onion were influenced by the application methods as well as levels of potassium. Three-split of potassium application (B_2) produced statistically higher number of bulbs than basal application (B_0) or two-split application (B_1). Sangakkara and Piyadasa (1993) also reported that the increased number of bulbs was due to split application of potassium. In case of sweet potato, split application of potassium was also reported to increase tuber number (Mukhopadhyay *et al.*, 1992). Bulb diameter, bulb length and average bulb weight varied significantly among the application methods. Three equal split application of potassium (B_2) gave the highest bulb yield (11.85 t ha^{-1}) while the basal application of potassium (B_0) gave the lowest bulb yield (11.49 t ha^{-1}). These results are in good agreement with Bhuyan (1979). The highest bulb yield was recorded from B_2 due to higher bulb diameter and higher bulb weight of summer onion. Higher yield of summer onion was recorded in three-split application of potassium (B_2) than two-split (B_1) or basal application of potassium (B_0), which might be due to the loss of potassium through fixation at B_1 or B_0. Potassium may not be utilized effectively when two-split or basal dose applied. Relatively higher yield of summer onion due to split application of potassium have been also reported by Balasa and Valentin (1971); Mukhopadhyay *et al.* (1992); Bhuyan (1979); Tseng (1972) and Sangakkara and Piyadasa (1993).

4.8.2 Effect of different levels of potassium

Among the levels of potassium 120 kg ha^{-1} potassium (K_4) produced the highest number of bulbs (51.11) while 0 kg ha^{-1} potassium (K_0) produced the lowest number of bulbs (42.00) [Table 6 (b)]. Similar trend was also observed in yield and yield attributes. Significantly higher bulb yield (14.76 t ha^{-1}) was recorded from the plots that received 120 kg ha^{-1} (K_4) and lower bulb yield (7.94 t ha^{-1}) was recorded from the plots that received 0 kg ha^{-1} (K_4). An estimated yield increase due to the increasing level of potassium except 150 Kg ha^{-1} of potassium indicated that the uptake of potassium at vegetative as well as bulb formation stage was much better than the other levels of potassium. This result is in agreement with the findings of Rahman *et al.* (1976), Jiang *et al.* (1998), Raza and shaikh(1972), Katyal(1977) and Nagaich *et. al.* (1998).

4.8.3 Interaction effect of different levels of potassium and its application methods

Interaction effect of methods and levels of potassium was found to have significant influence on yield and yield attributes of summer onion [Table 6 (c)]. The highest diameter of bulb (4.32 cm) was produced from the treatment combination of three-splits of K at 120 kg ha^{-1} (K_4B_2) and the lowest diameter of bulb (2.84 cm) was produced from the control (K_0B_0). The number of harvested bulbs in one square meter area, bulb diameter, average bulb weight and yield of summer onion were statistically significant. The highest length of bulb (4.33 cm) was observed from the treatment combination of K_4B_2 and the lowest length of bulb (2.46 cm) was produced by unfertilized control treatment (K_0B_0). The highest number of bulbs m^{-2} (53.33) was recorded from the treatment combination of three-split with 120 kg ha^{-1} potassium (K_4B_2)

and the lowest number of bulbs m^{-2} (42.00) was recorded from the treatment combination of basal application of 0 kg ha^{-1} potassium (K_0B_0). Incase of bulb weight, the highest bulb weight (52.67 g) was recorded from the treatment combination of three-split with 120 kg ha^{-1} potassium (K_4B_2) and the lowest bulb weight (14.13 g) was recorded from the treatment combination of basal application of 0 kg ha^{-1} potassium (K_0B_0). Above all yield attributes had impact on yield. The highest bulb yield (15.27 t ha^{-1}) was recorded from the treatment combination of three-split with 120 kg ha^{-1} potassium (K_4B_2) and the lowest bulb yield (7.94 t ha^{-1}) from the treatment combination of (K_0B_0).

Table 6 (a). Yield and yield attribute of summer onion as influenced by different methods of application

Treatment	Diameter of bulb (cm)	Length of bulb (cm)	Weight of single bulb (g)	Number of bulbs /m^2	Yield (t ha^{-1})
B_0	3.58 c	3.49 c	31.40 c	46.89 c	11.49 c
B_1	3.65 b	3.54 b	33.47 b	46.97 b	11.63 b
B_2	3.71 a	3.64 a	35.78 a	47.10 a	11.85 a
LSD	0.04790	0.03710	0.09817	0.05247	0.08297
Level of significance	**	**	**	**	**
CV %	3.93	4.58	2.43	3.48	4.06

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

** = Significant at 1% level of significance	B_0 Basal: B_1: $^1/_2$ Basal + $^1/_2$ top dressing at 20 DAT B_2: $^1/_3$ Basal + $^1/_3$ top dressing at 20 DAT + $^1/_3$top dressing at 40 DAT

Table 6 (b) Yield and yield attributes of summer onion as influenced by different levels of potash

Treatment	Diameter of bulb (cm)	Length of bulb (cm)	Weight of single bulb (g)	Number of bulbs /m^2	Yield (t ha^{-1})
K_0	2.84 e	2.46 f	14.13 f	42.00 e	7.94 f
K_1	3.25 d	3.22 e	22.02 e	44.22 d	10.74 e
K_2	3.60 c	3.48 d	26.12 d	46.89 c	11.29 d
K_3	3.80 b	3.77 c	37.73 c	48.33 b	12.27 c
K_4	4.22 a	4.28 a	51.96 a	51.11 a	14.76 a
K_5	4.19 a	4.14 b	49.33 b	48.33 b	12.92 b
LSD	0.06774	0.05247	0.1388	0.6630	0.1173
Level of significance	**	**	**	**	**
CV %	3.93	4.58	2.43	3.48	4.06

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

** = Significant at 1% level of significance	K_0: Control (0 kg ha^{-1} potassium) K_1: 30 kg ha^{-1} potassium K_2: 60 kg ha^{-1} potassium K_3: 90 kg ha^{-1} potassium K_4: 120 kg ha^{-1} potassium K_5: 150 kg ha^{-1} potassium

Table 6 (c). Yield and yield attributes of summer onion as influenced by interaction effect of different methods of application and levels of potash

Treatment	Diameter of bulb (cm)	Length of bulb (cm)	Weight of single bulb (g)	Number of bulbs /m^2	Yield (t ha^{-1})
$K_0 B_0$	2.84 j	2.46 i	14.13 o	42.00 j	7.94 m
$K_0 B_1$	2.89 j	2.49 i	14.18 o	42.00 j	7.96 m
$K_0 B_2$	2.91 j	2.51 i	14.23 o	43.00 j	7.97 m
$K_1 B_0$	3.09 i	3.17 h	19.30 n	43.67 i	10.61 l
$K_1 B_1$	3.29 h	3.20 h	22.33 m	44.00 hi	10.77 kl
$K_1 B_2$	3.36 h	3.31 g	24.43 k	45.00 h	10.83 k
$K_2 B_0$	3.53 g	3.39 fg	23.73 l	46.33 g	10.89 k
$K_2 B_1$	3.59 fg	3.47 f	26.20 j	47.00 fg	11.39 j
$K_2 B_2$	3.68 f	3.58 e	28.43 i	47.33 efg	11.61 i
$K_3 B_0$	3.70 ef	3.69 d	32.27 h	47.67 ef	12.00 h
$K_3 B_1$	3.81 de	3.76 d	38.20 g	48.33 de	12.27 g
$K_3 B_2$	3.90 d	3.86 c	42.73 f	49.00 cd	12.55 f
$K_4 B_0$	4.24 ab	4.00 b	46.73 e	49.67 bc	12.77 e
$K_4 B_1$	4.23 ab	4.08 b	48.60 d	50.33 b	12.89 e
$K_4 B_2$	4.32 a	4.33 a	52.67 a	53.33 a	15.27 a
$K_5 B_0$	4.09 c	4.24 a	52.23 b	47.67 fe	13.11 d
$K_5 B_1$	4.15 bc	4.28 a	51.33 c	48.33 de	14.39 c
$K_5 B_2$	4.18 bc	4.31 a	52.30 b	49.00 cd	14.61 b
LSD	0.1173	0.09088	0.2405	1.148	0.2032
Level of significance	**	**	**	**	**
CV %	3.93	4.58	2.43	3.48	4.06

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

** = Significant at 1% level of significance

$K_0 B_0$	Basal doses of 0 kg ha^{-1} potassium
$K_0 B_1$:	Two split application of 0 kg ha^{-1} potassium
$K_0 B_2$:	Three split application of 0 kg ha^{-1} potassium
$K_1 B_0$:	Basal doses of 30 kg ha^{-1} potassium
$K_1 B_1$:	Two split application of 30 kg ha^{-1} potassium
$K_1 B_2$:	Three split application of 30 kg ha^{-1} potassium
$K_2 B_0$:	Basal doses of 60 kg ha^{-1} potassium
$K_2 B_1$:	Two split application of 60 kg ha^{-1} potassium
$K_2 B_2$:	Three split application of 60 kg ha^{-1} potassium
$K_3 B_0$:	Basal doses of 90 kg ha^{-1} potassium
$K_3 B_1$:	Two split application of 90 kg ha^{-1} potassium
$K_3 B_2$:	Three split application of 90 kg ha^{-1} potassium
$K_4 B_0$:	Basal doses of 120 kg ha^{-1} potassium
$K_4 B_1$:	Two split application of 120 kg ha^{-1} potassium
$K_4 B_2$:	Three split application of 120 kg ha^{-1} potassium
$K_5 B_0$:	Basal doses of 150 kg ha^{-1} potassium
$K_5 B_1$:	Two split application of 150 kg ha^{-1} potassium
$K_5 B_2$:	Three split application of 150 kg ha^{-1} potassium

4.9 Effect of different levels of potash and its application methods on the uptake of nutrients by summer onion

4.9.1 Nitrogen uptake (kg ha^{-1})

4.9.1 (a) Effect of different methods of potassium application

N uptake by plant was significantly influenced by both application methods and levels of potassium [Table 7 (a)]. Three-split application (B_2) helped the plant to uptake potassium more efficiently than other two methods. The maximum uptake of nitrogen (38.19 kg ha^{-1}) was observed in three-split application of potassium (B_2) and minimum uptake of nitrogen (36.82 kg ha^{-1}) by summer onion was recorded from basal application of potassium (B_0), which were significantly different from each other. These results were observed possibly due to the higher biomass production.

4.9.1 (b) Effect of different levels of potassium

Among the levels of potassium 120 kg ha^{-1} potassium (K_4) showed better performance in nitrogen uptake by plants [Table 7 (b)]. Significantly highest and lowest nitrogen uptake by summer onion was observed from 120 kg ha^{-1} potassium (K_4) and 0 kg ha^{-1} potassium (K_0), respectively. The highest uptake of nitrogen (42.92 kg ha^{-1}) by plant was recorded from 120 kg ha^{-1} potassium (K_4) and the lowest uptake of nitrogen (30.63 kg ha^{-1}) by plant was recorded from 0 kg ha^{-1} potassium (K_0), which indicated that 120 kg ha^{-1} potassium (K_4) was more efficient than other levels.

4.9.1 (c) Interaction effect of different levels of potassium and its application methods

The application methods and levels of potash [Table 7 (c)] significantly influenced nitrogen uptake by summer onion among the different treatment combinations. The highest nitrogen uptake (43.86 kg ha^{-1}) by summer onion was recoded from three split application of 120 kg ha^{-1} potassium (K_4B_2) and the lowest nitrogen uptake (30.63 kg ha^{-1}) from zero application of potassium (K_0B_0). These results were obtained probably due to the efficient utilization of potassium by the plants through split application.

4.9.2 Phosphorus uptake (kg ha^{-1})

4.9.2 (a) Effect of different methods of potassium application

Phosphorus uptake by plant was significantly influenced by the application method of potassium [Table 7 (a)]. The highest uptake of phosphorus (8.73 kg ha^{-1}) by plant was recorded from three-split application (B_2), which helped the plant to uptake phosphorus more efficiently than other two methods. The minimum uptake of phosphorus (7.85 kg ha^{-1}) by summer onion was recorded at basal application of potassium (B_0), which was significantly different from each other. These results were observed possibly due to the higher biomass production, which were also supported by the observation of Hedge (1988) and Sangakkara and Piyadasa (1993).

4.9.2 (b) Effect of different levels of potassium

Among the levels of potassium 120 kg ha^{-1} potassium (K_4) showed better performance in phosphorus uptake by plants [Table 7 (b)]. Significantly the highest (11.49 kg ha^{-1}) and the lowest (5.41 kg ha^{-1}) phosphorus uptake by summer onion was observed @ 120 kg ha^{-1} potassium (K_4) and 0 kg ha^{-1} potassium (K_0), respectively. This indicated that 120 kg ha^{-1} potassium (K_4) was more effective than other levels.

4.9.2 (c) Interaction effect of different levels of potassium and its application methods

Phosphorus uptake by summer onion among the different treatment combinations was significantly influenced by the application methods and levels of potash [Table 7 (c)]. The highest phosphorus uptake (12.94 kg ha^{-1}) by summer onion was recoded at (K_4B_2) and the lowest phosphorus uptake (5.41 kg ha^{-1}) by summer onion was recoded at (K_0B_0). These results were obtained probably due to the efficient utilization of phosphorus by the plants through split application of potassium.

4.9.3 Potassium uptake (kg ha^{-1})

4.9.3 (a) Effect of different methods of potassium application

Potassium uptake by plant was significantly influenced by the application method[Table 7 (a)]. The maximum uptake of potassium (35.63 kg ha^{-1}) and minimum uptake of potassium (30.45 kg ha^{-1}) by summer onion found significantly different from each other. These results were observed possibly due to the higher biomass production. The result corroborates with the observation of Islam (1999); Hedge (1988) and Sangakkara and piyadasa (1993).

4.9.3 (b) Effect of different levels of potassium

Among the levels 120 kg ha^{-1} potassium (K_4) showed better performance in respect of K uptake by plants [Table 7 (b)]. Significantly the highest (50.51 kg ha^{-1}) and the lowest (9.37 kg ha^{-1}) potassium uptake by summer onion was observed from 120 kg ha^{-1} potassium (K_4) and 0 kg ha^{-1} potassium (K_0), respectively. This indicated that 120 kg ha^{-1} potassium (K_4) was optimum for cultivation of summer onion. The results were similar to those of average bulb weight, bulb diameter and bulb yield of summer onion.

4.9.3 (c) Interaction effect of different levels of potassium and its application methods

Potassium uptake by summer onion among the different treatment combinations was significantly influenced by the application methods and levels of potash [Table 7 (c)]. The highest potassium uptake (53.39 kg ha^{-1}) by summer onion was recoded from treatment combination of three split application of 120 kg ha^{-1} (K_4B_2) and the lowest uptake (9.37 kg ha^{-1}) by summer onion was recoded from treatment combination of basal application of 0 kg ha^{-1} potassium (K_0B_0). These results were obtained probably due to the efficient utilization of potassium by the plants during growing period.

4.9.4 Sulphur uptake (kg ha^{-1})

4.9.4 (a) Effect of different methods of potassium application

Sulphur uptake by plant was significantly influenced by application methods of potassium [Table 7 (a)]. The highest uptake of sulphur (9.43 kg ha^{-1}) by plant was recorded from three-split application (B_2), which helped the plant to uptake sulphur more efficiently than other two methods. The minimum uptake of sulphur (8.39 kg ha^{-1}) by summer onion was recorded from basal application of potassium (B_0) and maximum uptake of sulphur (9.43 kg ha^{-1}) by summer onion was observed in three-splits application of potassium (B_2), which were significantly different from each other. These results were observed possibly due to the efficient application and uptake of potassium.

4.9.4 (b) Effect of different levels of potassium

Among the levels of potassium 120 kg ha^{-1} potassium (K_4) showed better performance in sulphur uptake by plants [Table 7(b)]. Significantly the highest (12.84 kg ha^{-1}) and the lowest (3.38 kg ha^{-1}) sulphur uptake by summer onion was observed from 120 kg ha^{-1} potassium (K_4) and 0 kg ha^{-1} potassium (K_0), respectively. This indicated that 120 kg ha^{-1} potassium (K_4) was more efficient than other levels.

4.9.4 (c) Interaction effect of different levels of potassium and its application methods

Sulphur uptake by summer onion among the different treatment combinations was significantly influenced by the application methods and levels of potash [Table 7 (c)]. The highest sulphur uptake (13.45 kg ha^{-1}) by summer onion was recoded from the treatment combination of three split application of 120 kg ha^{-1} potassium (K_4B_2) and the lowest sulphur uptake (3.38 kg ha^{-1}) by summer onion was recoded at the treatment combination of basal application of 0 kg ha^{-1} potassium (K_0B_0). These results were obtained probably due to the efficient utilization of sulphur by the plants through split application of potassium.

Table 7 (a). Nutrients uptake by summer onion influenced by different methods of application at various growth stages

Treatment	Nutrients uptake (kg ha^{-1})			
	N	P	K	S
B_0	36.82 c	7.856 c	30.45 c	8.392 c
B_1	37.14 b	8.214 b	35.33 b	8.935 b
B_2	38.19 a	8.732 a	35.63 a	9.430 a
LSD	0.2185	0.2121	0.2077	0.1405
Level of significance	**	**	**	**
CV %	4.86	3.79	2.94	4.33

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

** = Significant at 1% level of significance

B_0 Basal:
B_1: $^1/_2$ Basal + $^1/_2$ top dressing at 20 DAT
B_2: $^1/_3$ Basal + $^1/_3$ top dressing at 20 DAT + $^1/_3$top dressing at 40 DAT

Table 7 (b). Nutrients uptake by summer onion influenced by different levels of potash

Treatment	Nutrients uptake (kg ha^{-1})			
	N	P	K	S
K_0	30.63 f	5.410 f	9.370 f	3.38 f
K_1	34.74 e	6.406 e	21.55 e	6.34 e
K_2	36.77 d	7.637 d	29.55 d	8.43 d
K_3	39.08 c	8.750 c	41.06 c	10.75 c
K_4	42.92 a	11.49 a	50.51 a	12.84 a
K_5	40.16 b	9.907 b	44.39 b	11.77 b
LSD	0.3089	0.2999	0.2937	0.1987
Level of significance	**	**	**	**
CV %	4.86	3.79	2.94	4.33

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

** = Significant at 1% level of significance

K_0: 0 kg ha^{-1} potassium (Control)
K_1: 30 kg ha^{-1} potassium
K_2: 60 kg ha^{-1} potassium
K_3: 90 kg ha^{-1} potassium
K_4: 120 kg ha^{-1} potassium
K_5: 150 kg ha^{-1} potassium

Table 7 (c). Nutrients uptake of summer onion as influenced by interaction effect of different methods of application and levels of potash

Treatment	Nutrients uptake (kg ha^{-1})			
	N	P	K	S
$K_0 B_0$	30.63 k	5.41 m	9.37 p	3.38 m
$K_0 B_1$	30.65 k	5.43 m	9.38 p	3.39 m
$K_0 B_2$	30.68 k	5.46 m	9.41 p	3.42 m
$K_1 B_0$	34.17 j	6.18 l	18.53 o	5.87 l
$K_1 B_1$	34.91 i	6.42 l	21.63 n	6.44 k
$K_1 B_2$	35.15 i	6.61 l	24.49 m	6.71 k
$K_2 B_0$	36.07 h	7.28 k	26.72 l	7.34 j
$K_2 B_1$	36.38 h	7.71 jk	29.29 k	8.61 i
$K_2 B_2$	37.85 g	7.92 ij	32.63 j	9.34 h
$K_3 B_0$	38.46 f	8.37 hi	36.34 i	10.17 g
$K_3 B_1$	38.66 f	8.71 gh	40.49 h	10.75 f
$K_3 B_2$	40.13 d	9.17 fg	46.34 d	11.34 e
$K_4 B_0$	42.25 b	10.28 cd	48.76 c	12.33 c
$K_4 B_1$	42.65 b	11.26 b	50.57 b	12.74 b
$K_4 B_2$	43.86 a	12.94 a	53.39 a	13.45 a
$K_5 B_0$	39.36 e	9.610 ef	42.96 g	11.26 e
$K_5 B_1$	39.59 e	9.770 de	44.43 f	11.69 d
$K_5 B_2$	41.52 c	10.34 c	45.77 e	12.36 c
LSD	0.5351	0.5194	0.5087	0.3441
Level of significance	**	**	**	**
CV %	4.86	3.79	2.94	4.33

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

** = Significant at 1% level of significance

$K_0 B_0$:	Basal doses of 0 kg ha^{-1} potassium
$K_0 B_1$:	Two split application of 0 kg ha^{-1} potassium
$K_0 B_2$:	Three split application of 0 kg ha^{-1} potassium
$K_1 B_0$:	Basal doses of 30 kg ha^{-1} potassium
$K_1 B_1$:	Two split application of 30 kg ha^{-1} potassium
$K_1 B_2$:	Three split application of 30 kg ha^{-1} potassium
$K_2 B_0$:	Basal doses of 60 kg ha^{-1} potassium
$K_2 B_1$:	Two split application of 60 kg ha^{-1} potassium
$K_2 B_2$:	Three split application of 60 kg ha^{-1} potassium
$K_3 B_0$:	Basal doses of 90 kg ha^{-1} potassium
$K_3 B_1$:	Two split application of 90 kg ha^{-1} potassium
$K_3 B_2$:	Three split application of 90 kg ha^{-1} potassium
$K_4 B_0$:	Basal doses of 120 kg ha^{-1} potassium
$K_4 B_1$:	Two split application of 120 kg ha^{-1} potassium
$K_4 B_2$:	Three split application of 120 kg ha^{-1} potassium
$K_5 B_0$:	Basal doses of 150 kg ha^{-1} potassium
$K_5 B_1$:	Two split application of 150 kg ha^{-1} potassium
$K_5 B_2$:	Three split application of 150 kg ha^{-1} potassium

4.10 Relationship between yield and application methods of potassium

The relationship between yield and application methods of potassium is presented in figure 10. The regression analysis indicated that yield of summer onion was linearly and positively correlated to the application methods of potassium. The best fitted relationship was as follows:

$Y = 11.29 + 0.18\ b$

$R^2 = 0.931$

Where, Y= yield in t ha^{-1}

b= application methods of potassium

The co-efficient of determination indicated that application methods of potassium accounted for 93.1 % of the variation in yield. It was also evident from the regression equation that an increase of 0.18 t ha^{-1} yield of summer onion can be expected from per unit increase of application methods of potassium.

4.11 Relationship between yield and potassium levels

The relationship between yield and potassium levels was statistically modeled and presented in figure 11. The best fitted relationship was as follows:

$Y = 1.084\, x + 7.85$

$R^2 = 0.779$

Where, Y= yield in t ha^{-1}

x = Different levels of potassium

The bulb yield of summer onion increased with the increasing levels of potassium except 150 kg ha^{-1} potassium(K_5) and the highest yield (14.76 t ha^{-1}) was obtained from 120 kg ha^{-1} potassium (K_4). Further application of potassium fertilizer decreased the yield. The co-efficient of determination indicated that levels of potassium accounted for 77.9 % of variation in yield. It was also evident from the regression equation that an increase of 1.084 t ha^{-1} the yield of summer onion can be expected from per unit increase in levels of potassium.

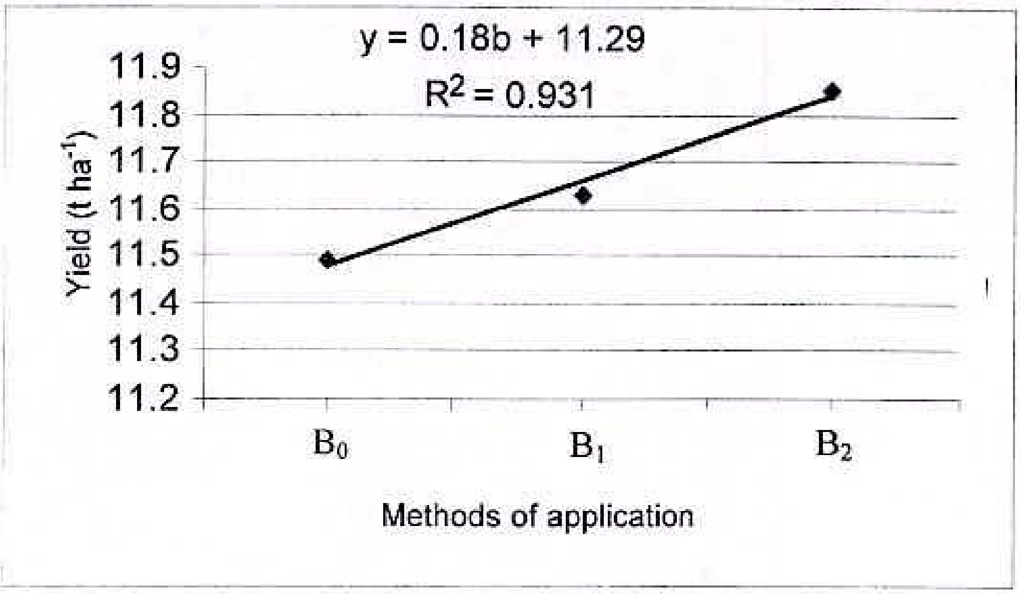


Fig.10 Relationship between yield and different methods of potassium application

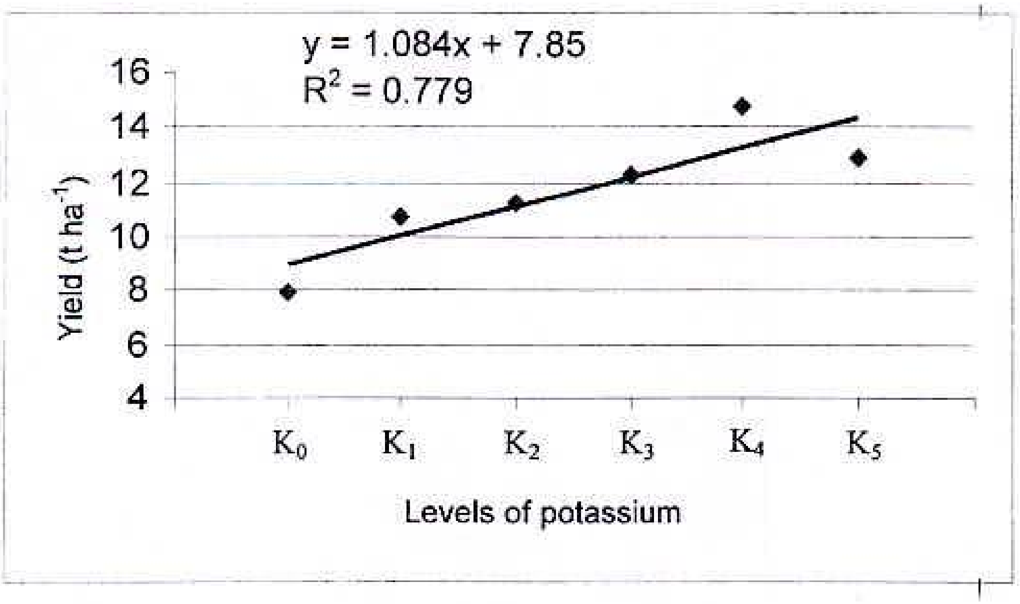


Fig.11 Relationship between yield and different levels of potassium

4.12 Effect of different levels of potassium and application methods on the nutrient status of soil after harvest of the crop

4.12.1 pH value of soil

4.12.1 (a) Effect of different methods of potassium application

There was no significant variation in the pH value after harvesting of summer onion, when various application methods of potassium fertilizer were applied [Table 8 (a)]. The pH was almost the same (6.38 to 6.40) in all application methods of potassium after harvest of the crop.

4.12.1 (b) Effect of different levels of potassium

A significant variation was recorded in the pH of soil after harvesting of summer onion crop when different levels of potassium fertilizer were applied [Table 8 (b)]. In considering the different levels of potassium, K_4 (120 kg ha^{-1} potassium) showed the highest pH (6.43). On the other hand, the lowest pH (6.35) was observed in the K_0 treatment where no fertilizer was applied.

4.12.1 (c) Interaction effect of different levels of potassium and application methods

Combined effect of different levels of potassium and application methods showed significant effect on pH of soil after harvest [Table 8 (c)]. The highest pH of crop-harvested soil (6.50) was recorded in the treatment combination of K_4B_2 (three-split application of potassium 120kg ha^{-1}), which was statistically similar with K_5B_1 and K_5B_2. On the other hand, the lowest pH value (6.30) was recorded in K_0B_0 (control), which was statistically similar with K_0B_1.

4.12.2 Organic matter content of soil

4.12.2 (a) Effect of different methods of potassium application

There was no significant variation in the organic matter content after harvest, when various application methods of potassium fertilizer were applied [Table 8 (a)]. The contents of organic matter were almost the same (1.076 to 1.099 %) in all application methods of potassium after harvest of the crop.

4.12.2 (b) Effect of different levels of potassium

A significant variation was observed on the content of organic matter after harvest when different levels of potassium were incorporated in plots [Table 8 (b)]. Among the different levels of potassium, K_4 (120 kg ha^{-1} potassium) treatment showed the highest organic matter content (1.28 %) after the harvest of crop. On the other hand, the lowest organic matter content (0.78%) was observed in the K_0 treatment where no potassium was applied.

4.12.2 (c) Interaction effect of different levels of potassium and its application methods

Combined effect of different levels of potassium and application methods showed significant effect on the organic matter content of soil after harvest [Table 8 (c)]. The lowest organic matter content of the soil (0.78 %) after harvest was recorded in the treatment combinations of K_0B_0 (control). On the other hand, the highest organic matter contents (1.30 %) was recorded in the treatment combination of K_4B_2 (Three-split application of 120 kg ha^{-1} potassium), which was statistically similar with K_4B_1.

4.12.3 Nitrogen content of soil

4.12.3 (a) Effect of different methods of potassium application

There was no significant variation in the nitrogen content after harvest, when various application methods of potassium fertilizer were applied [Table 8 (a)]. The contents of nitrogen were almost the same (0.053 to 0.056 %) after harvest of the crop in all application methods of potassium.

4.12.3 (b) Effect of different levels of potassium

There was no significant variation in the nitrogen content after harvest, when different levels of potassium fertilizer were applied [Table 8 (b)]. The contents of nitrogen were almost the same (0.044 to 0.065 %) after harvest of the crop in all the potassium fertilizer treated plots.

4.12.3 (c) Interaction effect of different levels of potassium and its application methods

Combined effect of different levels of potassium and application methods showed significant effect on nitrogen content of soil after harvest [Table 8 (c)]. The highest nitrogen content of crop-harvested soil (0.068 %) was recorded in the treatment combination of K_4B_2 (three-split application of potassium 120 kg ha^{-1}). On the other hand, the lowest nitrogen content (0.041 %) was recorded in K_0B_0 (control), which was statistically similar with K_0B_1 and K_0B_2.

4.12.4 Phosphorous content of soil

4.12.4 (a) Effect of different methods of potassium application

There was no significant variation in the phosphorus content after harvest, when various application methods of potassium fertilizer were applied [Table 8 (a)]. The contents of phosphorus were almost the same (19.38 to 19.94 %) after harvest of the crop in all application methods of potassium fertilizer treated plots.

4.12.4 (b) Effect of different levels of potassium

A significant variation was recorded in the phosphorus content of soil after harvest of summer onion crop when different levels of potassium fertilizer were applied [Table 8 (b)]. In considering the different levels of potassium, K_4 (120 kg ha^{-1} potassium) showed the highest phosphorus content (28.00 ppm) followed by K_5 (150 kg ha^{-1} potassium). On the other hand, the lowest phosphorus content (10.67 ppm) was observed in the K_0 treatment where no potassium fertilizer was applied.

4.12.3 (c) Interaction effect of different levels of potassium and its application methods

Combined effect of different levels of potassium and application methods showed significant effect on phosphorus content of soil after harvest [Table 8 (c)]. The highest phosphorus content of crop-harvested soil (29.00 ppm) was recorded in the treatment combination of K_4B_2 (three-split application of potassium 120 kg ha^{-1}), which was statistically similar with K_5B_2. On the other hand, the lowest phosphorus content (9.00 ppm) was recorded in K_0B_0 (control), which was statistically similar with K_0B_1.

4.12.5 Potassium content of soil

4.12.5 (a) Effect of different methods of potassium application

Significant variation was recorded in the potassium content of soil in the summer onion field after harvest of the crop where different application methods of potassium were applied [Table 8 (a)]. Three split application of potassium (B_2) showed the highest potassium content (0.19 Cmol Kg^{-1}), which was closely followed by B_1 (two split application of potassium). On the other hand, the lowest potassium content (0.14 Cmol Kg^{-1}) was observed in the B_0 treatment.

4.12.5 (b) Effect of different levels of potassium

A significant variation was recorded in the potassium content of soil after harvest of the summer onion crop when different levels of potassium fertilizer were applied [Table 8 (b)]. In considering the different levels of potassium, K_4 (120 kg ha^{-1} potassium) showed the highest potassium content (0.28 Cmol Kg^{-1}). On the other hand, the lowest potassium content (0.09 Cmol Kg^{-1}) was observed in the K_0 treatment where no potassium fertilizer was applied.

4.12.5 (c) Interaction effect of different levels of potassium and its application methods

Combined effect of different levels of potassium and application methods showed significant effect on potassium content of soil after harvest [Table 8 (c)]. The highest potassium content of crop-harvested soil (0.30 Cmol Kg^{-1}) was recorded in the treatment combination of K_4B_2 (three-split application of potassium 120kg ha^{-1}), which was statistically similar with K_5B_1 and K_5B_2. On the other hand, the lowest potassium content (0.08 Cmol Kg^{-1}) was recorded in K_0B_0 (control), which was statistically similar with K_0B_1, K_0B_2, K_1B_0 and K_1B_1.

4.12.6 Sulphur content of soil

4.12.6 (a) Effect of different methods of potassium application

Significant variation was recorded in the sulphur content of soil after summer onion harvest where the plots were fertilized by different application methods of potassium [Table 8 (a)]. Three split application of potassium (B_2) showed the highest sulphur content (21.89 ppm) after the harvest of crop and the lowest sulphur content (20.83 ppm) was observed in the B_0 treatment.

4.12.6 (b) Effect of different levels of potassium

A significant variation was recorded in the sulphur content of soil after harvest of the summer onion crop when different levels of potassium fertilizer were applied [Table 8 (b)]. In considering the different levels of potassium, K_4 (120 kg ha^{-1} potassium) showed the highest sulphur content (24.89 ppm). On the other hand, the lowest sulphur content (17.78 ppm) was observed in the K_0 treatment where no fertilizer was applied.

4.12.6 (c) Interaction effect of different levels of potassium and its application methods

Combined effect of different levels of potassium and application methods showed significant effect on sulphur content of soil after harvest [Table 8 (c)]. The highest sulphur content of crop-harvested soil (25.33 ppm) was recorded in the treatment combination of K_4B_2 (three-split application of potassium 120kg ha^{-1}), which was statistically similar with K_5B_1 and K_5B_2. On the other hand, the lowest sulphur content (16.33 ppm) was recorded in K_0B_0 (control), which was closely followed by K_0B_1.

Table 8(a). Effect of different application methods of potassium on the pH, organic matter, total N, available P, available K and available S in the soil after summer onion harvest

Treatment	Nutrients status of post harvest soil					
	pH	Organic matter (%)	N (%)	P (ppm)	K (Cmol Kg^{-1})	S (ppm)
B_0	6.38	1.076	0.053	19.38	0.14 c	20.83 b
B_1	6.39	1.091	0.054	19.72	0.16 b	21.39 ab
B_2	6.40	1.099	0.056	19.94	0.19 a	21.89 a
LSD	0.04790	0.03710	0.03029	0.5478	0.07234	0.7343
Level of significance	NS	NS	NS	NS	**	**
CV %	53.5	1.08	6.71	4.08	7.14	5.07

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

NS = Non significant
** = Significant at 1% level of significance

B_0 Basal:
B_1: $^1/_2$ Basal + $^1/_2$ top dressing at 20 DAT
B_2: $^1/_3$ Basal + $^1/_3$ top dressing at 20 DAT + $^1/_3$top dressing at 40 DAT

Table 8 (b). Effect of different levels of potassium on the pH, organic matter, total N, available P, available K and available S in the soil after summer onion harvest

Treatment	Nutrients status of post harvest soil					
	pH	Organic matter (%)	N (%)	P (ppm)	K (Cmol Kg^{-1})	S (ppm)
K_0	6.35 d	0.78 e	0.044	10.67 f	0.09 c	17.78 e
K_1	6.36 cd	1.06 d	0.055	15.33 e	0.10 c	20.11 d
K_2	6.37 bcd	1.10 c	0.057	18.89 d	0.10 c	20.89 c
K_3	6.41 abc	1.11 c	0.059	20.78 c	0.14 bc	21.11 c
K_4	6.43 a	1.28 a	0.065	28.00 a	0.28 a	24.89 a
K_5	6.42 ab	1.17 b	0.050	25.33 b	0.21 b	23.44 b
LSD	0.04790	0.03710	0.07421	0.03029	0.07421	0.7343
Level of significance	*	*	NS	**	**	**
CV %	53.5	1.08	6.71	4.08	7.14	5.07

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

NS = Non significant
** = Significant at 1% level of significance
* = Significant at 5% level of significance

K_0: 0 kg ha^{-1} potassium (Control)
K_1: 30 kg ha^{-1} potassium
K_2: 60 kg ha^{-1} potassium
K_3: 90 kg ha^{-1} potassium
K_4: 120 kg ha^{-1} potassium
K_5: 150 kg ha^{-1} potassium

Table 8 (c). Combined effect of different levels of potash and its application methods on the pH, organic matter, total N, available P, available K and available S contents in the soil after summer onion harvest

Treatment	Nutrients status of post harvest soil					
	pH	OM (%)	N (%)	P (ppm)	K (Cmol Kg^{-1})	S (ppm)
$K_0 B_0$	6.30 d	0.78 h	0.041 b	9.00 m	0.08 f	16.33 h
$K_0 B_1$	6.30 d	0.82 g	0.042 b	10.67 lm	0.08 f	17.00 g
$K_0 B_2$	6.33 cd	0.85 g	0.044 b	12.33 kl	0.09 f	17.67 f
$K_1 B_0$	6.33 cd	1.04 f	0.051 ab	13.67 jk	0.09 f	19.33 ef
$K_1 B_1$	6.33 cd	1.06 f	0.056 ab	15.33 ij	0.09 f	20.33 de
$K_1 B_2$	6.36 c	1.08 ef	0.057 ab	17.00 hi	0.10 ef	20.33 de
$K_2 B_0$	6.36 c	1.10 de	0.057 ab	17.00 hi	0.11 ef	20.67 d
$K_2 B_1$	6.36 c	1.10 de	0.058 ab	18.33 gh	0.11 ef	21.00 d
$K_2 B_2$	6.36 c	1.11 de	0.058 ab	19.67 fg	0.11 ef	21.00 d
$K_3 B_0$	6.36 c	1.11 de	0.058 ab	21.00 ef	0.13 def	21.00 d
$K_3 B_1$	6.43 b	1.11 de	0.059 ab	21.00 ef	0.14 de	21.33 d
$K_3 B_2$	6.43 b	1.12 de	0.060 ab	21.67 e	0.16 cd	21.67 d
$K_4 B_0$	6.43 b	1.14 d	0.061 ab	24.00 d	0.20 bc	23.00 c
$K_4 B_1$	6.43 b	1.28 ab	0.064 ab	25.00 cd	0.21 b	23.67 bc
$K_4 B_2$	6.50 a	1.30 a	0.068 a	29.00 a	0.30 a	25.33 a
$K_5 B_0$	6.43 b	1.18 c	0.046 ab	26.00 cd	0.22 b	23.67 bc
$K_5 B_1$	6.50 a	1.19 c	0.051 ab	27.00 bc	0.27 a	24.33 ab
$K_5 B_2$	6.50 a	1.26 b	0.053 ab	28.00 ab	0.28 a	25.00 a
LSD	0.04790	0.03710	0.02032	1.740	0.03710	1.212
Level of significance	*	*	*	**	*	*
CV %	53.5	1.08	6.71	4.08	7.14	5.07

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

** = Significant at 1% level of significance

* = Significant at 5% level of significance

$K_0 B_0$: Basal doses of 0 kg ha^{-1} potassium
$K_0 B_1$: Two split application of 0 kg ha^{-1} potassium
$K_0 B_2$: Three split application of 0 kg ha^{-1} potassium
$K_1 B_0$: Basal doses of 30 kg ha^{-1} potassium
$K_1 B_1$: Two split application of 30 kg ha^{-1} potassium
$K_1 B_2$: Three split application of 30 kg ha^{-1} potassium
$K_2 B_0$: Basal doses of 60 kg ha^{-1} potassium
$K_2 B_1$: Two split application of 60 kg ha^{-1} potassium
$K_2 B_2$: Three split application of 60 kg ha^{-1} potassium
$K_3 B_0$: Basal doses of 90 kg ha^{-1} potassium
$K_3 B_1$: Two split application of 90 kg ha^{-1} potassium
$K_3 B_2$: Three split application of 90 kg ha^{-1} potassium
$K_4 B_0$: Basal doses of 120 kg ha^{-1} potassium
$K_4 B_1$: Two split application of 120 kg ha^{-1} potassium
$K_4 B_2$: Three split application of 120 kg ha^{-1} potassium
$K_5 B_0$: Basal doses of 150 kg ha^{-1} potassium
$K_5 B_1$: Two split application of 150 kg ha^{-1} potassium
$K_5 B_2$: Three split application of 150 kg ha^{-1} potassium

4.13 Economic analysis

The analysis was done in order to find out the most profitable treatment based on cost and benefit of various treatments. Net benefit was calculated by subtracting the total input cost from the gross income. Gross income was calculated as the total market value of onion bulb. The input cost was calculated as the market value of fertilizers, and other material and non-material cost. The results of economic analysis of summer onion showed that the highest net benefit of Tk. 1,46,100.00 ha^{-1} was obtained in K_4B_2 treatment followed by Tk. 1,37,760.00 ha^{-1}, Tk. 1,35,120.00 ha^{-1}, Tk.1,19,760.00 ha^{-1}, Tk.1,17,540.00 ha^{-1} and Tk. 1,16,100.00 ha^{-1} in K_5B_2, K_5B_1, K_5B_0, K_4B_1 and K_4B_0 treatments, respectively (Table 09). Hence, three split application of 120 kg ha^{-1} potassium appeared to be most suitable fertilizer dose for summer onion in the present agro ecological environment of Joydebpur, Gazipur from economic point of view.

Table 9. Economics for fertilizer use in crop production under onion during summer season, 2005

Treatments	Total output (t ha^{-1})	Gross income (Tk ha^{-1})	Total input cost (Tk. ha^{-1})	Net benefit (Tk. ha^{-1})	Net benefit due to addition of potassium over control (Tk ha^{-1})
$K_0 B_0$	7.94	95,280.00	35,460.00	**59,820.00**	
$K_0 B_1$	7.96	95,520.00	35,460.00	**60,060.00**	240.00
$K_0 B_2$	7.97	95,640.00	35,460.00	**60,180.00**	360.00
$K_1 B_0$	10.61	1,27,320.00	35,880.00	**91,440.00**	31,620.00
$K_1 B_1$	10.77	1,29,240.00	35,880.00	**93,360.00**	33,540.00
$K_1 B_2$	10.83	1,29,960.00	35,880.00	**94,080.00**	34,260.00
$K_2 B_0$	10.89	1,30,680.00	36,300.00	**94,380.00**	34,560.00
$K_2 B_1$	11.39	1,36,680.00	36,300.00	**1,00,380.00**	40,560.00
$K_2 B_2$	11.61	1,39,320.00	36,300.00	**1,03,020.00**	43,200.00
$K_3 B_0$	12.00	1,44,000.00	36,720.00	**1,07,280.00**	47,460.00
$K_3 B_1$	12.27	1,47,240.00	36,720.00	**1,10,520.00**	50,700.00
$K_3 B_2$	12.55	1,50,600.00	36,720.00	**1,13,880.00**	54,060.00
$K_4 B_0$	12.77	1,53,240.00	37,140.00	**1,16,100.00**	56,280.00
$K_4 B_1$	12.89	1,54,680.00	37,140.00	**1,17,540.00**	57,720.00
$K_4 B_2$	15.27	1,83,240.00	37,140.00	**1,46,100.00**	86,280.00
$K_5 B_0$	13.11	1,57,320.00	37,560.00	**1,19,760.00**	59,940.00
$K_5 B_1$	14.39	1,72,680.00	37,560.00	**1,35,120.00**	75,300.00
$K_5 B_2$	14.61	1,75,320.00	37,560.00	**1,37,760.00**	77,940.00

* Production cost other fertilizer remain same in all treatments.

** Current market prices were used for onion bulbs are listed value.

1. **INPUT COST**

   a) Material cost

   Urea @ Tk. 8.00 kg^{-1}
   TSP @ Tk. 16.00 kg^{-1}
   MOP @ Tk. 14.00 kg^{-1}
   Gypsum @ Tk. 6.00 kg^{-1}
   Irrigation - Tk. 900.00
   Pesticide- Tk.400.00
   Rubral @ Tk.85 packet^{-1}
   Seed @ Tk.900.00 kg^{-1}

   b) Non-material cost

   Labour cost @ Tk. 70 day^{-1}
   Total number of labour-242
   Total labour cost- Tk. 9940.00
   Ploughing- Tk. 2500.00

2. **OUTPUT COST**

   Bulb of onion @ Tk. 12.00 kg^{-1}.

Chapter 5

Summary and Conclusion

SUMMARY AND CONCLUSION

The experiment was conducted at the Bangladesh Agricultural Research Institute, Gazipur during the period from April 2005 to July 2005. Six different levels of potassium viz. 0, 30 , 60, 90, 120 and 150 and three application methods viz. basal (B_0), ½ basal + ½ at 20 DAT (B_1) and 1/3 basal + 1/3 at 20 DAT + 1/3 at 40 DAT (B_2) were studied. The experiment was laid out in Randomized Block Design with three replications. The unit plot size was 3m x 2m. Forty five days old seedlings of variety "BARI Peaj 2" were transplanted on 27th April, 2005 maintaining 15 cm x 10 cm plant spacing. The crop was fertilized as per assigned treatments and flood irrigation was given when necessary. The crop was harvested on 28th July, 2005. Data on plant height, leaf length, number of leaves plant^{-1}, diameter of bulb, length of bulb, individual weight of bulb were recorded. Onion bulbs were collected from each plot. Plant samples at different growth stages were also collected for chemical analysis. The collected data on various parameters were statistically analyzed. The differences between mean values were separated by DMRT.

The results of the experiment revealed that the different application methods and levels of potassium significantly influenced the plant height of summer onion at different days after transplanting (DAT). There was a gradual increase in plant height up to 70 DAT and decreased thereafter. The shortest plants were always found in the treatment combination of K_0B_0 and the tallest plants in three-splits with 120 kg K ha^{-1} (K_4B_2). Methods of application and levels of potassium also had a significant influence in leaf length. Levels of potassium provided significant variation in leaf length at all DAT and K_4B_2 always produced longer leaf. Dose of 120 kg K ha^{-1} with three-splits application had a tendency to produce longer leaf at all growth stages. An increasing trend in the bulb diameter was observed along with the application methods in all treatments and 120 kg K ha^{-1} level always produced bigger bulb than other levels and their combined effect had also similar trend. However, the biggest bulbs were always recorded in plots receiving the treatment combination of three-splits with 120 kg K ha^{-1} level (K_4B_2).

The number of harvested bulb in 1 m^2 area, bulb diameter, length of bulb, weight of single bulb and bulb yield of onion was significantly influenced both by application methods and levels of potassium. Three-split application of potash (B_2) produced statistically highest number of bulbs whereas two-split (B_1) produced higher bulb diameter than single application as a basal (B_0). Although three-splits gave relatively higher bulb diameter, single bulb weight as well as highest bulb yield (1.85 t ha^{-1}) and with 120 kg K ha^{-1} the yield was highest (14.76 t ha^{-1}). When combination of application methods and levels of potassium were considered, the K_4B_2 (three-split of 120 kg ha^{-1} Potassium) produced relatively higher bulb diameter, single bulb weight and bulb yield

(15.27 t ha^{-1}) as well as higher net profit (Tk. 1,46,100.00 ha^{-1}) of summer onion at Chhiata series of Grey Terrace soils.

The nitrogen, phosphorus, potassium and sulphur uptake by plant parts was significantly influenced both by methods and levels of potassium. The highest uptake was observed in B_2 with 38.19 kg ha^{-1} of N, 8.732 kg ha^{-1} of P, 35.33 kg ha^{-1} of K and 9.430 kg ha^{-1} of S) and the minimum of 36.82 kg ha^{-1} of N, 7.856 kg ha^{-1} of P, 30.45 kg ha^{-1} of K and 8.392 kg ha^{-1} of S as basal application method. The levels of potassium always showed better performance in respect nutrient uptake .The highest uptake (42.92 kg ha^{-1} of N, 11.49 kg ha^{-1} of P, 50.91 kg ha^{-1} of K and 12.84 kg ha^{-1} of S) and the lowest uptake (30.63 kg ha^{-1} of N, 5.41 kg ha^{-1} of P, 9.37 kg ha^{-1} of K and 3.38 kg ha^{-1} of S) was recorded when potassium level was used @ 120 kg ha^{-1} and 0 kg ha^{-1}, respectively. Regarding combined different methods of application and levels of potassium, the highest uptake was always observed from the combination of K_4B_2 (three-splits application of 120 kg K ha^{-1}). The highest total uptake was 43.86 kg ha^{-1} of N, 12.94 kg ha^{-1} of P, 53.39 kg ha^{-1} of K and 13.45 kg ha^{-1} of S, which was assumed to be the key factor for producing higher yield of summer onion. Analyses of multiple correlations co-efficient revealed positively significant correlation between and among yield and yield components.

The result of the present experiment clearly indicated that growth, yield and yield attributes of summer onion were greatly influenced by application methods and levels of potassium. Three-split application of 120 kg K ha^{-1} proved to be superior to the traditional practice of applying potassium for higher production in case of summer onion. The present result can be used as prime source for the development of future research program of similar aspect. Introduction of newer approach regarding fertilizer management should be encouraged; it would maximum option of summer onion growers. However, further studies are suggested with various levels of potassium and application methods in different agro-ecological zones of Bangladesh for validation and to make the present findings acceptable to the end users.

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Appendices

Appendix I: Monthly temperature, total rainfall, average evaporation, humidity and sunshine data during March to July, 2005 of experimental site (Gazipur)

Month	Air temperature °C			Total rainfall (mm)	Total evaporation (mm)	Average relative humidity (%)		Average sunshine (Hrs day^{-1})
	Maximum	Minimum	Average			Maximum	Minimum	
March	31.29	21.92	26.61	175.2	128.65	81.63	59.54	6.61
April	33.99	22.84	26.90	84.4	153.11	76.9	59.7	8.22
May	33.22	24.40	28.81	153.4	154.14	82.54	64.45	7.10
June	31.17	26.59	28.83	121.2	115.24	84.3	81.1	1.67
July	33.1	26.82	29.96	444.2	115.00	78.54	67.09	7.68

Appendix II (a). Plant height of summer onion as influenced by different methods of application at various growth stages.

Treatment	Plant height (cm)			
	30 DAT	50 DAT	70 DAT	90 DAT
B_0	29.58 c	35.11 b	46.17 c	41.95 c
B_1	30.31 b	35.82 ab	46.83 b	42.54 b
B_2	31.31 a	36.36 a	47.54 a	43.26 a
LSD	0.3305	0.7753	0.3346	0.3623
Level of significance	**	**	**	**
CV %	6.6	3.2	4.05	2.26

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

Appendix II (b). Plant height of onion as influenced by different levels of potassium at various growth stages.

Treatment	Plant height (cm)			
	30 DAT	50 DAT	70 DAT	90 DAT
K_0	22.43 e	29.71 e	40.98 e	36.56 f
K_1	24.73 d	31.87 d	43.95 d	39.46 e
K_2	27.90 c	34.27 c	46.31 c	41.38 d
K_3	32.52 b	37.56 b	48.94 b	44.52 c
K_4	37.36 a	40.92 a	51.82 a	47.66 a
K_5	37.45 a	40.26 a	49.09 b	45.90 b
LSD	0.4674	1.096	0.4732	0.5123
Level of significance	**	**	**	**
CV %	6.6	3.2	4.05	2.26

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

Appendix III (a). Leaf length of summer onion as influenced by different methods of K application at various growth stages.

Treatment	Leaf length (cm)			
	30 DAT	50 DAT	70 DAT	90 DAT
B_0	24.70 c	29.48 c	40.73 b	36.15 b
B_1	25.35 b	29.83 b	41.06 a	36.53 a
B_2	26.54 a	30.44 a	41.01 a	36.66 a
LSD	0.1843	0.1645	0.1071	0.1545
Level of significance	**	**	**	**
CV %	5.06	4.81	3.38	4.62

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT

Appendix III (b). Leaf length of onion as influenced by different levels of potash at various growth stages.

Treatment	Leaf length (cm)			
	30 DAT	50 DAT	70 DAT	90 DAT
K_0	17.23 f	23.57 f	35.13 f	31.60 f
K_1	19.47 e	25.57 e	38.50 e	34.67 e
K_2	22.76 d	27.78 d	40.44 d	36.47 d
K_3	27.31 c	31.11 c	43.49 b	38.12 b
K_4	34.37 a	36.78 a	45.14 a	40.92 a
K_5	32.04 b	34.71 b	42.89 c	36.91 c
LSD	0.2606	0.2327	0.1515	0.2185
Level of significance	**	**	**	**
CV %	5.06	4.81	3.38	4.62

** = Significant at 1% level of significance

Figures in a column having common letter(s) do not differ significantly at 5% level of significance by DMRT